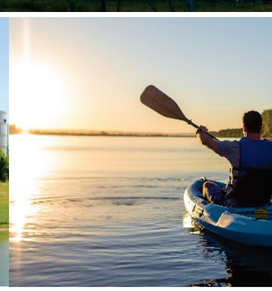
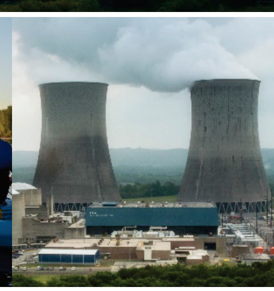
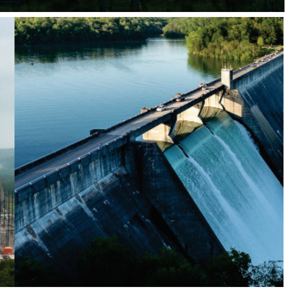
2019 Integrated Resource Plan

VOLUME II - FINAL ENVIRONMENTAL IMPACT STATEMENT







TENNESSEE VALLEY AUTHORITY

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Abstract: The 2019 Integrated Resource Plan (IRP) is a long-term plan that provides direction on how TVA can best meet future demand for power. It will shape how TVA provides low-cost, reliable electricity; supports environmental stewardship; and fosters economic development in the Tennessee Valley for the next 20 years. TVA's IRP is based upon a "scenario" planning approach that provides an understanding of how future decisions would play out in future scenarios. A wide variety of resource options and business strategies are considered in this IRP. TVA identified six scenarios: (1) The Current Outlook, (2) Economic Downturn, (3) Valley Load Growth, (4) Decarbonization, (5) Rapid Distributed Energy Resources (DER) Adoption, and (6) No Nuclear Extensions. Five planning strategies were evaluated against the backdrop of these scenarios: (A) Base Case, (B) Promote Distributed Energy Resources (DER), (C) Promote Resiliency, (D) Promote Efficient Load Shape and (E) Promote Renewables. The modeling process applied each strategy to each scenario, resulting in 30 resource portfolios. The model analyzed how to achieve the lowest-cost portfolio with each strategy in each scenario, looking for the optimal solution within that particular combination.

The EIS assesses the natural, cultural and socioeconomic impacts associated with the implementation of the 2019 IRP. The Base Case serves as the No-Action Alternative, and the remaining four strategies and the Target Power Supply Mix are the Action Alternatives. The EIS analyzes and identifies the relationship of the natural and human environment to each of the five strategies considered in the IRP. Under all the portfolios, there is a need for new capacity in all scenarios modeled, in part to replace expiring or retiring capacity. Uncertainty around future environmental standards for CO_2, along with lower loads and gas prices, are key considerations when evaluating potential coal retirements.

Emissions of air pollutants, the intensity of greenhouse gas emissions and generation of coal waste decrease under all strategies and the Target Power Supply Mix. Strategies focused on resiliency, load shape and renewables have the largest amounts of solar and storage expansion and coal retirements, resulting in lower environmental impact overall but higher land use. For most environmental resources, the impacts are greatest for Strategy A (the No Action alternative) except for the land area required for new generating facilities, which is greater for the action alternatives, particularly Strategies C, D, and E.

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List of Acronyms

Acronym	Description
4th NCA	Fourth National Climate Assessment
AC	Alternating Current
ACS	American Community Survey
APWR	Advanced Pressurized Water Reactor
ARC	Appalachian Regional Commission
B.P.	before present
BART	Best Available Retrofit Technology
BCF	billion cubic feet
Btu	British Thermal Units
CAA	Clean Air Act
CAES	compressed air energy storage
CAGR	compound annual growth rate
CC	Combined Cycle
CCR	Coal Combustion Residuals
CCS	carbon capture and storage/sequestration
CCW	condenser cooling water
CEQ	Council on Environmental Quality
CFR	Code of Federal Regulations
CHP	Combined Heat and Power
CO	carbon monoxide
CO_2	carbon dioxide
CO_2-eq	CO_2-equivalent emissions
CRM	Clinch River Mile
CT	Combustion Turbine
CWA	Clean Water Act
DC	Direct Current
DDT	Dichlorodiphenyltrichloroethane
DER	Distributed Energy Resources
DGIX	Distributed Generation Information Exchange
DO	dissolved oxygen
DOE	Department of Energy
DP	Data Profile
DR	demand response
DSM	Demand Side management
dV	deciview
E.O.	Executive Order
EA	Environmental Assessment
EBCI	Eastern Band of Cherokee Indians
EE	energy efficiency
EIS	Environmental Impact Statement
EPRI	Electric Power Research Institute

Acronym	Description
ERM	Emory River Mile
ESA	Endangered Species Act
FERC	Federal Energy Regulatory Commission
FGD	flue gas desulphurization
FOM	Fixed operating and maintenance costs
FY	Fiscal Year
gal/d/mi^2	gallons per day per square mile
GDP	Gross Domestic Product
GHG	greenhouse gas
GP	Generation Partners
GPP	Green Power Providers
GW	gigawatt
GWh	gigawatt hours
HAP	Hazardous Air Pollutants
HFC	hydroflurocarbons
Hg	Mercury
HUC	Hydrologic Unit Code
HVAC	heating, ventilation, and air conditioning
HVDC	high voltage direct current
IGCC	integrated gasification combined cycle
IMP	Internal Monitoring Point
IPP	Independent power producers
IRP	Integrated Resource Plan
KDFWR	Kentucky Department of Fish and Wildlife Resources
KPDES	Kentucky Pollutant Discharge Elimination System
kV	kilovolt
KWh	kilowatt-hours
LCA	life cycle assessments
LED	light emitting diode
LPC	Local Power Companies
MAPE	Mean absolute percent error
MATs	Mercury and Air Toxics Standards
MBCI	Mississippi Band of Choctaw Indians
MBTA	Migratory Bird Treaty Act
MBtu	Million British Thermal Units
MGD	million gallons per day
MISO	Midcontinent Independent System Operator
MLGW	Memphis Light, Gas and Water
MSAs	metropolitan statistical areas
MW	Megawatt
MWh	Megawatt-hour
N2O	Nitrous oxide
NAAQS	National Ambient Air Quality Standards
NEPA	National Environmental Policy Act

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Acronym	Description
NFIP	National Flood Insurance Program
NHPA	National Historic Preservation Act
NO_2	nitrogen dioxide
NOI	Notice of Intent
NPDES	National Pollutant Discharge Elimination System
NPS	National Park Service
NRC	Nuclear Regulatory Commission
NREL	National Renewable Energy Laboratory
NRHP	National Register of Historic Places
NWS	National Weather Service
ORSANCO	Ohio River Valley Water Sanitation Commission
PCB	polychlorinated biphenyl
PEP	Population Estimates Program
PFC	perfluorocarbons
PFOS	Perfluorooctane sulfonate
PM	particulate matter
PPA	Power Purchase Agreement
ppm	parts per million
PSA	Power Service Area
PURPA	Public Utility Regulatory Policies Act
PV	photovoltaic
PVRR	Present Value of Revenue Requirement
PWR	Pressurized Water Reactor
QCN	Quality Contractor Network
RBI	Reservoir Benthic Index
RCP	representative concentration pathway
RCRA	Resource Conservation and Recovery Act
REC	Renewable Energy Certificate
RFAI	Reservoir Fish Assemblage Index
RICE	reciprocating internal combustion engines
ROD	Record of Decision
ROS	Reservoir Operations Study
RSO	Renewable Standard Offer
SAE	Statistically Adjusted End-use model
SCPC	supercritical pulverized coal
SCR	selective catalytic reduction
SDTSA	state-designated tribal statistical areas
SEPA	Southeastern Power Administration
SLR	Second License Renewal
SMR	small modular reactors
SND	summer net dependable
SO_2	sulfur dioxide
SOC	Special Opportunities Counties
SPCP	supercritical pulverized coal plant

Acronym	Description
SPP	Southwest Power Pool
T&D	transmission and distribution
TCP	Traditional Cultural Properties
TDEC	Tennessee Department of Environment and Conservation
TDS	total dissolved solids
TRM	Tennessee River Mile
TSCA	Toxic Substances Control Act
TSS	total suspended solids
TVA	Tennessee Valley Authority
TWRA	Tennessee Wildlife Resources Agency
USACE	U.S. Army Corps of Engineers
USBEA	U.S. Bureau of Economic Analysis
USBLS	U.S. Bureau of Labor Statistics
USCB	U.S. Census Bureau
USDA	U.S. Department of Agriculture
USDOE	U.S. Department of Energy
USET	United South and Eastern Tribes, Inc.
USFWS	U.S. Fish and Wildlife Service
USGS	U.S. Geological Survey
VOC	volatile organic compounds
VOM	Variable operating and maintenance costs
WAP	Weatherization Assistance Program
WKWMA	Western Kentucky Wildlife Management Area

1 Introduction

The Tennessee Valley Authority (TVA) has developed the Integrated Resource Plan (IRP) and associated programmatic Environmental Impact Statement (EIS) to address the demand for power in the TVA power service area (PSA), the resource options available for meeting that demand, and the potential environmental, economic and operating impacts of these options. The IRP will serve as a roadmap for meeting the energy needs of TVA's customers over the next 20 years.

TVA is the largest producer of public power in the United States. TVA provides wholesale power to 154 local power companies and directly sells power to 58 industrial and federal customers. TVA's power system serves nearly 10 million people in a seven-state, 80,000-square-mile region (Figure 1-1). TVA's PSA includes virtually all counties in Tennessee and portions of Alabama, Georgia, Kentucky, Mississippi, North Carolina, and Virginia.

TVA's generating assets include: six fossil plants, three nuclear plants, 29 conventional hydroelectric plants, one pumped storage hydroelectric plant, nine natural gas combustion turbine (CT) gas plants, eight natural gas combined cycle (CC) gas plants, one diesel generator site and 14 solar energy sites. TVA has gas-co-firing potential at one coal-fired site as well as biomass co-firing potential at its coal-fired sites. In total, these assets constitute a portfolio of 33,500 megawatts (MW).

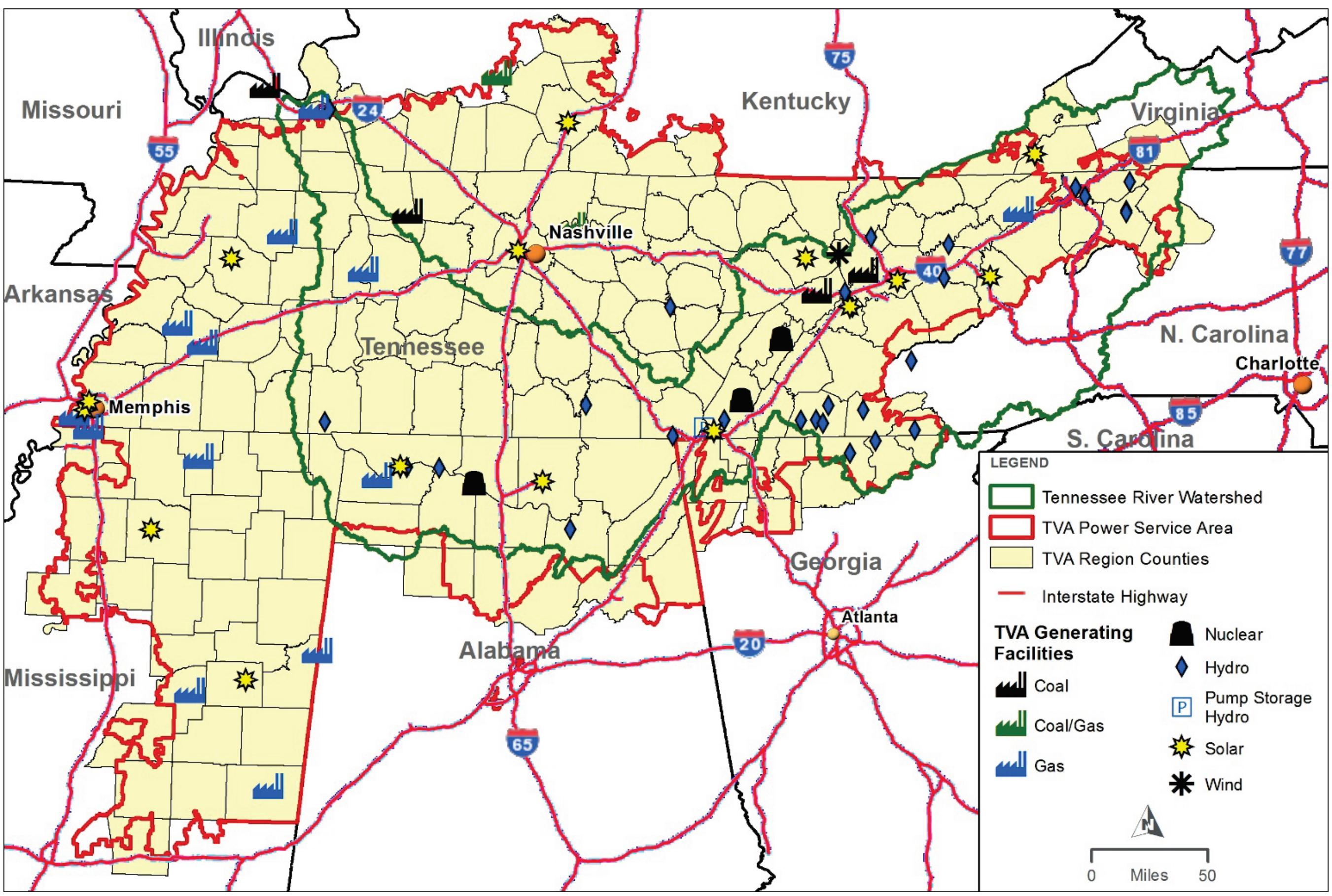

Figure 1-1: Power Service Area and Tennessee River Watershed, herein the TVA region.

1.1 Purpose and Need for Integrated Resource Planning

TVA is developing this new IRP and associated EIS to proactively address regional and national changes within the utility marketplace, including the expansion of distributed energy resources (DER) in the Tennessee Valley. Upon adoption by the TVA Board, the new IRP will replace the 2015 IRP (TVA 2015a). The purpose of the IRP and EIS is to provide TVA with direction on how to best meet future electricity demand. The IRP process evaluates TVA's current energy resource portfolio and alternative future portfolios of energy resource options on a "lowest system cost" basis to meet the future electrical energy needs of the TVA region while taking into account TVA's mission of energy, environmental stewardship and economic development.

1.2 Statutory Overview

In addition to Section 113 of the Energy Policy Act of 1992 (now the least-cost, system-wide planning provision of the TVA Act), several federal laws and executive orders are relevant to TVA's integrated resource planning. Those that are specific to the natural, cultural and socioeconomic resources potentially affected by the TVA power system are described below. This section begins with a detailed description of the National Environmental Policy Act and then lists other potentially applicable laws and executive orders.

1.2.1 National Environmental Policy Act

This EIS has been prepared by TVA in accordance with the National Environmental Policy Act (NEPA) of 1969 (42 United States Code [U.S.C.] §§ 4321 *et seq.*), regulations implementing NEPA promulgated by the Council on Environmental Quality (CEQ) (40 Code of Federal Regulations [C.F.R] Parts 1500 to 1508), and TVA NEPA procedures. TVA's Board of Directors will consider the analyses in this EIS and IRP when it selects the resource plan to be implemented.

NEPA requires federal agencies to consider the impact of their proposed actions on the environment before making decisions. Actions, in this context, can include new and continuing activities that are conducted, financed, assisted, regulated or approved by federal agencies, as well as new or revised plans, policies, or procedures. For major federal actions with significant environmental impacts, NEPA requires that an EIS be prepared. This process must include public involvement and analysis of a reasonable range of alternatives.

According to CEQ regulations, a programmatic EIS is appropriate when a decision involves a policy or program, or a series of related actions by an agency over a broad geographic area. Due to the comprehensive nature of the IRP, this EIS meets that criterion. The environmental impacts of the alternative actions are, therefore, addressed at a regional level, with some extending to a national or global level. The more site-specific effects of actions that are later proposed to implement the IRP will be addressed in subsequent tiered environmental reviews.

The IRP and EIS are developed with public input. TVA used the input from the scoping period, summarized below, in development of the draft EIS and the draft IRP. The draft IRP and draft EIS were distributed to interested individuals; groups; and federal, state and local agencies for their review and comment. During the public comment period for the draft EIS and draft IRP, TVA conducted public meetings throughout the Tennessee Valley region. Following the public comment period, TVA responded to the comments received on the draft IRP and draft EIS and incorporated any necessary changes into the final IRP and final EIS (Appendix F).

The completed final EIS has been placed on TVA's website, and notice of its availability was sent to those who received the draft EIS or submitted comments on the draft EIS. TVA also submitted the final IRP and final EIS to the U.S. Environmental Protection Agency (USEPA), which published a notice of its availability in the Federal Register.

The TVA Board of Directors will make the final decision on the IRP no sooner than 30 days after the publication of the Federal Register notice of the filing of the final EIS and final IRP. The TVA Board of Directors will consider the analyses in the EIS and IRP when it selects the resource plan to be implemented. Following a decision by the TVA Board of Directors, TVA will then issue a Record of Decision (ROD), which will include (1) the decision; (2) the rationale for the decision; (3) alternatives that were considered; (4) the alternative that was considered environmentally preferable; and (5) associated mitigation measures and monitoring, and enforcement requirements.

1.2.2 Other Laws and Executive Orders

Several other laws and executive orders are relevant to the construction and operation of TVA's electric power system (Table 1-1). These laws and executive orders may affect the environmental consequences of an alternative plan, or measures needed during its implementation. Most of these laws also have associated implementing regulations.

Chapter 4 (Affected Environment) describes the regulatory setting for each resource in more detail. Chapter 5 (Anticipated Environmental Impacts) discusses applicable laws and their relevance to this analysis.

Table 1-1: Laws and Executive Orders relevant to the environmental effects of power system planning, construction and operation.

Environmental Resource Area	Law / Executive Order
Water Quality	• Clean Water Act
Groundwater	• Safe Drinking Water Act • Resource Conservation and Recovery Act • Comprehensive Environmental Response, Compensation, and Liability Act • Federal Insecticide, Fungicide, and Rodenticide Act
Air Quality	• Clean Air Act
Wetlands and Waters	• Clean Water Act • Executive Order 11990 – Protection of Wetlands • Executive Order 13778 – Restoring the Rule of Law, Federalism, and Economic Growth by Reviewing the "Waters of the United States" Rule
Floodplains	• Executive Order 11988 – Floodplain Management
Endangered and Threatened Species	• Endangered Species Act
Cultural Resources	• National Historic Preservation Act • Archaeological Resources Protection Act • Native American Graves Protection and Repatriation Act
Environmental Justice	• Executive Order 12898 – Federal Actions to Address Environmental Justice in Minority and Low-Income Populations
Land Use	• Farmland Protection Policy Act
Coal Mining	• Surface Mining Control and Reclamation Act
Waste Management	• Resource Conservation and Recovery Act • Comprehensive Environmental Response, Compensation, and Liability Act • Toxic Substances Control Act

1.3 Relationship with Other NEPA Reviews

Several environmental documents and reviews are relevant to TVA's IRP and are briefly discussed in the sections below. They are arranged by the type of action.

1.3.1 Programs, Plans and Policies

Diesel-fueled Generation in TVA Demand Response Program Environmental Assessment (February 2017)
Evaluated the potential use of diesel-fueled generators by participants in TVA demand response programs to provide backup generation during certain demand response events (TVA 2017a).

2015 Integrated Resource Plan (August 2015)
Provides direction for how TVA will meet the long-term energy needs of the Tennessee Valley region. This document and the associated supplemental EIS evaluated scenarios and strategies for providing electricity through 2033.

Natural Resource Plan (July 2011)
Guides TVA's natural resource stewardship efforts over the following twenty years. This document and the associated EIS evaluated the resource management programs and activities, alternative approaches to TVA's resource management efforts, and the environmental impacts of the alternatives.

Reservoir Operations Study Environmental Impact Statement (May 2004)
Evaluated changes in TVA's policy for operating its reservoir system.

TVA Solar Photovoltaic Projects Programmatic Environmental Assessment (September 2014)
Evaluated the potential impacts of constructing and operating small solar photovoltaic (PV) systems providing power for the TVA system.

1.3.2 Power Generation – Coal and Gas

Ash Impoundment Closure Programmatic EIS (June 2016)
Evaluated the closure of ash impoundments containing coal combustion residuals (CCR) at fossil fuel plants across the Tennessee Valley to support the implementation of TVA's goal to eliminate all wet CCR storage at its coal plants (TVA 2016e).

Bull Run Fossil Plant Ash Impoundment Closure Project Environmental Assessment (October 2017)
This environmental assessment (EA) tiers from the 2016 Ash Impoundment Closure Programmatic EIS, which evaluated the closure of the Bull Run Fossil Plant (herein, Bull Run) Sluice Channel and Fly Ash Impoundment. TVA expanded the closure area at BRF and determined a long-term need for wastewater treatment at Bull Run. The new proposed action included a plan to repurpose the Stilling Impoundment and possibly a portion of the Fly Ash Impoundment to be used as part of wastewater treatment at Bull Run.

Bull Run Fossil Plant Landfill Environmental Impact Statement (November 2016)
Addressed the continued disposal of CCR from the Bull Run Fossil Plant by constructing and operating a new landfill for storage of CCR on TVA property adjacent to the plant (TVA 2017b).

Colbert Fossil Plant Decontamination and Deconstruction Environmental Assessment (November 2016)
Evaluated the future disposition of the retired coal-fired plant, including the powerhouse, coal handling facilities, and support buildings.

Cumberland Fossil Plant Coal Combustion Residuals Management Operations Environmental Impact Statement (April 2018)
Evaluated the construction and operation of a bottom ash dewatering facility, an onsite CCR landfill, and process water basins at the Cumberland Fossil Plant.

Flue Gas Desulfurization System at Kingston Fossil Plant Supplemental Environmental Assessment (February 2018)
Supplemented a 2006 EA to evaluate changes to the proposed construction support areas and environmental conditions within the area of the Phase 2 part of the landfill.

Gallatin Fossil Plant Bottom Ash Process Dewatering Facility Environmental Assessment (July 2017)
Evaluated the construction of a bottom ash process dewatering facility and sluice water recirculation system at Gallatin Fossil Plant.

Gallatin Fossil Plant—Installation of Air Pollution Control Equipment and Associated Facilities (March 2013)
Evaluated the construction and operation of air pollution control equipment and associated facilities at Gallatin Fossil Plant. The EA also evaluated the construction and operation of a landfill on the Gallatin plant site for the dry storage of the coal combustion residues.

Johnsonville Cogeneration Plant Environmental Assessment (June 2015)
Evaluated the addition of a heat recovery steam generator to an existing combustion turbine at the Johnsonville Fossil Plant. The steam generator would provide steam to an adjacent industrial customer that was previously provided by now-retired coal-fired units.

Johnsonville Fossil Plant Decontamination and Deconstruction Final Environmental Assessment (December 2018)
Evaluated the future disposition of the physical structures associated with the retired coal-fired plant units, including the powerhouse, coal handling facilities, and surrounding support buildings at Johnsonville Fossil Plant.

Johnsonville Fossil Plant Proposed Actions (December 2018)
Evaluating closure of the coal yard and coal yard runoff pond, construction and operatation of a process water basin for the Johnsonville CT plant site, and development of a borrow site to facilitate closure of the coal yard and coal yard runoff pond (TVA 2018m).

Paradise Coal Combustion Residuals Management Operations Environmental Assessment (June 2017)
Evaluated the implementation of projects proposed to support dry storage and CCR Rule compliance at Paradise Fossil Plant, including the construction and operation of a gypsum dewatering facility, a dry fly ash handling system, and an onsite CCR landfill. The EA also included the closures of the gypsum disposal area, slag impoundment 2A/2B and stilling impoundment 2C, and the Peabody ash impoundment.

Potential Retirement of Bull Run Fossil Plant Environmental Assessment (February 2019)
Evaluation of the potential retirement of a single-generator coal-fired plant in Anderson County, Tennessee.

Potential Retirement of Paradise Fossil Plant Environmental Assessment (February 2019)
Evaluation of the potential retirement of operating Unit 3 at a coal-fired plant in Muhlenberg County, Kentucky. Units 1 and 2 were replaced with natural gas generation in spring 2017.

Shawnee Fossil Plant Coal Combustion Residuals Management Environmental Impact Statement (December 2017, August 2018)
Evaluated the closure of an existing landfill and ash impoundment and the construction and operation of a new onsite CCR landfill. The 2017 EIS was supplemented in 2018 to include the construction and operation of two process water basins.

Widows Creek Fossil Plant Deconstruction Environmental Assessment (June 2016)
Evaluated the future disposition of the physical structures associated with the retired coal-fired plant, including the powerhouse, coal handling facilities and surrounding support buildings.

1.3.3 Power Generation – Nuclear

Watts Bar Nuclear Plant Unit 2 Replacement of Steam Generators Environmental Assessment (December 2017)
Evaluated the replacement of steam generators in Watts Bar Nuclear Plant Unit 2, which would allow TVA

to operate the plant more efficiently and maintain the generating capacity of Unit 2.

Sequoyah Nuclear Plant Units 1 and 2 License Renewal Supplemental Environmental Impact Statement (2011)
Evaluated the operation of the two units for an additional 20 years between 2020 and 2041.

1.3.4 Power Generation – Solar and Other Renewables

Cumberland Solar Project Environmental Assessment (January 2018)
Evaluated the construction and operation of a proposed 20- MW solar PV facility on approximately 140 acres in Limestone County, Alabama. This solar facility would connect to the existing adjacent 161-kilovolt (kV) TVA Ardmore Substation. TVA proposed to enter into a power purchase agreement (PPA) with Cumberland Land Holdings, LLC to purchase the electric power generated by the solar facility.

Latitude Solar Center Project Environmental Assessment (August 2016)
Evaluated the construction and operation of a proposed 20 MW solar PV facility on approximately 135 acres near Whiteville, Tennessee. The facility would connect to the TVA transmission system through a power line to an existing nearby Bolivar Electric Authority substation. TVA proposed to enter into a PPA with Latitude Solar Center, LLC.

Millington Solar Project Environmental Assessment (December 2017)
Evaluated the construction and operation of a proposed 53 MW solar PV facility on approximately 390 acres in Millington, Tennessee. The facility would connect to the TVA electrical transmission network via a new onsite substation and a new TVA 161-kV transmission line. TVA proposes to enter into a PPA with SR Millington, LLC (TVA 2017c).

Naval Air Station Meridian Solar Farm Environmental Assessment (April 2017)
Evaluated the construction and operation of a proposed 6 MW solar PV facility on approximately 45 acres on Naval Air Station Meridian in Lauderdale County, Mississippi. The facility would connect to the existing substation located approximately one mile away, which would transmit the power to the TVA network. TVA proposed to enter into a PPA with SR Meridian, LLC.

Providence Solar Center Environmental Assessment (March 2016)
Evaluated the construction and operation of a proposed 20 MW solar PV facility on approximately 118 acres in Madison County, Tennessee. The facility would tie into a nearby Southwest Tennessee Electric Membership Corporation substation. TVA proposed to enter into a PPA with Providence Solar Center, LLC.

River Bend Solar Project Environmental Assessment (November 2015)
Evaluated the construction and operation of a proposed 80 MW solar PV facility on approximately 645 acres in Lauderdale County, Alabama. The facility would be connected to TVA's Colbert Fossil Plant - Selmer 161-kV transmission line. TVA proposed to enter into a PPA with River Bend Solar, LLC, a subsidiary of NextEra Energy Resources, LLC (TVA 2015c).

Selmer North I Solar Project Environmental Assessment (October 2016)
Evaluated the construction and operation of a proposed 20 MW solar PV facility on approximately 99 acres near Selmer in McNairy County, Tennessee. The facility would connect to the TVA transmission system through a connection to an existing nearby Pickwick Electric Power Cooperative power line which would be rebuilt. TVA proposed to enter into a PPA with Selmer North I, LLC.

Selmer North II Solar Project Environmental Assessment (July 2016)
Evaluated the construction and operation of a proposed 10 MW solar PV facility on approximately 73 acres near Selmer in McNairy County, Tennessee. The facility would connect to the TVA transmission system through a connection to an existing nearby Pickwick Electric Cooperative power line. TVA proposed to enter into a PPA with Selmer North II, LLC.

Wildberry Solar Center Project Environmental Assessment (June 2016)
Evaluated the construction and operation of a proposed 20 MW solar PV facility on approximately 135 acres in Fayette County, Tennessee. The facility would tie into an existing nearby Chickasaw Electric Cooperative substation. TVA proposed to enter into a PPA with Wildberry Solar Center, LLC.

1.4 Overview of Volumes I and II

Volume I of this document contains the 2019 IRP along with descriptions on the methodology and development of the recommended resource plan. This works in conjunction with Volume II of this document, which contains the EIS. The EIS is a document required by NEPA which describes the environmental effects of proposed actions on the quality of the human environment.

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2 TVA Power System

2.1 Introduction

This chapter describes the Tennessee Valley Authority's (TVA) existing power system, including power sales and purchases; generating facilities; energy efficiency and demand response programs; and the transmission system.

As of September 30, 2018, TVA's power system had a summer net generating capability of 37,514 megawatts (MW). Approximately 33,526 MW of the total capability was provided by TVA facilities and the remainder was provided by non-TVA facilities under long-term power purchase agreements (PPAs). Power generation by these facilities for the 2015 – 2018 fiscal years is summarized in Table 2-1. TVA operates a network of approximately 16,200 miles of transmission lines and 508 substations, switching stations and switchyards. This system transmits power from TVA and non-TVA generating facilities to 1,321 customer connection points. TVA's power system is described in more detail in the remainder of this chapter. Unless stated otherwise, the capacity of energy resources described in this EIS is the net summer dependable capacity.

Table 2-1: Fiscal year 2015–2018 generation by type from both TVA facilities and purchased power.

	Generation in gigawatt-hours			
Type of generation	FY 2015	FY 2016	FY 2017	FY 2018
Nuclear	54,543	52,897	58,742	64,194
Coal	58,854	48,811	41.422	34,026
Natural Gas	26,639	37,494	36,597	43,481
Hydroelectric	16,453	15,018	13,250	16,399
Wind	4,171	4,129	4,245	4,055
Solar	202	350	534	491
Biomass	240	171	136	287
TOTAL	161,102	158,871	154,926	162,933

2.2 TVA Customers, Sales, and Power Exchanges

TVA is primarily a wholesaler of power. In fiscal year (FY) 2018, it sold nearly 163 billion kilowatt-hours (KWh) of electricity; total revenue from these sales was $10.6 billion. Wholesale power is delivered to 154 local power companies (LPCs) that, in turn, distribute electricity to residential, commercial and industrial customers within their service areas. These non-profit, publicly owned LPCs are diverse and include municipal systems and rural electric cooperatives. The largest, Memphis Light, Gas and Water Division, serves approximately 421,000 electric customers and accounted for 9 percent of TVA's 2018 operating revenues. Some of the smallest LPCs serve less than 1,500 customers. Many provide only electrical service while others also provide water, wastewater, telecommunications and/or natural gas service. Sales to LPCs comprised 87.8 percent of TVA 2018 power sales and 92.6 percent of power sale revenues.

In addition to the LPCs, TVA sells power directly to 58 industries and federal installations. The directly served industries include chemical, metal, paper, textile, data centers, and automotive manufacturers. The federal installations include the Department of Energy (DOE) Oak Ridge Operations in Tennessee and military bases. Sales to directly served industries and federal installations comprised 12.2 percent of 2018 power sales and 7.4 percent of power sale revenues. Since 2015, power sales to federal installations have decreased while sales to directly served industries have increased.

The TVA PSA (Figure 1-1) is defined by the TVA Act. The TVA Act restricts TVA from entering into contracts that would make TVA or its LPCs a source of power outside the area for which TVA or its LPCs were the primary source of power on July 1, 1957. The Federal Power Act prevents the Federal Energy Regulatory Commission (FERC) from ordering TVA to deliver power generated by other entities to customers within the TVA PSA.

The TVA Act authorizes TVA to exchange, buy or sell power with 13 neighboring electric utilities. This arrangement gives TVA the ability to purchase power when its generating capacity cannot meet demand or when purchasing power from a neighboring utility is more economical for TVA than generating it. The arrangement also allows TVA to sell power to neighboring utilities when its generation exceeds demand. TVA conducts these exchanges through 69 transmission system interconnections. To the extent allowed by Federal law, TVA offers transmission services to others to transmit or “wheel” power through the TVA PSA.

2.3 TVA-Owned Generating Facilities

TVA owns and/or operates under long-term lease 33,526 MW of summer generating capability (Figure 2-1). These facilities generated about 141,505 million kWh in FY18, a small increase over the preceding two years.

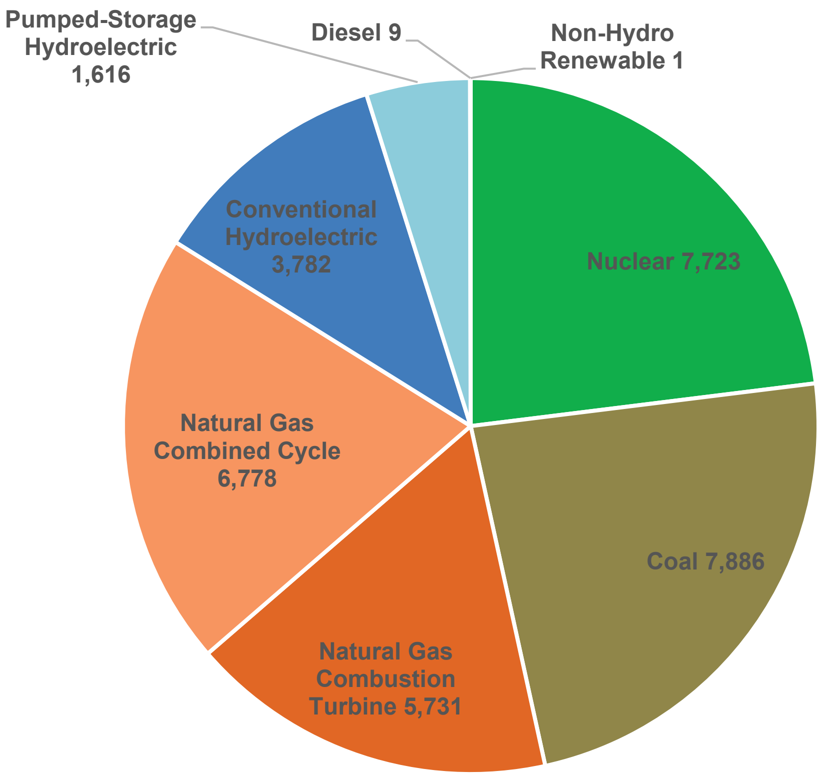

Figure 2-1: Fiscal Year 2018 TVA-owned summer generating capability in megawatts by type of generation.
Source: FY2018 TVA 10-K Report.

2.3.1 Coal-Fired Generation

As of October 2018, TVA had 26 active coal-fired generating units at six plant sites with a total summer net dependable capability of approximately 7,886 MW (Figure 1-1, Table 2-2). The coal-fired units range in size from 134 MW (Shawnee Units 1 – 9) to 1,239 MW (Cumberland Unit 1). The oldest unit was placed in service in 1953 at Shawnee, and the newest is Cumberland Unit 2, which began operation in 1973.

Table 2-2: Characteristics of TVA coal-fired generating facilities.

Facility	Number of Units	2018 Summer Net Capability (MW)	Commercial Operation Date (First and Last Unit)	Boiler Type*	Emissions Controls**
Bull Run	1	865	1967	SCPC	FGD, SCR
Cumberland	2	2,470	1973	SCPC	FGD, LNB, SCR
Gallatin	4	976	1956, 1959	PC	FGD, SCR
Kingston	9	1,398	1954, 1955	PC	LNB (4 units), SCR, FGD
Paradise	1	971	1970	SCPC	FGD, SCR
Shawnee	9	1,206	1953, 1955	PC	DSI, FGD (2 units), LSC, LNB, SCR (2 units), SNCR
Total Coal	26	7,886			

*CF – cyclone furnace; PC – pulverized coal; SCPC – supercritical pulverized coal
**DSI – Dry sorbent injection; FGD – Flue gas desulfurization (“scrubber”); LNB – low-NO_x burner; LSC – low sulfur coal, may be blended with high sulfur coal; SCR – selective catalytic reduction; SNCR – selective non-catalytic reduction.

Since 2010, TVA has retired the 4-unit, 704-MW John Sevier Fossil Plant; the 8-unit, 1,499-MW Widows Creek Fossil Plant; the 126-MW, Unit 10 at Shawnee; the 10 coal-burning units, totaling 2,130 MWs, at Johnsonville Fossil Plant; the five coal-burning units, totaling 1,542 MWs, at Colbert Fossil Plant; Units 1 and 2, totaling 1,176 MW, at Paradise Fossil Plant; and the 3 coal-burning units, totaling 741 MWs, at Allen Fossil Plant. The potential retirements of the remaining operating unit at Paradise in 2020 and of Bull Run in 2023 were the subject of environmental assessments issued for public review in November 2018, and finalized in February 2019 just prior to the release of this EIS (TVA 2019a, 2019b). Both EAs resulted in a finding of no significant impact. Based on these assessments, the TVA Board made a decision to retire Paradise Unit 3 in 2020 and Bull Run in 2023.

In April 2011, TVA entered into two agreements to resolve litigation over Clean Air Act (CAA) New Source Review requirements for maintenance and repair of its coal-fired units. The first agreement is a Federal Facilities Compliance Agreement with U.S. Environmental Protection Agency (USEPA). The second agreement is a Consent Decree with Alabama, Kentucky, North Carolina, Tennessee, the Sierra Club, National Parks Conservation Association and Our Children’s Earth Foundation. Under the terms of these agreements (collectively the “CAA Environmental Agreements”), TVA agreed to either install and operate selective catalytic reduction (SCR), nitrogen oxide emission reduction equipment, and/or flue gas desulphurization (FGD, “scrubber”) sulfur dioxide emission reduction equipment; convert to burn renewable biomass fuels, or retire specified units; and operate emission reduction equipment at specified units year-round instead of seasonally. TVA has substantially completed these actions and the coal-fired unit retirements listed above (except those for Paradise Units 1 and 2, Shawnee Unit 10 and Widows Creek Units 7 and 8) were in response to the CAA Environmental Agreements

In order to maintain adequate generating capacity in the vicinity of some retired coal plants or units, TVA recently constructed and operates natural gas-fired combined cycle (CC) plants at the Allen, John Sevier, and Paradise fossil plant sites. These CC plants are described below.

Fuel Procurement – TVA coal consumption has greatly decreased since 2010 as a result of the coal unit retirements described above, increased generation by other types of power plants and increased energy efficiency. From 2015 through 2018, TVA's coal consumption decreased from 28 to 17 million tons (Figure 2-2). In 2017, the most recent year for which detailed U.S. production data is available (USEIA 2018a), TVA consumed about 2.3 percent of eastern U.S. coal production and 2.1 percent of western U.S. coal production. In recent years, TVA has obtained coal from the Central Appalachians (eastern Kentucky, southern West Virginia, and Virginia) and Illinois Basin (Illinois, Indiana, and western Kentucky) regions in the eastern U.S. and from the Powder River Basin (Wyoming and Montana) and Uinta Basin (Colorado and Utah) regions in the western U.S.

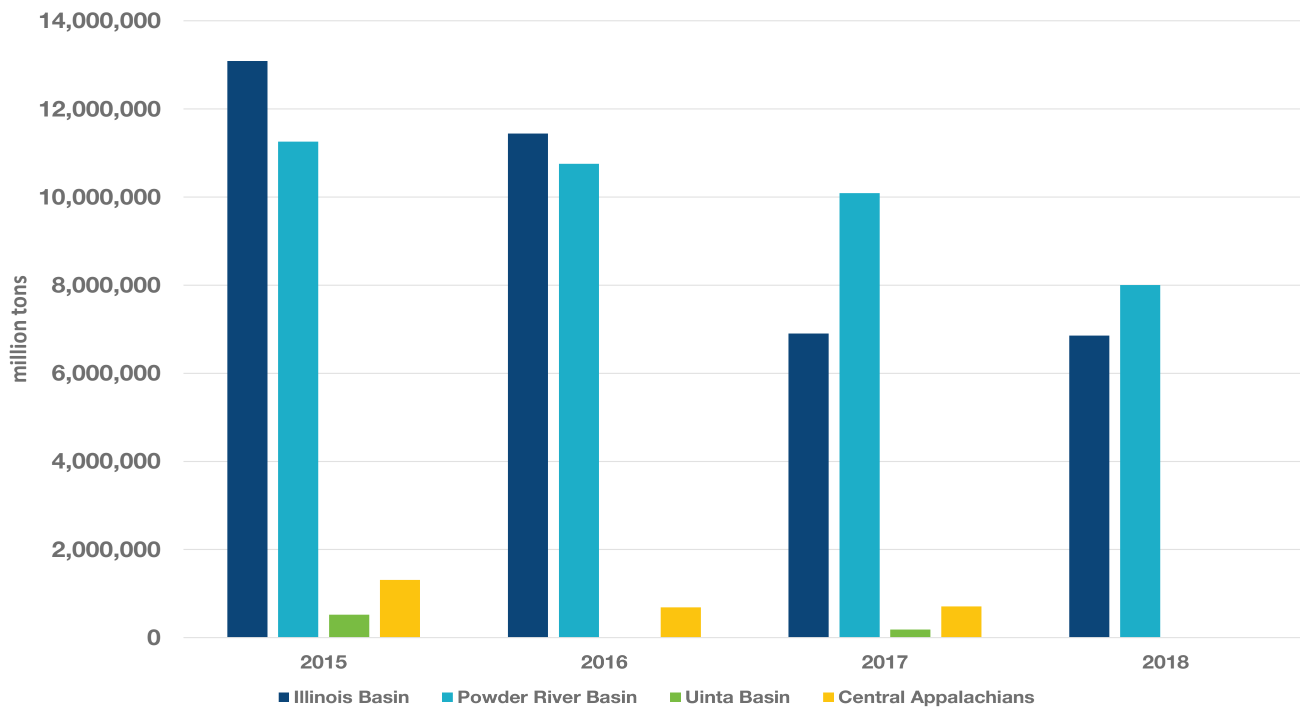

Figure 2-2: Fiscal Year 2015-2018 coal purchases by mining region.

Approximately 43 percent of the 14.9 million tons of coal that TVA contracted to purchase in FY18 was mined by underground mining methods; all of this coal was from the Illinois Basin region (Figure 2-2, Table 2-3). The remaining coal was mined from open pit/area surface mines. The proportion of coal consumed by TVA that is mined by each mining method, as well as the proportion from each of the major mining regions, varies somewhat from year to year due to market conditions and the operating characteristics of TVA coal units. All of the coal that TVA has purchased in recent years from the Powder River Basin was mined by open pit/area mining methods. All of the coal that TVA has recently purchased from the Uinta Basin was mined by underground mining methods, as was over 90 percent of the coal that TVA has recently purchased from the Illinois Basin and Central Appalachians. Surface-mined coal from the Illinois Basin was mined by open pit/area mining methods, and surface-mined coal from the Central Appalachians was mined by contour/highwall mining methods. TVA has not purchased coal from Appalachian mountaintop removal surface mines in recent years.

Table 2-3: TVA coal purchase contracts for FY18, in millions of tons, by mining region and mining method.

Region	Underground	Mining Method: Surface - Open Pit/Area	Surface - Contour/ Highwall	Totals
Illinois Basin	6.4	0.5	0	6.9 (54%)
Powder River Basin	0	8.0	0	8.0 (46%)
Uinta Basin	0	0	0	0
Central Appalachians	0	0	0	0
Totals	6.4 (43%)	8.5 (57%)	0	14.9

TVA purchases coal under both long-term (more than one year) and short-term (one year or less) contracts; 97 percent of 2018 purchases were with long-term contracts. During 2018, 36 percent of TVA's coal supply was delivered by rail, 15 percent was delivered by barge, and 43 percent was delivered by a combination of barge and rail. The remaining 6 percent was delivered by truck. These percentages vary from year to year depending on the coal sourcing areas and other factors.

TVA uses large quantities of limestone to operate the FGD systems at its six coal plants. This limestone is acquired from quarries in the vicinity of the plants and transported to the plants primarily by truck.

2.3.2 Nuclear Generation

TVA operates seven nuclear units at three sites with a total net summer dependable capacity of 7,723 MW (Figure 1-1, Table 2-4). The newest nuclear unit, Watts Bar Unit 2, began commercial operation in 2016 after initial construction efforts were halted in the mid-1980s. In 2017, TVA received approval from the Nuclear Regulatory Commission for an extended power uprate at Browns Ferry. The first of these uprates, completed in July 2018, increased the capacity of Unit 3 by 155 MW. The uprate to Unit 3 was completed January 31, 2019, enabling the unit to generate an additional 155 MW of electricity (up to 1,311 MW electricity total). After the planned completion of the remaining uprate, the total generating capacity of Browns Ferry will be increased by 465 MW.

Table 2-4: Characteristics of TVA nuclear generating units.

Facility	Units	2018 Net Summer Capability (MW)	Type	Commercial Operation Date (First and Last Unit)	Operating License Expiration
Browns Ferry	3	3,309	Boiling Water	1974, 1977	2033, 2034, 2036
Sequoyah	2	2,292	Pressurized Water	1981, 1982	2040, 2041
Watts Bar	2	2,122	Pressurized Water	1996, 2016	2035, 2055
Total	7	7,723			

Fuel Procurement - TVA's seven nuclear units use a total of about 4 million pounds of natural uranium equivalent (U_{235}) per year. Natural uranium equivalent is used to make enriched uranium, which has a higher concentration of the uranium U_{235} isotope than natural uranium. This uranium, which comes from uranium producing areas around the world, is processed into enriched uranium and fabricated in North American locations. In October 2018, TVA entered into a DOE program for downblending highly enriched uranium to low enriched uranium for use in TVA nuclear units. TVA currently has sufficient enriched uranium and fabrication in inventory or under contract to provide all of its requirements through 2022.

2.3.3 Natural Gas-Fired Generation

TVA has 87 natural gas-fueled simple-cycle combustion turbine (CT) units at 9 sites (Figure 1-1, Table 2-5). The oldest CTs were completed in 1971 and the newest in 2002. Eight CTs are co-located at the coal-fired Gallatin plant site and 48 are at the sites of three now-retired coal plants (Allen, Colbert, and Johnsonville). The remaining 31 CTs are located at five stand-alone plant sites. The individual CT units range in generating capacity from 15 MW (Allen CT Units 1 – 16) to 180 MW (Gleason CT Units 1 and 2). Eighty of the CT units are capable of using fuel oil and 60 are capable of quick start-up, reaching full generation capability in about 10 minutes. One of the newer CT units at Johnsonville was recently converted to power a steam generator to provide steam to an adjacent chemical plant. This steam was previously produced by now-retired Johnsonville coal plant.

Table 2-5: Characteristics of TVA natural gas-fueled plants.

Facility	Combustion Turbine Units	Steam Turbine Units	2018 Summer Net Capability (MW)	Commercial Operation Date (First and Last Unit)	Oil Fueling Capability
Simple Cycle (CT)					
Allen	20	--	456	1971, 1972	Yes
Brownsville	4	--	468	1999	No
Colbert	8	--	392	1972	Yes
Gallatin	8	--	642	1975, 2000	Yes
Gleason	3	--	500	2000	No
Johnsonville	20	--	1,269	1975, 2000	Yes
Kemper	4	--	348	2002	Yes
Lagoon Creek	12	--	1,048	2001, 2002	Yes
Marshall	8	--	608e	2002	Yes
CT Subtotal	87	--	5,731		
Combined Cycle (CC)					
Ackerman	2	1	713	2007	No
Allen	2	1	1,106	2018	No
Caledonia	3	3	765	2003	No
John Sevier	3	1	871	2012	Yes
Lagoon Creek	2	1	525	2010	No
Magnolia	3	3	918	2003	No

Facility	Combustion Turbine Units	Steam Turbine Units	2018 Summer Net Capability (MW)	Commercial Operation Date (First and Last Unit)	Oil Fueling Capability
Paradise	3	1	1,100	2017	No
Southaven	3	3	780	2003	No
CC Subtotal	21	15	6,778		
Total Gas-Fueled	108	15	12,509		

TVA also has 21 natural-gas fueled CC units at eight sites. At CC plants, electricity is generated by combustion turbines as at simple-cycle CT plants; the hot exhaust from the combustion turbines drives a heat recovery steam generator and the steam drives a steam turbine generator. Two of the CC sites are adjacent to now-retired coal plants (Allen, John Sevier), and two are co-located with CT units (Allen, Lagoon Creek). The Paradise CC plant is near the remaining operating Paradise coal unit. The three-unit Caledonia plant is leased by TVA and the other CC plants are owned by TVA. The arrangement of CTs and steam generators varies, with each steam generator paired with a combustion turbine at some plants while at other plants two or three CTs drive each steam generator. Some of the turbines at the newest CC plants can be operated as quick-start CT units, as well as more efficient CC units. The total net summer dependable capacities are 5,731 MW for the combustion turbine units and 6,778 MW for the combined cycle units.

Fuel Procurement – TVA's consumption of natural gas has greatly increased in recent years as natural gas-fueled generation, particularly from CC plants, has increased and coal-fired generation decreased. In 2014, TVA used about 56 billion cubic feet (BCF) of natural gas to fuel its CT and CC plants and to fuel generating facilities at some non-TVA plants that sell power to TVA under terms of a PPA. Since 2014, natural gas consumption increased to 213 BCF in 2015, 270 BCF in 2016, and 241 BCF in 2017. The consumption in 2018 further increased to 297 BCF with the start-up of the Allen CC plant and the year-long operation of the Paradise CC plant.

TVA purchases natural gas from multiple suppliers under contracts with terms of up to three years. TVA transports the gas across multiple interstate pipelines to gas generating facilities. TVA contracts for natural gas storage to provide peaking supply and balancing services to accommodate changes in generation. Due to the variety of suppliers and characteristics of the pipeline transportation network, it is not possible to break down the natural gas supply by sourcing area or extraction technique.

Fuel oil is purchased on the spot market for immediate delivery to the plants. TVA maintains an inventory of fuel oil at all of its plants with oil fueling capability to provide a short-term backup supply in the event the gas supply is disrupted.

2.3.4 Diesel-Fired Generation

TVA owns one diesel generating facility with a total net summer capacity of 9 MW. This plant, located in Meridian, Mississippi, consists of 5 units completed in 1998. Diesel fuel is purchased on the spot market and transported via TVA tanker trucks from third party terminals and/or other TVA on-site fuel tanks.

2.3.5 Hydroelectric Generation

The TVA hydroelectric generating system consists of 29 hydroelectric dams with 109 conventional hydroelectric generating units. Twenty-eight of these dams are on the Tennessee River and its tributaries and one dam (Great Falls) is on a Cumberland River tributary (Figure 1-1). TVA also operates the four-unit Raccoon Mountain pumped storage hydroelectric facility near Chattanooga, Tennessee. The 85-MW Unit 2 at the Hiwassee hydroelectric plant in southwestern North

Carolina is a reversible turbine-generator with the ability to operate as a pumped storage hydroelectric plant.

The total net summer capability of the TVA hydroelectric system is 5,398 MW; this includes 3,782 MW of conventional hydroelectric generation and 1,616 MW from Raccoon Mountain. Conventional hydroelectric plants range in size from the 4-unit, 11-MW Wilbur plant to the 21-unit, 675-MW Wilson plant. The oldest of the conventional plants, Ocoee No. 1, was completed in 1911 and the newest, Tims Ford, was completed in 1970. In 1992, TVA began its Hydro Modernization Program to replace outdated turbines and other equipment in the hydroelectric plants. At the end of FY18, these modernization efforts had been completed on 60 out of 109 conventional hydroelectric units and the four pumped hydroelectric units. These efforts resulted in a 444-MW increase in generating capacity of the conventional units and an average efficiency gain of 5 percent.

TVA is in the process of making additional improvements and uprates to the Raccoon Mountain facility which will add 76 MW of pumped storage capacity. TVA is continuing the modernization of the remaining hydroelectric units at the rate of two or three units per year. These ongoing efforts are designed to maintain the units' generating capacity and improve their efficiency; they will not necessarily result in increased capacity. Details about the hydroelectric plants and the operation of the hydroelectric system are available in the *Reservoir Operations Study* (TVA 2004).

2.3.6 Non-Hydro Renewable Generation

TVA owns 14 small photovoltaic (PV) solar installations with a total capacity of about 1,400 kW (Figure 1-1). These include 13 small (<100 kW) installations which generate power marketed through TVA's Green Power Switch program (see Section 2.5) and a recently completed 1-MW facility at the Allen CC plant.

2.4 Purchased Power

For FY 2010 through 2018, purchased power comprised 11 to 16 percent of TVA's total power supply. In FY18, TVA purchased 18,740 million kWh, 13 percent of its total power supply. Approximately 11 percent of this purchased power was purchased on the spot market, one percent through short-term PPAs, and 88 percent through long-term PPAs.

TVA has long-term PPAs for about 3,800 MW of generating capacity; the major PPA contracts/facilities other than those that are part of specific programs, are listed in Table 2-6.

TVA purchases hydroelectric generation from nine U.S. Army Corps of Engineers (USACE) dams on the Cumberland River and its tributaries through a long-term contract with the Southeastern Power Administration, a federal power marketing agency. The power generated by the Buffalo Mountain wind farm, completed in 2004, is marketed through the Green Power Switch program (see Section 2.5).

Table 2-6: Major power purchase agreement contracts/facilities.

Facility	Owner/Marketer	Location	Capacity (MW)[1]	Contract End Date
Natural Gas – Combined Cycle				
Decatur Energy Center	Capital Power	Decatur, AL	720	2023
Morgan Energy Center	Calpine	Decatur, AL	615	2026
Lignite Coal				
Red Hills Power Plant	SE Choctaw (Southern Company)	Choctaw County, MS	440	2032
Diesel				

Facility	Owner/Marketer	Location	Capacity (MW)[1]	Contract End Date
Diesel	various	various	total of 112	various
Wind				
Buffalo Mountain Windfarm	Invenergy	Oliver Springs, TN	27	2024
Lost Lakes Wind Farm	EDP Renewables North America	Dickinson County, IA	101	2030
Caney River Wind	ENEL Green Power North America	Elk County, KS	201	2031
Pioneer Prairie I Wind Farm	EDP Renewables North America	Howard, Mitchell Counties, IA	198	2031
White Oak Energy Center	NextEra Energy Resources	McClean County, IL	150	2031
Bishop Hill Wind Energy Center	Invenergy	Henry County, IL	200	2032
Cimarron Wind Energy Center	NextEra Energy Resources	Gray County, KS	165	2032
California Ridge Wind Energy Center	Invenergy	Champaign County, IL	200	2032
Solar				
West Tennessee Solar Farm	University of Tennessee	Haywood County, TN	5	2032
River Bend Solar Energy Center	NextEra Energy Resources	Lauderdale County, AL	101	2036
Millington Solar Facility	SR Millington (Silicon Ranch Corp.)	Shelby County, TN	69.5	2038
Biomass				
Chestnut Ridge Landfill Gas	WM Renewable Energy	Heiskell, TN	4.8	2031
Hydroelectric				
Cumberland River Hydroelectric Dams (9 dams)	Southeast Power Administration/ USACE	TN, KY	405	2037

[1]Capacities for the Solar PV facilities are direct current; all other capacities are alternating current.

TVA entered into PPAs with the other seven wind farms listed in Table 2-6 in 2009 and 2010, after issuing a request for proposals (RFP) in December 2008 for up to 2,000 MW of electricity from renewable and/or clean sources to be delivered by 2011. The Pioneer Prairie wind farm in Iowa began delivering power to TVA in 2010 and the other six wind farms were delivering power by late 2012. TVA entered into a PPA with an additional wind farm, the 300-MW Streator-Cayuga Ridge wind farm in Livingston County, Illinois, which also began delivering power in 2010. TVA canceled this PPA in May 31, 2016.

Under the Public Utility Regulatory Policies Act (PURPA), TVA is required to purchase energy from qualifying facilities at TVA's avoided cost of either generating this energy itself or purchasing this energy from another source (TVA 2007a). Qualifying facilities are cogeneration or small power production facilities that meet certain ownership, operating, and efficiency criteria. Cogeneration (also known as combined heat and power) facilities produce electricity and another form of useful thermal energy (heat or steam) for industrial or other uses. A qualifying small power production facility has a capacity of between 7 kW and 80 MW and generates power through renewable (hydro, wind or solar), biomass, waste, or geothermal resources. TVA fulfills this requirement through the Dispersed Power Production program. As of December 1, 2018, there were 44 generation sources, with a combined qualifying capacity of 157 MW, whose power TVA purchases through the Dispersed Power Production program. The majority of this power is generated by a 40-MW cogeneration plant operated by International Paper in Lowndes County, MS. and by a 26-MW cogeneration plant operated by DTE Energy in Marshall County, Kentucky. Most of the smaller Dispersed Power Production generation sources are solar PV facilities with a capacity of less than 600 kW installed on or in association with municipal, institutional, and commercial buildings.

The Green Power Providers (GPP) program is an end-user generation program that began in 2003 as the Generation Partners (GP) pilot program. Under the GP pilot program, TVA purchased renewable energy generated by facilities installed by residential, commercial, and industrial customers. TVA purchased qualifying renewable generation at retail plus a premium rate via a generation credit on the participant's monthly bill via a 10 year power purchase agreement. In 2007, the TVA Board adopted a dual metering standard under PURPA that required TVA to make available to its distributors the option to participate in a dual metering program "modeled after" the GP pilot program.

In 2012, the GP pilot program was replaced with the GPP program, which operated similarly to its predecessor and consistent with the dual metering standard TVA adopted in 2007. Qualifying generating systems had a maximum capacity of 50 kW (direct current, DC) and included solar photovoltaic panels, wind turbines, low-impact hydropower, and systems using several types of biomass fuels. A $1,000 incentive for new participants was phased out in 2015 for new non-residential participants and in 2016 for new residential participants. Additionally, the generation credit paid decreased in concert with the significant decrease in the installed cost of solar. For calendar year 2018, the Green Power Providers program capacity for new applicants was capped at 10 MW_{DC}. Generation credit rates for the 20-year contract period were $0.09/kWh for systems with a capacity of up to 10 kW_{DC} and $0.07/kWh for larger systems.

The maximum capacity of individual systems installed under the two programs has varied from a high of 1 MW_{DC} to the current 50 kW_{DC}. As of December 2018, the combined GP and GPP program had over 3,500 generating systems with a total nameplate capacity of about 109 MW_{DC}. Solar PV facilities comprised about 90 percent of this capacity. Biomass (landfill gas, wastewater methane and wood waste and chips) comprised about 10 percent of capacity. Wind generation provided about 96 kW_{DC} and small hydroelectric systems provided 9 kW_{DC}. An additional 171 projects, all solar, with a total capacity of about 4 MW_{DC} have been approved by TVA, under the GPP program, and are in various stages of construction. Additional information on the program is available at https://www.tva.gov/Energy/Valley-Renewable-Energy/Green-Power-Providers.

The GPP program is accepting applications for new installations through the end of 2019. In February 2019, the TVA Board approved a revised net metering standard, the closure of the GPP program to new applicants effective January 1, 2020, and the phasing out of the GPP program completely as existing contracts with participants expire. The Board delegated to the CEO the authority to design and implement a new program to replace the GPP program.

In October 2010, TVA issued the Renewable Standard Offer (RSO) to promote the development of renewable energy in the TVA PSA. RSO offered set prices to developers of small to mid-size renewable projects under long-term contracts up to 20 years. The generating facilities must be between 50 kW and 20 MW in size and located within the TVA region. Qualifying fuel sources included solar photovoltaic, wind, and biomass from wood waste, agricultural crops or waste, animal and other organic waste, energy crops, and landfill gas and wastewater methane. The RSO program was closed to new proposals in 2015. As of December 2018, 20 RSO facilities with over 157 MW_{DC} of generating capacity were operating (Table 2-7). An additional 2 facilities with a total capacity of 40 MW_{DC} have been approved but are not yet operating.

In February 2012, TVA initiated the Solar Solutions Initiative (SSI), a targeted incentive program aimed to support the existing TVA-region's solar industry and to recruit new industry to the region. In addition to terms similar to those of the RSO, SSI provided incentive payments for solar projects in the RSO program greater than 50 kW and less than or equal to 1 MW that used local certified solar installers. As of December 2018, the program had 56 operating facilities with a total capacity of about 43 MW_{DC} and 1 facility with a total capacity of 1 MW_{DC} approved but not yet operating.

At the end of 2015, TVA closed the SSI program to new proposals and initiated the Distributed Solar Solutions (DSS) program. The DSS program was designed to encourage the TVA-region LPCs to develop and operate solar projects with capacities between 50 kW and 2 MW. The program was offered in 2016 and 2017, and as of December 2018, the program had 2 operating facilities with a total capacity of 3 MW_{DC} and 11 facilities with a total capacity of about 23 MW_{DC} approved but not yet operating.

In September 2017, TVA issued an RFP for the procurement of new renewable energy resources. Qualifying facilities had to be located within the TVA Power Service Area or be capable of delivering energy to TVA through TVA's interconnections with neighboring transmission systems. TVA received multiple proposals in response to the RFP. These proposals offered a total capacity of 6,700 MWac of capacity, with 69 percent of this capacity from solar PV facilities, 29 percent from wind facilities, and 2 percent from biomass-fueled facilities. TVA closed the RFP in December of 2017 and, as a result of the proposals received, awarded four contracts to build 674 MWac of new solar power.

In 2018 TVA launched two programs to support accelerated renewable investment: Renewable Investment Agreement (RIA) and the Flexibility Research Project (FRP) pilot. RIA supports utility scale renewable generating facilities for large commercial and industrial customers, and FRP supports community solar, in partnership with LPCs. Community scale solar provides opportunities for LPC customers to invest in LPC-sponsored community solar facilities as a lower cost alternative to constructing and operating their own rooftop or other solar facilities.

In April 2019, TVA issued an RFP for procurement of 200 MW of new renewable energy resources. Proposals could include battery storage. Qualifying facilities had to be located within the TVA Power Service Area or be capable of delivering energy to TVA through TVA's interconnections with neighboring transmission systems. This RFP closed in May 2019; as of late June, 2019, the evaluation of responses to the RFP was still in progress.

Table 2-7: Renewable Standard Offer generating facilities operating in May 2018.

Facility	Owner/Marketer	Location	Fuel	Capacity[1]
West Camden Renewable Energy Facility	Waste Management	Benton County, TN	Landfill gas	4.8

1 Capacities for the solar PV facilities are direct current; all other capacities are alternating current.

Facility	Owner/Marketer	Location	Fuel	Capacity[1]
Prairie Bluff Renewable Energy Facility	Waste Management	Chickasaw County, MS	Landfill gas	1.6
BioEnergy Sand Valley	BioEnergy (Alabama) LLC	DeKalb County, AL	Landfill gas	4.8
Columbus Cellulose Fibers Cogeneration Facility	International Paper	Columbus, MS	Biomass	20
Bristol Landfill Gas	Ingenco Renewable Development, LLC	Bristol, VA	Landfill gas	2.3
Mulberry Solar Farm	Mulberry Farm LLC (Dominion)	McNairy County, TN	Solar PV	20
Selmer Solar Farm	Selmer Farm LLC (Dominion)	McNairy County, TN	Solar PV	20
Bi-County Landfill Gas	Bi-County Landfill Gas Producers LLC	Montgomery County, TN	Landfill Gas	2
Selmer North I Solar Farm	Selmer North I LLC (Silicon Ranch Corp.)	McNairy County, TN	Solar PV	10
Providence Solar Center	Providence Solar Center LLC (Silicon Ranch Corp.)	Madison County, TN	Solar PV	20
Wildberry Solar Center	Wildberry Solar Center LLC	Fayette County, TN	Solar PV	20
Selmer North II Solar Farm	Selmer North II LLC (Silicon Ranch Corp.)	McNairy County, TN	Solar PV	10
Hampton Solar	Cumberland Land Holdings LLC (Silicon Ranch Corp.)	Limestone County, AL	Solar PV	20
Haywood County Solar Farm	Haywood Solar LLC (Silicon Ranch Corp.)	Haywood County, TN	Solar PV	3.9
Latitude Solar Center	Latitude Solar Center LLC (Coronal Energy)	Hardeman County, TN	Solar PV	20
Chickasaw County Solar Farm	SR Houston Holdings LLC (Silicon Ranch Corp.)	Chickasaw County, MS	Solar PV	3.9
Jonesborogh Solar	SR Jonesborough LLC (Silicon Ranch Corp.)	Washington County, TN	Solar PV	5

2.5 Demand-Side Management Programs

TVA has had a portfolio of demand-side management programs focusing on energy efficiency and demand response for many years. Energy efficiency (EE) programs are designed to reduce the use of energy while still providing reliable electric service. Smart electric technology programs improve consumer energy performance, safety, and comfort. Demand response (DR) programs are designed to temporarily reduce a customer's use of electricity, typically during peak periods and for system reliability or economic reasons. Because the energy use is typically shifted to off-peak times, demand response typically has little effect on total energy use. It does, however, provide system reliability and reduce the need for peaking generation capacity. DR program participants receive credits on their electric bills. The TVA demand-side management (DSM) portfolio is a combination of fully deployed mature programs, recently initiated programs and programs under development.

The 2015 Integrated Resource Plan (IRP) identified goals of additional energy efficiency savings, through programs administered by TVA and the LPCs, of 900 to 1,300 MW by 2023 and 2,000 to 2,800 MW by 2033. It also identified the demand response goal of 450 to 750 MW of additional demand reduction by 2023 and similar additional amounts by 2033. Through its EnergyRight Solutions program (described in more detail below), TVA realized 379 gigawatt hours (GWh), 378 GWh, and 170 GWh of energy efficiency savings in 2016, 2017, and 2018, respectively. Based on the rate at which additional energy efficiency savings are being realized, TVA is unlikely to meet the 2023 goal. TVA also provided 1,547 MW, 1,614, and 1,635 MW of potential demand reduction through DR in 2016, 2017, and 2018, respectively. Following are descriptions of DSM programs that have operated since 2015.

2.5.1 Energy Efficiency Programs and Smart Energy Technologies

TVA implements its DSM efforts through its EnergyRight® Solutions (ERS) portfolio. EnergyRight® Solutions targets three sectors: EnergyRight® Solutions for the Home, EnergyRight® Solutions for Business, and EnergyRight® Solutions for Industry. The ERS programs include a variety of energy-saving tools and incentives that help save energy and reduce power costs while providing peak reduction benefits for the power system. They change over time to adapt to new technologies, TVA system needs, and other factors. Unlike integrated power systems where the utility generates and distributes electricity to end users, most of the electricity TVA generates is distributed to end users by the 154 LPCs. This complicates the development and implementation of many types of DSM programs that are delivered through partnerships with participating LPCs, which requires coordination.. The TVA DSM portfolio is described in more detail below; information about programs is also available at http://www.energyright.com/.

EnergyRight® Solutions for the Home

eScore Program – eScore is a home energy upgrade program designed to provide homeowners with smart energy advice, access to a network of specially trained and approved contractors through the TVA Quality Contractor Network, a free inspection of any work performed, and the assurance that the job will be done correctly. The eScore Program is delivered by LPCs and TVA. Homeowners can reengage with the program as many times as needed to achieve their home's best possible energy performance. Financing is available in most areas to help homeowners make upgrades. Rebates are available for qualifying smart energy technology upgrades. Through the end of 2018, over 150,000 customers registered for the program and nearly 70,000 have completed eScores. The eScore program was created as part of the CAA Environmental Agreement described in Section 2.3.

eScore Self Audit Program – Homeowners complete an online home energy survey. The homeowners then receive a personalized report that breaks down their annual and monthly energy usage by category and makes recommendations for increasing energy efficiency. Participants also receive a free energy efficiency kit that may include items such as light emitting diode (LED) light bulbs and gaskets for wall outlet and light switches. Over 37,000 self-audits were conducted by the end of 2018.

Heat Pump Program – Under this program, TVA promoted the installation of high-efficiency heat pumps by providing low-interest, fixed-rate financing for up to 10 years through a third-party lender, with repayment through the consumer's electric bill. Installations were performed by a member of the QCN and TVA reimbursed LPCs for inspection and loan processing/collection. During 2017, 939 heat pumps were installed through the program with an estimated annual energy saving of 1.78 GWh. In late 2017, the Heat Pump Program was merged into the eScore Program.

Volume Heat Pump Program for Manufactured Homes –The Volume Heat Pump Program was an upstream program that promoted the installation of electric heat pumps in qualified manufactured homes. Its features included a network of heating, ventilation, and air conditioning (HVAC) wholesalers, incentives and an on-site validation of 10 percent of randomly-selected installations. The program had 128 installations in 2017 with annual energy savings of 504,220 kWh. This program has since been terminated.

ENERGY STAR© Pilot Program for Manufactured Homes – This program was an upstream program administered by Systems Building Research Alliance. A rebate was paid to manufactured homes producers to encourage them to build ENERGY STAR homes to be sited in the Tennessee Valley. The program yielded 1,731 manufactured homes in 2014. It was terminated in 2016.

New Homes Program – The New Homes Program offers a suite of HVAC and water heating equipment incentives to encourage builders to use electric equipment instead of non-electric alternatives. Incentives are offered for single family homes, duplexes, and multi-family homes. The program incentives help builders purchase technologies that are highly desired for efficiency, effectiveness, and longevity, making these new homes more marketable. Over 500 homebuilders have applied for membership in the Homebuilder Network. In FY18, nearly 4,500 homes received incentives through the redesigned program.

Smart Communities Program – Smart Communities is a mitigation program developed as part of TVA's CAA Environmental Agreements described above in Section 2.3. The program is made up of two components: Smart Energy Technologies and Extreme Energy Makeovers. The Smart Energy Technologies component tested the integration of ultra-efficient homes with smart grid technologies, and the human interaction with such technologies, in the Glasgow (Kentucky) Electric Plant Board service area. The ultimate goal of the program was to reduce emissions of air pollutants. The Smart Communities Program ended in 2017.

As part of the Extreme Energy Makeovers component, whole-home, deep energy retrofits for 20-year-old or older homes in lower income communities were provided in the service areas of 4-County Electric Power Association and Columbus Light & Water in Mississippi, Cleveland Utilities, Knoxville Utilities Board, and Oak Ridge Electric Department in Tennessee, Huntsville Utilities in Alabama, and North Georgia Electric Membership Corporation. The program goal was to achieve a 25 percent energy reduction in each home's energy use for an estimated energy savings of 1,000 MWh/year at a cost of approximately $10/square foot. Typical retrofits included insulation, new or repaired heating, ventilation, and air conditioning (HVAC) systems, air sealing, new windows/doors, and energy-saving appliances. Through 2017, the program had 3,400 participants and resulted in an average energy bill reduction of 35 percent.

Home Energy Improvement Program – This pilot program, begun in 2017, was modeled after the Department of Energy (DOE) Weatherization Assistance Program (WAP). It provided approximately $8,000 per home for improvements to about 125 homes in the Memphis area at no cost to the low-income homeowners. Typical improvements included insulation, air sealing, HVAC repair or replacement, and water heater upgrades.

Home Uplift – Launched in 2018 in collaboration with state and local community groups, Home Uplift provides energy upgrades for low-to-moderate households. Modeled after the DOE WAP, this program provides approximately $8,000 per home at no cost to qualified homeowners for improvements such as HVAC repair or replacement, insulation, air sealing, replacement windows, and water heater upgrades. As of September 2018, 531 homes participated in this pilot.

Weatherization Assistance Program – This program is a partnership with the Tennessee Housing and Development Agency to provide support for the DOE-funded WAP program in Tennessee. Since 2010, TVA has provided direct install kits for all pre-audits and in 2018 created an innovative platform, WAPez, to streamline the WAP administrative process to help serve more consumers and leverage all sources of funding. As of September 2018, TVA has provided support for 22,834 homes.

Home Energy Workshops – Launched as a Middle Tennessee pilot in 2015, the Home Energy Workshops expanded in 2018 to provide energy education workshops throughout the Valley. Through September 2018, 1,236 participants attended workshops.

Water Heating Program – The Water Heater Program promotes the installation of electric water heaters in homes and small businesses. A principal program feature is a Market Value Payment from TVA to the LPC for each electric water heater installed. In FY18, over 8,099 water heaters came through the program.

EnergyRight® Solutions for Business

ERS for Business program transitioned during 2018 from providing incentives for energy efficiency upgrades through measures such as lighting upgrades to providing incentives for smart energy technologies such as dual fuel heat pumps, variable refrigerant flow HVAC units, outdoor lighting for safety, and food service equipment.

During the transition year, the ERS for Business program saved 61 GWh, while providing incentives of $4.9 million through 116 LPCs. Approximately 86 percent of the energy savings were through lighting upgrades, and about 5 percent through HVAC upgrades. The remaining 9 percent of energy savings were through other comparatively small measures. Incentives for energy efficiency measures through this program were discontinued in 2018. TVA continues to support energy efficiency through engagement initiatives such as Strategic Energy Management.

While transitioning away from incentives for energy efficiency, efforts to incentivize smart energy technologies continue to grow. In 2018, the ERS for Business program added 21.3 GWh of load while providing incentives of $2.8 million through 39 LPCs. Approximately 31 percent of load added was from HVAC measures, 23 percent from non-road electric vehicles, and 32 percent from custom projects where TVA personnel found tailored solutions for consumers. The remaining 14 percent of load was added from other comparatively small measures.

EnergyRight® Solutions for Industry

EnergyRight® Solutions (ERS) for Industry program transitioned during 2018 from providing incentives for energy efficiency upgrades through measures like lighting upgrades to providing incentives for smart energy technologies such as dual fuel heat pumps, variable refrigerant flow HVAC units, outdoor lighting for safety, and process heating equipment.

During the transition year, the ERS for Industry program saved 74.8 GWh, while providing incentives of $5.9 million through 82 LPCs. Approximately 58 percent of the energy savings were through lighting upgrades, 19 percent through compressed air upgrades, and about 15 percent through HVAC upgrades. The remaining 8 percent of energy savings were through other comparatively small measures. Incentives for energy efficiency measures through this program were discontinued in 2018. TVA continues to support energy efficiency through engagement initiatives like Strategic Energy Management.

While transitioning away from energy efficiency, efforts to incent smart energy technologies continue to grow. In 2018, the ERS for Industry program added 38.3 GWh of load while providing incentives of $3.2 million through 27 LPCs. Approximately 19 percent of load added was from process heating solutions, motors and HVAC contributed approximately 7 percent of the projects, and 63 percent was contributed from custom projects where TVA personnel found tailored solutions for consumers. The remaining 4 percent of load was added from other comparatively small measures.

Education and Outreach

The EnergyRight® Solutions for Youth energy education program that was in place in 2015 is now run by the Tennessee Valley Public Power Association.

2.5.2 TVA Facilities

The Internal Energy Management Program, created by TVA in 1978, is responsible for the planning, coordination of regulatory reviews, performance analysis and reporting, oversight of energy related audits, and sustainable design for TVA facilities. The program coordinates TVA compliance with energy efficiency goals and objectives for Federal agencies established by the National Energy Conservation Policy Act, the subsequent Energy Policy Acts of 1992 and 2005, Energy Independence and Security Act of 2007, and several Executive Orders (E.O.) including E.O. 13834, Efficient Federal Operations (2018). This program has resulted in significant reductions in energy use; for example, between 2003 and 2017 energy intensity in TVA facilities was reduced by 36.9 percent. Over the past 10 years the program, through the implementation of energy efficient projects in TVA buildings, helped TVA save 540 GWh cumulatively, which is enough to power 36,800 Valley homes for one year. See https://www.tva.gov/About-TVA/Guidelines-and-Reports/Sustainability-Plans-and-Performance for more information and annual reports of accomplishments.

2.5.3 Demand Response Programs

Interruptible Power – These programs enable TVA to suspend a portion of the electric load of participants during times of power system need. The three Interruptible Power programs had a total capacity of 1,716 MW at the end of 2018. The programs are differentiated by the time period between when participants are notified to reduce their load and when the load reductions must be in place. These programs are Interruptible Power – 5 minutes (650 MW in 2018), Interruptible Power – 30 minutes (769 MW), and Instantaneous Response (297 MW). In early 2017, TVA changed its policies to allow participants in the Interruptible Power programs to generate power using diesel-fueled generators during DR events.

Aggregated Demand Response – This program provides peak load reduction to TVA during periods of power system need, at TVA's request. This program had a total capacity of 188 MW at the end of 2018; most of this capacity is implemented by Enel X (formerly known as EnerNOC).

Voltage Optimization – This is a mitigation program developed as part of TVA's CAA Environmental Agreements described above in Section 2.3. In this program, TVA works with LPCs to operate their distribution lines in the lower half of the acceptable voltage range, thereby lowering demand and reducing energy consumption.

2.5.4 Renewable Energy Certificate (REC) Programs

Under the Green Power Switch program, TVA customers can support renewable energy by purchasing 150-kWh blocks of renewable energy for $4/block/month. TVA generates or acquires the renewable energy from specific sources, including the Buffalo Mountain Windfarm described above and the Green Power Providers program participants. In fiscal year 2018, 10,568 residential and 425 business participants in the Green Power Switch program supported the generation of 62,641 MWh of renewable energy. For 2018, 70 percent of this energy marketed through the Green Power Switch program was from solar, 20 percent from wind, and 10 percent from biomass.

Green Power Switch Southeastern RECs is a pilot program initiated in 2012 that provides a bulk purchase option for businesses in the Valley. It gives an organization the ability to make renewable energy claims, using Green-e certified RECs, and allows them to demonstrate to their customers and stakeholders that they support green initiatives. The RECs purchased through the program are delivered to the Valley along with the renewable energy, and the cost of the RECs are added to the customer's regular electricity bill. In fiscal year 2018, 14 customers supported green initiatives through this program accounting for 629,176 MWh sold.

2.6 Transmission System

TVA operates one of the largest transmission systems in the U.S. It serves an area of 80,000 square miles through a network of approximately 16,200 miles of transmission line; 508 substations, switchyards and switching stations; and 1,321 individual customer connection points. The system connects to switchyards at generating facilities and transmits power from them at either 161 kV or 500 kV to LPCs and directly served customers. Substations at delivery points reduce the voltage for delivery through LPC distribution lines serving end users.

The TVA transmission system operates at a range of voltages:

500-kV lines – 2,471 miles

345- and 230-kV lines – 150 miles

161-kV lines – 11,625 miles

138- and 115-kV lines – 202 miles

69-kV lines – 1,120 miles

46-kV lines – 608 miles

26- and 13-kV lines – 15 miles

The TVA transmission system has 69 interconnections with 13 neighboring utilities at interconnection voltages ranging from 69-kV to 500-kV. These interconnections allow TVA and its neighboring utilities to buy and sell power from each other and to wheel power through their systems to other utilities. To the extent that Federal law requires access to the TVA transmission system, the TVA transmission organization offers transmission services to others to transmit power at wholesale in a manner that is comparable to TVA's own use of the transmission system. TVA has also adopted and operates in accordance with the Standards of Conduct for Transmission Providers (FERC 2008), and appropriately separates its transmission functions from its marketing functions.

In recent years, TVA has built an average of about 150 miles of new transmission lines and several new substations and switching stations per year to serve new customer connection points and/or to increase the capacity and reliability of the transmission system. The majority of these new lines are 161-kV. In 2008, TVA completed a 39-mile 500-kV transmission line in Tennessee which was the first major TVA 500-kV line built since the 1980s. TVA also completed a 27-mile 500-kV transmission line in Tennessee in 2010. TVA has also upgraded many existing transmission lines in recent years to increase their capacity and reliability by re-tensioning or replacing conductors, installing lightning arrestors and other measures.

A major focus of recent transmission system upgrades has been to maintain reliability when coal units are retired. Between 2011 and 2018, TVA spent $419 million on these upgrades and anticipates spending $10 million on coal-retirement related transmission system upgrades in 2019 and 2020. The upgrades include modifications of existing lines and substations and new installations as necessary to provide adequate power transmission capacity, maintain voltage support and ensure generating plant and transmission system stability. In May 2017, TVA began a $300 million, multi-year effort to upgrade and expand its fiber-optic network to help meet the power system’s growing need for bandwidth as well as accommodate the integration of new distributed energy resources.

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3 Alternatives

Tennessee Valley Authority (TVA) uses a scenario planning approach in integrated resource planning, a common approach in the utility industry. Scenario planning is useful for determining how various business decisions will perform in an uncertain future. The goal of the Integrated Resource Plan (IRP) is to develop a least-cost plan that is consistent with TVA's legislatively mandated mission described in Section 1.1.1 of Volume I and the IRP objectives described in Section 1.2.1 of Volume I. The final, optimal plan will be low-cost, risk-informed, environmentally responsible, reliable, diverse, and flexible.

Multiple strategies, which represent business decisions that TVA can control, are modeled against multiple scenarios, which represent uncertain futures outside of TVA's control. The intersection of a single strategy and a single scenario results in a resource portfolio. A portfolio is a 20-year capacity plan that is unique to each combination of strategy and scenario. A detailed description of the development of the portfolios is in IRP Chapter 6).

3.1 Development of Scenarios

Based on the scoping comments, IRP Working Group input, and further analysis, TVA identified six scenarios:

1. The Current Outlook – Continuation of TVA's current forecasts, including a regional gross domestic product growth rate of 2 percent, slow customer growth, and declining customer energy use.
2. Economic Downturn – Prolonged, stagnant economy resulting in weak growth and delayed need for new generation.
3. Valley Load Growth – Rapid regional economic growth resulting in higher energy sales.
4. Decarbonization – Federal push to curb greenhouse gas (GHG) emissions with CO_2 emission penalties and incentives for non-emitting technologies.
5. Rapid Distributed Energy Resources (DER) Adoption – High penetration of distributed generation, energy storage, and energy management resulting in decreased demand from utilities.
6. No Nuclear Extensions – Regulatory challenges to relicensing existing and constructing new large-scale nuclear plants.

Each of the scenarios has a unique set of uncertainties, attributes that are likely to change in the future. These include the demand for electricity, the market price of power, fuel prices, regulations affecting electric utilities, regulations on CO_2 emissions, availablility of power for purchase from other producers, national energy efficiency adoption, and regional and national economic conditions. These and other aspects of the scenarios are described in detail in IRP Section 6.1.

3.2 Alternative Strategies and Associated Capacity Expansion Plans

3.2.1 Development of Alternative Strategies

After review of the scoping comments, five alternative planning strategies were developed by TVA in coordination with the IRP Working Group. The five alternative strategies include the Base Case, which represents the continued implementation of the 2015 IRP in accordance with least-cost optimization and reliability constraints. For purposes of the Environmental Impact Statement (EIS), Strategy A – Base Case represents the No Action alternative and the four other strategies represent action alternatives.

- Strategy A: Base Case
- Strategy B: Promote Distributed Energy Resources (DER)
- Strategy C: Promote Resiliency
- Strategy D: Promote Efficient Load Shape
- Strategy E: Promote Renewables

The five alternative strategies differ in, among other things, whether or not they include incentives for particular resources. In this context, an incentive is the mechanism to promote additional penetration of a resource and is equal to the difference between the cost of a resource in the Base Case and the cost to achieve the targeted level of penetration in the other four strategies.

Strategy attributes were used in the modeling in several different ways. Resources that were promoted generally received a modeled incentive that improved economics for their adoption or selection. In some cases, a resource category may be limited, such as new coal being excluded in the Promote Distributed Energy Resources (DER) and Promote Renewables strategies. Others have temporal restrictions, such as allowing retirements to take effect in a certain year when transmission work to allow plant separation could be completed.

The Base Case represents the continuation of TVA's current power supply plan based on least-cost planning with no specific resources promoted and reflects decisions made to date by the TVA Board of Directors. Between the draft EIS and final EIS, TVA updated the Base Case to reflect the Board of Directors' decision in February 2019 to retire the Paradise Fossil Plant Unit #3 by the end of 2020 and the Bull Run Fossil Plant by the end of 2023. The remaining strategies provide incentives to promote adoption of certain resources, with consideration of market potential, pace of adoption, and reserve margin.

After defining each strategy's key characteristics, three incentive levels – Base (no incentive), Moderate, and High – were determined to achieve the objectives of the strategy as shown in Figure 3-1. These incentive levels influenced the selection of the affected energy resources during the development of the resource portfolios. The Strategy Design Matrix provided the roadmap for how resource promotions were applied in capacity planning. The key characteristics of each alternative strategy are summarized in Table 3-1. Further information on the strategies can be found in IRP Section 6.2 and IRP Appendix E.

Strategy	Distributed Resources & Electrification						Utility Scale Resources					
	Distributed Solar	Distributed Storage	Combined Heat & Power	Energy Efficiency	Demand Response	Beneficial Electrification	Solar	Wind	Biomass & Biogas	Storage	Aero CTs & Recip Engines	Small Modular Reactors
Base Case	Base	Base	Base	Base	Base	Base	Base	Base	Base	Base	Base	Base
Promote DER	High	Moderate	High	Moderate	Moderate	Base	Base	Base	Base	Base	Base	Base
Promote Resiliency	Moderate	High	Moderate	Base	Moderate	Base	Base	Base	Base	Moderate	Moderate	Moderate
Promote Efficient Load Shape	Base	Moderate	Base	High	High	Moderate	Base	Base	Base	High	Base	Base
Promote Renewables	Moderate	Moderate	Base	Base	Base	Base	Moderate	Moderate	Moderate	Moderate	Base	Base

Figure 3-1: Incentive levels for selected energy resources associated with each strategy.

Table 3-1. Key characteristics of the five alternative strategies.

Strategies	Description and Attributes
A- Base Case	• Planning Reserve margins for summer and winter peak seasons are applied, targeting an industry best-practice level of reliability (applies in all strategies) • No specific resource types are promoted beyond business as usual
B- Promote DER	• DER is incented to achieve higher end of long-term penetration levels • New coal is excluded, and all other technologies are available while Energy Efficiency, demand response, distributed generation and storage are promoted • Programs targeting low income customers will be part of Energy Efficiency promotion
C- Promote Resiliency	• Small, agile capacity is incented to maximize flexibility and promote ability to respond to short-term disruptions on the power system • All technologies are available while small modular reactors (SMRs) and small gas additions (aeroderivative turbines, reciprocating engines), demand response, storage and distributed generation are promoted • Combinations of storage and distributed generation could be installed as microgrids • Flexible loads and DERs are aggregated to provide synthetic reserves to the grid to promote resiliency
D- Promote Efficient Load Shape	• Targeted electrification and demand and energy management are incented to minimize peaks and troughs and promote an efficient load shape • All technologies are available but those that minimize load swings, including energy efficiency, demand response and storage, are promoted • Programs targeting low-income customers will be a part of EE promotion
E- Promote Renewables	• Renewables at all scales are incented to meet growing prospective or existing customer demands for renewable energy • New coal is excluded, and all other technologies are available while renewables are promoted

3.2.2 Capacity Expansion Plans

The following section provides a summary of the capacity expansion plans, also known as resource portfolios, developed for each of the alternative strategies. Capacity additions and reductions are quantified in megawatts (MW) and energy additions and reductions are quantified in gigawatt hours (GWh).

The capacity expansion plans are based on the assumption that all pending coal unit or plant retirements described in Section 3.2.3 will occur as scheduled, with all retired by 2038. Several current Power Purchase Agreements (PPAs) are assumed to expire during the planning period, including wind energy PPAs from 2024 through 2032, PPAs for diesel-generated power totaling 115 MW, and the Red Hills lignite coal plant PPA in 2032.

All portfolios considered in the 2019 IRP have the following common features:

- In all strategies, except for Strategy A - Base Case, promotions are applied first, and then the balance of the system is optimized in a least-cost manner.

- No new hydroelectric or coal plants were selected in any portfolio.
- Hydroelectric capacity and generation are the same across all portfolios.
- Coal capacity is the same or less than currently planned, as no coal was added. Coal generation reflects potential facility retirements described in Section 3.2.3.
- No new wind was selected in the portfolios, while solar expansion was significant.

In the following descriptions of the alternative strategies, the stated capacities are summer net dependable (SND) capacities except for wind and solar generation, which are nameplate capacities. For wind and solar generation, SND capacities are significantly less than nameplate capacities due to their intermittent nature. For the other energy resources, the difference between SND capacities and nameplate capacities is relatively small. These differences, as well as the methodology used to determine SND, are described in Appendix A of Volume I. The portfolios associated with the alternative strategies are described in greater detail in Chapter 7 of Volume I.

3.2.3 Potential Retirement of TVA Generating Facilities

Several TVA facilities have units that are being considered for retirement during the planning period. The following sections describe in general the activities that would occur upon potential retirement of these facilities.

Combustion Turbine Facilities

All of the alternatives and portfolios include the potential retirement of Allen CT Plant, Colbert CT Plant, Johnsonville CT Units 1 – 16, and Gallatin CT Units 1 – 8 as early as 2020. Because these facilities are considered for potential retirement within the next five years, Chapter 4 and Chapter 5 of Volume II provide site-specific information about the affected environment and impacts of retirement and decommissioning activities for each CT facility.

Decommissioning is the performance of activities required to ready a facility for deactivation. Key decommissioning activities at CTs include:

- Tag out all unit or plant equipment except service water, lighting, etc.
- Remove and properly dispose of hazardous and other wastes, including polychlorinated biphenyl (PCB)-containing equipment
- Empty all storage tanks and reuse or dispose of contents (fuel oil, glycol, demin water, raw water, condensable fluids from gas supply)
- Open all equipment electrical breakers not in use
- Drain oil, fuel and fluids
- Salvage, store, and relocate as practical all useable equipment, components, materials, spare parts, office products, etc.
- Salvage and store all key plant records.

Deactivation is the shutting down of power and energized systems as appropriate as well as severing and/or isolating power, water, fuel supply and piping to the plant to provide a cold, dark and dry structure. Activities may also include rerouting of power and services as required for any facilities that will remain operational.

Limited decontamination involves removing select regulated materials in a safe and practical manner in such a way that the plant is left in a status that does not present a hazard or risk to the environment or personnel. Work may include abatement and disposal of regulated materials. Regulated materials include but are not limited to PCB equipment, asbestos, hazardous waste, solid waste, products, etc. Key decontamination activities at CTs include:

- Removal and proper disposal of regulated materials, as practical.
- Periodic materials condition monitoring.
- Periodic waste removal as materials deteriorate over time.

Coal Plants

All of the alternatives and portfolios include the potential retirement of the coal-fired Shawnee, Cumberland, Gallatin, and Kingston Fossil Plants by 2038.

Depending on the plan selected for implementation, these facilities could be retired in whole or in part during the planning period. The strategies and portfolios also include the retirement of the Paradise and Bull Run Fossil Plants, which was approved by the Board of Directors in February 2019. Actions associated with the retirement of these two plants, and the associated environmental impacts, are described in TVA 2019a and TVA 2019b.

For coal plants or units selected for retirement, TVA would cease most plant operations and reduce plant staff at the time of retirement. In order to minimize environmental and safety risks and comply with applicable laws and regulations, TVA would implement the actions described below.

Decommissioning is the performance of activities required to ready a facility for deactivation. Work performed includes removal of equipment, components, and parts that can be used at other sites, draining of oil/fluids from equipment, removal of coal and ash from boilers and other equipment, removal of hazardous materials and potential waste like materials, removal of PCB equipment, removal of furniture/furnishings, removal of installation technology assets, removal of plant records. Key decommissioning activities at coal plants include:

- Tagging out all unit or plant equipment except service water, lighting, etc.
- Emptying and cleaning hoppers, bins, bunkers, etc.
- Opening all equipment electrical breakers not in use.
- Draining oil and fluids
- Salvaging, storing, and relocating as practical all useable equipment, components, materials, spare parts, office products, etc.
- Salvaging and storing all key plant records.

Deactivation is the shutting down of power and energized systems as appropriate as well as isolating and/or severing power, water and piping to the plant to provide a cold, dark and dry structure. Work includes removing power and services, installing bulkheads, and sealing tunnels. Activities may also include rerouting of power and services as required for any facilities that would remain operational. Key deactivation activities at coal plants include:

- Performing electrical and mechanical isolation of systems, components and areas.
- Installing bulkheads and/or fill tunnels.
- Providing alternate power and services (sump pumps, Federal Aviation Administration stack lighting, etc.).

Limited decontamination involves removing select regulated materials in a safe and practical manner in such a way that the plant is left in a status that does not present a hazard or risk to the environment or personnel. Limited contamination work may include abatement and disposal of regulated materials, which include but are not limited to PCB equipment, asbestos, hazardous waste, solid waste, products, etc. Key decontamination activities at coal plants include:

- Removal and proper disposal of regulated materials, as practical.
- Periodic materials condition monitoring.
- Periodic waste removal as materials deteriorate over time.

3.3 Strategy A: Base Case - No Action Alternative

The No-Action Alternative is Strategy A: Base Case, which is TVA's least-cost optimization plan that applies no additional incentives or targets. Resources are chosen economically to meet the reserve margin constraint for reliability. In the Base Case, planning reserve margins for summer and winter peak seasons are applied, targeting an industry best-practice level of reliability (applies in all strategies). No specific resource types are promoted beyond business as usual.

Figure 3-2 summarizes the incremental capacity changes in the portfolios associated with each alternative strategy that would occur by 2038. Figure 3-3 presents the capacities, in SND MWs, of the various energy resources comprising each portfolio. The resulting generation by each energy resource is shown in Figure 3-4. Figure 3-5 provides additional detail on the solar additions in each portfolio.

The nuclear portfolio is the same in all Strategy A portfolios, except for Scenario 6 where the Browns Ferry units are retired between 2033 and 2036 at the expiration of their current operating licenses. Hydro capacity is the same in all cases. Coal capacity is the same in all scenarios, except for Scenario 4, where carbon regulation leads to additional coal retirements.. Solar capacity is added beginning in the mid-2020 time frame, and continues to be added throughout most of the planning period. Including hydro, renewables account for 18 percent of the capacity portfolio on average. Natural gas assets increase over time, beginning with CC additions that could be achieved through renewal of existing contracts, acquisitions or builds. These are augmented by combustion turbine (CT) plant additions in Scenarios 1, 3 and 6. With current cost projections and no promotion in Strategy A, no new storage appears in any portfolios. Energy efficiency increases modestly in all scenarios, with impacts lessened as efficiencies from codes and standards increase. Demand response increases similarly across scenarios, with some differentiation due to load shape and strategic focus.

Nuclear generation remains the same over time across the cases, with the exception of the Scenario 6 where energy from the retired Browns Ferry units is replaced primarily with solar and gas generation. Hydro energy remains the same across portfolios. Coal generation decreases over the planning horizon as units are retired and declines further in lower load cases, especially in Scenarios 4 and 5. Solar generation increases substantially in all cases, with the highest increases seen in the Scenario 3 and 4 portfolios. Including hydro, renewables account for 20 percent of total generation on average. Natural gas generation varies with load and strategic focus, with the highest gas generation seen in Scenario 3 and 6. The combination of incremental energy efficiency and demand response contributes a small amount to the portfolios. Strategy A results in 61 percent carbon-free generation in 2038 on average.

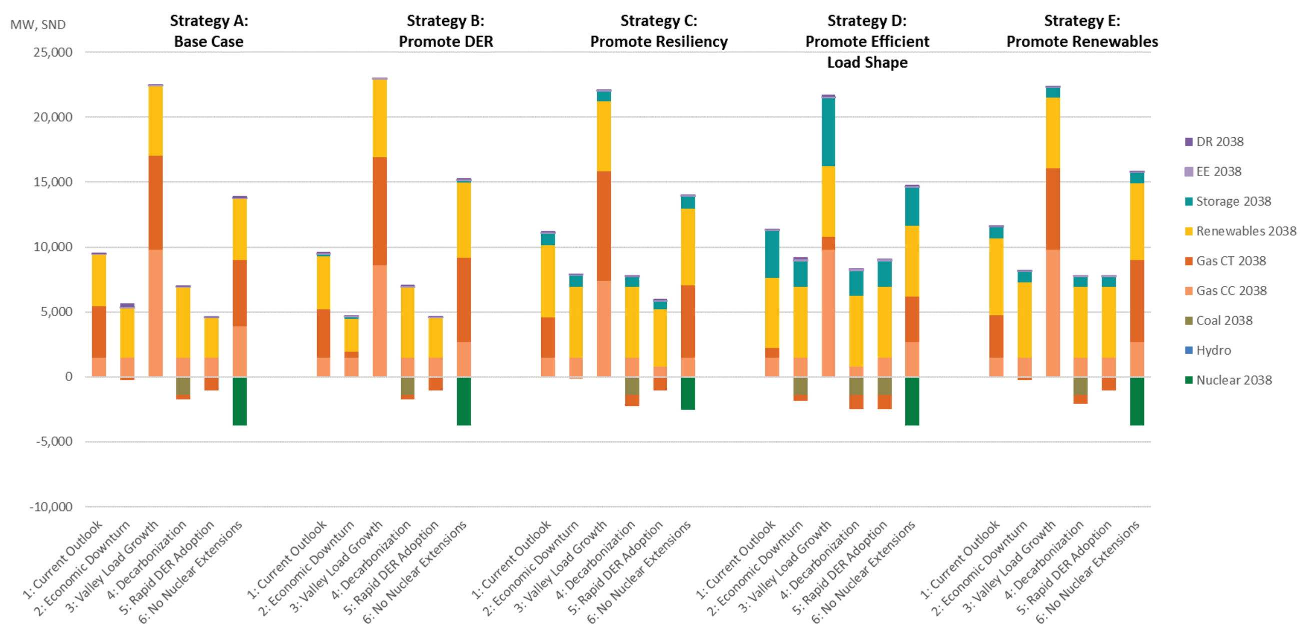

Figure 3-2: Incremental capacity by 2038, consisting of additions of new energy resources and retirement of existing energy resources, for the portfolios associated with each alternative strategy.

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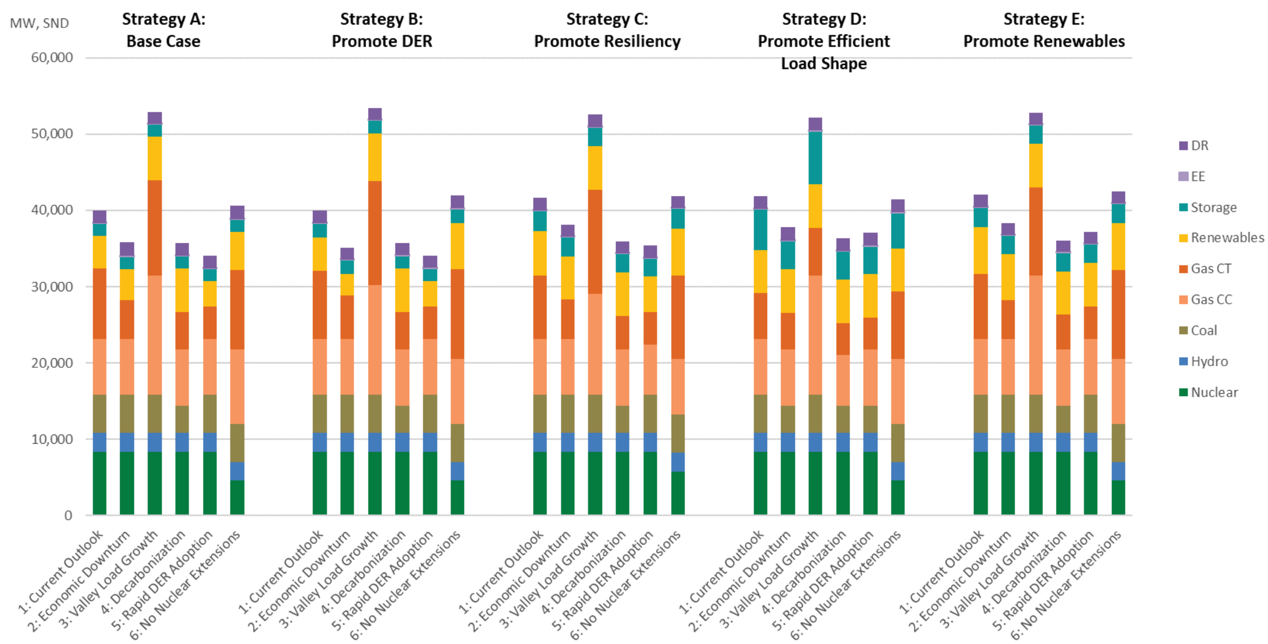


Figure 3-3: Total Capacity in 2038 by resource type in the portfolios associated with each alternative strategy.

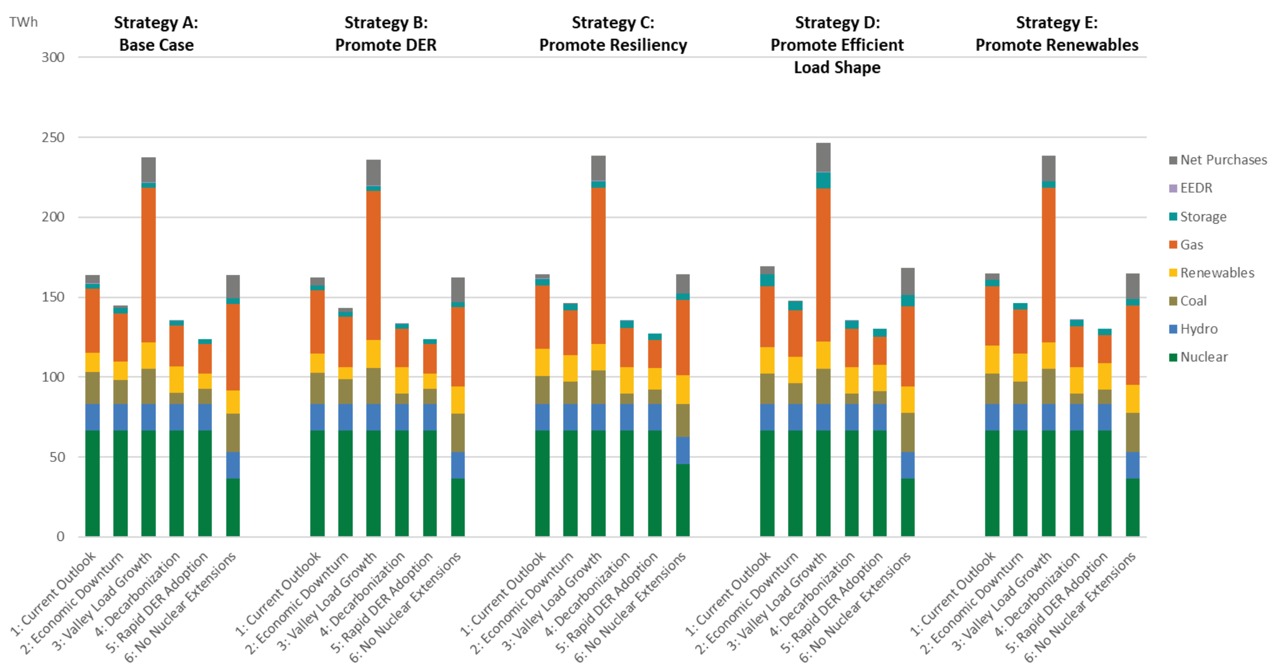


Figure 3-4: Energy in 2038 by resource type in the portfolios associated with each alternative strategy.

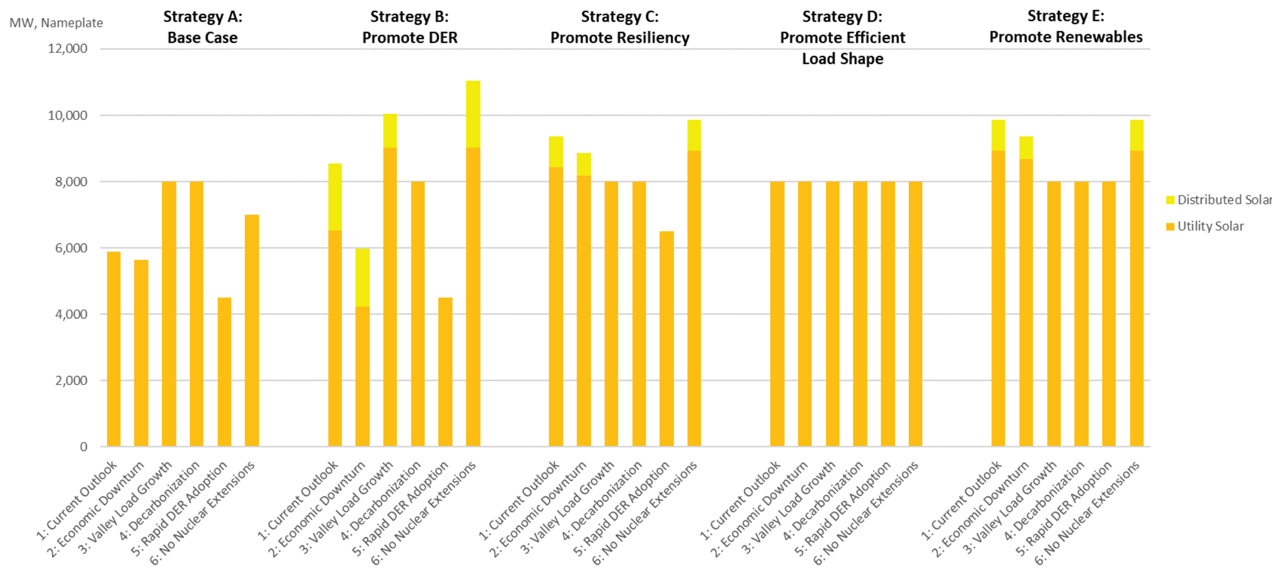


Figure 3-5: Solar capacity additions, in nameplate capacity, through 2038 in the portfolios associated with each alternative strategy.

3.4 Strategy B: Promote DER

Strategy B focuses on increasing the pace of DER adoption by incentivizing distributed solar and storage, combined heat and power, energy efficiency and demand response. Programs targeting low income customers is included in the EE promotion. Under Strategy B, the retirement of TVA generating facilities described in Section 3.2.3 can also occur. Figure 3-2 shows the capacity resources added by 2038 in Strategy B across the six scenarios. The results from this strategy are very similar to Strategy A with a few notable differences. Distributed solar is promoted in this strategy and generally replaces a portion of lower cost utility solar. Distributed storage is also promoted, replacing a portion of demand response but at a higher cost. Finally, combined heating and power is promoted, contributing to additional coal retirements in some cases.

Figure 3-4 shows how the energy portfolios for Strategy B play out driven by the capacity changes and other factors in the scenarios. Including hydro, renewables account for 21 percent of total generation on average. Strategy B results in 61 percent carbon-free generation in 2038 on average, similar to Strategy A.

3.5 Strategy C: Promote Resiliency

Strategy C promotes higher adoption of small, agile capacity to increase the operational flexibility of TVA's power system, while also improving the ability to respond locally to short-term disruptions. Under Strategy C, the retirement of TVA generating facilities described in Section 3.2.3 can also occur.

Figure 3-3 presents the total capacity portfolios in 2038 for Strategy C. The hydro portfolio is the same as in Strategy A. Nuclear capacity is the same as in Strategy A, with the exception of Scenario 6 where two 600 MW SMR units are added to replace one Browns Ferry nuclear unit. Coal capacity is the same across all scenarios, except for Scenario 4 in which carbon regulation leads to additional coal retirements. In cases where more coal is retired, solar capacity increases at both utility and distributed scales. Storage additions are promoted, resulting in somewhat lower gas capacity additions on average. Energy efficiency and demand response volumes remain similar across the scenarios in this strategy.

Figure 3-4 shows the resulting energy portfolios for Strategy C driven by the capacity changes and other factors in the scenarios. Including hydro, renewables account for 22 percent of total generation on average. Strategy C results in 63 percent carbon-free generation in 2038 on average compared to 61 percent in Strategy A.

3.6 Strategy D: Promote Efficient Load Shape

Strategy D promotes targeted electrification, demand response, and energy management to optimize load shape, including programs targeting low-income energy efficiency. Under Strategy D, the retirement of TVA generating facilities described in Section 3.2.3 can also occur. Figure 3-2 shows the capacity resources added by 2038 in Strategy D across the six scenarios. The nuclear and hydro portfolios are the same as in Strategy A. This strategy results in the highest amount of coal retirements on average. That capacity is replaced with a combination of solar, storage and gas additions, with a high penetration solar achieved in all cases. Storage is promoted to the greatest degree in this strategy, resulting in the highest storage capacity overall. The storage additions drive the lowest need for gas capacity, especially CT peaking units. The highest energy efficiency volumes are seen in this strategy, and demand response volumes are similar to Strategy A, as the promotion of storage meets peaking needs.

Figure 3-4 shows the corresponding energy portfolios for Strategy D driven by the capacity changes and other factors in the scenarios. Including hydro, renewables account for 22 percent of total generation on average. Strategy D results in 61 percent carbon-free generation.

3.7 Strategy E: Promote Renewables

Strategy E promotes renewables at all scales to meet growing prospective or existing customer demands for renewable energy. Under Strategy E, the retirement of TVA generating facilities described in Section 3.2.3 can also occur.

Figure 3-3 presents the total capacity portfolios in 2038 for Strategy E. The nuclear and hydro portfolios are the same as in Strategy A. Strategy E cases have similar levels of additional coal retirements as in Strategy B. The highest levels of solar additions are seen in this strategy across all scenarios, averaging almost 6,000 MW SND capacity and 8,800 MW nameplate. Including hydro, renewables account for 20 percent of the capacity portfolio on average. Storage is also promoted, resulting in comparable levels of storage additions to Strategy C, and similarly reducing the need for gas capacity additions. Energy efficiency and demand response volumes remain similar across the scenarios in this strategy, also resembling Strategy C.

Figure 3-4 shows the corresponding energy portfolios for Strategy E driven by the capacity changes and other factors in the scenarios. Including hydro, renewables account for 22 percent of total generation on average. Strategy E results in 62 percent carbon-free generation in 2038 on average compared to 61 percent in the Base Case.

3.8 Target Power Supply Mix – Preferred Alternative

During and following the public review of the draft IRP and draft EIS, TVA began the process of developing the final, optimal resource plan. This process is described in detail in IRP Chapter 9 and was guided by the IRP objectives listed in IRP Section 1.2 and the goals of being low-cost, risk-informed, environmentally responsible, reliable, diverse, and flexible. The resulting Target Power Supply Mix is TVA's preferred alternative.

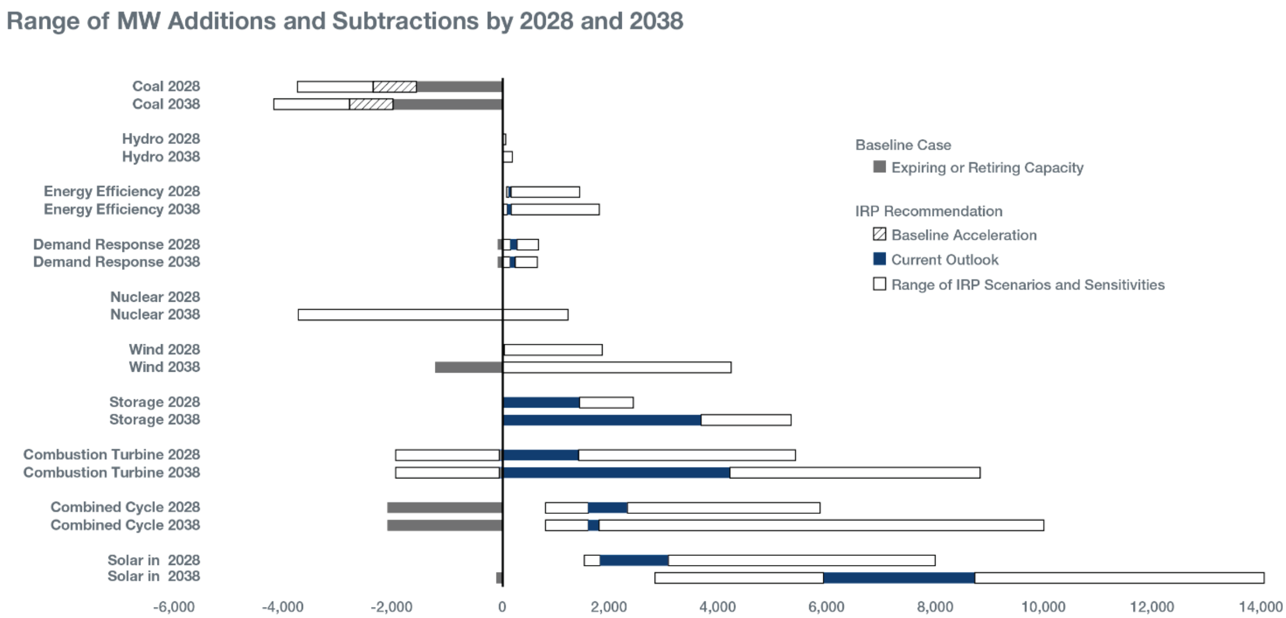
When analyzing results from the draft IRP, TVA identified questions that warranted further evaluation prior to finalizing the study. In addition, TVA received stakeholder input from the IRP Working Group and the Regional Energy Resource Council, as well as through comments received from the public during the comment period for the draft IRP and draft EIS. TVA performed additional detailed modeling, termed sensitivity analyses, to explore the impacts of changes in key assumptions and to inform the development of the Target Supply Mix. These sensitivities include:

- Natural gas prices
- Storage, wind, CHP, and SMR capital costs
- Greater EE and DR market depth
- Integration cost and flexibility benefit
- Pace and magnitude of solar additions
- Higher operating costs for coal plants
- More stringent carbon constraints
- Variation in climate.

These sensitivity analyses and their results are described in more detail in IRP Section 8.2.

In developing the Target Power Supply Mix, TVA elected to establish guideline ranges for the key resource types, both TVA-owned and contracted. This general planning direction is expressed over the 20-year study period while also including more specific direction over the first 10-year period. In order to distill the considerable number of cases evaluated through the original scenario and strategy analysis and the sensitivity cases, the plan uses ranges that are centered on results obtained under the Current Outlook scenario. The other scenario and sensitivity results provide a sense of how the power supply mix may change as the future changes.

Figure 3-6 shows, in megawatts (MW), the range of resource additions and retirements proposed by the end of the first 10 years of the study (2028) and by the end of the study period (2038). The solid gray bars represent expiring or retiring capacity included in the Base Case and all of the other strategies. The solid blue bars represent the range of results from all strategies evaluated in the Current Outlook scenario, which represents the best estimation of the future. The broader ranges shown in horizontal black lines represent potential changes in the resource portfolio in response to different future scenarios and to conditions under which the evaluated sensitivities are realized.



Notes

- MWs are incremental additions from 2019 forward. Board-approved coal retirements are excluded from the totals.
- Browns Ferry Nuclear Plant license is not extended in the No Nuclear Extensions Scenario (outside of TVA control).
- Upper bounds of potential natural gas and solar additions are driven by the Valley Load Growth Scenario.
- Solar and wind are shown in nameplate capacity; accelerated solar additions are reflected in the IRP Recommendation.
- Solar, gas, and storage ranges include utility-scale and distributed additions (where promoted in a strategy).

Figure 3-6: Summary of the Target Power Supply Mix – Preferred Alternative.

The recommended ranges represent incremental additions (or retirements) to the existing resource fleet and could include contracted assets or new TVA builds, providing flexibility for the portfolio. The results are bounded by the full range of the alternative strategies and sensitivity analyses which affirm the merits of a diverse portfolio.

The implementation of this Target Power Supply Mix will result in a diverse portfolio and provide TVA the flexibility to make energy resource decisions, consistent with least-cost planning, that fall within the power supply ranges depicted in Figure 3-6. As the IRP is implemented, TVA will closely monitor key input variables, including changing market conditions, more stringent regulations and technology advancements to inform appropriate actions within the recommended ranges and appropriate timing for initiating the next IRP.

Following is a summary of the Target Power Supply Mix by resource type:

Coal: Continue with announced plans to retire Paradise Unit 3 in 2020 and Bull Run in 2023. Evaluate retirements of up to 2,200 MW of additional coal capacity if cost effective.

Hydro: All portfolios include continued investment in the hydro fleet to maintain capacity. Consider additional hydro capacity where feasible.

Energy Efficiency: Achieve savings of up to 1,800 MW by 2028 and up to 2,200 MW by 2038. Work with local power company partners to expand programs for low-income residents and refine program designs and delivery mechanisms with the goal of lowering total cost.

Demand Response: Add up to 500 MW of demand response by 2038, depending on availability and cost of the resource.

Nuclear: Pursue option for secondary license renewal of Browns Ferry for an additional 20 years. Continue to evaluate emerging nuclear technologies including Small Modular Reactors as part of technology innovation efforts.

Wind: Existing wind contracts expire in the early 2030s. Consider the addition of up to 1,800 MW of wind by 2028 and up to 4,200 MW by 2038 if cost effective.

Storage: Add up to 2,400 MW of storage by 2028 and up to 5,300 MW by 2038. Additions may be a combination of utility and distributed scale, and are assumed to utilize batteries. The trajectory and timing of additions will be highly dependent on the evolution of storage technologies.

Gas Combustion Turbine: Evaluate retirements of up to 2,000 MW of existing combustion turbines (CT) if cost effective. Add up to 5,200 MW of CT by 2028 and up to 8,600 MW by 2038 if a high level of load growth materializes. Future CT needs are driven by demand for electricity, solar penetration, and evolution of other peaking technologies.

Gas Combined Cycle: Add between 800 and 5,700 MW of combined cycle (CC) by 2028 and up to 9,800 MW by 2038 if a high level of load growth materializes. Future CC needs are driven by demand for electricity and gas prices, as well as by solar penetration that tends to drive CT instead of CC additions.

Solar: Add between 1,500 and 8,000 MW of solar by 2028 and up to 14,000 MW by 2038 if a high level of load growth materializes. Additions may be a combination of utility and distributed scale. Future solar needs are driven by pricing, customer demand, and demand for electricity.

3.9 Comparison of Environmental Impacts of the Alternatives

This section provides a summary of the environmental impacts of the alternatives. Detailed analysis of the anticipated environmental impacts is provided in Chapter 5. Emissions of air pollutants, the intensity of greenhouse gas emissions and generation of coal waste decrease under all strategies. Strategies focused on resiliency, load shape and renewables have the largest amounts of solar and storage expansion and coal retirements, resulting in lower environmental impact overall but higher land use. For most environmental resources, the impacts are greatest for Strategy A, the No Action alternative, except for the land area required for new generating facilities that is greater for the action alternatives, particularly Strategies C, D, and E.

All alternative strategies and the Target Power Supply Mix will result in significant long-term reductions in emissions of sulfur dioxide (SO_2), nitrogen oxides (NO_x), and mercury. A large portion of these reductions, especially for SO_2 and mercury, result from the full or partial retirement of coal plants. The overall reductions in emissions under each strategy, averaged across the associated scenarios, show relatively little variation. Total and annual direct emissions of CO_2, as well as CO_2 emission rates, also referred to as CO_2 intensity, decrease under all alternative strategies and the Target Power Supply Mix. The variation among the strategies for both CO_2 emissions and emission rates is relatively small and much less than the variation among the scenarios associated with each strategy. All alternatives will result in the continued, significant, long-term reductions in CO_2 emissions from the generation of power marketed by TVA. The reduction in CO_2 emissions will likely have small but beneficial impacts on the potential for associated climate change.

The volume of water used by thermal generating facilities, (i.e., nuclear, coal, and CC facilities) decreases between 2019 and 2038 under all alternative strategies and the Target Power Supply Mix. The reductions in water consumption would have beneficial impacts; these impacts would generally be small and vary with the characteristics of the source area of the water withdrawal. The potential retirement of generating facilities, as described in Section 3.2.3, would result in minor, beneficial impacts to nearby rivers and waterways. The reductions in water use would result in localized beneficial impacts to aquatic ecosystems.

All alternative strategies and the Target Power Supply Mix will result in long-term reductions in the production of CCRs due to the retirement of coal plants/units. The quantity of CCR produced during the 2019-2038 planning period shows little variation between alternative strategies. It varies much more between the scenarios associated with each strategy and is greatest with Scenario 3 and lowest with Scenario 5. Potential retirement of coal and CT plants (Section 3.2.3) would primarily result in a decrease in solid and hazardous waste produced.

For all combinations of strategies and scenarios and the Target Power Supply Mix, at least 97 percent of the land required for new generating and storage facilities is for utility-scale, single-axis tracking solar facilities. Relative to other types of generation, solar PV facilities have a high land requirement in relation to their generating capacity. Smaller land areas would be occupied by new natural gas-fired and storage facilities.

Socioeconomic impacts, as quantified by the change to per capita income of TVA service area residents that is attributable to the cost of operating of the TVA power system, are minimal. The differences in annual per capita income and employment of residents of the TVA service area were compared to Strategy A for each scenario. The differences in per capita income are small; averaged across scenarios, there would be no change in the per capita income under Strategies B and E and small decreases under Strategies C and D. The potential retirement of generating facilities, as described in Section 3.2.3, would result in minor, adverse, direct and indirect socioeconomic impacts.

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4 Affected Environment

4.1 Introduction

This chapter describes the natural and socioeconomic resources that could be affected by the alternative strategies and portfolios developed in the integrated resource planning process. These resources are generally described at a regional scale rather than a site-specific scale. Site-specific conditions are, however, described for some generating facilities that, depending on the plan selected for implementation, could be retired in whole or in part during the planning period.

The primary study area, hereinafter call the Tennessee Valley Authority (TVA) region, is the combined TVA PSA and the Tennessee River watershed (Figure 1-1), including all counties in Tennessee and portions of Alabama, Georgia, Kentucky, Mississippi, North Carolina, and Virginia. The TVA PSA is comprised of 202 counties and approximately 59 million acres. All but one of TVA's hydroelectric plants, as well as all of its nuclear plants, are located in the Tennessee River watershed. Its coal-fired plants are located in the Tennessee River watershed as well as along the Cumberland, Green, and Ohio rivers (Figure 1-1). Seven of the eight windfarms from which TVA purchases power (see Section 2.4) are outside the TVA region. TVA also purchases power from several U.S. Army Corps of Engineers' (USACE) hydroelectric plants in the Cumberland River drainage basin. Some of these plants are located in the TVA region, and the others are in southern Kentucky north of the TVA region.

For some resources such as air quality, climate change, and renewable energy resources, the assessment area extends beyond the TVA region. For most socioeconomic resources, the primary study area consists of the 180 counties where TVA is a major provider of electric power and Muhlenberg County, Kentucky, where the TVA Paradise coal and Combined Cycle (CC) plants are located. The economic model used to compare the effects of the alternative strategies on general economic conditions in the TVA region includes surrounding areas to address some of TVA's major fuel sourcing areas and inter-regional trade patterns.

4.2 Air Quality

4.2.1 Regulatory Framework for Air Quality

The Clean Air Act (CAA), as amended, is the comprehensive law that affects air quality by regulating emissions of air pollutants from stationary sources (such as power plants and factories) and mobile sources (such as automobiles). It requires U.S. Environmental Protection Agency (USEPA) to establish National Ambient Air Quality Standards (NAAQS) for specific air pollutants and directs the states to develop State Implementation Plans to achieve these standards. This is primarily accomplished through permitting programs that establish limits for emissions of air pollutants from various sources. The CAA also requires USEPA to set standards for emissions of hazardous air pollutants.

4.2.2 Criteria Air Pollutants

USEPA has established NAAQS for the six criteria air pollutants: carbon monoxide (CO), lead (Pb), nitrogen dioxide (NO_2), ozone, particulate matter (PM), and sulfur dioxide (SO_2). TVA's entire PSA, with the exception of a small SO_2 nonattainment area in part of Sullivan County, Tennessee, is currently designated as attainment, attainment/unclassifiable, or unclassifiable with respect to all NAAQS. There are currently no other NAAQS nonattainment areas within the TVA PSA.

An unclassifiable status or attainment/unclassifiable status means that an area has insufficient air quality monitoring data to make a firm determination of attainment. However, the unclassifiable or attainment/unclassifiable status areas are treated as in attainment with NAAQS, for the purposes of CAA planning and permitting requirements.

In general, for all of the six criteria pollutants regulated under the NAAQS, air quality nationwide has been improving for several decades. This has been due in large part to compliance with CAA-related regulations developed by the USEPA and state/local agencies that have dramatically reduced pollutant emissions from stationary and mobile sources. The reductions in emissions of air pollutants have come about as a result of the development and use of emission control technologies that prevent pollutants from forming during combustion or other processes, technologies that remove the pollutants from the exhaust streams after the pollutants have formed, and the switch to cleaner fuels. A summary of improvements in air quality nationally is provided in Table 4-1, which shows the percent improvement for each NAAQS-regulated pollutant from the start of each decade since 1980 through 2017. For some of the listed pollutants, there are multiple standards based on different sampling time intervals. The standards for PM also address two different sizes of particles, one for particles less than 10 microns in size (PM_{10}), and one for particles less than 2.5 microns in size ($PM_{2.5}$). The major criteria pollutants emitted by power plants are nitrogen oxides (NO_x including NO_2) and SO_2. Ozone is not directly emitted by any source; it is formed by a chemical reaction between NO_x and volatile organic compounds (VOCs) in the presence of sunlight. VOCs are produced by both man-made and natural sources; in the Southeast, most VOCs are from natural sources and power plants are not significant emitters of VOCs.

Improvement in air quality has been realized in TVA's service region as well, as many counties in this region were previously designated as nonattainment for one or more NAAQS, and in recent decades have come into attainment.

The improvement in air quality and attainment of NAAQS in the region is even more remarkable considering that several of the NAAQS have been made substantially more stringent in the past two decades. The improvements in air quality in TVA's service region is representative of what has happened nationally.

Regional emissions trends for the TVA PSA are approximated for this assessment by using statewide Tennessee emissions. TVA serves nearly all of Tennessee, and portions of several adjacent states, so the emissions trends for Tennessee are used here as a surrogate for regional emissions trends in the TVA service region. Figure 4-1 shows the trend lines of Tennessee pollutant emissions from 1990 through 2017, based on data obtained from USEPA's National Emissions Inventory web site at https://www.epa.gov/air-emissions-inventories/air-pollutant-emissions-trends-data (USEPA 2018b).

Table 4-1: Percent change in ambient concentrations of air pollutants in the United States, 1980-2017.

Air Pollutant	1980 to 2017	1990 to 2017	2000 to 2017	2010 to 2017
Carbon Monoxide	-84	-77	-61	-13
Lead	-99	-98	-94	-80
Nitrogen Dioxide (annual)	-63	-56	-49	-21
Nitrogen Dioxide (1-hour)	-60	-50	-35	-14
Ozone (8-hour)	-32	-22	-17	-5
PM_{10} (24-hour)	---	-34	-30	0
$PM_{2.5}$ (annual)	---	---	-41	-18
$PM_{2.5}$ (24-hour)	---	---	-40	-10
Sulfur Dioxide (1-hour)	-90	-88	-79	-66

Source: USEPA 2018a (https://www.epa.gov/air-trends/air-quality-national-summary)

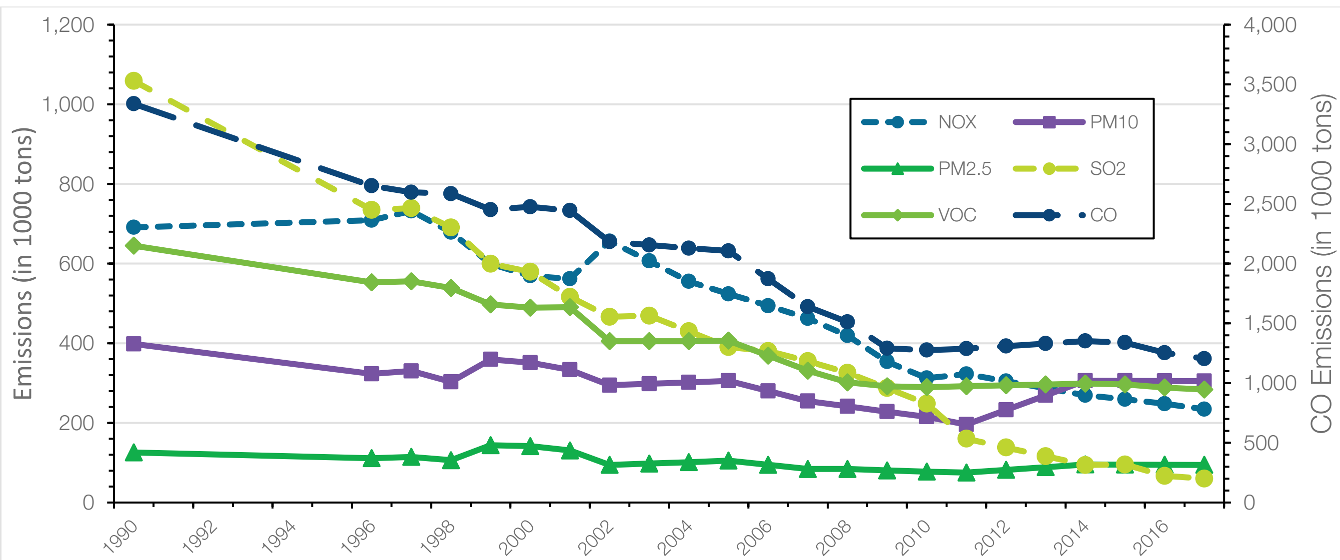


Figure 4-1: Trends in emissions of air pollutants in Tennessee, 1990-2017. Source: USEPA 2018b.

The data in Figure 4-1 represent, for each pollutant, the sum of emissions from all stationary and mobile source sectors, including wildfires and prescribed fires for those years where fires were inventoried. As shown in this chart, there is a significant downward trend for all pollutants in the region, especially for pollutants of concern emitted from stationary combustion sources such as SO_2 and NO_x.

TVA's emissions reductions are responsible for the majority of the statewide Tennessee stationary source SO_2 and NO_x emission reductions since 1990. The utility sector SO_2 emissions in Tennessee, the vast majority of which were from TVA in 1990, decreased from 817,612 tons in 1990 to 24,293 tons in 2017, a decrease of over 97 percent.

Utility sector NO_x emissions in Tennessee (most also due to TVA in 1990) increased from 240,359 tons in 1990 to 283,464 tons in 1997, before decreasing for the next two decades to 15,517 tons in 2017, a decrease of nearly 95 percent from the 1997 peak.

Electric utility emissions have fallen to the point where they no longer represent the largest emitting sector for the pollutants of primary focus. According to data from the 2014 National Emissions Inventory, on-road vehicles produce more than half (52%) of all NO_x emissions in Tennessee (147,638 tons per year) and non-road vehicles produce 9% of all NO_x emissions in Tennessee (25,953 tons per year). NOx is a concern due to its role as a precursor in the formation of fine particulate matter and ozone.

4.2.3 TVA Emissions

4.2.3.1 TVA System-Wide Emissions

The trends in TVA's reported SO_2, NO_x, and mercury emissions from 1990 through 2017 (TVA 2018a, TVA 2018b) are shown in Figure 4-2. These data represent emissions from TVA's facilities across its entire PSA.

4.2.3.2 Emissions from Facilities Considered for Retirement

Several TVA facilities have units that are being considered for retirement in the next decade. Table 4-2 lists those units and the emissions by plant for the potential retirement units over the past three years (2015-2017). Two scenarios are shown for the Shawnee Fossil Plant, one for retirement of just Units 1 and 4, and one for retirement of all units except for Units 1 and 4. Table 4-2 shows the annual emissions by plant in tons, and emission rates in units of pounds per megawatt-hour (lb/MWh).

The coal-fired units/plants have significantly higher emission rates than the Combustion Turbine (CT) units due to the higher concentrations of pollutant-forming compounds in coal. The relatively higher mercury emissions from the Allen CTs are because that plant burned mostly oil during the 3-year period from 2015 to 2017, whereas the other CT plants burned mostly natural gas.

Table 4-2: Three-Year (2015-2017) average emissions of units considered for future retirement.

Facility and Units	Generation (MWh)	SO_2 (3-yr average)		NOx (3-yr average)		Mercury (3-yr average)	
	3-year avg.	Tons/yr	lbs/MW-hr	Tons/yr	lbs/MW-hr	lbs/yr	lbs/GW-hr
Coal Units							
Shawnee 1, 4	1,461,122	4,841	6.63	2,213	3.03	14.73	1.01E-02
Shawnee 2, 3, 5-9	5,556,417	18,027	6.49	7,865	2.83	46.73	8.41E-03
Kingston 1-9	5,126,243	1,974	0.77	1,759	0.69	33.03	6.44E-03
Gallatin 1-4	5,308,503	4,942	1.86	5,837	2.20	66.16	1.25E-02
Cumberland 1-2	13,380,397	8,541	1.28	4,472	0.67	49.44	3.69E-03
Combustion Turbine Units							
Allen 1-16	3,388	0.018	0.01	12	6.81	0.03	9.54E-03
Allen 17-20	1,774	0.008	0.01	6	6.70	0.01	7.08E-03
Gallatin 1-4	35,406	0.155	0.01	122	6.91	0.01	2.35E-04
Colbert 1-8	9,449	0.040	0.01	29	6.09	0.01	6.20E-04
Johnsonville 1-16	42,237	0.156	0.01	117	5.53	0.04	9.74E-04
Total w/ Shawnee 1, 4 Retired	25,368,520	20,299	1.60	14,566	1.15	163	6.44E-03
Total w/all except Shawnee 1, 4 Retired	29,463,815	33,484	2.27	20,218	1.37	195	6.63E-03

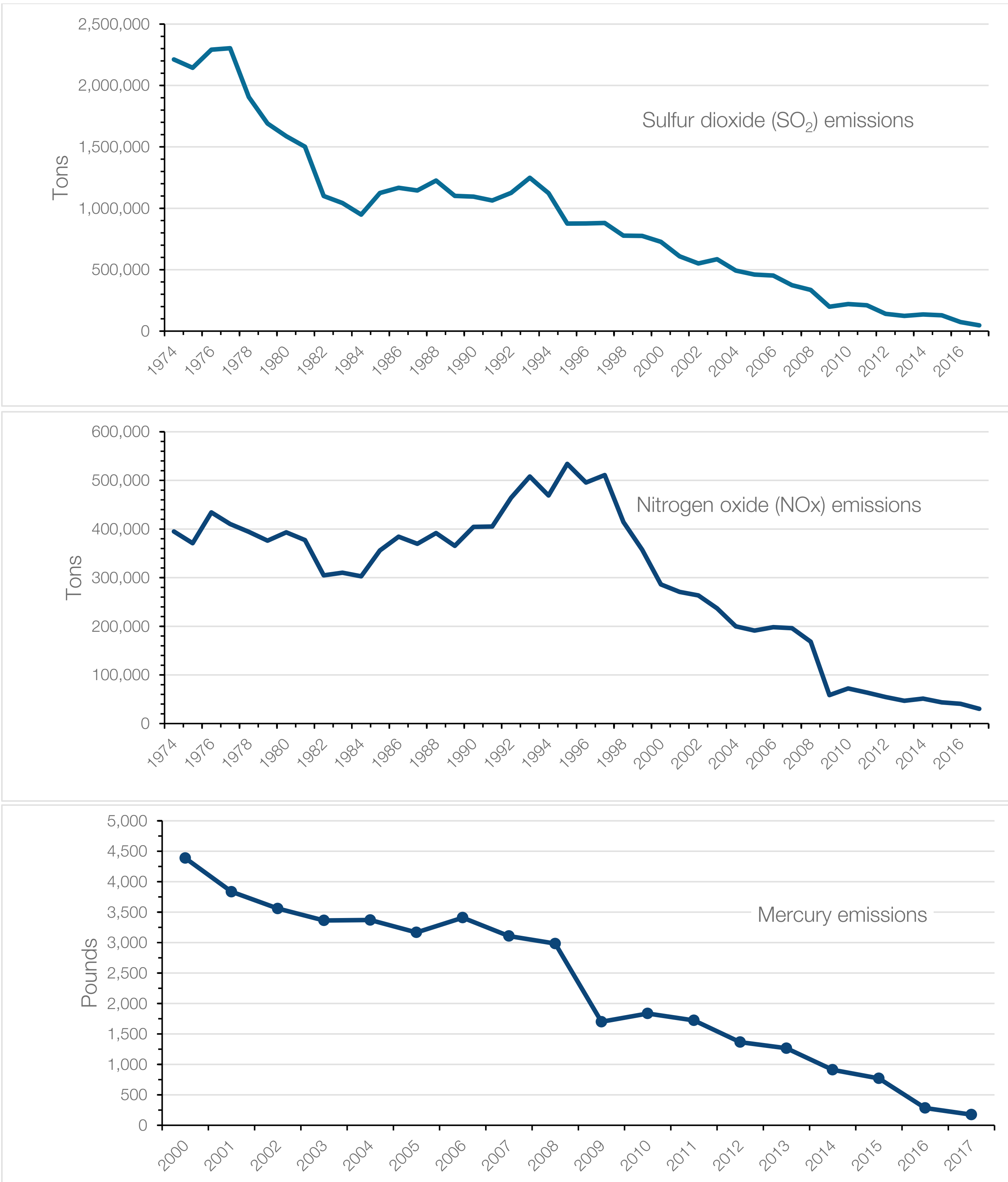


Figure 4-2: TVA emission trends for sulfur dioxide (SO2), 1974-2017 (top), nitrogen oxides (NOx), 1974-2017 (middle), and mercury, 2000-2017 (bottom). Sources: TVA 2015b, 2018a, 2018b

4.2.4 Hazardous Air Pollutants

Hazardous Air Pollutants (HAPs) are toxic air pollutants, which are known or suspected to cause cancer or other serious health effects or adverse environmental effects. The CAA identifies 187 pollutants as HAPs. Most HAPs are emitted by human activity, including motor vehicles, factories, refineries and power plants. There are also indoor sources of HAPs such as building materials and cleaning solvents. Some HAPs are emitted by natural sources, such as volcanic eruptions and forest fires. Exposure to HAPs can result from breathing air toxics, drinking water in which HAPs have deposited, or eating food exposed to HAPs deposition on soil or water. Exposure to high levels of HAPs can cause various chronic and acute harmful health effects, including cancer. The level of exposure which may result in adverse health impacts varies for each pollutant.

Emissions of HAPs including organic compounds, acid gases, and heavy metals have also been generally decreasing in recent decades along with the SO_2 and NO_x emissions, as coal use has decreased, and as coal and gas-fired electric generating units are fitted with better emissions controls.

4.2.5 Mercury

One HAP that has been singled out for a focused effort at emission reduction with respect to fossil-fueled facilities is mercury. Mercury is emitted to the air by human activities, such as burning coal or manufacturing, and from natural sources, such as volcanoes. Once it is in the environment, mercury cycles between air, water and soils, being re-emitted and re-deposited.

Once mercury is deposited in streams and lakes, it can be converted to methyl-mercury, the most toxic form of mercury, through microbial activity. Methyl-mercury accumulates in fish at levels that may cause harm to the fish and the animals that eat them. Some wildlife species with high exposures to methyl-mercury have shown increased mortality, reduced fertility, slower growth and development, and abnormal behavior that affects survival (USEPA 1997). Studies have also shown impaired neurological development in fetuses, infants and children with high exposures to methyl-mercury. In June 2014, USEPA and the Food and Drug Administration issued an updated draft fish consumption advisory recommending that pregnant and breastfeeding women, those who may become pregnant, and young children avoid some marine fish and limit consumption of others. TVA region states have also issued advisories on fish consumption due to mercury for several rivers and reservoirs across the TVA region (see Section 4.4.2).

Global emissions of mercury were estimated at approximately 6,500 tons/year in 2010 (UNEP 2013). As of 2011, USEPA estimated US mercury emissions at 52 tons/year (USEPA 2011), or 0.8 percent of the 2010 global total estimate.

In 2011, USEPA finalized the Mercury and Air Toxics Standards (MATS) rule to reduce mercury and other toxic air pollution from coal and oil-fired power plants. USEPA estimated this rule would prevent about 90 percent of the mercury in coal burned in power plants from being emitted to the air. USEPA also estimated the rule would result in a 5 percent reduction in U.S. nationwide mercury deposition from 2005 levels. This small overall reduction is largely due to the fact that mercury emissions tend to be deposited globally, rather than locally, with most of the deposition occurring in precipitation. In the technical support document for the 2011 MATS rule, USEPA estimated that with partial MATS and other emission control rule implementation, the contribution by US electric generating units (EGUs) to total US mercury deposition would drop from 5 percent in 2011 to 2 percent in 2016 (USEPA 2011).

Deposition occurs in two forms: wet (dissolved in rain, snow or fog) and dry (solid and gaseous particles deposited on surfaces during periods without precipitation). Wet mercury deposition is measured at Mercury Deposition Network monitors operated by the National Atmospheric Deposition Program. The highest wet deposition of mercury in the U.S. occurs in Florida and along the Gulf Coast, as shown in Figure 4-3. Mercury deposition in the TVA region ranges from nine to 15 micrograms per square meter, in the medium-high range for North America.

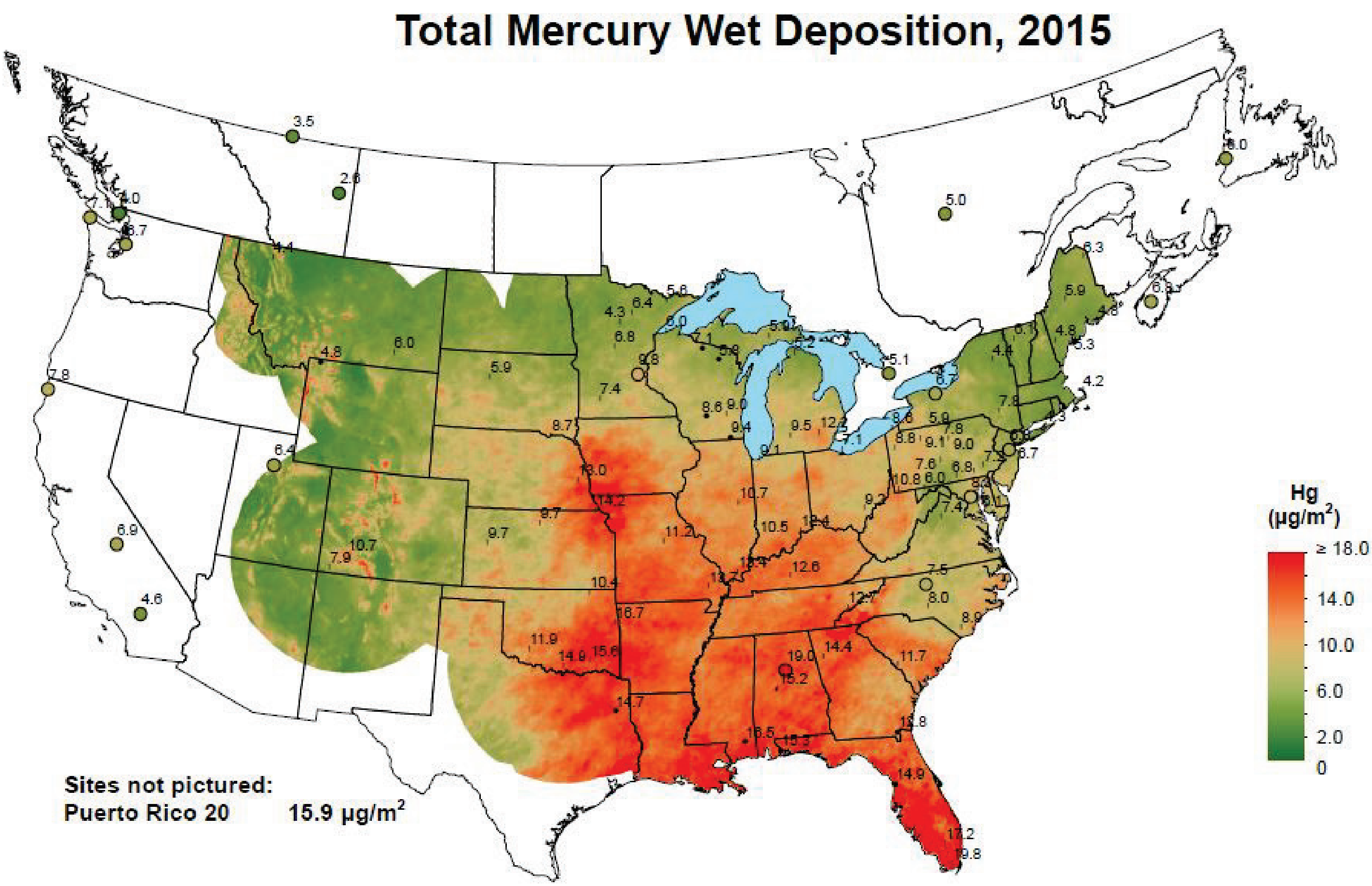


Figure 4-3: Total wet mercury deposition in the United States in 2015. Source: NADP 2018.

TVA mercury emissions have decreased 96 percent from 4,388 pounds in 2000 to 175 pounds in 2017 (Figure 4-2). Much of this reduction has resulted from the retirement of coal-fired units and the installation and operation of flue gas desulphurization (FGD) and selective catalytic reduction (SCR) systems on most of the remaining coal units. TVA has also taken specific measures to reduce mercury emissions in response to MATS, including the installation of activated carbon injection systems on some units and the retirement and replacement of Paradise Fossil Plant Units 1 and 2 with natural-gas fueled generation.

4.2.6 Visibility

Air pollution can impact visibility, which is a particularly important issue in national parks and wilderness areas where millions of visitors expect to be able to enjoy scenic views. Historically, "visibility" has been defined as the greatest distance at which an observer can see a black object viewed against the horizon sky. However, visibility is more than just a measurement of how far an object can be seen; it is a measurement of the conditions that allow appreciation of the inherent beauty of landscape features.

Visibility in the eastern United States is estimated to have declined by as much as 60 percent in the second half of the 20th Century (USEPA 2001). Visibility impairment is caused when sunlight is scattered or absorbed by fine particles of air pollution obscuring the view. Some haze-causing particles are emitted directly to the air, while others are formed when gases are transformed into particles. In the TVA region, the largest contributor to visibility impairment is ammonium sulfate particles formed from SO_2 emissions (primarily from coal-fired power plants). Other particles impacting visibility include nitrates (from motor vehicles, utilities, and industry), organic carbon (predominantly from motor vehicles), elemental carbon (from diesel exhaust and wood burning) and dust (from roads, construction, and agricultural activities). Visibility extinction is a measure of the ability of particles to scatter and absorb light and is expressed in units of inverse mega-meters (Mm^{-1}). Another metric used to measure visibility impairment is the deciview (dV), which is calculated from the atmospheric light extinction coefficient (b_{ext}) expressed in inverse megameters (Mm−1):

$$\text{Deciview index (dV)} = 10 \ln (b_{ext}/10\ Mm^{-1}).$$

The deciview unit is used to establish thresholds under visibility rules in 40 CFR 51, Appendix Y, as a basis for determining whether modeled visibility impacts from a source are great enough to warrant Best Available Retrofit Technology (BART) retrofits. Substantial progress toward attaining natural visibility conditions nationwide has been made since the issuance of the BART requirements in 2005. Some of the improvement has been due to BART implementation, and much improvement has also resulted from other regulatory programs to reduce stationary source and mobile source emissions.

The CAA designated national parks greater than 6,000 acres and wilderness areas greater than 5,000 acres as Class I areas in order to protect their air quality under more stringent regulations. There are eight Class I areas in the vicinity of the TVA region: Great Smoky Mountains National Park, Mammoth Cave National Park and the Joyce Kilmer, Shining Rock, Linville Gorge, Cohutta, Sipsey, and Upper Buffalo Wilderness Areas (Figure 4-4). The Great Smoky Mountains National Park is the largest Class I area in the TVA region.

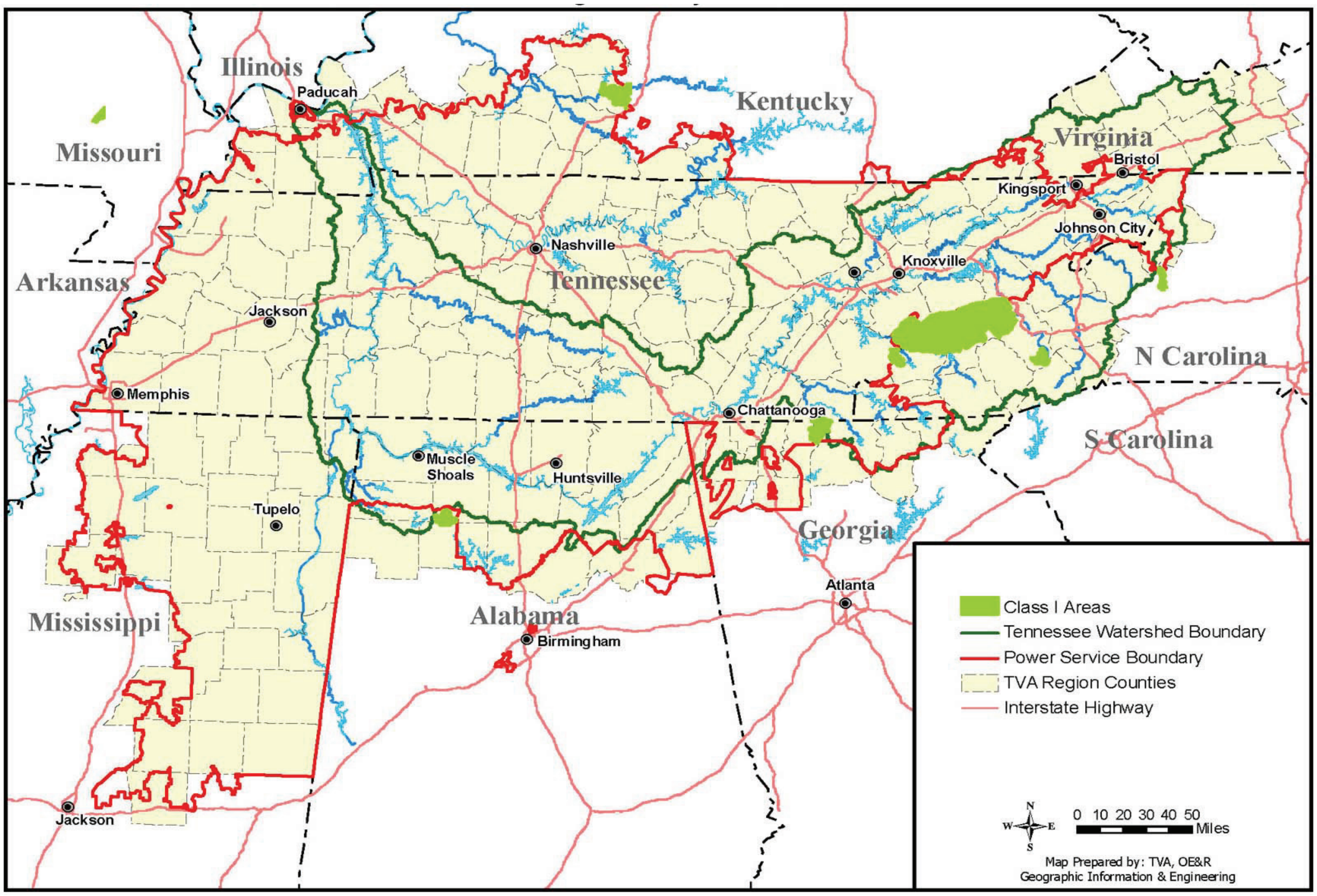


Figure 4-4: The TVA service area and Class I Areas.

In 1999, USEPA promulgated the Regional Haze Rule to improve visibility in Class I areas. This regulation requires states to develop long-term strategies to improve visibility with the ultimate goal of restoring natural background visibility conditions by 2064. Visibility trends are evaluated using the average of the 20 percent worst days and the 20 percent best days with the goal of improving conditions on the 20 percent worst days, while preserving visibility on the 20 percent best days.

The trend in visibility improvement measured at Great Smoky Mountains National Park is shown in Figure 4-5, which shows the visibility improvement in deciviews on average for the worst 20 percent of days and the best 20 percent of days. From 1990 to 2016, there was a 47 percent improvement in the visibility on the worst days and a 44 percent improvement on the best days. For a comparison with natural conditions (no human emissions impacts), the Federal Land Manager Environmental Database lists the natural conditions at the Great Smoky Mountains as 11.2 dV on the haziest days and 4.6 dV on the clearest days.

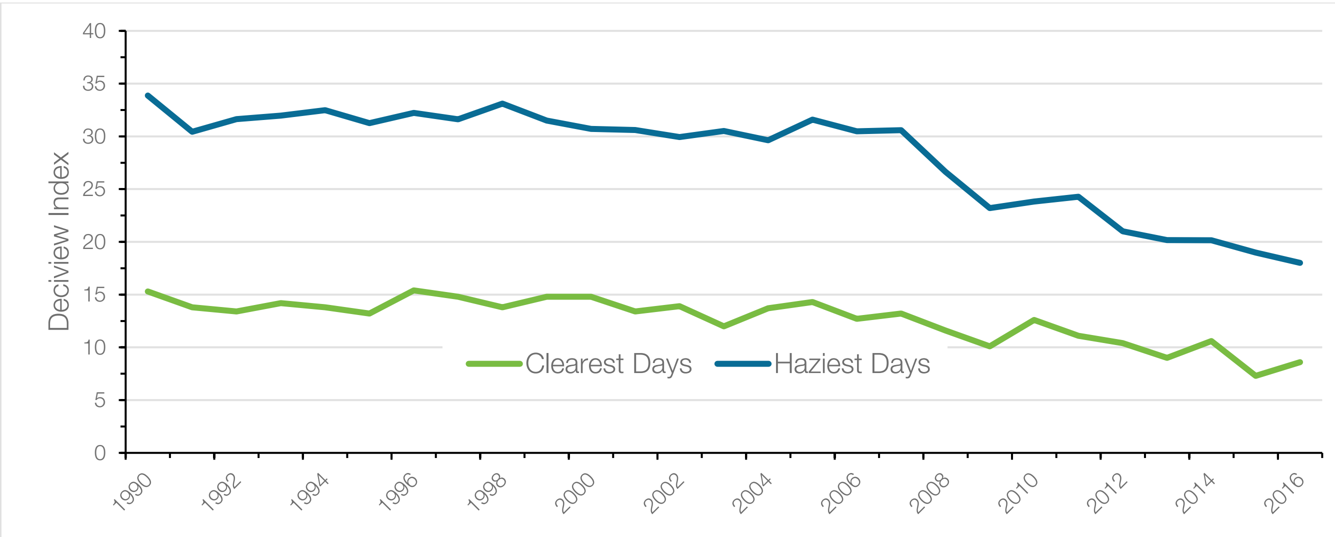


Figure 4-5: Change in visibility in the Great Smoky Mountains National Park on the worst 20 percent of days and the best 20 percent of days, 1990-2016. Smaller deciview values indicate better visibility. Source: FLMED 2018.

4.2.7 Acid Deposition

Acid deposition, also called acid rain, is primarily caused by SO_2 and NO_x emissions which are transformed into sulfate (SO_4) and nitrate (NO_3) aerosols, then deposited in precipitation (rain, snow, or fog). Acid deposition causes acidification of lakes and streams in sensitive ecosystems, which can adversely impact aquatic life. Acid deposition can also reduce agricultural and forest productivity. Some ecosystems, such as high elevation spruce-fir forests in the southern Appalachians, are quite sensitive to acidification, while other ecosystems with more buffering capacity are less sensitive to the effects of acid deposition. The acidity of precipitation is typically expressed on a logarithm scale called pH which ranges from zero to 14 with seven being neutral. pH values less than seven are considered acidic and values greater than seven are considered basic or alkaline. It is thought that the average pH of pre-industrial rainfall in the eastern United States was approximately 5.0 (Charlson and Rodhe 1982).

Based on the data reflected in Figure 4-1, together with TVA emissions data for Tennessee, as of 2017, the TVA SO2 and NOx emission represented 40 percent and less than 7 percent, respectively, of statewide total emissions of these pollutants. As stated above, TVA's SO_2 emissions in Tennessee have decreased by 97 percent since 1990 and its NO_x emissions in the state have decreased by 95 percent from their peak level in 1997. Emissions from utilities across the eastern US have also decreased significantly, and emissions from mobile sources have started a substantial downward trend as well in the past decade or more.

The 1990 CAA Amendments established the Acid Rain Program to reduce SO_2 and NO_x emissions and the resulting acid deposition. Since this program was implemented in 1995, reductions in SO_2 and NO_x emissions have contributed to significant reductions in acid deposition, concentrations of $PM_{2.5}$ and ground-level ozone, and regional haze. Other regulatory programs aimed at industrial emitters and vehicle engines (onroad and nonroad) are also driving down emissions.

Figure 4-6 and Figure 4-7 illustrate the dramatic decreases in total sulfate deposition between 2000 and 2016 (most recent data available) across the US (NADP 2018). Similar reductions in nitrate deposition have also occurred over the 2006 to 2016 period. Even by the year 2000, deposition of sulfate and nitrate was decreasing across the US, as pollution control retrofits were already in place for many large utility sources.

However, the decreases since that time have been even more dramatic. The values in Figure 4-6 and Figure 4-7 are based on a hybrid approach of combining monitoring and modeling to develop the plots.

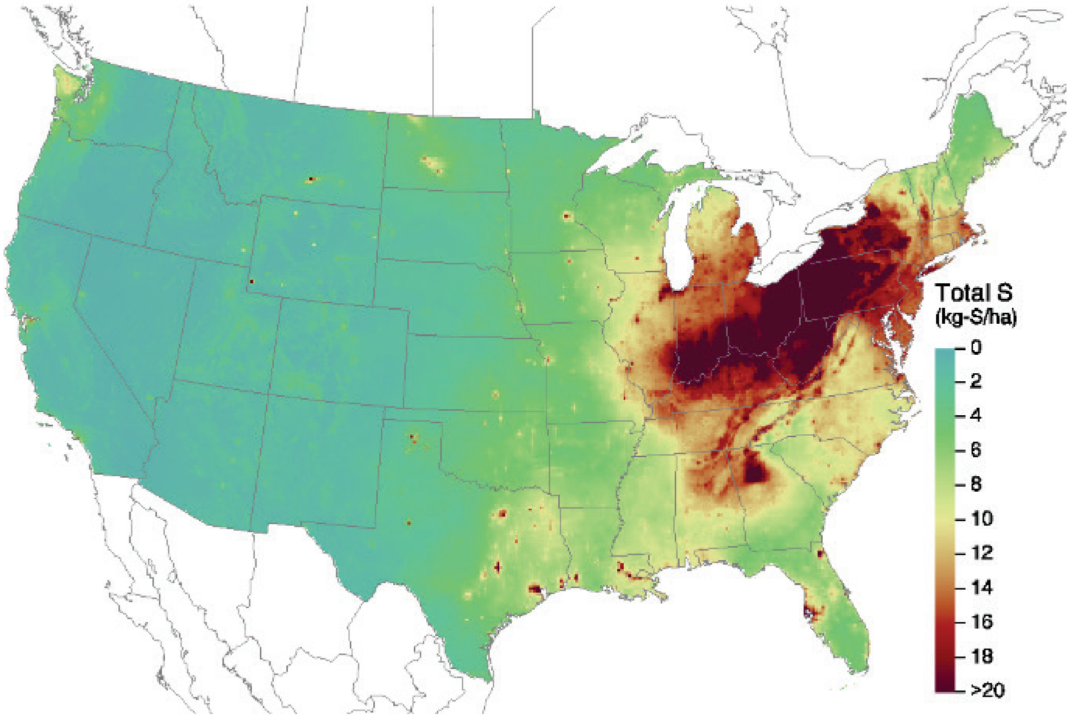


Figure 4-6: Year 2000 total sulfate deposition. USEPA 08/28/18. Source: CASTNET/CMAQ/NADP.

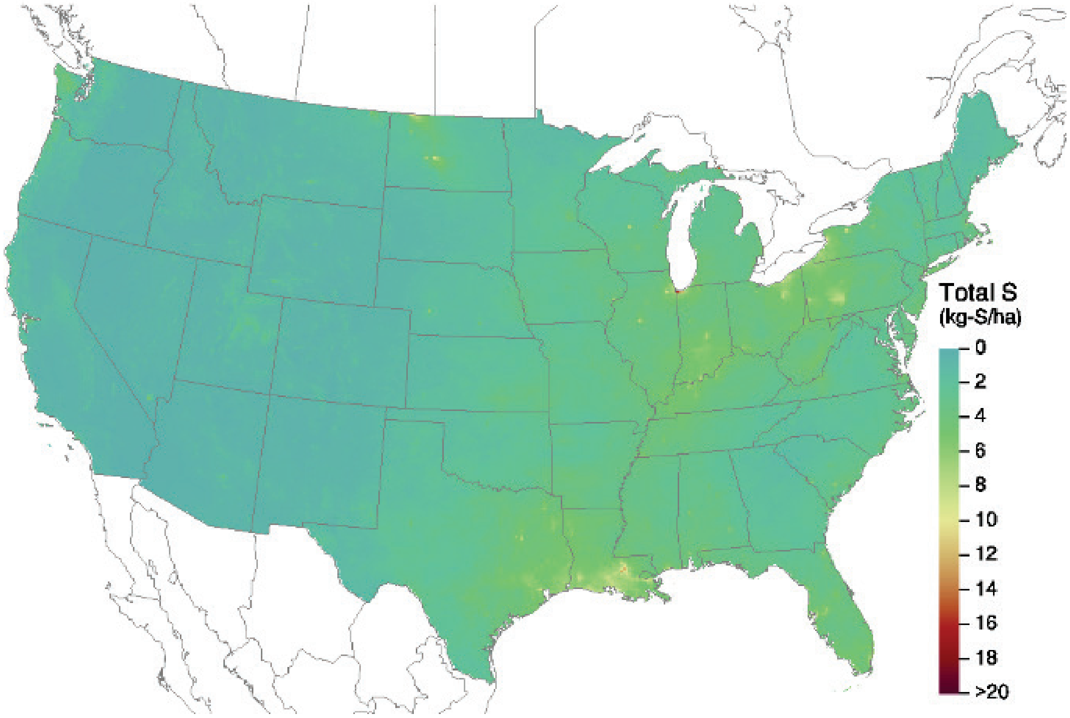


Figure 4-7: Year 2016 total sulfate deposition. USEPA 03/06/18. Source: CASTNET/CMAQ/NADP.

4.3 Climate and Greenhouse Gases

The TVA region spans the transition between a humid continental climate to the north and a humid subtropical climate to the south. This provides the region with generally mild temperatures (i.e., a limited number of days with temperature extremes), ample rainfall for agricultural and water resources, vegetation-killing freezes from mid-autumn through early spring, occasional severe thunderstorms, infrequent snow and infrequent impacts—primarily in the form of heavy rainfall—from tropical storms. The seasonal climate variation induces a dual-peak in annual power demand, one for winter heating and a second for summer cooling. Rainfall does not fall evenly throughout the year, but tends to peak in late winter/early spring and again in mid-summer. Winds over the region are generally strongest during winter and early spring and lightest in late summer and early autumn. Solar radiation (insolation) varies seasonally with the maximum sun elevation above the horizon and longest length in summer. However, insolation is moderated by frequent periods of cloud cover typical of a humid climate.

The remainder of this section describes the current climate and recent climate trends of the TVA region in more detail. It describes emissions of greenhouse gases (GHGs), widely considered to be a major source of climate change (NAS and RS 2014). It also describes projected changes in climate during this century, based on the Fourth National Climate Assessment (4th NCA, USGCRP 2017) and related sources. Identifying recent trends in regional climate parameters such as temperature and precipitation is a complex problem because year-to-year variation may be larger than the multi-decadal change in a climate variable. Climate is frequently described in terms of the climate "normal," the 30-year average for a climate parameter (NCEI 2011). The climate normals described below are for the most recent period of record, 1981–2010. Earlier and more recent data are also presented where available. The primary sources of these data are National Weather Service (NWS) records and records from the rain gauge network maintained by TVA in support of its reservoir operations. NWS records, unless stated otherwise, are from Memphis, Nashville, Chattanooga, Knoxville, and the Tri-Cities area in Tennessee and Huntsville, Alabama.

4.3.1 1981–2010 Climate Normals and Trends

Temperature – Observed average monthly temperatures for the TVA region during 1981–2010 ranged from 39.1°F in January to 79.3°F in July (Table 4-3). These data show considerable year-to-year variability with an overall warming trend of 0.4–0.5°F (0.2–0.3°C) per decade for 1981–2010. This is greater than the global average trend reported by the U.S. Climate Change Science Program (Lanzante et al. 2006), which shows an increase in global surface temperature of about 0.16°C per decade between 1979 and 2004. Longer term temperature data for Tennessee (assumed to be representative of the TVA region) are illustrated in Figures 4-8, 4-9, and 4-10. Both annual average temperature and annual average winter temperature showed very small increases (0.24°F/100 years and 0.67°F/100 years, respectively) since the 1890s. The annual average summer temperature showed a small, long-term decrease of 0.09°F/100 years.

Table 4-3: Monthly, seasonal and annual temperature averages for six NWS stations in the TVA region for 1981–2010. Source: NCEI 2011.

	Jan	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
ºF	39.1	59.7	68.1	76.0	79.3	78.6	71.9	60.8	50.5	41.5
ºC	3.9	15.4	20.1	24.4	26.3	25.9	22.1	16.0	10.3	5.3

	Winter	Spring	Summer	Fall	Annual
ºF	41.2	59.7	78.0	61.1	60.0
ºC	5.1	15.4	25.5	16.1	15.5

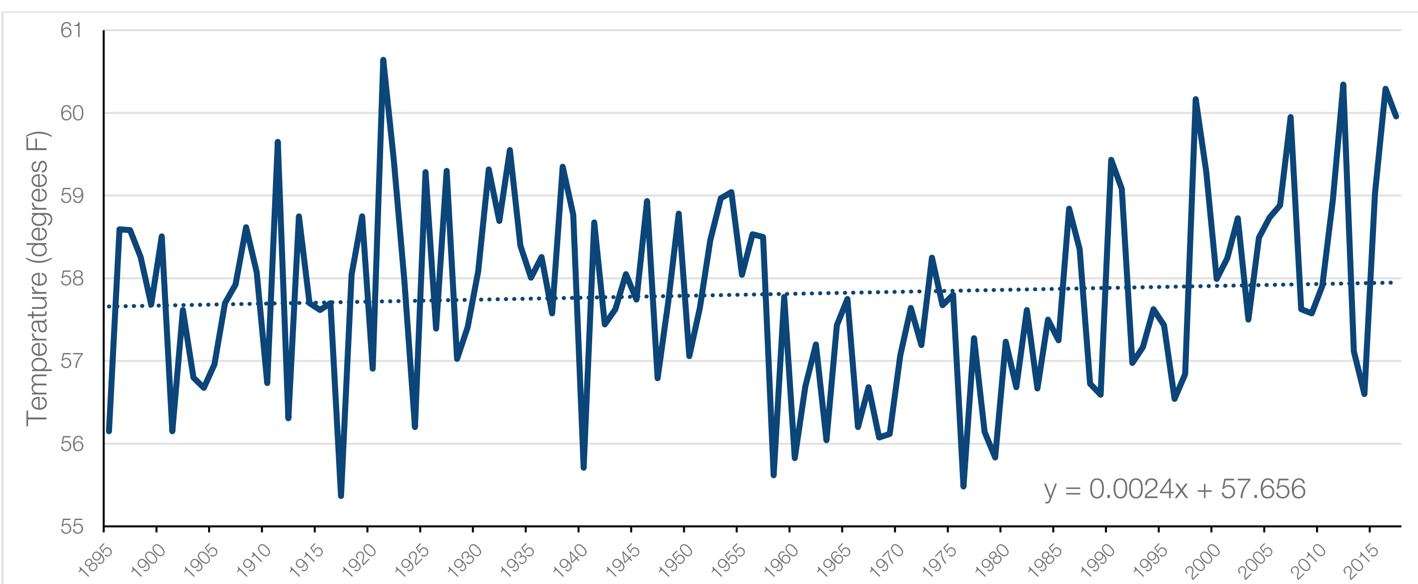


Figure 4-8: Annual average temperature (°F) in Tennessee, 1895–2017. The dashed line is the trend based on least squares regression analysis. Source: WRCC 2018.

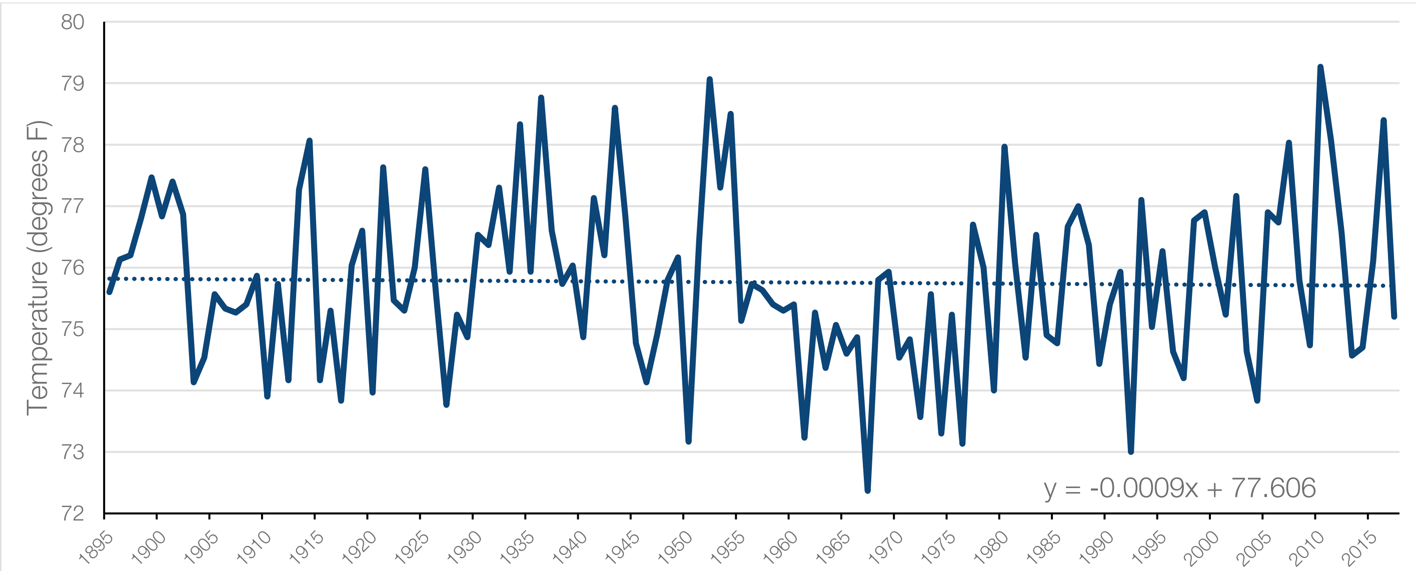


Figure 4-9: Annual average summer temperature (°F) in Tennessee, 1895–2017. The dashed line is the trend based on least squares regression analysis. Source: WRCC 2018.

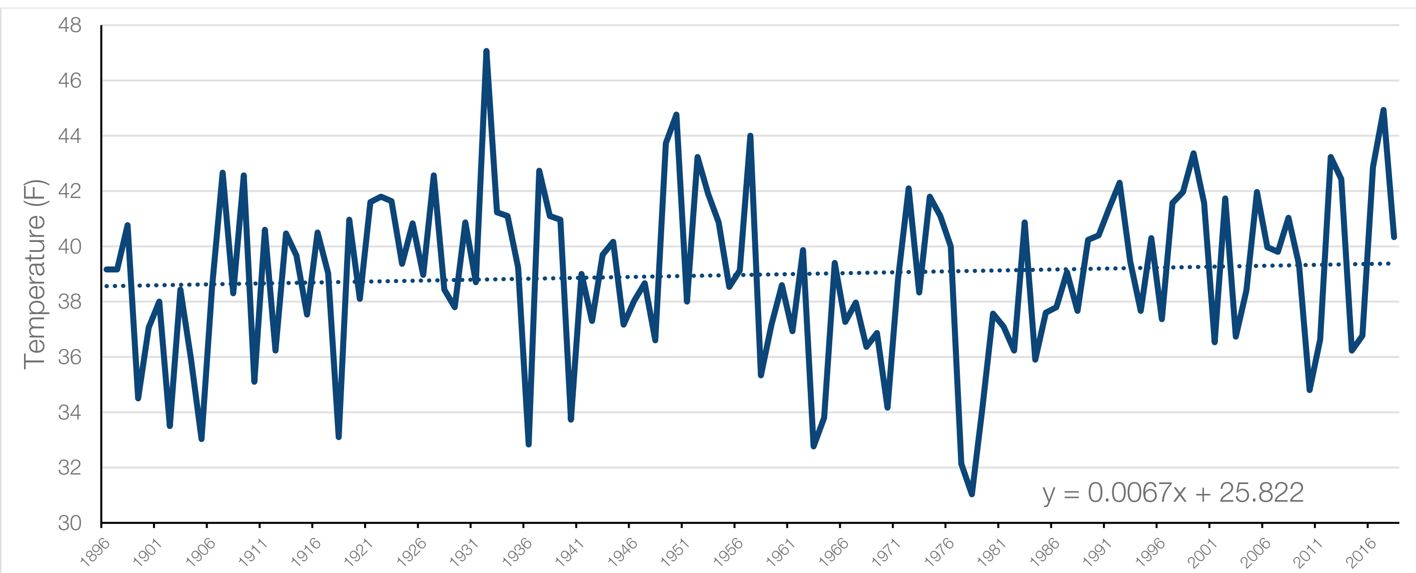


Figure 4-10: Annual average winter temperature (°F) in Tennessee, 1896–2018. The dashed line is the trend based on least squares regression analysis. Source: WRCC 2018.

Precipitation – The observed average annual precipitation in the Tennessee River watershed during 1981–2010 was 49.92 inches; monthly averages range from 2.86 inches in October to 4.73 inches in December (Table 4-4). There is significant year-to-year variability in precipitation with no discernable trend during the 30-year period. The wettest locations in the TVA region occur in southwestern North Carolina and the driest locations are in northeast Tennessee (SERCC 2018). The annual average of snowfall across most of the TVA region ranges from five to 25 inches, except in the higher elevations of the southern Appalachians in North Carolina and Tennessee. These locations can receive up to 100 inches of snowfall (Walsh et al. 2014a).

Table 4-4: Monthly, seasonal, and annual precipitation averages in the Tennessee River watershed for 1981-2010. Source: TVA rain gage network data.

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Inches	4.22	4.23	4.26	3.79	4.23	3.64	3.89	3.23	3.42	2.86	4.01	**4.73**
Centimeters	10.7	10.8	10.8	9.6	10.8	9.2	9.9	8.2	8.7	7.3	10.2	**12.0**

	Winter	Spring	Summer	Fall	Annual
Inches	13.18	12.28	10.76	10.29	**46.51**
Centimeters	33.5	31.2	27.3	26.1	**118.1**

Figure 4-11 shows Tennessee annual total precipitation for the period 1895 through 2017. These data show that over this period of record, the average annual precipitation has increased at an average rate of around 8 percent per 100 years, as is apparent from the linear regression equation provided on this chart. The increase in average annual precipitation occurred prior to 1970 and there has been no significant trend for the last 50 years.

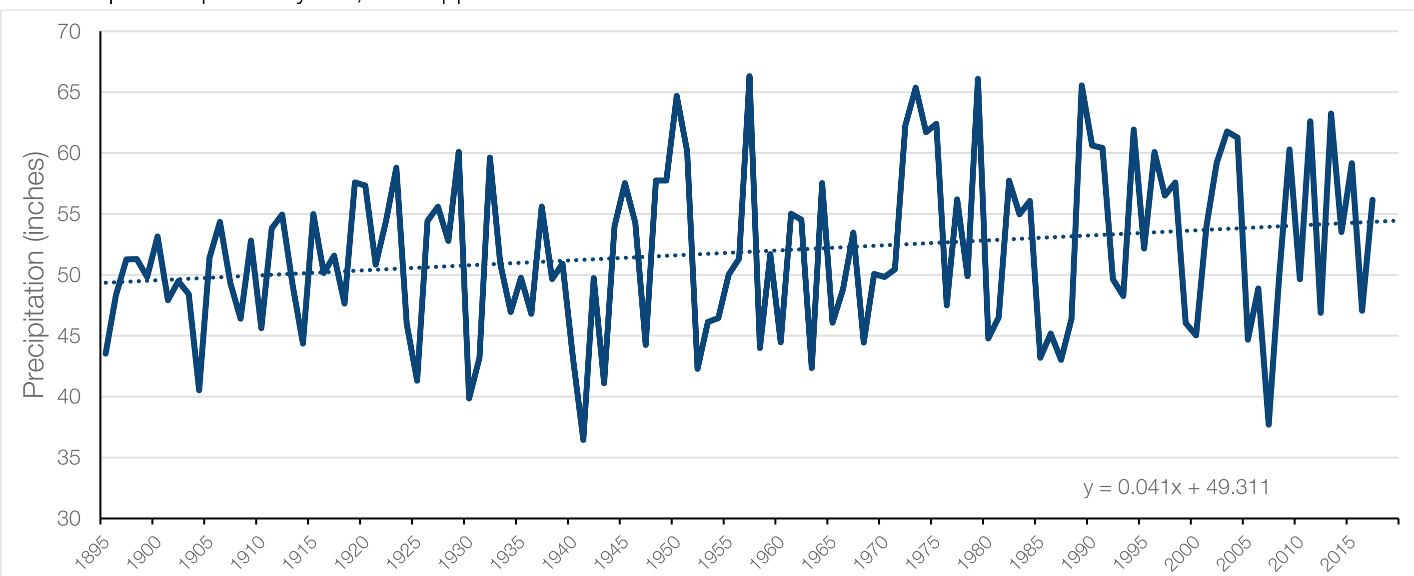


Figure 4-11: Annual average precipitation in Tennessee, 1895-2017. The dashed line is the trend based on least squares regression analysis.

4.3.2 Greenhouse Gas Emissions

The sun is the primary source of energy for the Earth's climate. About 30 percent of the sun's energy that reaches Earth is reflected back to space by clouds, gases and small particles in the atmosphere. The remainder is absorbed by the atmosphere and the surface. Earth's temperature depends on the balance between the energy entering and leaving the planet's system. When energy is absorbed by the Earth's system, global temperatures increase. Conversely, when the sun's energy is reflected back into space, global temperatures decrease (Walsh et al. 2014b).

In nature, carbon dioxide (CO_2) is exchanged continually between the atmosphere, plants and animals through processes of photosynthesis, respiration and decomposition, and between the atmosphere and oceans through gas exchange. Billions of tons of carbon in the form of CO_2 are annually absorbed by oceans and living biomass (i.e., sinks) and are annually emitted to the atmosphere through natural and man-made processes (i.e., sources). When in equilibrium, carbon fluxes among these various global reservoirs are roughly balanced (Galloway et al. 2014).

Similar to the glass in a greenhouse, certain gases, primarily CO_2, nitrous oxide (N_2O), methane (CH_4), hydroflurocarbons (HFCs), perflourocarbons (PFCs) and sulfur hexafluoride (SF_6), absorb heat that is radiated from the surface of the Earth. Increases in the atmospheric concentrations of these gases cause the Earth to warm by trapping more heat. The common term for this phenomenon is the "greenhouse effect," and these gases are typically referred to as GHGs. Atmospheric levels of CO_2 are currently increasing at a rate of 0.5 percent per year and between 1900 and 2017 increased from less than 300 parts per million (ppm) to 405 ppm (NOAA 2018), higher than the Earth has experienced in over a million years (Walsh et al. 2014b).

While water vapor is the most abundant GHG in the atmosphere, it is not included in the above list of GHGs because changes in the atmospheric concentration of water vapor are generally considered to be the result of climate feedbacks related to the warming of the atmosphere, rather than a direct result of human activity. That said, the impact of water vapor is critically important to projecting future climate change. Quantifying the effect of feedback loops on global and regional climate is the subject of ongoing data collection and active research (Walsh et al. 2014b).

The magnitude of the warming induced by the greenhouse effect depends largely on the amount of GHG accumulating in the atmosphere (Walsh et al. 2014a). GHGs can remain in the atmosphere for different amounts of time, ranging from a few years to thousands of years (NAS and RS 2014). GHGs are assigned global warming potentials, a measure of the relative amount of infrared radiation they absorb, their absorbing wavelengths and their persistence in the atmosphere. All of these gases remain in the atmosphere long enough to become well mixed, meaning the amount that is measured in the atmosphere is roughly the same all over the world, regardless of the source of the emissions.

The primary GHG emitted by electric utilities is CO_2 produced by the combustion of fossil fuels. CO_2 is also produced by the combustion of biomass fuels, although these fuels when derived from plant (i.e., vegetation) sources are often considered to be carbon-neutral since the subsequent plant regrowth sequesters carbon. Small amounts of SF_6, which has a very high global warming potential relative to other GHGs (Global Warming Potential for SF_6 = 22,800 times CO_2 on a pound-for-pound basis, per 40 CFR 98), are released due to its use in high-voltage circuit breakers, switchgears, and other electrical equipment. CH_4, which has a global warming potential of 25 times that of CO_2 (per 40 CFR 98), is emitted during coal mining and from natural gas wells and delivery systems.

Nationwide anthropogenic emissions of GHGs are estimated by USEPA annually, for each of several sectors of the economy. The 2016 estimates by sector are shown in the chart in Figure 4-12 and represent the most recent data available. Transportation and electricity generation each represented approximately 28 percent of nationwide GHG emissions in 2016, with industrial sources, commercial and residential buildings, and agriculture each representing successively smaller portions of the total.

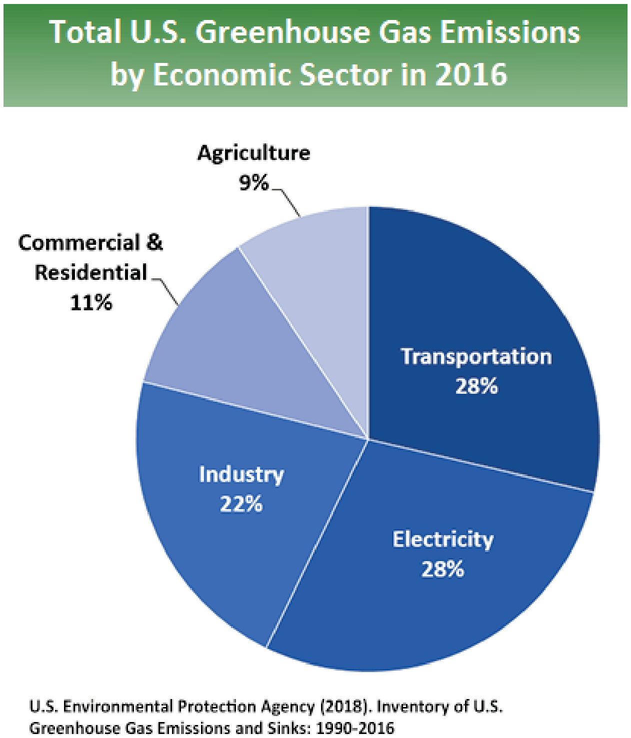


Figure 4-12: US 2016 GHG emissions by sector.

According to 2016 data from the U.S. Energy Information Administration, transportation comprises 42.4% of Tennessee's CO_2 emissions from fossil fuel consumption and is the largest CO_2 emitter of all end-use sectors in the state (USEIA 2019).

4.3.2.1 TVA System-Wide Emissions

CO_2 emissions from the TVA power system have decreased by 51 percent since 1995 (Figure 4-13). This decrease is mainly due to the retirement of coal plants, which emit large quantities of CO_2 relative to other types of electrical generation, and the replacement of coal generation with nuclear and natural gas-fueled generation. Nuclear generation does not result in emissions of CO_2, and CO_2 emissions from natural gas-fueled generation are about half that of coal.

Figure 4-13 also shows the trend in TVA system-wide emission rate on a pounds per megawatt-hour (lb/MWh) basis. This value has decreased as more coal units have shut down, replaced by lower-emitting natural gas-fired units and by renewables. The lb/MWh rates included purchased and owned generation.

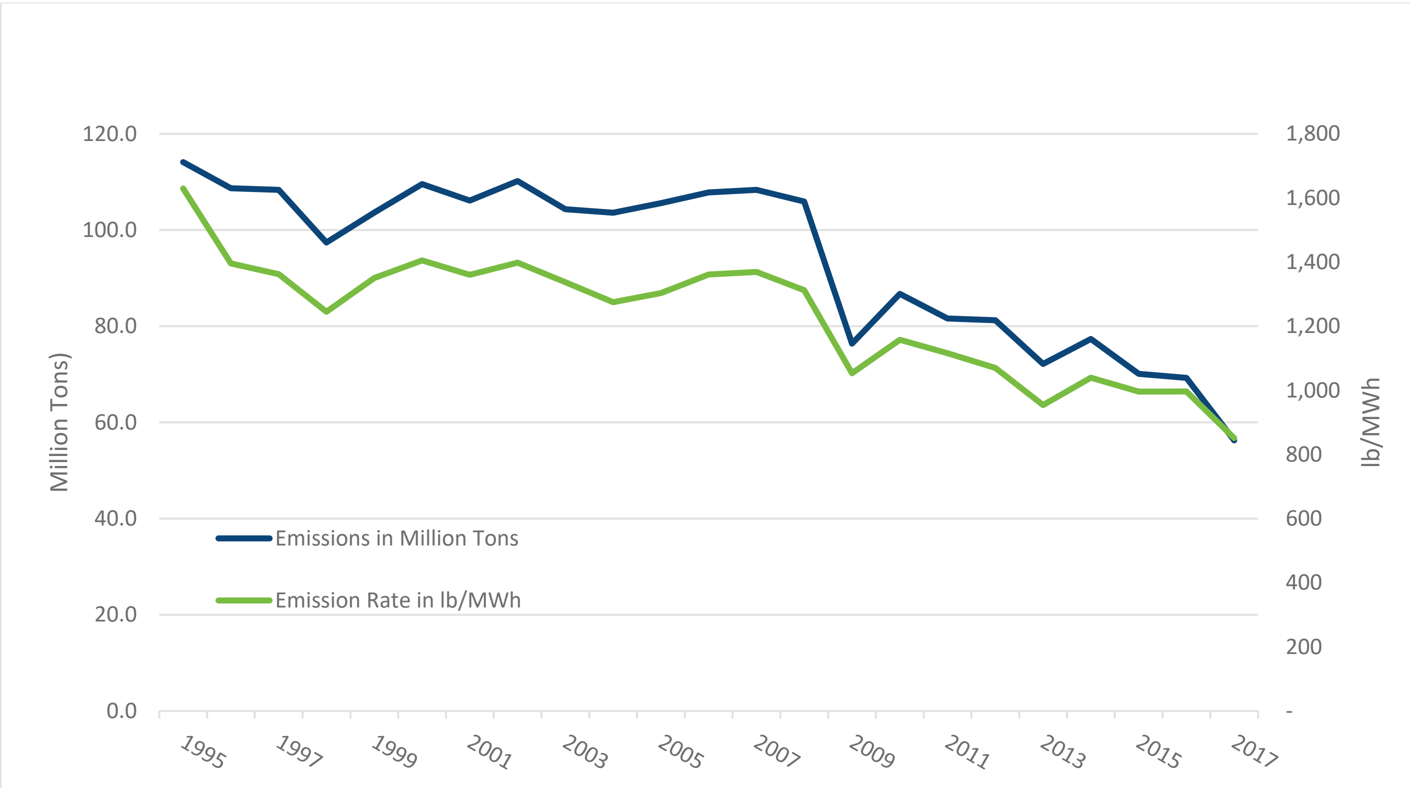


Figure 4-13: 1995-2017 CO_2 emissions (million tons) and emission rate (lb/MWh) from generation of power marketed by TVA. Source: TVA 2018c.

4.3.2.2 Emissions from Facilities Considered for Retirement

Table 4-5 shows the 2015-2017 three-year average CO_2-equivalent emissions (CO_2-eq) reported for the facilities being considered for potential retirement. These are the same facilities listed in Table 4-2 that shows emissions of SO_2, NO_x, and mercury.

Table 4-5: Three-Year (2015-2017) average CO_2-eq emissions and emission rates of units considered for future retirement. Source: TVA annual emissions reports.

Facility and Units	Gen. (MWh)	CO_2-eq (3-yr average)	CO_2-eq (3-yr average)
	3-year avg.	Tons/yr	lbs/MW-hr
Coal Units			
Shawnee 1, 4	1,461,122	1,693,176	2318
Shawnee 2, 3, 5-9	5,556,417	6,298,424	2267
Kingston 1-9	5,126,243	5,636,184	2199
Gallatin 1-4	5,308,503	5,819,979	2193
Cumberland 1-2	13,380,397	12,943,973	1935
Combustion Turbine Units			
Allen 1-16	3,388	3,304	1950
Allen 17-20	1,774	1,566	1766
Gallatin 1-4	35,406	29,547	1669
Colbert 1-8	9,449	8,375	1773
Johnsonville 1-16	42,237	33,917	1606
Total w/ Shawnee 1, 4 Retired	25,368,520	26,170,021	2063
Total w/all except Shawnee 1, 4	29,463,815	30,775,270	2089

4.3.3 Forecast Climate Trends

The modeled projections of temperature and precipitation cited here are from the Fourth National Climate Assessment (4th NCA) published by the U.S. Global Change Research Program (USGCRP 2017). This publication cites climate change projections for various emissions scenarios, which result in “representative concentration pathways” (RCPs) that each relate to a given amount of radiative forcing in the year 2100. For example, an RCP2.6 scenario means that emissions would increase at a rate sufficient to create 2.6 watts/m^2 of radiative forcing in 2100.

For the southeast U.S., the 4th NCA projects that temperatures will rise under all emissions scenarios presented, including a “very low” scenario where emissions peak soon and begin to decrease globally (RCP2.6). Under a low emissions increase scenario (RCP4.5) that includes a modest rise in global GHG emissions that peaks in about 20 years and then declines steeply, the 4th NCA projects that average annual temperatures in the Southeast U.S. will be 3.4°F higher than recent climate normals by mid-century with temperatures 4.4°F higher by late century. The report, however, notes that Southeast temperatures have not increased in the last century, contrary to climate model projections of what should have happened with the increase in atmospheric GHG concentrations that has already occurred.

For extreme high temperatures, under a high emissions scenario (RCP8.5, with GHG emissions continuing to increase at near their present rate of increase) the 4th NCA states that climate model predictions show large changes from the near present climate normals. For the coldest and warmest day of the year, the climate modeling predicts that the coldest day of the year will be on average nearly 5°F warmer and the warmest day of the year will be nearly 6°F warmer by mid-century in the Southeast. The 4th NCA concludes that extreme temperatures will increase by even more than average temperatures. This prediction also deviates from observed trends for hot days, which have decreased in the Southeast over the past century.

Climate models are generally not good at predicting precipitation variability and amounts across different geographic areas, or variability over time. One reason for this is their inability to simulate convective precipitation processes, given that these processes occur at scales smaller than the grid scales used to run global circulation climate models. However, the 4th NCA (see Figure 7.5 of that report) provides projections for changes in seasonal precipitation across North America for late this century, assuming the RCP8.5 high emissions scenario. For the Southeast, the modeled changes from current (1976-2005 average) precipitation conditions are generally within the range of natural variability, with the exception of a slightly greater amount of winter precipitation predicted for much of the TVA region.

4.3.4 Climate Adaptation

TVA has adopted a climate adaptation plan that establishes adaptation planning goals and describes the challenges and opportunities a challenging climate may present to its mission and operations (TVA 2016g). The goal of TVA's adaptation planning process is to ensure that the Agency continues to achieve its mission and program goals and to operate in a secure, effective and efficient manner in a changing climate.

TVA manages the effects of climate change on its mission, programs and operations within its environmental management processes. TVA's Environmental Policy (TVA 2008a) provides objectives for an integrated approach related to providing cleaner, reliable and affordable energy, supporting sustainable economic growth and engaging in proactive environmental stewardship. The policy includes the specific objective of stopping the growth in mass of emissions and reducing the rate of carbon emissions by 2020 by supporting a full slate of reliable, affordable, lower-CO_2 energy-supply opportunities and energy efficiency. TVA's Adaptation Plan (TVA 2016g) specifies that each TVA major planning process shall identify any significant climate change risks. Significant climate change risks are those with the potential to substantially impair, obstruct or prevent the success of agency mission activities, both in the near term and particularly in the long term, using the best available science and information.

4.4 Water Resources

This section describes water resources in the TVA region that could be affected by the alternative strategies. Potentially affected water resources include groundwater, surface water, water supply, and aquatic life.

4.4.1 Groundwater

4.4.1.1 Regulatory Framework for Groundwater

The Safe Drinking Water Act of 1974 established the sole source aquifer protection program which regulates certain activities in areas where the aquifer (water-bearing geologic formations) provides at least half of the drinking water consumed in the overlying area. This act also established both the Wellhead Protection Program, a pollution prevention and management program used to protect underground sources of drinking water, and the Underground Injection Control Program to protect underground sources of drinking water from contamination by fluids injected into wells. Several other environmental laws contain provisions aimed at protecting groundwater, including the Resource Conservation and Recovery Act (RCRA), the Comprehensive Environmental Response, Compensation, and Liability Act and the Federal Insecticide, Fungicide, and Rodenticide Act. On April 17, 2015, the USEPA published the Disposal of Coal Combustion Residuals from Electric Utilities final rule (CCR Rule) in the *Federal Register* to provide a comprehensive set of requirements for the safe disposal of CCRs from coal-fired power plants. The CCR Rule addresses the risks of coal ash contaminants migrating into groundwater.

4.4.1.2 TVA Region Aquifers

Three basic types of aquifers occur in the TVA region: unconsolidated sedimentary sand, carbonate rocks, and fractured non-carbonate rocks. Unconsolidated sedimentary sand formations, composed primarily of sand with lesser amounts of gravel, clay and silt, constitute some of the most productive aquifers. Groundwater movement in sand aquifers occurs through the pore spaces between sediment particles. Carbonate rocks are another important class of aquifers. Carbonate rocks, such as limestone and dolomite, contain a high percentage of carbonate minerals (e.g., calcite) in the rock matrix. Carbonate rocks in some parts of the region readily transmit groundwater through enlarged fractures and cavities created by dissolution of carbonate minerals by acidic groundwater. Fractured non-carbonate rocks represent the third type of aquifer found in the region. These aquifers include sedimentary and metamorphic rocks (e.g., sandstone, conglomerate, and granite gneiss) which transmit groundwater through fractures, joints, and beddings planes. Eight major aquifers occur in the TVA region (Table 4-6). These aquifers generally align with the major physiographic divisions of the region (Figure 4-18).

The aquifers include (in order of increasing geologic age): Quaternary age alluvium occupying the floodplains of major rivers, notably the Mississippi River; Tertiary and Cretaceous age sand aquifers of the Coastal Plain Province; Pennsylvanian sandstone units found mainly in the Cumberland Plateau section; carbonate rocks of Mississippian, Silurian and Devonian age of the Highland Rim section; Ordovician age carbonate rocks of the Nashville Basin section; Cambrian-Ordovician age carbonate rocks within the Valley and Ridge Province; and Cambrian-Precambrian metamorphic and igneous crystalline rocks of the Blue Ridge Province.

The largest withdrawals of groundwater for public water supply are from the Tertiary and Cretaceous sand aquifers in the Mississippi Alluvial Plain and Coastal Plain physiographic areas. These withdrawals account for about two-thirds of all groundwater withdrawals for public water supply in the TVA region. The Pennsylvanian sandstone and Orodovician carbonate aquifers have the lowest groundwater use (less than 1 percent of withdrawals) and lowest potential for groundwater use. Groundwater use is described in more detail in Section 4.4.3.

The quality of groundwater in the TVA region largely depends on the chemical composition of the aquifer in which the water occurs (Table 4-6). Precipitation entering the aquifer is generally low in dissolved solids and slightly acidic. As it seeps through the aquifer it reacts with the aquifer matrix and the concentration of dissolved solids increases.

Table 4-6: Aquifer, well, and water quality characteristics in the TVA region. Source: Webbers (2003).

Aquifer Description	Well Characteristics (common range, maximum)		Water Quality Characteristics
	Depth (feet)	Yield (gpm*)	
Quaternary alluvium: Sand, gravel, and clay. Unconfined.	10–75, 100	20–50, 1,500	High iron concentrations in some areas.
Tertiary sand: Multi-aquifer unit of sand, clay, silt and some gravel and lignite. Confined; unconfined in the outcrop area.	100–1,300, 1,500	200–1,000, 2,000	Problems with high iron concentrations in some places
Cretaceous sand: Multi-aquifer unit of interbedded sand, marl and gravel. Confined; unconfined in the outcrop area.	100–1,500, 2,500	50–500, 1,000	High iron concentrations in some areas

Aquifer Description	Well Characteristics (common range, maximum)		Water Quality Characteristics
Pennsylvanian sandstone: Multi-aquifer unit, primarily sandstone and conglomerate, interbedded shale and some coal. Unconfined near land surface; confined at depth.	100–200, 250	5–50, 200	High iron concentrations are a problem; high dissolved solids, sulfide or sulfate are problems in some areas
Mississippian carbonate rock: Multi-aquifer unit of limestone, dolomite, and some shale. Water occurs in solution and bedding-plane openings. Unconfined or partly confined near land surface; may be confined at depth.	50–200, 250	5–50, 400	Generally hard; high iron, sulfide, or sulfate concentrations are a problem in some areas
Ordovician carbonate rock: Multi-aquifer unit of limestone, dolomite, and shale. Partly confined to unconfined near land surface; confined at depth.	50–150, 200	5–20, 300	Generally hard; some high sulfide or sulfate concentrations in places
Cambrian-Ordovician carbonate rock: Highly faulted multi-aquifer unit of limestone, dolomite, sandstone, and shale; structurally complex. Unconfined; confined at depth.	100–300, 400	5–200, 2,000	Generally hard, brine below 3,000 feet
Cambrian-Precambrian crystalline rock: Multi-aquifer unit of dolomite, granite gneiss, phyllite, and metasedimentary rocks overlain by thick regolith. High yields occur in dolomite or deep colluvium and alluvium. Generally unconfined.	50–150, 200	5–50, 1,000	Low pH and high iron concentrations may be problems in some areas

*gpm = gallons per minute
Source: TVA 2015b

4.4.1.3 Causes of Degraded Groundwater Quality

Causes of degraded groundwater quality include:

- Spills - Electrical generating plants and other industrial facilities often utilize chemicals, including fuels, in their processes or to operate machinery. If accidental spills of these chemicals occur during usage, storage, or transport, vertical migration of the chemicals into the underlying groundwater aquifer may occur.
- Waste Storage – Over time, many electrical generating stations stored waste byproducts (e.g., CCRs) either in landfills or in surface impoundments. Rainfall infiltration into and through dry stacked waste can migrate vertically downward over time, carrying contaminants into groundwater, particularly in unlined landfills or surface impoundments. Storage of waste in unlined landfills and surface impondments may result in direct contact between the waste material and groundwater, whereby contaminants can leach from the waste material into groundwater over time. Storage of waste in lined landfills could result in degraded groundwater quality if the liner fails and contaminants leach from the landfill into groundwater over time.

- Air pollution – Airborne pollutants (e.g., mercury, sulfates) can affect groundwater through rainfall and infiltration.

4.4.1.4 Groundwater Quality at Facilities Considered for Future Retirement

Several TVA facilities have units that are being considered for retirement in the next decade. The following sections provide an overview of the groundwater conditions at each of these facilities.

Cumberland Fossil Plant

Cumberland Fossil Plant (herein, Cumberland) is located on the southern side of the Cumberland River and is bordered by Wells Creek to the south and west. It is located within the Wells Creek Impact Structure of the Highland Rim Physiographic Province, which is underlain by a sequence of sedimentary bedrock that extends from Mississippi and Northern Alabama through Tennessee, northward into Kentucky, Indiana, and Illinois. The formations that underlie this province consist of dolostone, limestone, shale, and sandstone. Aquifers near Cumberland are described as the bedrock carbonate aquifer and the alluvial aquifer associated with the Wells Creek Embayment and the Cumberland River. It is thought that groundwater recharge occurs primarily along the elevated perimeter of the basin where a portion of rainfall percolates into the near-surface rock outcrops and overburden soils. Groundwater flows downgradient by forces of gravity through the pore spaces of soils and along any fractures, faults, or joints in the bedrock (Law Engineering 1992). The results of groundwater monitoring at Cumberland indicate that groundwater occurs in the unconsolidated alluvial aquifer and the bedrock aquifer beneath the site.

In accordance with Rule 0400-11-.04(7) and the current Groundwater Quality Assessment Plan approved by TDEC on November 9, 2018, TVA conducted the most recent groundwater sampling event at Cumberland between October 3 and 10, 2018. The October 2018 groundwater assessment monitoring results indicated an exceedance of the arsenic maximum contaminant level (MCL) in one monitoring well at the site; this concentration was consistent with historical levels. A newly established federally listed alternate regulatory limit was also exceeded for lithium in one monitoring well; however, this limit has not yet been adopted by TDEC. Over 13 consecutive sampling events from July 2013 to July 2016, no MCL exceedances were observed for target analytes. Since October 2016, only arsenic has been detected at concentrations that exceed the MCL. Note that trends for several groundwater constituents demonstrated stable or decreasing concentrations. In addition to the exceedances of regulatory criteria, statistical exceedances of upper prediction limits (UPLs) established from background sampling were observed for barium, cobalt, fluoride, nickel, vanadium, and zinc. TVA currently conducts quarterly monitoring, but will monitor in accordance with TDEC and USEPA CCR Rule requirements, which may change that frequency.

In accordance with the CCR Rule, TVA established groundwater monitoring well networks to evaluate potential impacts to groundwater from four CCR units: Dry Ash Stack, Gypsum Storage Area, Bottom Ash Pond, and Stilling Pond (including Retention Pond). The results of detection monitoring and comparison to background concentrations indicated that statistically significant increases (SSIs) of Appendix III constituents (boron, calcium, chloride, pH, sulfate, and TDS) above background were detected at the Bottom Ash Pond, Gypsum Storage Area, and Dry Ash Stack multi-unit CCR unit. As allowed under 40 CFR 257.94(e)(2), TVA performed an Alternate Source Demonstration (ASD) for the multi-unit CCR unit to evaluate if an alternate source was responsible for the SSIs. The ASD did not conclusively demonstrate an alternate source. Thus, TVA has established an Assessment Monitoring Program at the multi-unit CCR unit in accordance with 40 CFR 257.94(e)(2) and will continue to investigate groundwater quality under the requirements of the CCR Rule. On April 15, 2019, TVA initiated assessment of corrective measures for the multi-unit CCR unit. TVA will complete that assessment and any required Corrective Action.

Gallatin Fossil Plant

Gallatin Fossil Plant (herein, Gallatin) is located on the northern side of Odoms Bend in the Cumberland River. It is located within the Interior Low Plateaus Physiographic Province, which is characterized by carbonate rock (karst) aquifers composed of limestone and minor dolostone, interlayered with shale and shaley limestone confining layers (TVA 2017e). Groundwater is present in fractures within the limestone bedrock. Locally, these fractures may be enlarged due to dissolution of the limestone. Features characteristic of karst development, such as sinkholes, have been observed in specific areas at Gallatin, but there does not appear to be significant groundwater conduit flow. Beneath portions of the plant site, the limestone bedrock is overlain by variable thicknesses of overburden consisting primarily of residuum derived from weathering of the underlying bedrock. Closer to the river, significant thicknesses of a clay alluvium are present. Groundwater at the project site is encountered within the residuum and rocks of the Carters and Lebanon Limestones. Groundwater is expected to flow vertically downward from the clay-rich residuum to the underlying bedrock, and then through bedrock fractures towards the Cumberland River.

The groundwater in the carbonate formations in the Central Basin aquifer system is typically of the calcium or calcium-magnesium bicarbonate water type. Groundwater chemistry is controlled primary by dissolution of limestones, dolomites, and gypsum (Hileman and Lee 1993). Water quality conditions can be highly variable, with total dissolved solids varying from under 500 mg/l to over 10,000 mg/l, due to the presence of localized flow systems. Groundwater in the Central Basin is commonly hard and contains hydrogen sulfide gas (Brahana and Bradley 1986).

TVA has been working with TDEC to monitor the closed ash impoundment (Non-Registered Site (NRS) #83-1324)) and the North Rail Loop Landfill (NRL; IDL #83-0219) in accordance with Rule 0400-11-01-.04(7) and the facility Groundwater Monitoring Program Plan that was approved by TDEC on October 14, 2009. At the NRS, Groundwater Protection Standards (GWPSs) historically are exceeded for beryllium, cadmium and nickel at one of the four compliance wells (GAF-19R). Similar results were observed during recent sampling conducted in October 2018. Elevated levels of beryllium, cadmium and nickel at GAF-19R are associated with unusually low pH (i.e., median pH is 3.8 standard units (SU) at this location). By comparison, median pH values for compliance and background wells range from 5.7 and 7.1 SU. The unusually low pH is currently under investigation by TVA. Groundwater sampling results for GAF-19R may be localized to this portion of the NRS because the other three compliance wells, along with the background well, did not exhibit sampling results exceeding GWPs; therefore, the results from those compliance wells may be more representative of a greater portion of the site (TVA 2016h). At the NRL, no MCL exceedances were reported during the recent sampling event conducted in October 2018. Statistical analysis of the October 2018 data did indicate exceedances of the UPLs for barium, calcium, chloride, fluoride, nickel, and sulfate. However, based on evaluation of concentrations over time (time series plots), the October 2018 results were within the baseline range of concentrations and deemed to not be the result of the landfill. Exceedances of alternative regulatory limits recently promulgated by USEPA under the CCR Rule were observed for lithium; however, these limits have not yet been adopted by TDEC. The results for lithium are consistent with historical results, including results obtained prior to placement of waste in the landfill. TVA continues to work with TDEC at the site under a Groundwater Assessment Program.

In accordance with the CCR Rule, TVA established groundwater monitoring well networks to evaluate potential impacts to groundwater from five CCR units: North Rail Loop Landfill, Ash Pond A, Ash Pond E, Middle Pond A, and Bottom Ash Pond. As allowed under the CCR Rule, Ash Pond A, Ash Pond E, Middle Pond A, and Bottom Ash Pond were grouped in to a multi-unit CCR unit for monitoring purposes. The results of detection monitoring and comparison to background concentrations indicated that SSIs of Appendix III constituents (boron, calcium, pH, and sulfate) above background were detected at the multi-unit CCR unit. TVA performed an ASD for the multi-unit CCR unit to evaluate if an alternate source was responsible for the SSIs. The ASD did not conclusively demonstrate an alternate source. Thus, TVA has established an Assessment Monitoring Program at the multi-unit CCR unit and will continue to investigate groundwater in accordance with the requirements of the CCR Rule. On April 15, 2019, TVA initiated assessment of corrective measures for the multi-unit CCR unit. SSIs for boron and chloride were identified at the North Rail Loop Landfill CCR unit. An ASD was performed by TVA in 2018 and the source of SSIs for boron and chloride was determined to be the multi-unit CCR unit. Thus, the North Rail Loop Landfill remains in detection monitoring, in accordance with the CCR Rule.

In addition, TVA is conducting a site-wide environmental investigation, including groundwater monitoring, as a part of ongoing litigation related to the Gallatin. The groundwater monitoring results from that environmental investigation are consistent with the discussion above.

Kingston Fossil Plant

Kingston Fossil Plant (herein, Kingston) is situated on a peninsula formed by the confluence of the Clinch and Emory Rivers. It is located in the Valley and Ridge Physiographic Province and is underlain by folded and faulted carbonate, sandstone, and shale bedrock. Groundwater is derived from infiltration of precipitation and from lateral inflow along the western boundary of the reservation. Groundwater movement generally follows topography with flow in an easterly direction from Pine Ridge toward the Emory River and Watts Bar Reservoir. An exception to this trend occurs on the northern margin of the ash disposal area where groundwater movement is northerly toward Swan Pond Creek. Groundwater originating on, or flowing beneath, the site ultimately discharges to the reservoir without traversing off-site property.

In accordance with TDEC Rule 0400-11-01.04(7) and the facility Groundwater Monitoring Plan, TVA conducts periodic groundwater monitoring at the Kingston Class II Gypsum Disposal Facility, Ash Processing Area, and the Ash Disposal Area (ADA; IDL #73-0094). Results of recent sampling activities conducted in September 2018 at the Gypsum Disposal Facility indicated that concentrations for all Appendix I constituents (of Rule 0400-11-01.04) were below the site-specific Groundwater Protection Standards (GWPs). Statistical analysis of the September 2018 data identified exceedances of background for arsenic and fluoride in residuum and boron, calcium, chloride, sulfate, and TDS in bedrock. These constituents have historically exhibited statistical exceedances at this site. Observed metals concentrations continue to decline from peak levels following the conversion of the Gypsum Disposal Facility from wet to dry disposal in 2011. Although the concentrations have been around the GWPs, they do not display a discernable trend. It is possible these fluctuations are related to seasonality variations and/or associated with solids remaining in the aquifer. As demonstrated by historic arsenic results from the facility compliance wells, TVA believes that elevated turbidity and TSS values reflects the potential to impact / elevate metal concentrations detected in the groundwater samples collected from this site. Declining TDS levels appear to correspond to the decreasing detections noted for sample constituents since 2010. This indicates the detections are not associated with a new release from the lined landfill. Constituents will continue to be closely examined and efforts to reduce turbidity in samples collected from the facility wells and the collection of filtered metals samples will continue.

Results of recent sampling activities conducted in September 2018 at the Ash Processing Area indicate that constituent concentrations reported for all samples were below USEPA primary MCLs and TDEC MCLs, except for zinc in two of the three wells sampled. This constituent had been at or near the laboratory detection limit during previous sampling events; therefore, these detections appear anomalous. Data from subsequent sampling events at the site will be closely examined to see if a trend is developing. Results from sampling conducted at the ADA in September 2018 indicate that arsenic and zinc were detected above the MCLs in select wells. Concentrations of all other Appendix I inorganic constituents were below applicable MCLs. Statistical analysis of the September 2018 data indicated exceedances of UPLs for arsenic, cobalt, nickel, and zinc. Confirmation resampling was not conducted for these constituents since the results are consistent with historical values. TVA continues to work with TDEC to evaluate the MCL exceedance for arsenic.

Also in accordance with the CCR Rule, TVA established groundwater monitoring well networks to evaluate potential impacts to groundwater from three CCR units:

Peninsula Disposal Area, Stilling Pond, and Sluice Trench and Area East of Sluice Trench. The results of detection monitoring and comparison to background concentrations indicated that SSIs of Appendix III constituents (boron, calcium, chloride, fluoride, pH, sulfate, and TDS) above background were detected at the Peninsula Disposal Area CCR unit. TVA is currently working to identify and assess, if necessary, the source of SSIs at this CCR unit. The Stilling Pond, and Sluice Trench and Area East of Sluice Trench were originally identified as a type of CCR unit known as an inactive impoundment and, as a result, were subject to different requirements under the CCR Rule when it was first promulgated. Since then, the CCR Rule has been modified to incorporate the same requirements for inactive impoundments as active impoundments, though on a different schedule. Accordingly, TVA is currently evaluating groundwater quality data associated with these CCR units to determine whether SSIs exist. If SSIs are identified, TVA will continue to investigate groundwater quality in accordance with the CCR Rule and TDEC requirements.

Shawnee Fossil Plant

The Shawnee Fossil Plant (herein, Shawnee) is bounded by the Ohio River to the northeast and Little Bayou Creek to the southwest. It is located within the northwestern limit of the Mississippi Embayment and within the Gulf Coastal Plain Physiographic Province. The plant site is underlain by more than 300 ft of unconsolidated deposits of clay, silt, sand, and gravel, ranging from Cretaceous to Holocene in age. The principal aquifer beneath Shawnee is referred to as the Regional Gravel Aquifer, which represents the lower part of alluvial terrace deposits of the Ohio River and averages approximately 47 feet thick in the vicinity of the Dry Stack Area.

Groundwater sampling at the Shawnee Special Waste Landfill is conducted semi-annually and has been permitted by the Kentucky Division of Waste Management (KDWM) since 1993. During sampling conducted in June 2017, statistical exceedances were identified for total alpha, aluminum, boron, calcium, cobalt, fluoride, iron, magnesium, manganese, molybdenum, nickel, pH, potassium, specific conductance, strontium, sulfate, total organic carbon, and total dissolved solids. Flood waters in May 2017 resulted in submerged wells within the sampling network. Although wells were redeveloped prior to the June sampling event, it is possible that the statistical exceedances were, in part, attributable to the flooding and not necessarily related to the Special Waste Landfill (SWL) itself. Statistical findings indicate the likelihood of coal-combustion by-product effects on groundwater beneath and downgradient of the SWL. However, current groundwater quality in the landfill locality does not exceed KDEP or USEPA MCLs for drinking water. In addition, the entire Shawnee reservation is within the Department of Energy (DOE) Water Policy Boundary, restricting use of groundwater and surface water (Little Bayou Creek) due to adjacent DOE activities over the past 50 years. Studies have not been conducted to fully evaluate and distinguish between the constituents in groundwater on the Shawnee reservation that originate from off-site, as compared to on-site contribution. TVA continues to monitor groundwater in accordance with the requirements of KDWM.

In accordance with the CCR Rule, TVA established groundwater monitoring well networks to evaluate potential impacts to groundwater from a CCR multiunit which combines the Special Waste Landfill with Ash Pond 2 (Main Ash Pond and Stilling Pond). The results of detection monitoring and comparison to background concentrations indicated that SSIs of Appendix III constituents (boron, calcium, pH, sulfate, and TDS) above background were detected at the multi-unit CCR unit. TVA performed an ASD for the multi-unit CCR unit to evaluate if an alternate source was responsible for the SSIs. The ASD did not conclusively demonstrate an alternate source. Thus, TVA has established an Assessment Monitoring Program at the multi-unit CCR unit and will continue to investigate groundwater quality in accordance with the requirements of the CCR Rule. On April 15, 2019, TVA initiated assessment of corrective measures for the multi-unit CCR unit.

4.4.2 Surface Water

The quality of the region’s surface waters – its streams, rivers, lakes, and reservoirs – is critical to protection of human health and aquatic life. Water resources provide habitat for aquatic life, recreation opportunities, domestic and industrial water supplies and other benefits. Major watersheds in the TVA region include the entire Tennessee River basin, most of the Cumberland River basin, and portions of the lower Ohio, lower Mississippi, Green, Pearl, Tombigbee, and Coosa River basins. Fresh water abounds in much of this area and generally supports most beneficial uses, including fish and aquatic life, public and industrial water supply, waste assimilation, agriculture, and water-contact recreation, such as swimming. Water quality in the TVA region is generally good.

4.4.2.1 Regulatory Framework for Surface Water Quality

The Federal Water Pollution Control Act, commonly known as the Clean Water Act (CWA), is the primary law that affects water quality. It establishes standards for the quality of surface waters and prohibits the discharge of pollutants from point sources unless a National Pollutant Discharge Elimination System (NPDES) permit is obtained. NPDES permits also address CWA Section 316(b) requirements for the design, location, construction and capacity of cooling water intakes to reflect the best technology available for minimizing environmental impact as well as Section 316(a) requirements for effluent limitations on thermal discharges to assure maintenance of a balanced indigenous population of fish and wildlife. Section 404 of the CWA further prohibits the discharge of dredge and fill material to waters of the United States, which include many wetlands, unless authorized by a permit issued by the USACE.

The seven states in the TVA PSA have enacted laws regulating water quality and implementing the CWA. As part of this implementation, the states classify water bodies according to their uses and establish water quality criteria specific to these uses. Each state has also issued an antidegradation statement containing specific conditions for regulated actions and designed to maintain and protect current uses and water quality conditions.

4.4.2.2 Surface Water Quality of TVA Region River Systems

Tennessee River Basin

The Tennessee River basin contains all except one of TVA's dams and covers about half of the TVA PSA (Figure 4-14). A series of nine locks and dams built mostly in the 1930s and 1940s regulates the entire length of the Tennessee River and allows navigation from the Ohio River upstream to Knoxville (TVA 2004). Almost all the major tributaries have at least one dam, creating 14 multi-purpose storage reservoirs and seven single-purpose power reservoirs. The construction of the TVA dam and reservoir system fundamentally altered both the water quality and physical environment of the Tennessee River and its tributaries. While dams promote navigation, flood damage reduction, power generation, water supply, water quality, and river-based recreation by moderating the flow effects of floods and droughts throughout the year, they also disrupt the daily, seasonal and annual flow patterns characteristic of a river. Damming of most of the rivers was done at a time when there was little regard for aquatic resources (Voigtlander and Poppe 1989). Beyond changes in water quality, flood control activities and hydropower generation have altered the flow regime (the main variable in aquatic systems) to suit human demands (Cushman 1985). This system of dams and their operation is the most significant factor affecting water quality and aquatic habitats in the Tennessee River and its major tributaries. Portions of several rivers downstream of dams are included on state CWA Section 303(d) lists of impaired waters (e.g., Tennessee Department of Environment and Conservation (TDEC) 2018) due to low dissolved oxygen (DO) levels, flow modifications and thermal modifications resulting from impoundment. TVA has undertaken several major efforts (e.g., TVA's Lake Improvement Plan, Reservoir Release Improvement Plans, and Reservoir Operations Study (ROS, TVA 2004)) to mitigate some of these impacts on aquatic habitats and organisms. While these actions have resulted in improvements to water quality and habitat conditions in the Tennessee River basin, the Tennessee River and its tributaries remain substantially altered by human activity.

Major water quality concerns within the Tennessee River drainage basin include point and nonpoint sources of pollution that degrade water quality at several locations on mainstream reservoirs and tributary rivers and reservoirs.

Mainstem Reservoirs - The nine mainstem reservoirs on the Tennessee River differ from TVA's tributary reservoirs primarily in that they are shallower, have greater flows and retain the water in the reservoir for a shorter period of time. Although DO in the lower lake levels is often reduced, it is seldom depleted. Winter drawdowns on mainstem reservoirs are much less severe than tributaries, so bottom habitats generally remain wetted all year. This benefits benthic (bottom-dwelling) organisms, but promotes the growth of aquatic plants in the extensive shallow overbank areas of some reservoirs. Tennessee River mainstem reservoirs generally support healthy fish communities, ranging from about 50 to 90 species per reservoir. Good to excellent sport fisheries exist, primarily for black bass, crappie, sauger, white and striped bass, sunfish and catfish. The primary commercial species are channel and blue catfish and buffalo.

Tributary Reservoirs and Tailwaters - Tributary reservoirs are typically deep and retain water for long periods of time. This results in thermal stratification, the formation of an upper layer that is warmer and well oxygenated (high DO), an intermediate layer of variable thickness and a lower layer that is colder and poorly oxygenated (low DO). These aquatic habitats are simplified compared to undammed streams and fewer species are found. Aquatic habitats in the tailwater can also be impaired due to intermittent flows and low DO levels which restrict the movement, migration, reproduction and available food supply of fish and other organisms. Dams on tributary rivers affect the habitat of benthic invertebrates, which are a vital part of the food chain of aquatic ecosystems. Benthic invertebrates include worms, snails and crayfish (which spend all of their lives in or on the stream beds), and mussels, clams and aquatic insects (which live on the stream beds during all or part of their life cycles). Many benthic organisms have narrow habitat requirements that are not always met in reservoirs or tailwaters below dams. Farther downstream from dams, the number of benthic species increases as natural re-aeration occurs and DO levels and water temperatures rise.

TVA regularly evaluates several water quality indicators as well as the overall ecological health of reservoirs through its Ecological Health Monitoring Program. This program evaluates five metrics: chlorophyll concentration, fish community health, bottom life, sediment contamination and DO (TVA 2004: 4.4-3, -4). Scores for each metric from monitoring sites in the deep area near the dam (forebay), mid-reservoir, and at the upstream end of the reservoir (inflow) are combined for a summary score and rating. Vital Signs ratings, major areas of concern, and fish consumption advisories are listed in Table 4-7.

Two of TVA's six operating coal-fired power plants, one CC natural gas plant and all of TVA's nuclear plants are in the Tennessee River watershed. All of these facilities depend on the river system for cooling water. Two of TVA's CT plants are along or close to the Tennessee River; they are not dependent for cooling water.

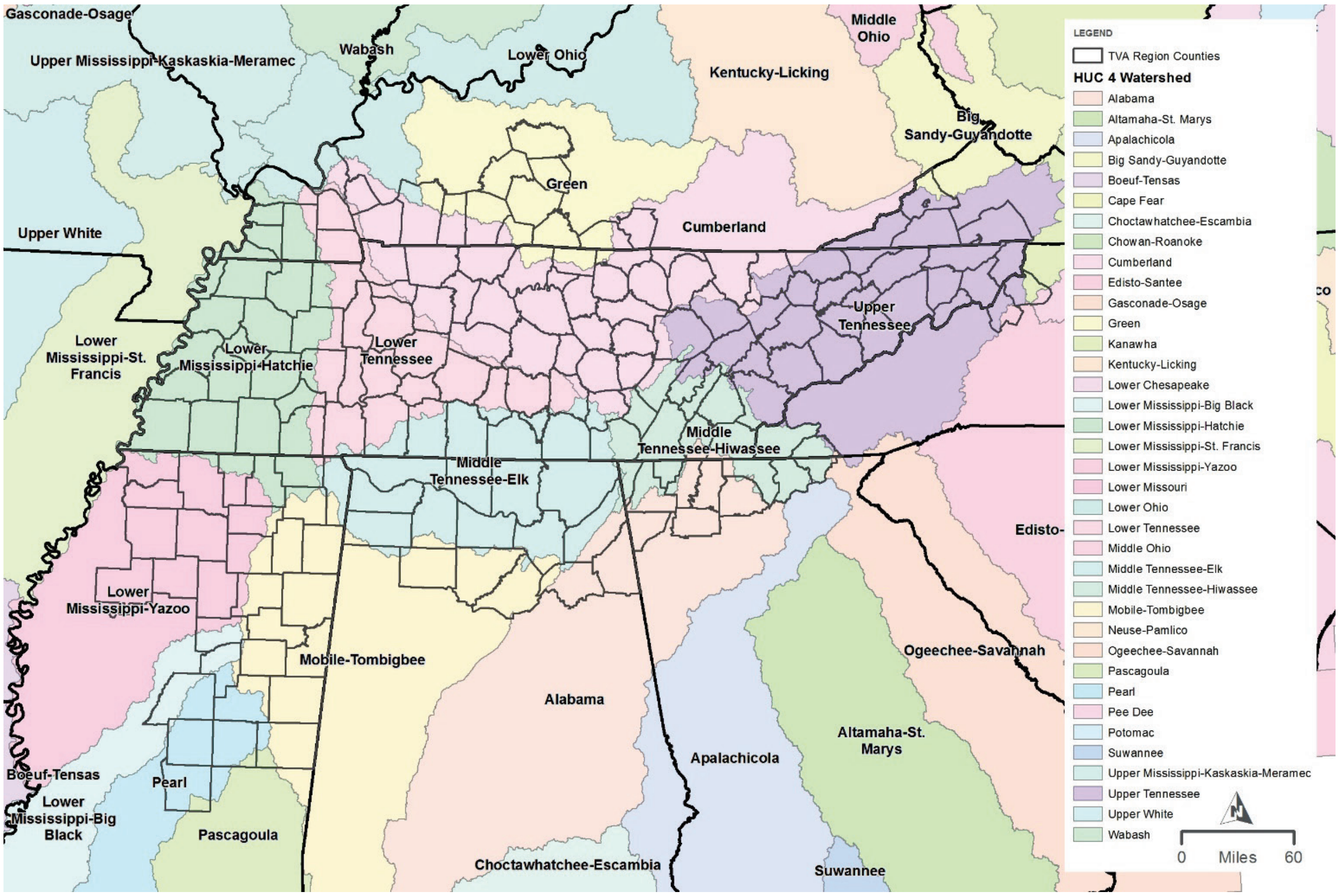


Figure 4-14: Major watersheds within TVA region.

Other Major River Systems

The other major river drainages within the TVA region (the Cumberland, Mobile, and Mississippi River drainages) share a diversity of aquatic life equal to or greater than the Tennessee River drainage. As with the Tennessee River, these river systems have seen extensive human alteration including construction of reservoirs, navigation channels and locks. Despite these changes (as with the Tennessee River drainage), diverse aquatic communities are present in each of these river systems.

Major TVA generating facilities located in these watersheds include Cumberland and Gallatin Fossil Plants (Cumberland River), Paradise Fossil and CC Plants (Green River/Ohio River) and Shawnee Fossil Plant (Ohio River). CT and CC plants are also located on the Mississippi River, in the Hatchie, Obion and Tallahatchie River (tributaries to the Mississippi River) drainage basins, and the Tombigbee and Pearl River drainage basins.

TVA operates two coal-fired plants on the main stem of the Cumberland River and Great Falls, a small hydroelectric plant on the Caney Fork River, a Cumberland River tributary. In 2007, because of low summer flows in the Cumberland River due to repairs on Wolf Creek Dam by the USACE and drought conditions, thermal discharges from the Cumberland Fossil Plant led the State of Tennessee to place the Barkley Reservoir segment of the Cumberland River on the state 303(d) list of impaired waters (TDEC 2008). The segment was listed as impaired due to low levels of DO and temperature alterations. Repairs to Wolf Creek Dam were completed in late 2013 and river flows greatly improved in the summer of 2014, leading to the delisting of DO as an impairment for the stream (TDEC

2016). Due to a continued lowering of ambient temperatures. the Barkley Reservoir segment was completely delisted in the latest state 303(d) list (TDEC 2018). Fish consumption advisories are in effect for waters in the vicinity of the Shawnee Fossil and Allen CC plants. Otherwise, water resources conditions and characteristics in these river systems are generally similar to those in the Tennessee system.

Table 4-7: Ecological health ratings, major water quality concerns, and fish consumption.

Reservoir	Ecological Health Rating – Score	Latest Survey Date	Concerns	Fish Consumption Advisories
Apalachia	Good – 75	2015	--	Mercury (NC statewide)
Bear Creek	Poor – 54	2017	DO[1], chlorophyll, bottom life	Mercury (dam forebay area)
Beech	Fair – 66	2015	DO, chlorophyll	Mercury
Blue Ridge	Good – 84	2017	--	Mercury
Boone	Fair – 63	2016	DO, chlorophyll, bottom life, sediments	PCBs[2], chlordane
Cedar Creek	Fair – 69	2017	DO	Mercury (dam forebay to 1 mile upstream of dam
Chatuge	Fair – 62	2015	DO, chlorophyll	Mercury
Cherokee	Poor – 56	2015	DO, chlorophyll, bottom life	None
Chickamauga	Good – 83	2017	--	Mercury (Hiwassee River from Hwy 58 (river mile 7.4) upstream to river mile 18.9.
Douglas	Poor – 63	2016	DO, chlorophyll	None
Fontana	Fair – 67	2016	DO, bottom life	Mercury
Fort Loudoun	Fair – 60	2017	DO, chlorophyll, bottom life	PCBs, mercury (upstream US 129)
Fort Patrick Henry	Fair – 69	2016	Chlorophyll	None
Guntersville	Fair – 72	2016	Chlorophyll	Mercury (Vicinity of Tennessee River mile 408, just downstream of Widows Creek; Sequatchie River)
Hiwassee	Fair – 67	2015	DO	Mercury (Statewide advisory)
Kentucky	Good – 75	2017	Chlorophyll (Big Sandy only - DO, bottom life)	Mercury (State of Kentucky statewide advisory; State of Tennessee, Big Sandy River and embayment)
Little Bear Creek	Fair – 69	2017	DO	Mercury
Melton Hill	Good – 80	2016	Sediments	PCBs, mercury (Poplar Creek embayment)
Nickajack	Good – 84	2016	--	PCBs, chlordane (Chattanooga Creek)
Normandy	Poor – 40	2016	DO, chlorophyll, bottom life	None
Norris	Fair – 69	2014	DO	Mercury (Clinch River portion)

Reservoir	Ecological Health Rating – Score	Latest Survey Date	Concerns	Fish Consumption Advisories
Nottely	Poor – 47	2014	DO, chlorophyll, bottom life	Mercury
Parksville	Fair – 66	2017	Sediments	None
Pickwick	Fair – 59	2016	DO, chlorophyll, bottom life	None
South Holston	Fair - 67	2015	DO	Mercury (Tennessee portion)
Tellico	Fair – 63	2015	DO, bottom life	PCBs
Tims Ford	Poor – 52	2016	DO, chlorophyll, bottom life	None
Watauga	Good - 77	2015	DO	Mercury
Watts Bar	Fair - 62	2016	DO, chlorophyll, bottom life	PCBs
Wheeler	Fair - 68	2015	DO, chlorophyll, bottom life	Mercury (Limestone Creek, Round Island Creek embayments); PFOS[3] (Baker Creek embayment, river miles 296-303)
Wilson	Poor - 57	2016	DO, chlorophyll, bottom life	Mercury (Big Nance Creek embayment)

Source: TVA 2018d
Notes:
1. DO = Dissolved Oxygen
2. PCB = Polychlorinated biphenyls
3. PFOS = Perfluorooctane sulfonate

4.4.2.3 Causes of Degraded Surface Water Quality

Causes of degraded surface water quality include:

- Wastewater discharges – Municipal sewage treatment systems, industrial facilities, concentrated animal feeding operations and other sources discharge waste into streams and reservoirs. These discharges are controlled through state-issued NPDES permits issued under the authority of the CWA. NPDES permits regulate the amounts of various pollutants in the discharges (including heat) and establish monitoring and reporting requirements.
- Runoff discharges – Runoff from agriculture, forest management (silvicultural) activities, urban uses and mined land can transport sediment and other pollutants into streams and reservoirs. Runoff from some commercial and industrial facilities and some construction sites is regulated through state NPDES stormwater permitting programs. Runoff from agriculture, silvicultural and other sources not regulated under the NPDES program is referred to as "nonpoint source" runoff.
- Cooling Systems – Electrical generating plants and other industrial facilities withdraw water from streams or reservoirs, use it to cool facility operations, and discharge heated water into streams or reservoirs. The aquatic community may be impacted due to temperature changes in the receiving waters and from fish and other organisms being trapped against the intake screens or sucked into the facility cooling system. These water intakes and discharges are controlled through state-issued NPDES permits.
- Air pollution – Airborne pollutants (e.g., mercury, sulfates) can affect surface waters through rainout and deposition.

Following is an overview of how power generation can affect water quality.

Coal and Natural Gas Plant Wastewater – Coal-fired power plants have several liquid waste streams that are released to surface waters following any required treatment. These include condenser cooling water, cooling tower blowdown, ash sluice water, metal-cleaning wastewaters and various low volume wastes including sumps and drains. Combined cycle natural gas plant wastewaters include cooling tower blowdown and various low volume wastewaters. Coal and gas plant sites use best management practices to control stormwater runoff such as retention ponds to capture sediment and oil/water separators to remove oil and grease. Discharges are regulated by each state under the NPDES program. Many of the waste streams receive treatment before they are discharged. Analytical monitoring and periodic toxicity testing ensure there are no acute or chronic toxic effects to aquatic life. Discharges from coal plants include those from Coal Combustion Residuals (CCR) storage areas; these discharges can occur through permitted discharges and from seepage into groundwater which then enters surface waters. See Section 4.7 for further discussion of CCR management at TVA coal plants.

Nuclear Plant Wastewater – Liquid waste streams at nuclear plant sites include condenser cooling water, cooling tower blowdown, water treatment wastewaters, steam generator blowdown, liquid rad-waste including tritiated wastewater and various low volume wastes including sumps and drains.

Periodic analytical monitoring and toxicity testing is performed on these discharges as required by the NPDES permit to ensure that plant wastes do not contain chemicals at deleterious levels that could affect aquatic life. Best management practices are used to control stormwater runoff and may include retention ponds to capture sediment and oil/water separators. The radiological component of discharges from nuclear plants is regulated by the Nuclear Regulatory Commission (NRC) and by states under the CWA.

Thermal Plant Cooling Systems – All of TVA's coal-fired and nuclear plants and two CC gas plants withdraw water from reservoirs or rivers for cooling and discharge the heated water back into the water body (see Section 4.4.3). In some cases, the cooling water is chemically treated to prevent corrosion or biofouling of the cooling system. TVA conducts extensive monitoring programs to help ensure permit compliance and to provide information about potential adverse effects from the heated and/or chemically treated discharges. Plant-specific monitoring includes concentrations of various chemicals, toxicity, discharge flow rates, discharge and receiving stream temperatures, DO, fish communities, and benthic organisms.

Recent programs have also focused on spawning and development of cool-water fish species such as sauger, the attraction of fish to the heated discharges and changes in undesirable aquatic micro-organisms such as blue-green algae. In general, these monitoring programs have not detected significant negative effects resulting from release of heated water from TVA facilities in the Tennessee River drainage basin.

Runoff and Air Pollution – Many nonpoint sources of water pollution are not subject to government regulations or control. Principal causes of non-point source pollution are agriculture, including runoff from fertilizer, pesticide applications, erosion and animal wastes; silvicultural activities; mining, including erosion and acid drainage; and urban runoff. Pollutants reach the ground from the atmosphere as dust fall or are carried to the ground by precipitation.

Low DO Levels and Low Flow Downstream of Dams – A major water quality concern is low DO levels in reservoirs and in the tailwaters downstream of dams. Long stretches of river can be affected, especially in areas where pollution further depletes DO. In addition, flow in these tailwaters is heavily influenced by the amount of water released from the upstream dams; in the past, some of the tailwaters were subject to periods of little or no flow. Since the early 1990s, TVA has addressed these issues in the Tennessee River system by installing equipment and making operational changes to increase DO concentrations below 16 dams and to maintain minimum flows in tailwaters (TVA 2004: 4.4-3).

NPDES Permit Requirements – All of TVA's coal, CC natural gas, and nuclear generating facilities have state-issued NPDES permits for discharging to surface waters or pretreatment permits issued under state-approved programs for discharging into public sewer systems. At a minimum, these permits restrict the discharge of pollutants to levels established by USEPA Effluent Limitation Guidelines. Additional, and sometimes more restrictive, limits may also be included based on state water quality standards.

USEPA published an update of the Effluent Limitation Guidelines rule on November 3, 2015, that revised and strengthened the technology-based effluent limitations guidelines and standards for discharges from steam electric power plants. The final rule sets limits on the amount of metals and other pollutants that are allowed to be discharged from several of the largest sources of wastewater at steam electric power plants, based on technology improvements in the industry over the last three decades. Generally, the final rule established new requirements for wastewater streams from the following processes and byproducts associated with steam electric power generation: flue gas desulfurization, fly ash, bottom ash, flue gas mercury control, and gasification of fuels such as coal and petroleum coke. The final rule phases in more stringent requirements in the form of effluent limits for arsenic, mercury, selenium, and nitrate/nitrite as nitrogen for wastewater discharged from wet scrubber systems (flue gas desulfurization waste stream) and zero discharge of pollutants in ash transport water that must be incorporated into the plants' NPDES permits. The rule has currently been stayed and certain points are being reevaluated; however, it still requires that each plant must comply between 2018 and 2023 depending on when its NPDES permit is due for renewal.

After publication of the rule, the USEPA postponed the earliest compliance dates for the new, more stringent, best available technology effluent limitations and pretreatment standards for bottom ash transport water and FGD wastewater for a period of two years. The outermost compliance date of 2023 remains in effect.

Finalized 316(b) regulations for existing facilities (USEPA 2014) require TVA and other utilities to perform additional evaluations of the impacts of their facilities and cooling water intakes and may require modifications to plant cooling systems and/or plant operations to reduce impacts to fish and other aquatic organisms.

Fuel Cycle Impacts – The extraction, processing, and transportation of fuel can affect water quality. Runoff and other discharges from coal and uranium mines, natural gas well sites, and from fuel processing facilities can discharge sediment and other pollutants into surface waters. These discharges are typically subject to NPDES permit requirements, as well as permit requirements specific to coal and uranium mining. Mining operations can also result in the alteration and elimination of streams. Mining and natural gas extraction can also affect groundwater quality and quantity. Impacts to water quality from the extraction of natural gas by hydraulic fracturing are described in more detail in Section 5.2.1.3.

4.4.2.4 Surface Water Quality at Facilities Considered for Future Retirement

Several TVA facilities have units that may be considered for retirement in the next decade. The following sections provide an overview of the surface water conditions at each of these facilities. Stormwater discharges from each of TVA's coal-fired power plants are regulated under NPDES individual permits that are administered at the state level. For those plants located in Tennessee, some stormwater discharge associated with industrial activity is also regulated under Tennessee Storm Water Multi-Sector General Permit for Industrial Activities permits. In general, storm water is either comingled with process water or discharged through permitted outfalls; only the major outfalls at each plant are discussed herein.

Cumberland Fossil Plant

Cumberland Fossil Plant (herein, Cumberland) is located on the southern side of the Cumberland River and is bordered by Wells Creek to the south and west. Cumberland withdraws an average of 2,096 million gallons per day (MGD) from the Cumberland River for use as condenser cooling water (CCW) and plant process water (e.g., sluice water, fire protection, boiler feed water, safety, and miscellaneous water uses). Approximately 98 percent of the water withdrawal is used for cooling, while approximately 2 percent is used for other uses including process water. The withdrawn water is returned to the river after appropriate treatment and complies with Cumberland's NPDES permit requirements.

Existing wastewater streams at Cumberland are permitted under TDEC NPDES Permit No. TN0005789, effective through 2023. The Internal Monitoring Point (IMP) 001 discharges process and stormwater from the Main Ash Impoundment to the CCW channel at an average flow of 21.73 MGD. TVA is required under NPDES Permit No. TN0005789 to meet pH, total suspended solids (TSS), and oil and grease effluent limitations at IMP 001. TVA is required to report flow, nitrogen, ammonia, fluoride, calcium, sulfate, total dissolved solids (TDS), radium 226 and 228, and 20 additional metals on a monthly to quarterly basis under the current NPDES permit.

Outfall 002 discharges approximately 2,097 MGD of once-through condenser cooling water, in addition to flows from IMP 001 to the Cumberland River. Per the 2018 NPDES permit, TVA is required to meet effluent limitations for temperature, toxicity, and total residual oxidants on a daily to annual basis.

Gallatin Fossil Plant

Gallatin Fossil Plant (herein, Gallatin) is located on the northern side of Odoms Bend in the Cumberland River. Gallatin withdraws approximately 916 MGD for use as CCW and plant process water (i.e., sluice water, fire protection, boiler feed water, miscellaneous water uses). Approximately 97 percent of the water withdrawal is used for cooling, while approximately 3 percent is used for process water. The withdrawn water is returned to the river after appropriate treatment and complies with Gallatin's NPDES permit.

There are several existing wastewater streams at Gallatin permitted under NPDES No. TN0005428, effective through May 2023. The main plant area is drained by permitted stormwater outfalls, wet weather conveyances, intermittent streams, the condenser cooling water discharge (Outfall 002), and the intake screen backwash (Outfall 004) along with process and storm water discharges which were historically discharged from the ash impoundment system (Outfall 001). However, now process waters are discharged from a newly permitted outfall (Outfall 010) and only storm water driven flows and landfill underdrains are discharged from Outfall 001.

From 2015 to 2018, an average of 20.86 MGD of water was discharged from the ash pond system through Outfall 001. Now approximately 20 MGD of process waters are discharged from Outfall 010. Under the current NPDES permit, TVA is currently required to meet effluent limitations at Outfall 001 for pH, TSS, oil and grease, and toxicity, in addition to periodic reporting of flow, sulfate, fluoride, calcium, TDS, radium 226 and 228, and 19 metals. These limitations and reporting requirements will change as dewatering of the impoundment system is completed and bottom ash transport waters discharge requirements change. Required limitations and reporting requirements at Outfall 010 currently include limitations on pH, TSS, oil and grease, and toxicity, in addition to periodic reporting of flow and 16 metals.

Approximately 855 MGD is discharged from the CCW discharge channel through Outfall 002. The plant's permitted discharges from Outfall 002 are once-through cooling water, auxiliary cooling water, and storm water runoff. The current NPDES permit contains limitations on the CCW discharge for temperature, and total residual oxidants and toxicity (when chlorine, bromine, or other oxidants are added to the cooling water). This permit also requires reporting of flow and intake temperature.

Kingston Fossil Plant

Kingston Fossil Plant (herein, Kingston) is situated on a peninsula formed by the confluence of the Clinch and Emory Rivers. Kingston withdraws approximately 1,107 MGD from the Clinch and Emory rivers for use as CCW and plant process water (e.g., sluice water, fire protection, boiler feed water, and other miscellaneous uses). Approximately 99 percent of the water withdrawal (1,096 MGD) is used for cooling, while approximately 1 percent is used for other uses including process water. The withdrawn water is returned to the river after appropriate treatment and complies with Kingston's NPDES permit.

There are several existing wastewater streams at Kingston permitted to be discharged under the Kingston NPDES permit (Number TN0005452), effective through February 2023. The main plant area is drained by permitted stormwater outfalls, wet weather conveyances, intermittent streams, the CCW discharge (Outfall 002), and the intake screen backwash (Outfall 004) along with process and storm water discharges from the ash impoundment system (Outfall 001). Outfall 001 conveys an average of 13.67 MGD of treated ash pond effluent and other wastewater, based on flow data recorded by TVA between November 2016 and November 2018. TVA is required to meet effluent limitations at Outfall 001 for pH, TSS, and oil and grease, while reporting flow and 16 metals on a weekly to monthly basis.

Over the same 2016-2018 time period, an average of approximately 1,096 MGD of CCW and 7.42 MGD of wastewater were discharged through Outfall 002. Under the current NPDES permit, TVA is required to meet effluent limitations for pH, temperature, mercury, toxicity, duration of chlorination, and total residual oxidants, while reporting flow and intake temperature.

Shawnee Fossil Plant

The Shawnee Fossil Plant (herein, Shawnee) is bounded by the Ohio River to the northeast and Little Bayou Creek to the southwest. Shawnee withdraws an average of 1,487.72 MGD of water for use as CCW and plant process water. Approximately 98 percent of the water withdrawal is used for cooling, while approximately 2 percent is used for process water. Essentially all of the water withdrawn is returned to the Ohio River.

There are several existing wastewater streams at Shawnee permitted under Kentucky Pollutant Discharge Elimination System (KPDES) Permit Number KY0004219, effective through June 2023. The main plant area is drained by permitted storm water outfalls, wet weather conveyances, the CCW discharge (Outfall 002), the chemical treatment pond (Outfall 004), and process and storm water discharges from the ash pond system (Outfall 001). Potentially impacted onsite wastewater streams include the dry stack storm water discharge, CCW discharge channel, and ash pond discharge.

The majority of wastewater from the Shawnee site is discharged to the Ohio River through Outfalls 001 and 002. From August to November 2018 (under the new KPDES Permit), an average of 19.74 MGD were discharged from the ash pond through Outfall 001. Outfall 001 discharges into the CCW discharge channel. During the same time period, the pH (a measure of acidity) of the ash pond discharge ranged from 7.31 to 8.22. The ash pond is being dewatered, closed, and capped. From the effective date of the permit until commencement of mechanical dewatering, TVA is required to meet the ash pond effluent limits for pH, oil and grease, total suspended solids, and acute toxicity. During dewatering, TVA is required to meet limitations for pH, oil and grease, total suspended solids, and acute toxicity, in addition to the following metals: antimony, arsenic, beryllium, cadmium, chromium, copper, lead, mercury, nickel, selenium, silver, thallium, and zinc, while reporting hardness. Subsequent to completion of dewatering, the KPDES permit reverts back to monitoring consistent with the pre-dewatering requirements previously noted. Based on data from weekly monitoring conducted between August and October 2018, all permit-required constituents were within regulatory limits at Outfall 001.

From 2016 to 2018, an average of 872 MGD of once-through cooling water was discharged from the CCW discharge channel through KPDES Outfall 002. The current KPDES permit contains limitations on the CCW discharge for temperature, free available chlorine, total residual chlorine, total residual oxidants, and time of oxidant addition, as well as reporting of flow, discharge temperature, and pH.

Combustion Turbine Facilities

TVA currently operates CTs at their Allen (20 turbines), Colbert (8 turbines), Gallatin (8 turbines), and Johnsonville (20 turbines) plants. CTs require no cooling, and therefore, operation and/or retirement of CTs does not affect surface water at these facilities.

4.4.3 Water Supply

The TVA PSA contains most of the Tennessee River Basin, which is considered one of the most water rich basins in the United States (Figure 4-14). The Tennessee River Basin, which is about half of the TVA PSA, has been defined as the most intensively used basin in the contiguous United States as measured by intensity of freshwater withdrawals in gallons per day per square mile (gal/d/mi2) (Hutson et al. 2004). While the withdrawal rate is highest, the basin has the lowest consumptive use in the nation by returning about 96 percent of the withdrawals back for downstream use (Bowen and Springston 2018).

In 2015, estimated average daily water withdrawals in the TVA PSA totaled 12,966 MGD (Dieter et al. 2018, Bowen and Springston 2018). About 6.6 percent of these water withdrawals were groundwater and the remainder was surface water. The largest water use (77.7 percent of all withdrawals) was for thermoelectric generation as shown in Figure 4-15. Even though thermoelectric generation has the greatest withdrawal, about 99.2 percent is recycled and returned for downstream use in the TVA system (Bowen and Springston 2018).

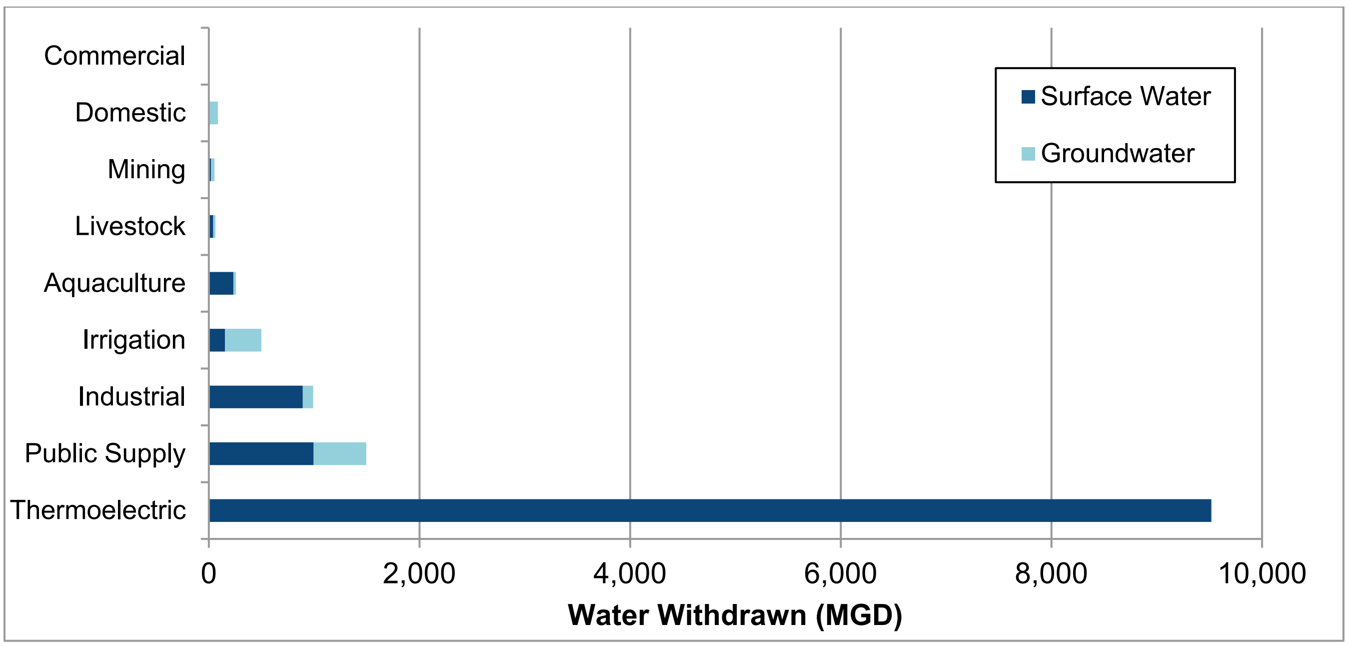


Figure 4-15: 2015 water withdrawals in the TVA power service area by source and type of use Source: Dieter et al. (2018), Bowen and Springston (2018).

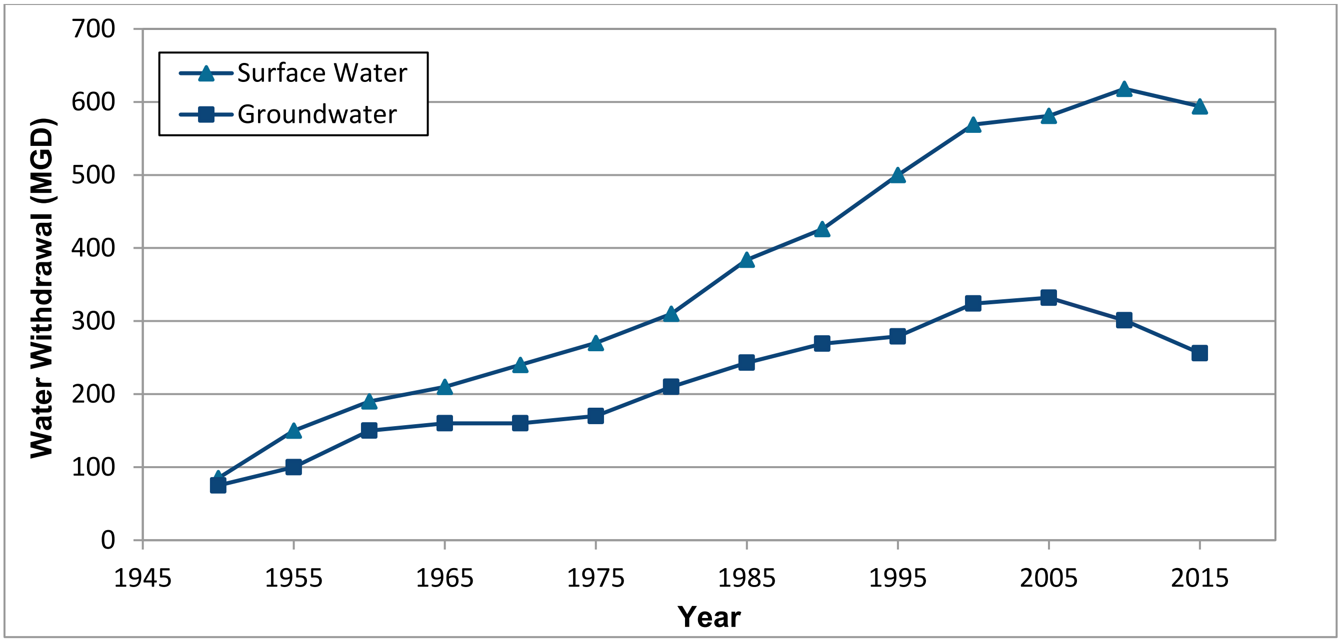


Figure 4-16: Groundwater and surface water withdrawals by water public systems in Tennessee, 1950 to 2015. Adapted from Webbers (2003). Additional Data: Kenny et al. (2009), Bohac and Bowen (2012), Bowen and Springston (2018).

Since 1950, the annual increase in groundwater withdrawals for public supply in Tennessee has averaged about 2.2 percent and the increase in surface water withdrawals has averaged about 3.5 percent (Figure 4-16). For the first time since 1950, there was a decrease in surface water withdrawal for public supply systems in Tennessee between 2010 and 2015. Although these data are for Tennessee public water supplies, they are representative of the overall trends in water use for the TVA PSA.

4.4.3.1 Groundwater Use

Groundwater data are compiled by the U.S. Geological Survey (USGS) and cooperating state agencies in connection with the national public water use inventory conducted every five years (Dieter et al. 2018, Bowen and Springston 2018). The largest use of groundwater is for public water supply, illustrated in Figure 4-16. Almost all of the water used for domestic supply and 55 percent of water used for irrigation in the TVA PSA is groundwater. Groundwater is also used for industrial, mining, livestock, and aquaculture purposes.

The use of groundwater to meet public water supply needs varies across the TVA PSA and is the greatest in West Tennessee and Northern Mississippi. This variation is the result of several factors, including groundwater availability, surface water availability, where both surface and groundwater are present in adequate quantity and quality, which water source can be developed most economically, and public water demand, which is largely a function of population. There are numerous sparsely populated, rural counties in the region with no public water systems. Residents in these areas are self-served by individual wells or springs.

Total groundwater use for public water supply in 2015 was 500 MGD in the TVA PSA. Approximately 60 percent of all groundwater withdrawals were supplied by Tertiary sand aquifers in West Tennessee and North Mississippi. Shelby County, Tennessee (Memphis) accounted for about 38 percent of the total 2015 public supply regional pumpage. The dominance of groundwater use over surface water use in the western portion of the TVA PSA is due to the availability of prolific aquifers and the absence of adequate surface water resources in some areas. Additionally, several TVA facilities, primarily combined cycle plants, which use groundwater for industrial purposes are in this area.

Generally those purposes are for fire protection and cooling, and are discharged through an NPDES outfall.

4.4.3.2 Surface Water Use

The majority of water used for thermoelectric, public supply, aquaculture, and industrial uses is surface water (Figure 4-15). Large public supply withdrawals correspond to the population centers throughout the valley. The top five counties for surface water public supply are Davidson, Knox, Hamilton, and Rutherford counties, Tennessee, and Madison County, Alabama. These counties contain the large cities of Nashville, Knoxville, Chattanooga, and Murfreesboro, Tennessee, and Huntsville, Alabama, respectively. These five counties account for 40 percent of all surface water public supply for the entire TVA PSA. The remaining 60 percent of surface water public supply within the TVA PSA is generally located in less-populated counties and communities.

Thermoelectric withdrawal decreased about 2,400 MGD in 2015 compared to 2010. This was due to the retirement of TVA coal-fired power plants that used water withdrawals for cooling water. Public supply, industrial, and livestock uses decreased in 2015. Decrease in public supply use can be attributed to technology upgrades at two of the most populous counties in the PSA and general public decrease of per-capita use. Industrial use decreased because of the closure of a few larger demand plants. Mining, aquaculture, and irrigation uses increased in 2015, but these uses are more variable because they are sensitive to weather and economic conditions.

4.4.3.3 Water Use for Thermoelectric Power Generation

Thermoelectric power generation uses steam produced from the combustion of fossil fuels or from a nuclear reaction. A substantial volume of cooling water is required to condense steam into water. All TVA coal-fired plants and nuclear plants are cooled by water withdrawn from adjacent rivers or reservoirs. Surface water withdrawals may be supplemented by groundwater withdrawn via production wells at some plants, though the quantity of groundwater withdrawn is significantly less than the quantity of surface water withdrawn. The amount of water required is highly dependent on the type of cooling system employed. While the volume of water used to cool the plants is large, most of this water is returned to the adjacent rivers or reservoirs.

In 2015, TVA's three nuclear plants and the 10 coal-fired plants then in operation withdrew an average of 12,699 MGD (Table 4-8). The total plant water withdrawal divided by the net generation is the water use factor. All TVA coal-fired plants except Paradise employ open-cycle (once-through) cooling all the time. In open cycle systems, water is withdrawn from a water body, circulated through the plant cooling condensers, and then discharged back to the water body. Plant water use factors for the coal plants, except for Colbert, Johnsonville and Paradise, ranged from about 54,000 to 83,000 gal/MWh of net generation. Differences in river temperature, plant design, atmospheric conditions, and plant operation account for the variability in water use factors.

Plant water use factors for Colbert were not within this range because the plant was offline for a portion of 2016, so for several months the pumps were still operational even though the units were not generating electricity. Johnsonville was excluded from the plant water use factor range because the plant was converted to a CT plant, and four units were operating at a decreased production, without commensurate withdrawal reductions.

Table 4-8: 2015 water use for TVA coal-fired and nuclear generating plants. (TVA unpublished data)

Plant	Units	Withdrawal (MGD)	Return (MGD)	Consumption (Withdrawal - Return, MGD)	Net Generation (MWh/year)	Water Use Factor (gallons/MWh)
Coal-Fired						
Allen[1]	3	490.2	490.1	0.1	3,129,703	57,173

Plant	Units	Withdrawal (MGD)	Return (MGD)	Consumption (Withdrawal - Return, MGD)	Net Generation (MWh/year)	Water Use Factor (gallons/MWh)
Bull Run	1	528.6	528.2	0.4	2,487,210	64,611
Colbert[1]	5	963.9	963.1	0.8	2,685,375	131,015
Cumberland	2	2319.2	2311.6	7.6	14,438,617	58,627
Gallatin	4	678.6	678.3	0.3	3,826,403	64,730
Johnsonville[1]	4	491.3	490.9	0.4	1,964,467	91,276
Kingston	9	956.6	955.7	0.8	3,857,821	83,006
Paradise[2]	3	333.8	273.1	60.7	12,008,149	10,145
Shawnee	9	902.8	902.4	0.4	6,141,807	53,654
Widows Creek[1]	2	470.7	470.0	0.7	1,627,447	78,957
Nuclear						
Browns Ferry	3	2850.6	2840.2	10.4	27,669,694	37,603
Sequoyah	2	1526.6	1524.3	2.3	16,511,322	33,747
Watts Bar	1	185.9	170.7	15.2	8,449,150	8,030

[1]Subsequently retired.
[2]Subsequently partially retired.

Paradise employs substantial use of cooling towers (closed-cycle cooling) resulting in a relatively low plant water use factor and less water returned to the river (Table 4-8). In closed-cycle systems, water from the steam turbine condensers is circulated through cooling tower where the condenser water is cooled by transfer of heat to the air by evaporation, conduction, and convection. The proportion of cooling water discharged to the river or reservoir is lower than for open-cycle systems, as are the overall volume of water required and the plant water use factor.

Browns Ferry and Sequoyah nuclear plants operate primarily in the open-cycle mode, with infrequent use of cooling towers. Watts Bar nuclear plant uses a combination of open-cycle and closed-cycle cooling.

Natural gas-fueled CC plants (gas turbine followed by a steam turbine) require water for steam generation and condensation. Water use in 2015 for TVA's CC plants are shown in Table 4-9. The Caledonia plant uses reclaimed wastewater. Ackerman, Lagoon Creek, Magnolia, and Southaven use groundwater. John Sevier uses surface water and closed-cycle cooling. With the exception of the Ackerman plant, all of these facilities return their process water to surface waters. Ackerman does not discharge process water.

Although TVA generates the majority of electrical energy in the TVA PSA and Tennessee River basin, there are non-TVA power plants in these areas that used substantial volumes of water in 2015 (Table 4-10). Two of the non-TVA plants (Decatur and Morgan) sell all or a large amount of their electricity to TVA. The Clinch River (closed during 2015) and Asheville coal-fired plants withdraw surface water from Tennessee River tributaries, but are located outside of TVA's PSA. The coal-fired Asheville plant is scheduled to be retired in 2020, following the completion of an adjacent 2-unit combined cycle natural gas plant that is currently under construction. Batesville, Morgan and Decatur withdraw surface water and are in the TVA PSA. The Choctaw Gas Plant is also in the TVA PSA, but utilizes saline groundwater instead of fresh water.

Table 4-9: 2015 water use for TVA combined cycle generating plants (TVA unpublished data).

Plant	Units	Withdrawal (MGD)	Return (MGD)	Consumption (Withdrawal - Return, MGD)	Net Generation (MWh/year)	Water Use Factor (gallons/MWh)
Ackerman	1	1.3	0.0	1.3	1,991,097	935
Caledonia	3	2.3	0.6	1.7	3,390,679	244
John Sevier	3	3.6	0.9	2.7	4,766,759	279
Lagoon Creek	3	2.2	0.6	1.6	3,171,381	258
Magnolia	3	3.7	0.7	3.0	4,972,280	269
Southaven	3	2.2	0.4	1.8	3,798,356	208

Note: The TVA CC generating plants at Paradise and Allen are not included because these plants began commercial operation in 2017 and 2018, respectively.

Table 4-10: 2015 water use by non-TVA thermal generating plants in the TVA power service area and Tennessee River basin. Source: U.S. Department of Energy EIA-923 Database (2015).

Plant	Units	Withdrawal (MGD)	Return (MGD)	Consumption (Withdrawal - Return, MGD)	Net Generation (MWh/year)	Water Use Factor (gallons/MWh)
Coal						
Asheville, NC	4	116.8	2.3	114.5	1,590,539	26,803
Clinch River, VA	3	9.2	3.5	5.7	461,977	7,269
Combined Cycle						
Batesville, MS	3	3.2	0.2	0.2	3,761,639	311
Decatur Energy Center, AL		0.7	0.1	0.6	1,486,854	172
Morgan Energy Center, AL		3.2	0.4	2.8	4,955,877	236
Choctaw Gas, MS[1]		4.1			3,033,410	493

[1]Saline groundwater.

4.4.3.4 Trends in Thermoelectric Water Withdrawal

Nationally, water use factors have been declining since the 1960s. The national power plant water use factors have declined from a high of about 60,000 gal/MWh to a low of about 23,000 gal/MWh (Electric Power Research Institute (EPRI) 2002). The reduction was primarily due to increasing use of closed-cycle cooling, particularly in the western United States where water is relatively scarce. TVA's water use factor is higher than the national average because the TVA system was designed and located to specifically take advantage of open-cycle cooling, and therefore has a lower percentage of closed-cycle cooling systems than the national average. While closed-cycle cooling systems withdraw less water, they actually consume more water in their cooling tower systems due to evaporation. TVA's systems are designed for less overall water consumption, even though they do require more water withdrawal upfront.

Figure 4-17 shows the total withdrawal from 2000 to 2015 and the combined water use factor for TVA's coal-fired, nuclear, and CC plants. The combined water use factors for 2000 and 2005 were about 39,300 gal/MWh. A slight increase was observed in 2010 to 42,300 gal/MWh, largely as the result of abnormal operation at Kingston Fossil Plant and reduced generation without commensurate withdrawal reductions at other plants such as Cumberland and Bull Run. The combined water use factor remained fairly steady in 2015 at 40,743 gal/MWh because while Colbert and Widows Creek were being prepared to be retired, the pumps for the open cycle cooling systems were still operating even though the units were not generating electricity. Further, while a heat recovery steam generator was being added to a CT unit at Johnsonville, a few coal units were still operating at a decreased production rate.

In addition to recent historic combined water use factors, Figure 4-17 also shows the anticipated combined water use factor for changes that have occurred since 2015. Those changes include the startup of Watts Bar Unit 2, the retirement of the coal units and construction of a CC plant at Allen, the retirement of two coal units and construction of a CC plant at Paradise, the closure of Colbert and Widows Creek Fossil plants, and the retirement of the coal units and startup of a heat recovery steam generator at Johnsonville. The startup of Watts Bar Unit 2 results in approximately 33 percent reduction in water use factor because Watts Bar Unit 2 primarily operates in closed-cycle mode. Therefore, the plant water use factor with both units operating will decrease but water consumption will increase from that of Unit 1 operation. The Johnsonville heat recovery steam generator is not included in the water use projections as this generator does not use water.

Table 4-11 shows the changes in the combined water use factor after the changes described in the previous paragraph for Allen, Paradise and Watts Bar went into effect. The additions, conversions, and closures would reduce the combined water use factor for TVA-owned facilities to about 24,100 gal/MWh in 2025. The data point in Figure 4-17 in year 2025 is based on the assumption that the plant modifications that are currently under way are completed. It does not include the proposed retirement of Paradise Fossil Plant Unit 3 and Bull Run Fossil Plant.

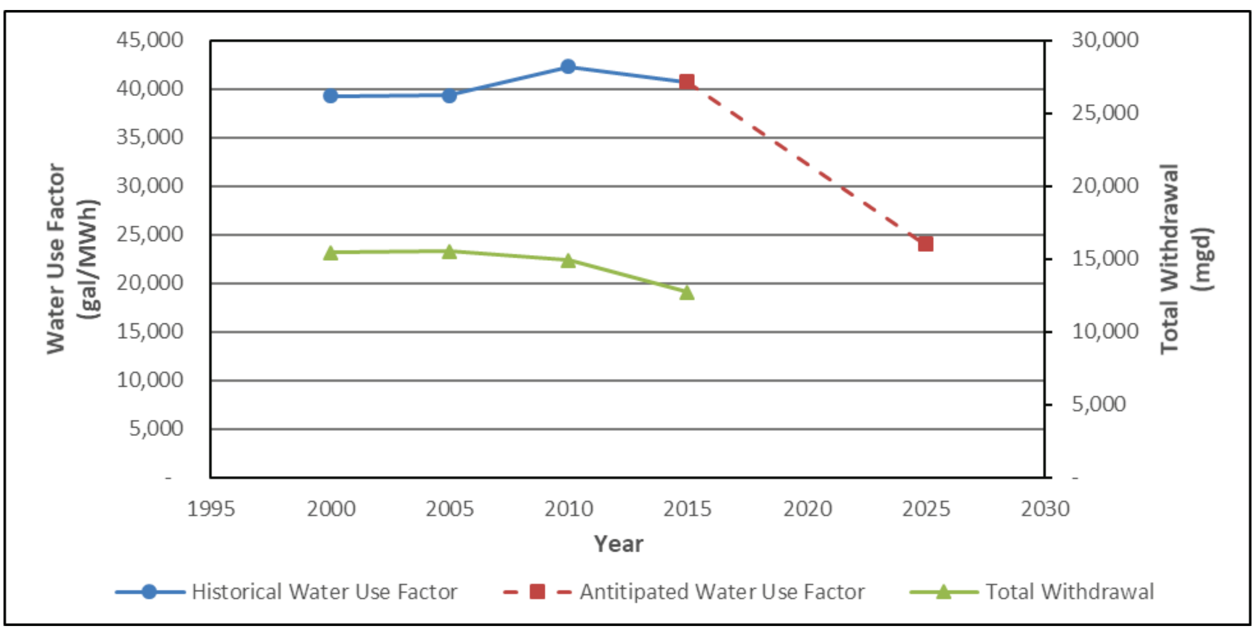


Figure 4-17: Total withdrawal and combined water use factor for TVA-owned thermal generating plants.

Table 4-11: Changes in water use factors for 2016-2018 plant conversions and unit additions .

Plant	Year Completed	Average Water Use Factor 2000 – 2010 gal/MWh	Water Use Factor after Modification – gal/MWh
Allen	2018	33,801	364
Paradise	2017	8,990	3,108
Watts Bar	2016	7,525	4,927

4.4.3.5 Water Use at Facilities Considered for Future Retirement

Several TVA facilities have units that are identified for potential retirement in the 20-year study period of this IRP. Recent water use at the coal plants identified for potential retirement (Shawnee, Cumberland, Gallatin, and Kingston), as well as their water use factors, are shown in Table 4-8. The CT units identified for potential retirement (Allen, Gallatin, Colbert, and Johnsonville) do not make water withdrawals and are not included in water use factor calculations.

4.4.4 Aquatic Life

4.4.4.1 Regulatory Framework for Aquatic Life

Aside from the Endangered Species Act (ESA) and related state laws described in Section 4.5.3, and harvest regulations established by states, the CWA is the major law affecting aquatic life. Water quality standards and NPDES discharge limits are established, in part, to protect aquatic life. CWA Section 316 regulates (a) the design and operation of cooling water intake structures to minimize adverse effects to aquatic life from entrainment and impingement, and (b) wastewater discharges in order to minimize adverse effects of heat on aquatic life.

4.4.4.2 Aquatic Life within the TVA Region

The TVA region encompasses portions of several major river systems including all of the Tennessee River drainage and portions of the Cumberland River drainage, Mobile River drainage (primarily the Coosa and Tombigbee Rivers), and larger eastern tributaries to the Mississippi River in Tennessee and Mississippi (Figure 4-14). These river systems support a large variety of freshwater fishes and invertebrates (including freshwater mussels, snails, crayfish, and insects). Due to the presence of several major river systems, the region's high geologic diversity (see Section 4.5.1), and the lack of glaciation, the region is recognized as a globally important area for freshwater biodiversity (Stein et al. 2000).

4.4.4.3 Aquatic Life at Facilities Considered for Future Retirement

Aquatic life in the vicinity of the eight TVA plants that are candidates for partial or full retirement is described in this subsection.

Shawnee Fossil Plant

Shawnee Fossil Plant is located approximately 10 miles west of Paducah, Kentucky along the Ohio River and within the Ohio River–Bayou Creek Hydrologic Unit (Code 051402060701). Natural streams in this region generally are low-gradient, meandering channels with silt and sand bottoms, often filled with woody debris, and inhabited by fish fauna typical of the Ohio River basin. The Shawnee facility is bordered by the Ohio River and Little Bayou Creek, which are all classified as warm-water aquatic habitat (TVA 2018e).

The Ohio River Valley Water Sanitation Commission (ORSANCO) operates programs to improve water quality in the Ohio River and its tributaries, including setting waste water discharge standards, performing biological assessments, and monitoring the physical and chemical properties of the waterway. Fish population data was collected in 2009 at 17 randomly selected locations throughout the reach of the Ohio River near Shawnee (ORSANCO 2009). Forty-eight fish species and one hybrid taxon were collected, representing 13 different families. Overall, the most abundant species collected was gizzard shad, with large numbers of freshwater drum, river carpsucker, channel catfish, sauger, longear sunfish, yellow bass, and bluegill also collected. Benthic substrate samples collected in the river revealed that it is dominated by sand followed by fines then gravel. Woody cover was present at all of the 17 sample sites and riparian land cover was primarily natural forest with some agriculture and residential uses present. The section of the Ohio River adjacent to Shawnee is designated critical habitat for the threatened rabbitsfoot mussel. A generally balanced, indigenous, aquatic community exists in the Ohio River adjacent to Shawnee, although fish consumption advisories are in effect for Little Bayou Creek due to pollutants that include metals and radiation (KDEP 2016).

Kingston Fossil Plant

Kingston Fossil Plant is located on a peninsula at the confluence of the Emory and Clinch rivers on Watts Bar Reservoir. The Kingston discharge point is located across the peninsula at Clinch River Mile (CRM) 2.6, while the intake is located at Emory River Mile (ERM) 1.9. The Watts Bar Dam impounds the 39,090-ac Watts Bar Lake (TVA 2016a).

Shoreline and substrate sections were evaluated for aquatic habitat upstream and downstream of Kingston in 2013. The shoreline sections had average scores of "fair," while limited aquatic macrophytes were noted along approximately 25 percent of the banks during the shoreline evaluation. The substrate was dominated by clay (56.8 percent), silt (14.9 percent) and bedrock (9.3 percent) downstream of Kingston and by clay (36.7 percent), detritus (19.4 percent) and sand (14.7 percent) upstream of Kingston (TVA 2014a).

TVA has evaluated the health of the fish community near CRM 1.5 downstream of Kingston and at CRM 4.4 upstream of Kingston. The fish community rated "good" at both of these locations in 2013. Historically, the fish community has rated "good" at these locations. During the 2013 study, 31 indigenous species were collected at the downstream site and 31 at the upstream site; this includes 16 commercially valuable and 23 recreationally valuable species as follows:

- Common centrarchid species present at Kingston included bluegill, longear sunfish, redear sunfish, warmouth and green sunfish.
- Benthic invertivore species present included black redhorse, freshwater drum, logperch, northern hogsucker, spotted sucker, golden redhorse and silver redhorse.
- Top carnivore species present included largemouth bass, skipjack herring, smallmouth bass, spotted gar, yellow bass, striped bass, spotted bass, hybrid bass, sauger, walleye, rock bass and flathead catfish.
- Intolerant species present included skipjack herring, northern hogsucker, spotted sucker, black redhorse, longear sunfish, smallmouth bass, brook silverside and rock bass. In addition, two thermally sensitive species, spotted sucker and logperch, were present.
- Aquatic nuisance species included common carp, redbreast sunfish, striped bass and Mississippi silverside that were collected at the downstream and upstream of Kingston and yellow perch that was collected upstream of Kingston (TVA 2014a).

Benthic community data was collected from three sites upstream and downstream of Kingston in 2013. Monitoring results for 2013 support the conclusion that a balanced indigenous population of benthic macroinvertebrates is maintained downstream of Kingston. Sites had taxa averages of 17.0, 14.1 and 17.5 at CRM 1.5, 2.2 and 3.75, respectively. The Ephemeroptera, Plecoptera and Trichoptera taxa present were 1.2, 1.7 and 1.5 at CRM 1.5, 2.2 and 3.75, respectively, mid- to high-range numbers. In addition, the proportion of oligochaetes were 15 percent, 7.2 percent and 10 percent, also mid- to high-range numbers (TVA 2014a).

The mussel fauna in the Emory River near Kingston has been greatly altered by the impoundment of Watts Bar Reservoir while upstream impacts include mining and urbanization. Six mussel species (the giant floater, fragile papershell, pistolgrip, pimpleback, wartyback and three-horn wartyback) and a common aquatic snail (hornsnail) were found in a survey of this area (Yokley 2005; Parmalee and Bogan 1998). All of these species, except pistolgrip, are considered tolerant of reservoir conditions.

Cumberland Fossil Plant

Cumberland Fossil Plant is located on Barkley Reservoir (Cumberland River, a tributary to the Ohio River). The Cumberland River is impounded prior to its confluence with the Ohio River to create Lake Barkley (TVA 2018f). Near Cumberland, Lake Barkley-Cumberland River is more riverine, approximately 72 miles upstream of Lake Barkley Dam. Cumberland is located along the left descending bank near river mile (RM) 103. Lake Barkley-Cumberland River adjacent to Cumberland is characterized as having poor to fair shoreline aquatic habitat with no aquatic macrophytes. The fish community consists of more warmwater species with a mix of species typical of both rivers and reservoirs due to the Cumberland proximity to the main stem of Lake Barkley and more riverine conditions near the Cumberland (TVA 2016b).

Wells Creek is a small tributary of the Cumberland River that flows south-north through the central portion of the Cumberland property. Scott Branch is a tributary of Wells Creek that flows west-east through the property. Due to their proximity and connection to the Cumberland River, species composition and abundances are expected to be similar to that described above for the Cumberland River.

TVA has used a Reservoir Ecological Health monitoring program since 1990 to evaluate ecological conditions in major reservoirs in the region. A component of this monitoring program is a multi-metric approach to data evaluation for fish communities known as the Reservoir Fish Assemblage Index (RFAI). Fish communities are used to evaluate ecological conditions because of their importance in the aquatic food web and because fish life cycles are long enough to integrate conditions over time. Benthic macroinvertebrate populations are assessed using the Reservoir Benthic Index (RBI) methodology. Because benthic macroinvertebrates are relatively immobile, negative impacts to aquatic ecosystems can be detected earlier in benthic macroinvertebrate communities than in fish communities. A component of this monitoring program includes sampling the benthic macroinvertebrate community (TVA 2016b).

TVA sampled fish upstream and downstream of Cumberland between RM 102 and 107 in the spring, summer, and autumn of 2015. Upstream of Cumberland, 1,576 fish (34 species) were collected in the spring 2015, 753 fish (32 species) were collected in the summer 2015, and 597 fish (37 species) were collected in the autumn 2015. Typical species upstream of Cumberland included gizzard shad, spotfin shiner, emerald shiner, yellow bass, bluegill, longear sunfish, and largemouth bass. Downstream of Cumberland, 1,643 fish (32 species) were collected in the spring 2015, 604 fish (27 species) were collected in the summer 2015, and 705 fish (31 species) were collected in the autumn 2015. Typical species downstream of Cumberland included threadfin shad, longear sunfish, emerald shiner, largemouth bass, bluegill, gizzard shad, and yellow bass. Ecological health ratings were similar for both the upstream and downstream sites for all three seasons, ranging from fair to good (TVA 2016b).

As part of the same TVA 2015 study, benthic (or bottom-dwelling) invertebrates were also collected. Oligochaetes, chironomids, and Asiatic clams were the dominant taxa both upstream and downstream of Cumberland. Ecological health ratings were similar between the upstream and downstream sites for all three seasons, ranging from fair to good (TVA 2016b).

A 2011 mussel survey conducted to characterize the freshwater mollusk community on the Cumberland River (spot dives) and Wells Creek (along sampling transects) near Cumberland found low abundances of a small number of relatively common mussel species. The three most numerous freshwater mussel species included mapleleaf, wartyback, and pink heelsplitter. On the Cumberland River, 24 mussels were collected from 23 locations (catch per unit effort = 9 mussels/hour). On Wells Creek, 11 mussels were collected along four transect locations (density = 0.05 mussels/square meter) (Third Rock Consultants 2011).

Gallatin Fossil Plant

The Gallatin Fossil Plant is located within a large peninsula on Old Hickory Lake at Cumberland River mile (RM) 241.5 to 246.0. The Cumberland River was altered from a free-flowing river to a reservoir due to impoundment by Old Hickory Dam, located 27 river miles downstream. Upstream of Gallatin, Old Hickory Lake extends 70 river miles to Cordell Hull Dam (TVA 2017e).

The cooling water discharge channel is commonly visited by local fishermen on the reservoir, particularly in winter when the warm water of the discharge attracts fish. Beginning in 2001, TVA began a fish community monitoring program in the Cumberland River downstream (RM 239 to 240.6) and upstream (RM 248.4 to 249.9) of the Gallatin discharge in order to verify that a Balanced Indigenous Population of aquatic life was being maintained. Fish community monitoring was conducted during 2001, 2002, 2003, 2005, 2007, 2008, 2010, 2011, 2012, 2013, and 2014. (TVA 2016c). Over the 11 sampling years, the average RFAI scores at the location just downstream of the Gallatin discharge and at the reference location upstream of Gallatin were identical, and differences between the scores for each location was six points or less each sample year, with the downstream location scoring higher than or within two points of the upstream location in eight of 11 years. The condition of the fish community downstream of Gallatin has been rated as fair to good in each of the years it was evaluated, with an average rating of fair based on an average score of 40. The condition of the fish community upstream of Gallatin also has been rated as fair to good in each of the years it was evaluated, with an average rating of good based on an average score of 41. Thus, the difference in fish community ratings upstream and downstream of Gallatin is minimal and does not indicate that the fish community has been adversely affected by the long-term operation of Gallatin.

Similar to the fish community monitoring program, the benthic macroinvertebrate community is monitored at two upstream and two downstream locations in the Cumberland River. Benthic macroinvertebrate monitoring was conducted during 2010, 2011, 2012, 2013, and 2014 (TVA 2016c). Recent benthic macroinvertebrate data indicated healthy benthic communities downstream and upstream of Gallatin, with the downstream locations consistently scoring higher than the upstream locations and rated as excellent the last two years. Thus, the benthic community ratings upstream and downstream of Gallatin do not indicate that the benthic macroinvertebrate community has been adversely affected by the operation of Gallatin. Neither fish nor benthic macroinvertebrate data indicate adverse impacts from Gallatin to the aquatic community downstream of the Gallatin discharge (TVA 2013a and 2016c).

Allen Combustion Turbine Plant

Allen CT Plant is co-located on the Allen Fossil Plant and CC plant reservation. Allen CT Plant and Fossil Plant lies approximately 1.8 miles east of the Mississippi River at Mississippi River Mile 725, and is located approximately 7.7 miles from downtown Memphis along the southern shore of McKellar Lake. McKellar Lake is an oxbow lake (a lake formed in the bend of a river) that has a watershed area of 2,176 ac (TVA 2014b). It connects to the Mississippi and much of the lake shoreline is developed for industrial and commercial purposes. The water quality in the lake is considered impaired (TDEC 2014). Fish consumption advisories have been in effect for the entirety of McKellar Lake since 2010 due to elevated levels of mercury, chlordane and other organics.

Gallatin Combustion Turbine Plant

The Gallatin CT Plant is located adjacent to the Gallatin Fossil Plant (see above).

Colbert Combustion Turbine Plant

The Colbert CT Plant is on the same reservation as the recently retired Colbert Fossil plant. Colbert Fossil plant is located within the Tennessee River-Pickwick Lake watershed, on the eastern shore of the Pickwick Reservoir at Tennessee River Mile (TRM) 245. The reach of the Tennessee River adjacent to Colbert Fossil plant has been altered from its former free-flowing character by the presence of Pickwick Dam, located approximately 38 river miles downstream of COF, and Wilson Dam, located approximately 14 miles upstream of Colbert Fossil plant (TVA 2016d).

TVA initiated a study in 2000 to evaluate fish communities in areas immediately upstream and downstream of Colbert Fossil plant in Pickwick Reservoir using RFAI multimetric evaluation techniques.

Overall results indicate that the fish assemblage in Pickwick Reservoir has been consistently “good” to “fair” from 2000 to 2014.

Johnsonville Combustion Turbine Plant

The Johnsonville CT Plant is located adjacent to the retired Johnsonville Fossil Plant. Johnsonville Fossil Plant is located in Humphreys County, Tennessee, in the Western Highland Rim subregion of the greater Interior Plateau ecoregion (Griffith et al. 1998). Johnsonville Fossil Plant lies within the Tennessee River 10-digit Hydrologic Unit Code (HUC) watershed 0604000504. The Western Highland Rim of the Interior Plateau is characterized by dissected, rolling terrain of open hills, with elevations of 400-1000 feet. Soils in this region tend to be acidic, cherty, and moderate in fertility (Griffith et al. 1998). Streams in this region are relatively clear with moderate gradients, with substrates consisting primarily of course chert gravel and sand with some bedrock. Much of the region is heavily forested, with some agriculture in the stream and river valleys.

Johnsonville Fossil Plant and CT Plantare located on the eastern shore of Kentucky Reservoir at TRM 100. The reach of the Tennessee River adjacent to Johnsonville Fossil Plant has been altered from its former free-flowing character by the presence of Kentucky Dam, located approximately 76 river miles downstream of Johnsonville Fossil Plant, and Pickwick Dam, located approximately 107 river miles upstream (TVA 2018g).

Reservoir Benthic Index data was collected upstream and downstream of Johnsonville Fossil Plant from 2001 to 2017. Compared to stations at other TVA run-of-the-river reservoirs, monitoring sites on Kentucky Reservoir have consistently rated “Fair” to “Excellent” since 2001.

TVA initiated a study in 2001 to evaluate fish communities in areas immediately upstream and downstream of Johnsonville Fossil Plant using RFAI multi-metric evaluation techniques. Electrofishing and gill netting sampling stations correspond to those described for benthic macroinvertebrate sampling (TVA 2011a). Overall Reservoir Ecological Health fish community monitoring results indicate that the Kentucky fish assemblage has been consistently “good” from 2001 to 2017, with the exception of the “excellent” score at the inflow in 2011 (TVA 2011a).

4.5 Land Resources

This section describes the land resources in the TVA region that could be affected by the alternative strategies. The potentially affected land resources include geology, vegetation and wildlife, endangered and threatened species, wetlands, parks, managed areas and ecologically significant sites, land use, and cultural resources.

4.5.1 Geology

The TVA region encompasses portions of the following major physiographic provinces and physiographic sections (Figure 4-18) (Fenneman 1938, Miller 1974):

- Blue Ridge
- Valley and Ridge
- Interior Low Plateaus Province
    - Highland Rim
    - Nashville Basin
- Appalachian Plateaus Province
    - Cumberland Plateau
    - Cumberland Mountains
- Coastal Plain Province
    - East Gulf Coastal Plain

Physiographic provinces and sections are areas of characteristic geomorphology and geology resulting from similar geologic events.

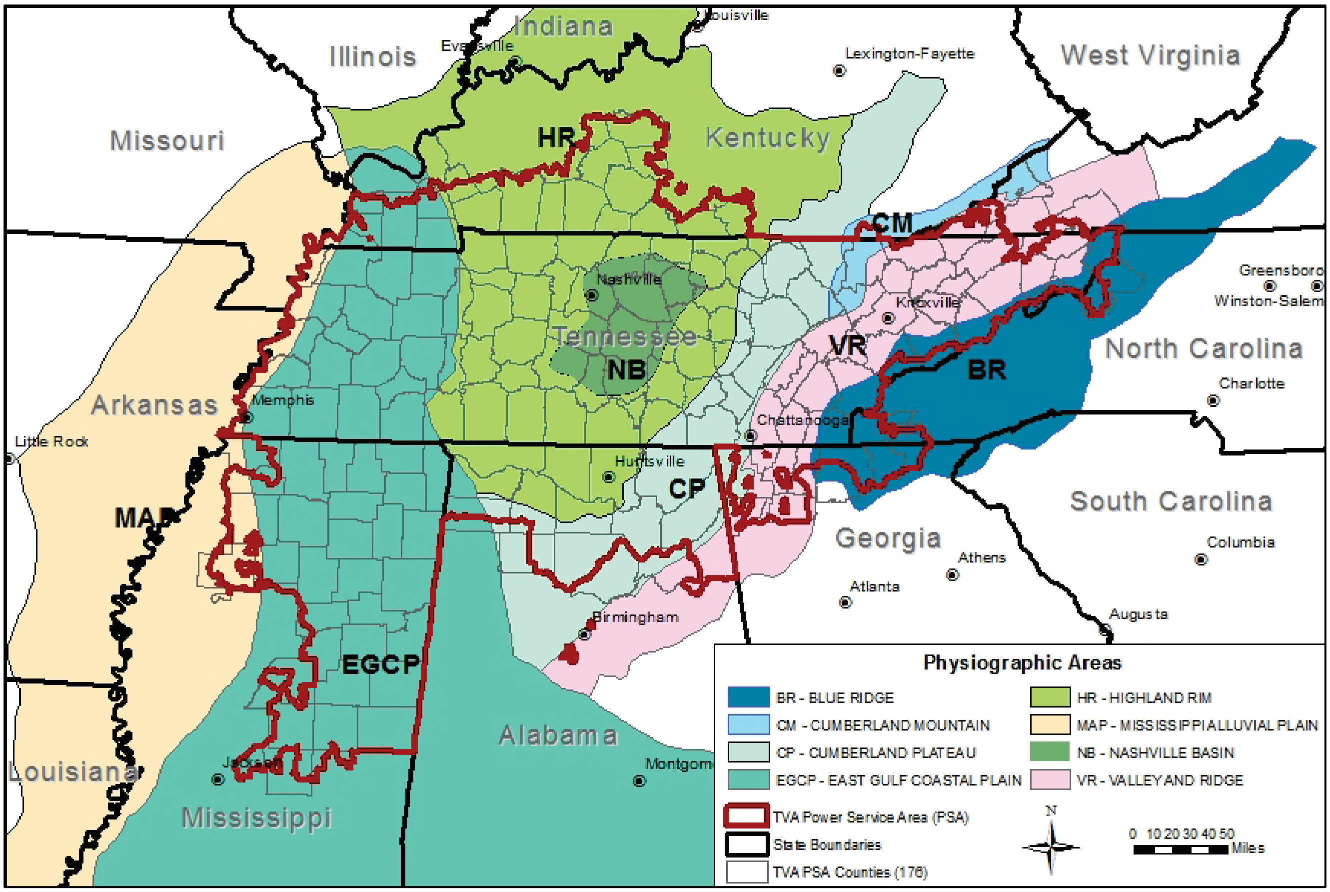


Figure 4-18: Physiographic areas of TVA region. Adapted from Fenneman (1938).

The easternmost part of the region is the Blue Ridge physiographic province, an area composed of the remnants of an ancient mountain chain. This province has the greatest variation in terrain within the TVA region. Terrain ranges from nearly level along floodplains at elevations of about 1,000 feet to rugged mountains that reach elevations greater than 6,000 feet above sea level. The rocks of the Blue Ridge have been subjected to significant folding and faulting and are primarily sedimentary (shales, sandstones, conglomerates, quartzite) and metamorphic (slate, phyllite, gneiss) rocks of Precambrian and Cambrian age.

Located west of the Blue Ridge and east of the Appalachian Plateau, the Valley and Ridge Province is characterized by alternating valleys and ridges that trend northeast to southwest. Ridges have elevations up to 3,000 feet and are generally capped by dolomites and resistant sandstones, while valleys have been formed in less resistant dolomites and limestones. Dominant soils in this province are residual clays and silts derived from in-place weathering of rock. Karst features such as sinkholes and springs are common in the Valley and Ridge province.

The Appalachian Plateaus Province is an elevated area between the Valley and Ridge and Interior Low Plateaus provinces. It is comprised of two sections in the TVA region: the extensive Cumberland Plateau and the smaller Cumberland Mountains (Figure 4-18). The Cumberland Plateau rises about 1,000 – 1,500 feet above the adjacent provinces and is formed by layers of near horizontal Pennsylvanian sandstones, shales, conglomerates and coals, underlain by Mississippian and older shale and limestones. The sandstones are resistant to erosion and have produced a relatively flat landscape cut by deep stream valleys. Toward the northeast, the Cumberland Mountains section is more rugged due to extensive faulting and several peaks exceeding 3,000 feet elevation. The province has a long history of coal mining and encompasses the Appalachian coal field (USGS 1996). Coal mining has historically occurred in much of the province. The most recent Appalachian coal mining within the TVA region has been from the southern end of the province in Alabama, the northern portion of the Cumberland Plateau section in Tennessee and the Cumberland Mountains section.

Two sections of the Interior Low Plateaus Province occur in the TVA region. The Highland Rim section is a plateau that occupies much of central Tennessee and parts of Kentucky and northern Alabama. The bedrock of the Highland Rim is Mississippian limestones, chert, shale, and sandstone. The terrain varies from hilly to rolling to extensive relatively flat areas in the northwest and southeast. The southern end of the Illinois Basin coal region (USGS 1996) overlaps the Highland Rim in northwest Kentucky and includes part of the TVA region. The Nashville Basin (also known as the Central Basin) section is an oval area in middle Tennessee with an elevation about 200 feet below the surrounding Highland Rim. The bedrock is composed of generally flat-lying limestones. Soil cover is usually thin and streams cut into bedrock. Karst is well-developed in parts of both the Highland Rim and the Nashville Basin.

The Coastal Plain Province encompasses much of the western and southwestern TVA region (Figure 4-18). Most of the Coastal Plain portion of the TVA region is in the extensive East Gulf Coastal Plain section. The underlying geology is a mix of poorly consolidated gravels, sands, silts and clays. Soils are primarily of windblown and alluvial (deposited by water) origin, low to moderate fertility and easily eroded. The terrain varies from hilly to flat in broad river bottoms. The Mississippi Alluvial Plain section occupies the western edge of the TVA region and much of the historic floodplain of the Mississippi River. Soils are deep and often poorly drained. The New Madrid Seismic Zone, an area of large prehistoric and historic earthquakes, is in the northern portion of the section.

4.5.1.1 Geologic Carbon Dioxide Sequestration Potential

The sequestration (i.e., capture and permanent storage) of CO_2 from large stationary point sources, such as coal-fired power plants, is potentially an important component of efforts to significantly reduce anthropogenic CO_2 emissions. Successful large-scale, economical CO_2 sequestration (also referred to as carbon capture and storage (CCS)) would enable coal to continue to be used as an energy source with greatly reduced CO_2 emissions. Few power plant CCS projects are currently operating and the technology is in a relatively early stage of development.

Geologic CO_2 storage involves capturing and separating the CO_2 from the power plant exhaust; drying, purifying, and compressing the CO_2; and transporting it by pipeline to the storage site where it is pumped through wells into deep geological formations. When the CO_2 capacity of the formation has been reached or when the pressure of the formation or injection well has reached a pre-determined level, CO_2 injection is stopped and the wells are permanently sealed. The storage site would then be monitored for a period of time.

The suitability of a particular underground formation for CO_2 storage depends on its geology, as well as the geology of adjacent and overlying formations. In the central and southeastern U.S., deep saline formations, unmineable coal seams, and oil and gas fields are considered to have the best potential to store CO_2 from large point sources (NETL 2012). A brief description of each of these formations, as well as its storage potential in and near the TVA PSA, is given below.

In 2002, the Department of Energy's National Energy Technology Laboratory launched the Regional Carbon Sequestration Program to identify and evaluate carbon sequestration in different regions of the country. Areas studied include parts of the Southeast and the Illinois Basin area of Illinois, Indiana and Kentucky. Experimental CO_2 injection tests for enhanced coalbed methane recovery have been conducted in southwest Virginia and for enhanced oil recovery in southwest Kentucky (NETL 2012a).

Saline Formations – Saline formations are layers of porous rock that are saturated with brine. They are more extensive than unmineable coal seams and oil and gas fields and have a high CO_2 storage potential. However, because they are less studied than the other two formations, less is known about their suitability and storage capacity. Potentially suitable saline formations are capped by one or more layers of non-porous rock, which would prevent the upward migration of injected CO_2. Saline formations also contain minerals that could react with injected CO_2 to form solid carbonates, further sequestering the CO_2. Saline formations provide the greatest potential for CO_2 storage in the TVA region. Middle Tennessee and much of west-central Kentucky are underlain by the Mt. Simon and associated basal sandstone formations. These deep formations have a potential CO_2 storage capacity of up to about 9 billion metric tons. Recent research conducted by the Tennessee Geological Survey has shown that the shallower Knox-Stones River Groups underlying the Cumberland Plateau may be a viable storage reservoir. The extensive Tuscaloosa Group in Alabama and Mississippi south of the TVA region also has a high potential for CO_2 storage (NETL 2012).

Unmineable Coal Seams – Unmineable coal seams are typically too deep or too thin to be economically mined. When CO_2 is injected into them, it is adsorbed onto the surface of the coal. Although their storage potential is much lower than saline formations, they are attractive because they are relatively shallow and because the injected CO_2 can be used to displace coalbed methane, which can be recovered in adjacent wells and used as a natural gas substitute. Coal seams within the TVA region in Tennessee and Alabama have little potential for CO_2 storage. Coal seams with greater potential near the TVA PSA occur in southwest Virginia, in Alabama and Mississippi south of the TVA PSA, and in the Illinois Basin of western Kentucky mostly north of the TVA PSA (NETL 2012).

Natural gas-producing shales in the Illinois Basin also offer the potential for storing CO_2, including its use for enhanced gas recovery (NETL 2012). The occurrence of suitable unmineable coal seams and organic-rich shales in the TVA region is limited, but more extensive elsewhere in the Illinois Basin, as well as in southeast Kentucky/southwest Virginia, west-central Alabama, and southwest Mississippi.

Oil and Gas Fields – Mature oil and gas fields/reservoirs are considered good storage formations because they held crude oil and natural gas for millions of years. Their storage characteristics are also well-known and some are currently used for storing natural gas. Like saline formations, they consist of layers of permeable rock with one or more layers of cap rock. Injected CO_2 can also enhance the recovery of oil or gas from mature fields. The potential for CO_2 storage in the oil and gas fields of Tennessee, southwest Virginia, and east-central Mississippi is limited (NETL 2012). Greater potential exists in oil and gas fields in central southern Mississippi. The potential for CO_2 storage is also high in the gas-rich New Albany Shale in northwest Kentucky and adjacent Illinois and Indiana (NETL 2012).

The Kemper County integrated gasification combined cycle (IGCC) plant was constructed near the southern edge of the TVA PSA in Mississippi; as originally designed, CO_2 from the plant would have been captured and used for enhanced oil recovery in oil fields south of the TVA PSA (USDOE 2010, NETL 2012). Due to problems unrelated to the area's CO_2 sequestration potential, the plant is being operated as a CC plant fueled by natural gas (Wagman 2017).

4.5.2 Vegetation and Wildlife

The TVA region encompasses nine ecoregions (Omernik 1987) which generally correspond with physiographic provinces and sections (see Section 4.5.1 and Figure 4-18):

1. Blue Ridge
2. Ridge and Valley
3. Central Appalachian
4. Southwestern Appalachian
5. Interior Plateau
6. River Valley and Hills
7. Southeastern Plains
8. Mississippi Valley Loess Plain
9. Mississippi Alluvial Plain

The terrain, plant communities, and associated wildlife habitats in these ecoregions vary from bottomland hardwood and cypress swamps in the floodplains of the Mississippi Alluvial Plain to high elevation balds and spruce-fir and northern hardwood forests in the Blue Ridge. About 3,500 species of herbs, shrubs and trees, 55 species of reptiles, 72 species of amphibians, 182 species of breeding birds and 76 species of mammals occur in the TVA region (Ricketts et al. 1999, Stein 2000, TWRA 2005, TOS 2014). Although many plants and animals are widespread across the region, others are restricted to one or a few ecoregions. For example, high elevation communities in the Blue Ridge support several plants and animals found nowhere else in the world (Ricketts et al. 1999), as well as isolated populations of species typically found in more northern latitudes.

4.5.2.1 Regulatory Framework for Vegetation and Wildlife

Aside from the ESA and related state laws described in Section 4.5.3, there are few laws specifically focused on protecting plant species and plant communities. The Plant Protection Act of 2000 consolidated previous legislation and authorized the U.S. Department of Agriculture (USDA) to issue regulations to prevent the introduction and movement of identified plant pests and noxious weeds. E.O. 13112 – Invasive Species directs Federal agencies to prevent the introduction of invasive species (both plants and animals), control their populations, restore invaded ecosystems and take other related actions. E.O. 13751 – Safeguarding the Nation from the Impacts of Invasive Species amends E.O. 13112 and directs actions to continue coordinated Federal prevention and control efforts related to invasive species. Agencies are also directed to incorporate consideration of human and environmental health, climate change, technological innovation, and other emerging priorities into their efforts to address invasive species (USDA 2018a).

A number of species of wildlife are protected under the ESA and related state laws. In addition to these laws, the regulatory framework for protecting birds includes the Migratory Bird Treaty Act (MBTA) of 1918, the Bald and Golden Eagle Protection Act of 1940 and E.O. 13186 – Responsibilities of Federal Agencies to Protect Migratory Birds. The MBTA and E.O. 13186 address most native birds occurring in the U.S. The MBTA makes the purposeful taking, killing, or possession of migratory birds, their eggs, or nests unlawful, except as authorized under a valid permit. Federal agency actions are not subject to the MBTA. E.O. 13186, however, focuses on Federal agencies taking actions with the potential to have negative impacts on populations of migratory birds. It provides broad guidelines on avian conservation responsibilities and requires agencies whose actions affect or could affect migratory bird populations to develop a memorandum of understanding (MOU) on migratory bird conservation with the U.S. Fish and Wildlife Service (USFWS). TVA is currently coordinating with USFWS the development of an MOU under the E.O. 13186.

Aside from federal and state laws regulating the hunting, trapping or other capture, and possession of some species, most wildlife other than birds generally receives no legal protection.

4.5.2.2 Regional Vegetation

The southern Blue Ridge Ecoregion, which corresponds to the Blue Ridge physiographic province, is one of the richest centers of biodiversity in the eastern United States and one of the most floristically diverse (Griffith et al. 1998). The most prevalent land cover (80 percent) is forest, dominated by the diverse, hardwood-rich mesophytic forest and its Appalachian oak subtype (Dyer 2006; USGS 2016). About 14 percent of the land cover is agricultural and most of the remaining area is developed. Relative to the other eight ecoregions, the Blue Ridge Ecoregion had the least change in land cover from 1973 through 2000 (USGS 2016).

Over half (56 percent) of the Ridge and Valley Ecoregion, which corresponds to the Valley and Ridge physiographic province, is forested. Dominant forest types are the mesophytic forest and Appalachian oak sub-type. In the southern portion of the region, the southern mixed forest and oak-pine sub-type (Dyer 2006, USGS 2016) dominate. About 30 percent of the area is agricultural and 9 percent is developed (USGS 2016).

The Cumberland Mountains physiographic section comprises the southern portion of the Central Appalachian Ecoregion. This ecoregion is heavily forested (83 percent), primarily with mesophytic forests including large areas of Appalachian oak (Dyer 2006, USGS 2016). The remaining land cover is mostly agriculture (7 percent), developed areas (3 percent) and mined areas (3 percent). The dominant source of land cover change from 1973 through 2000 was mining (USGS 2016), and this ecoregion, together with the Southwestern Appalachian Ecoregion, comprises much of the Appalachian coalfield.

The Southwestern Appalachian Ecoregion corresponds to the Cumberland Plateau physiographic section. About 75 percent of the land cover is forest, predominantly mesophytic forest; about 16 percent is agricultural and 3 percent is developed (USGS 2016). The rate of land cover change from 1973 through 2000 is relatively high, mostly due to forest management activities.

The Interior Plateau Ecoregion consists of the Highland Rim and Nashville Basin physiographic sections. The limestone cedar glades and barrens communities associated with thin soils and limestone outcrops in the Nashville Basin support rare, diverse plant communities with a high proportion of endemic (i.e., restricted to a particular area) species (Baskin and Baskin 2003). About 38 percent of the ecoregion is forested, 50 percent in agriculture and 9 percent developed (USGS 2016). Forests are predominantly mesophytic, with a higher proportion of American beech, American basswood and sugar maple than in the Appalachian oak subtype (Dyer 2006). Eastern red cedar is also common. For the ecoregion as a whole, the rate of land cover change has been relatively low, with the predominant changes from forest and agriculture to developed land. The rate of these changes from the 1970s to the present has been very high in the greater Nashville and Huntsville areas.

A small area in the northwest of the TVA region is in the Interior River Valley and Hills Ecoregion, which overlaps part of the Highland Rim physiographic section. This ecoregion is relatively flat lowland dominated by agriculture (almost two-thirds), with about 20 percent forested hills, 7 percent developed, and 5 percent wetlands (USGS 2016). It contains much of the Illinois Basin coalfield. Drainage conditions and terrain strongly affect land use. Bottomland deciduous forests and swamp forests were common on wet lowland sites, with mixed oak and oak-hickory forests on uplands. A large portion of the lowlands has been cleared for agriculture. The rate of land cover change from 1973 through 2000 is moderate and primarily from forest to agriculture and from agriculture and forest to developed.

The Southeastern Plains and Mississippi Valley Loess Plain Ecoregions correspond, respectively, to eastern and western portions of the East Gulf Coastal Plain physiographic section. These ecoregions are characterized by a mosaic of forests (52 percent of the land area), agriculture (22 percent), wetlands (10 percent) and developed areas (10 percent). Forest cover decreases and agricultural land increases from east to west. Natural forests of pine, hickory, and oak once covered most of the ecoregions, but much of the natural forest cover has been replaced by heavily managed timberlands, particularly in the Southeastern Plains (USGS 2016). The Southeastern Plains in Alabama and Mississippi include the Black Belt, an area of rich dark soils and prairies. Much of this area has been cleared for agricultural purposes and only remnant prairies remain. The rate of land cover change in the Southeastern Plains Ecoregion is the highest of the nine ecoregions in the TVA region, with intensive forest management practices the leading cause of the change. The rate of land cover change in the Mississippi Valley Loess Plain Ecoregion is moderate to high relative to the other ecoregions.

The Mississippi Alluvial Plain is a flat floodplain area originally covered by bottomland deciduous forests. A large portion has been cleared for agriculture and subjected to drainage activities including stream channelization and extensive levee construction. Most of the land cover is agricultural and the remaining forests are southern floodplain forests dominated by oak, tupelo and bald cypress. The rate of land cover change since the 1970s has been moderate (USGS 2016), with the major land cover change from agriculture to developed.

The major forest regions in the TVA region include mesophytic forest, southern-mixed forest, and

Mississippi alluvial plain (Dyer 2006). The mesophytic forest is the most diverse with 162 tree species. While canopy dominance is shared by several species, red maple and white oak have the highest average importance values. A distinct section of the mesophytic forest, the Appalachian oak section, is dominated by several species of oak including black, chestnut, northern red, scarlet and white oaks. The Nashville Basin mesophytic forest has close affinities with the beech-maple-basswood forest that dominates much of the Midwest. The oak-pine section of the southern mixed forest region occurs in portions of Alabama, Georgia and Mississippi, where the dominant species are loblolly pine, sweetgum, red maple and southern red oak (Dyer 2006). The Mississippi alluvial plain forest region is restricted to its namesake physiographic region. The bottomland forests in this region are dominated by American elm, bald cypress, green ash, sugarberry and sweetgum.

Numerous plant communities (recognizable assemblages of plant species) occur in the TVA region. Several of these communities are rare, restricted to very small geographic areas and/or threatened by human activities. A disproportionate number of these imperiled communities occur in the Blue Ridge region; smaller numbers are found in the other ecoregions (NatureServe 2018). Many of the imperiled communities occur in the Southern Appalachian spruce-fir forest; cedar glades; grasslands, prairies and barrens; Appalachian bogs, fens and seeps; and bottomland hardwood forest ecosystems. Major threats to the Southern Appalachian spruce-fir forest ecosystem include invasive species such as the balsam wooly adelgid, acid deposition, ozone exposure and climate change (TWRA 2009). The greatest concentration of cedar glades is in the Nashville Basin; a few also occur in the Highland Rim and the Valley and Ridge. Cedar glades contain many endemic plant species, including a few listed as endangered (Baskin and Baskin 2003); threats include urban development, highway construction, agricultural activities, reservoir impoundment and incompatible recreational use. The category of grasslands, prairies and barrens includes remnant native prairies; they are scattered across the TVA region but most common on the Highland Rim. This category also includes the high elevation grassy balds in the Blue Ridge and the Black Belt prairie in the East Gulf Coastal Plain. Threats to these areas include agricultural and other development, invasive plants and altered fire regimes. Appalachian bogs, fens and seeps are often small, isolated, and support several rare plants and animals. Threats include drainage for development and altered fire regimes. Bottomland hardwood forests are most common in the Mississippi Alluvial Plain and East Gulf Coastal Plain; they also occur in other physiographic regions. About 60 percent of their original area is estimated to have been lost, largely by conversion to croplands (USEPA 2018d).

4.5.2.3 Wildlife Population Trends

Many animals are wide-ranging throughout the TVA region; most species tolerant of humans have stable or increasing populations. The populations of many animals have been greatly altered by changes in habitats from agriculture, mining, forestry, urban and suburban development and the construction of reservoirs. While some species flourish under these changes, others have shown marked declines. For example, populations of several birds dependent on grassland and forest have shown dramatic decreases in their numbers (SAMAB 1996). Across North America, 27 percent of grassland-breeding birds are of high conservation concern because of declining populations, as are 22 percent of temperate forest-breeding birds (NABCI 2016). A large number of the declining birds are Neotropical migrants, species that nest in the United States and Canada and winter south of the United States. Over 30 species of birds breeding in the TVA region are considered to be of conservation concern (USFWS 2008). A few additional bird species are considered to be of management concern because of overly abundant populations, leading to damage to natural ecosystems and human interests (USFWS 2011); the resident population of the Canada Goose in the TVA region is an example of such species. Global amphibian declines have been well documented, but declines in amphibian populations in the TVA region also have been reported (Caruso and Lips 2012). The primary causes for these declines are the loss and fragmentation of habitats from urban and suburban development and agricultural and forest management practices. Introduced pathogens have also contributed to wildlife population declines. Populations of bats have been observed dying off in the TVA region after the introduction of a novel pathogen causing white nose-syndrome. In general gulls, wading birds, waterfowl, raptors, upland game birds (with the exception of the northern bobwhite) and game mammals are stable or increasing in the TVA region.

The construction of the TVA and USACE reservoir systems created large areas of habitat for waterfowl, herons and egrets, ospreys, gulls and shorebirds, especially in the central and eastern portions of the TVA region where this habitat was limited. Ash and gypsum settling and storage ponds at TVA fossil plants also provide regionally important habitat for these birds and other wetland species although many of these are being closed (see Section 4.7). These overall increases in aquatic habitats, as well as the ban on the use of the pesticide dichlorodiphenyltrichloroethane (DDT), have resulted in large increases in resident and migratory populations of several birds in the TVA region. Both short-term and long-term changes in the operation of the reservoir system affect the quality of habitat for these species (TVA 2004), as do pond management practices at fossil plants.

4.5.2.4 Invasive Species

Invasive species are species that are not native to the ecosystem under consideration and whose introduction causes or is likely to cause economic or environmental harm or harm to human health (NISC 2016). Invasive species include terrestrial and aquatic plants and animals as well as other organisms such as microbes. Human actions, both intentional and unintentional, are the primary means of their introductions.

Four plants designated by the USDA as noxious weeds under the Plant Protection Act occur in the TVA region: hydrilla, cogongrass and tropical soda apple (USDA 2010). Hydrilla is a submersed aquatic plant present in several TVA reservoirs. Giant salvinia, also an aquatic plant, occurs in ponds, reservoirs and slow-moving streams. It primarily occurs south of the TVA region and has not yet been reported from the Tennessee River drainage. Cogongrass is an upland plant present in several TVA region counties in Alabama and Mississippi. It occurs on and near several TVA transmission line right-of-ways and can be spread by line construction and maintenance activities. Tropical soda apple has been reported from a few counties in the TVA region and primarily occurs in agricultural areas.

Several additional invasive plants considered to be an established or emerging threat (TN-IPC 2018) occur on or near TVA generating facilities and transmission line right-of-ways. These include tree-of-heaven, Asian bittersweet, autumn olive, Chinese privet, kudzu, phragmites, Eurasian water-milfoil, multiflora rose, and tall fescue. Phragmites occurs in ash ponds at several TVA coal-fired plants and is otherwise uncommon in the TVA region.

Invasive aquatic animals in the TVA region that harm or potentially harm aquatic communities include the common, grass, bighead and silver carp; alewife; blueback herring; rusty crayfish; Asiatic clam and zebra mussel. Because of their potential to affect water intake systems, TVA uses chemical and warm-water treatments to control Asiatic clams and zebra mussels at its generating facilities.

Invasive terrestrial animals at TVA generating facilities which occasionally require management include the rock pigeon, European starling, house sparrow, and fire ant. These species have little effect on the operation of TVA's power system.

4.5.3 Endangered and Threatened Species

The TVA region provides habitat for numerous species of plants and animals that have declining populations or are otherwise rare and considered to be endangered, threatened, or of special concern at the national and state levels.

4.5.3.1 Regulatory Framework for Endangered and Threatened Species

The Endangered Species Act of 1973 (ESA; 16 U.S.C. §§ 1531-1543) was passed to conserve the ecosystems upon which endangered and threatened species depend and to conserve and recover those species. An endangered species is defined by the ESA as any species in danger of extinction throughout all or a significant portion of its range. A threatened species is likely to become endangered within the foreseeable future throughout all or a significant part of its range. Areas known as critical habitats, essential to the conservation of listed species, also can be designated under the ESA. The ESA establishes programs to conserve and recover endangered and threatened species and makes their conservation a priority for Federal agencies. Under Section 7 of the ESA, Federal agencies are required to consider the potential effects of their proposed action on endangered and threatened species and critical habitats. If the proposed action has the potential to affect these resources, the federal agency is required to consult with the USFWS and take measures to avoid or mitigate adverse effects.

All seven states in the TVA region have enacted laws protecting endangered and threatened species. In other states, the legal protections also apply to additional species designated by the state as endangered, threatened, or otherwise classified such as “in need of management.”

4.5.3.2 Endangered and Threatened Species in the TVA Region

Thirty-eight species of plants, one lichen and 127 species of animals in the TVA region area are listed under the ESA as endangered or threatened or formally proposed for such listing by the USFWS. One additional species in the TVA region has been identified by the USFWS as a candidate for listing under the ESA. Candidate species receives no statutory protection under the ESA but by definition may warrant future protection. Several areas across the TVA region are also designated as critical habitat essential to the conservation of listed species. In addition to the species listed under the ESA, about 1,350 plant and animal species are formally listed as protected species by one or more of the states or otherwise identified as species of conservation concern.

The highest concentrations of terrestrial and aquatic species listed under the ESA occur in the Blue Ridge, Appalachian Plateaus and Interior Low Plateau regions. Relatively few listed species occur in the Coastal Plain and Mississippi Alluvial Plain regions. The taxonomic groups with \the highest proportion of species listed under the ESA are fish and mollusks. Factors contributing to the high proportions of vulnerable species in these groups include the high number of endemic species in the TVA region and the alteration of their habitats by reservoir construction and water pollution. River systems with the highest numbers of listed aquatic species include the Tennessee, Cumberland and Coosa rivers.

Populations of a few listed species have increased, primarily because of conservation efforts, to the point where they are no longer listed under the ESA (e.g., bald eagle, peregrine falcon, Tennessee coneflower) or their listing status has been downgraded from endangered to threatened (e.g., snail darter, large flowered skullcap, small whorled pogonia). Among the listed species with populations that continue to decline are the American hart’s tongue fern and the Indiana bat. The formerly common northern long-eared bat was listed in 2015 under the ESA as threatened due to recent dramatic population declines caused by white-nose syndrome. In the TVA region, this pathogen was first reported in 2009. Population trends of many other listed species in the TVA region are poorly understood.

4.5.3.3 Endangered and Threatened Species in Vicinity of TVA Generating Facilities

In addition to ESA-listed species, several species listed by TVA-region states occur on or very near TVA generating facilities and transmission lines. Appendix A lists the endangered and threatened species reported in the vicinity of TVA generating facilities. Species considered to be locally extirpated are not listed in Appendix A.

4.5.4 Wetlands

Wetlands are areas that are inundated or saturated by water at a frequency and duration sufficient to support, and under normal circumstances do support, a prevalence of vegetation typically adapted for life in saturated soil conditions (USEPA regulations at 40 C.F.R § 230.3(t)). Wetlands generally include swamps, marshes, bogs and similar areas. Wetlands are highly productive and biologically diverse ecosystems that provide multiple public benefits such as flood control, reservoir shoreline stabilization, improved water quality and habitat for fish and wildlife resources.

4.5.4.1 Regulatory Framework for Wetlands

Section 404 of the CWA prohibits the discharge of dredge and fill material to waters of the United States, which include most wetlands, unless authorized by a permit issued by the USACE. The scope of this regulation includes most construction activities in wetlands. E.O. 11990 – Protection of Wetlands requires federal agencies to minimize the destruction, loss, or degradation of wetlands and to preserve and enhance their natural and beneficial values. Wetlands are also protected by state regulations (e.g. Tennessee's Aquatic Resources Alteration Permit program).

4.5.4.2 Wetlands in the TVA Region

Wetlands occur across the TVA region and are most extensive in the south and west where they comprise 5 percent or more of the landscape (USGS 2016). Wetlands in the TVA region consist of two main systems: palustrine wetlands such as marshes, swamps and bottomland forests dominated by trees, shrubs, and persistent emergent vegetation, and lacustrine wetlands associated with lakes such as aquatic bed wetlands (Cowardin et al. 1979). Riverine wetlands associated with moving water within a stream channel are also present but relatively uncommon. Almost 200,000 acres of wetlands are associated with the TVA reservoir system, where they are more prevalent on mainstem reservoirs and tailwaters than tributary reservoirs and tailwaters (TVA 2004). Almost half of this area is forested wetlands; other types include aquatic beds and flats, ponds, scrub/shrub wetlands and emergent wetlands.

Manmade emergent wetlands occur on many TVA generating facility sites, often in association with CCR disposal ponds and water treatment ponds. However, CCR and water treatment ponds are excluded from regulation under CWA Section 404. Some of these wetlands provide important wildlife habitat; due to their location and composition, they do not provide the surrounding watershed with any significant flood abatement, or nutrient or sediment retention wetland functions. Many of these wetlands are being eliminated as TVA converts wet CCR storage ponds to dry storage facilities. Approximately 6,750 acres of wetlands have been mapped within TVA transmission line right-of-ways (TVA 2018h). Due to periodic clearing, the right-of-ways are dominated by scrub-shrub and emergent wetlands; forest wetlands make up less than 1 percent of the wetlands. A large proportion of these wetlands were forested until cleared during transmission line construction.

National and regional trends studies have shown a large, long-term decline in wetland area both nationally and in the southeast (Dahl 2000, Dahl 2006, Dahl 2011, Hefner et al. 1994). Wetland losses have been greatest for forested and emergent wetlands and have resulted from drainage for agriculture, forest management activities, urban and suburban development and other factors. The rate of loss has significantly slowed over the past 20 years due to regulatory mechanisms for wetland protection. While the rate of wetland loss has slowed, urbanization continues to impact the ecological function of wetlands across the southeast. Threats to wetlands associated with urbanization include habitat fragmentation, invasive species, hydrologic alteration and changes in species composition due to global climate change (Wright et al. 2006).

4.5.5 Floodplains

Floodplains are the relatively level land areas along a stream or river that are subjected to periodic flooding. The area subject to a one-percent chance of flooding in any given year is normally called the 100-year floodplain. The area subject to a 0.2-percent-chance of flooding in any given year is normally called the 500-year floodplain. It is necessary to evaluate development in the 100-year floodplain to ensure that the project is consistent with the requirements of E.O. 11988 – Floodplain Management.

4.5.5.1 Regulatory Framework for Floodplains

TVA adheres to the requirements of E.O. 11988, Floodplain Management. The objective of E.O. 11988 is "…to avoid to the extent possible the long- and short-term adverse impacts associated with the occupancy and modification of floodplains and to avoid direct and indirect support of floodplain development wherever there is a practicable alternative" (E.O. 11988, Floodplain Management). The E.O. is not intended to prohibit floodplain development in all cases, but rather to create a consistent government policy against such development under most circumstances (U.S. Water Resources Council 1978). The E.O. requires that agencies avoid the 100 year floodplain unless there is no practicable alternative.

For "Critical Actions", the minimum floodplain of concern is the 500-year floodplain. The U.S. Water Resources Council defines "critical actions" as "any activity for which even a slight chance of flooding would be too great" (U.S. Water Resources Council, 1978). Critical actions can include facilities producing hazardous materials (such as liquefied natural gas terminals), facilities whose occupants may be unable to evacuate quickly (such as schools and nursing homes), and facilities containing or providing essential and irreplaceable records, utilities, and/or emergency services (such as large power-generating facilities, data centers, museums, hospitals, or emergency operations centers).

4.5.5.2 Floodplains in the TVA Region

In the TVA region, floodplains are associated with reservoirs, streams, ponds, and sinkholes. Power generation facilities of any type, as well as electric transmission lines, could be proposed by TVA or outside entities anywhere in the TVA region.

Floodplains are mapped under the Federal Emergency Management Agency National Flood Insurance Program (NFIP). Through their floodplain ordinances, counties and municipalities ensure that development within the floodplain complies with the NFIP.

In addition, development across, along, or in the Tennessee River and its tributaries is also subject to the requirements of Section 26a of the TVA Act. Activities proposed within Section 26a jurisdiction and/or in places where TVA owns property or property rights would be subject to review under E.O. 11988 in connection with TVA's Section 26a or land use approvals, or both.

4.5.6 Parks, Managed Areas and Ecologically Significant Sites

4.5.6.1 Parks and Managed Areas in the TVA Region

Numerous areas across the TVA region are recognized and, in many cases, managed for their recreational, biological, historic and scenic resources. These areas are owned by 1) federal and state agencies 2) local governments 3) non-governmental organizations such as the Nature Conservancy 4) regional land trusts and private corporations and 5) private individuals.

Parks, managed areas and ecologically significant sites are typically managed for one or more of the following objectives:

- Recreation areas- managed for outdoor recreation or open space. Examples include national, state and local parks and recreation areas, reservoirs (TVA and other), picnic and camping areas; trails and greenways, and TVA small wild areas.
- Species/Habitat Protection- places with endangered or threatened plants or animals, unique natural habitats, or habitats for valued fish or wildlife populations. Examples include national and state wildlife refuges, mussel sanctuaries, TVA habitat protection areas and nature preserves.
- Resource Production/Harvest- lands managed for production of forest products, hunting and fishing. Examples include national and state forests, state game lands and wildlife management areas and national and state fish hatcheries.
- Scientific/Educational Resources- lands protected for scientific research and education. Examples include biosphere reserves, research natural areas, environmental education areas, TVA ecological study areas and federal research parks.
- Historic Resources- lands with significant historic resources. Examples include national

battlefields and military parks, state historic sites and state archeological areas.

- Scenic Resources- areas with exceptional scenic qualities or views. Examples include national and state scenic trails, scenic areas, wild and scenic rivers and wilderness areas.
- Agricultural Resources- lands with significant local agricultural production and open space value, often in areas where suburban development is increasing. Examples include working family farms protected by conservation easements.

Numerous parks, managed areas and ecologically significant sites occur throughout the TVA service area in all physiographic regions, but are mostly concentrated in the Blue Ridge and Mississippi Alluvial Plain physiographic regions. Individual ecologically significant areas vary in size from a few acres to thousands of acres. Many areas cross state boundaries or are managed cooperatively by multiple agencies.

Parks, managed areas, and ecologically significant sites occur on or very near many TVA generating plant reservations, including the Allen, Colbert, Gallatin, Kingston, and Shawnee plants. This is especially the case at hydroelectric plants, where portions of the original dam reservations and reservoir lands have been developed into state and local parks. TVA transmission line rights-of-way cross eleven National Park Service (NPS) units, nine National Forests, six National Wildlife Refuges, and numerous state wildlife management areas, state parks, and local parks (TVA 2018h).

4.5.6.2 Parks and Managed Areas at Facilities Identified for Potential Future Retirements

Parks, managed areas, and ecologically significant sites on and within a 1-mile radius of the eight generating plants considered for full or partial retirement are described in this subsection.

Cumberland Fossil Plant

A boat ramp with a capacity of approximately 15 vehicles/trailers is located on plant property. The ramp is located at RM 102.8L. The cooling water discharge attracts boat fishing and some bank fishing may also occur in this area.

Gallatin Fossil Plant and Combustion Turbine Plant

There are several managed areas on Gallatin Fossil Plant property. Most of the Gallatin reservation is designated as the Gallatin Steam Plant WMA. This WMA is managed by Tennessee Wildlife Resources Agency (TWRA) for hunting within specified hunting zones. Only deer and turkey can be hunted, and only with archery equipment. A special permit issued by TWRA is required to hunt on the WMA. About 229 acres of the Gallatin reservation and WMA are open to hunting. The ash impoundments, and to a lesser extent the stilling ponds, are used by shorebirds during migration and by waterfowl throughout much of the year, but especially during the winter.

The Old Hickory State WMA is managed by TWRA for small and large game, including waterfowl. It is located along the shoreline of the reservoir. The Old Hickory State WMA is to the east, adjacent to an approved onsite landfill. Portions of the Old Hickory WMA are located within the Gallatin property boundary, primarily along the shoreline. A boat ramp providing lake access is located on the eastern side of the Gallatin property off Steam Plant Road. In addition to hunting and fishing, these areas also provide limited public opportunities for watching wildlife, especially shorebirds, waterfowl, and wading birds.

There is a small boat ramp on the eastern edge of the plant property (RM 244.7R). Ramp parking capacity is limited to about 3 vehicles with boat trailers. Boat fishing occurs in the vicinity of the plant's water discharge area.

There are no parks, managed areas, or ecologically significant sites on the Gallatin CT Plant property.

Kingston Fossil Plant

There is a boat ramp near the cooling water discharge channel on the plant site that is accessible to the public. This ramp has a capacity of 15 vehicles/trailers and is located at CRM 2.5R. Bank fishing may also occur in the open space area adjacent to the ramp.

Shawnee Fossil Plant

There is one managed area on the Shawnee property. The Bayou Creek Ridge TVA Habitat Protection Area is one of the finest examples of a high-quality old-growth, mesic bottomland forest remaining in Kentucky. The largest eastern cottonwood tree in Kentucky is on the tract, which is dominated by white oak, northern red oak, tupelo, and swamp hickory.

Portions of the Western Kentucky Wildlife Management Area (WKWMA) are on the southwest side of Shawnee property. The WKWMA extends south from Shawnee and surrounds the Paducah Gaseous Diffusion Plant. The WKWMA consists of lands leased to the Kentucky Department of Fish and Wildlife Resources (KDFWR). Public activities in this area include hunting, horseback riding, hiking, and biking (KDFWR 2018a). This WMA also has a fishing pier and a boat ramp (KDFWR 2018b). The WKWMA allows hunting during the appropriate seasons and has a public skeet-shooting range (KDFWR 2018c).

Allen Combustion Turbine Plant

There are no parks, managed areas, or ecologically significant sites on the Allen CT Plant property. Such areas in the surrounding area are described in TVA (2014b).

Colbert Combustion Turbine Plant

Cane Creek Recreation Area is located near the mouth of Cane Creek at TRM 244L on the Colbert reservation, close to the Colbert CT site. Facilities include a boat ramp and picnic tables. The ramp has a capacity of 20 vehicles/trailers.

Johnsonville Combustion Turbine Plant

There are no parks, managed areas, or ecologically significant sites on the Johnsonville CT Plant property. Such areas elsewhere on or in the vicinity of the larger Johnsonville reservation are described in TVA (2018g).

4.5.7 Land Use

This section describes the range of land uses in the TVA region.

4.5.7.1 Regulatory Framework for Land Use

Use of federal lands is generally regulated by the acts establishing the various agencies as well as other laws. For example, the TVA Act gives TVA the authority to regulate the use of lands it manages as well as development across, along, or in the Tennessee River or any of its tributaries. The Farmland Protection Policy Act of 1981 (7 U.S.C. 4201 *et seq.*) recognizes the importance of prime farmland. Various state laws and local ordinances regulate land use, although a large portion of land in the TVA region is not subject to local zoning ordinances.

4.5.7.2 Major Land Uses in the TVA Region

Major land uses in the TVA region include forestry, agriculture and urban/suburban/industrial (USDA 2018b). About 3 percent of the TVA region is water, primarily lakes and rivers. This proportion has increased slightly since 1982, primarily due to the construction of small lakes and ponds. About 5.5 percent of the land area is in federal ownership; this proportion has also increased slightly since 1982. The major components of federal land are national parks, national forests, national wildlife refuges, and TVA reservoir lands. Of the remaining non-federal land area, about 12 percent is classified as developed and 88 percent as rural (USDA 2013). Rural undeveloped lands include farmlands (28 percent of the rural area) and forestland (about 60 percent of the rural area). The greatest change since 1982 has been in developed land, which almost doubled in area due to high rates of urban and suburban growth in much of the TVA region. The rate of land development was high during the 1990s and early 2000s and slowed in the late 2000s. More recent data for Tennessee shows that total developed land has grown by one percent between 2012 and 2015 (USDA 2018).

Approximately 51 percent of the TVA region is forested (Homer et al. 2015). Forestland increased in area through much of the 20th century; this rate of increase has slowed and/or reversed in parts of the TVA region in recent years (Conner and Hartsell 2002, USDA 2015). Forestland is predicted to decrease between 1997 and 2060 in the majority of counties in the TVA region, with several counties in the vicinity of Memphis, Nashville, Huntsville, Chattanooga, Knoxville and the

Tri-Cities area of Tennessee predicted to lose more than 25 percent of forest area (Wear and Greis 2013). Loss of forest area within the TVA region is primarily a result of increasing urbanization and development. Most of the TVA region in Mississippi, as well as some rural parts of western Tennessee and Kentucky are predicted to show little change, or in some scenarios, small increases in forestland by 2060 (Wear and Greis 2013).

Agriculture – Agriculture is a major land use and industry in the TVA region. In 2012, 41 percent of the land area in the TVA region was farmland that comprised 151,000 individual farms (USDA 2014). Average farm size was 160 acres, a 6.3 percent increase since 1982. The proportion of land in farms has decreased by 4.2 percent since 1982; since 2007, the decrease was 0.3 percent. Over the 1982–2012 period, the number of farms decreased by 14.7 percent while the average size of farms increased by 6.3 percent. Farm size in the TVA region varies considerably with numerous small farms and a smaller number of large farms. Statewide data for states within the TVA region shows a decline in the number of farms between 1997 and 2017. Between 2012 and 2017, statewide data for Tennessee and Georgia show a small increase in the number of farms (USDA 2019). The number of small farms (between 1 and 9 acres) in Tennessee has increased between 2012 and 2017, following a national trend (USDA 2019). Average farm sizes range between 155 and 326 acres for states within the TVA region and have generally increased in size between 1997 and 2017.

For the state of Tennessee, cropland and pastureland comprise 17 and 16 percent, respectively, of rural, non-federal land in 2017 (USDA 2018b). Both cropland and pastureland have decreased in area since 1982; however, the rate of cropland and pastureland loss in Tennessee has declined between 2012 and 2015 (USDA 2018b). Farms in the TVA region produce a large variety of products that vary across the region. While the proportion of land in farms is greatest in Mississippi, southern Kentucky and central and western Tennessee, the highest farm income occurs in northern Alabama and Georgia (EPRI and TVA 2009). Compared to farms in the southern and western portions of the TVA region, farms in the eastern and northern portions tend to be smaller and receive a higher proportion of their income from livestock sales than from crop sales. Region-wide, the major crop items by land area are forage crops (hay and crops grown for silage), soy, corn and cotton. The major farm commodities by sales are cattle and calves, poultry and eggs, grains and beans, cotton and nursery products (USDA 2014).

Although the area of irrigated farmland is small (5.7 percent of farmland), it quadrupled between 1982 and 2012 to 1,271,043 acres (USDA 2014). Much of this increase was due to individual farmers increasing the acreage they irrigated, as the number of irrigated farms slightly more than doubled during this period. The area of irrigated farmland is likely to increase in the future as temperature and precipitation patterns become less predictable or if drought conditions become more prevalent (EPRI and TVA 2009). Between 2012 and 2017, statewide data from Arkansas, Kentucky, Tennessee, North Carolina, and Virginia shows minor decreases in the percentage of farms using irrigation; however, in most cases, the acres of irrigated farmland has increased (USDA 2019).

Crops grown specifically to produce biomass for use as fuels (dedicated energy crops) are a potentially important commodity in the TVA region. In 2002, the Census of Agriculture began recording information on short rotation woody crops, which grow from seed to harvestable tree in 10 years or less. These crops have traditionally been used by the forest products industry for producing pulp or engineered wood products and are also a potential source of biomass for power generation. In 2012, there were 117 farms in the TVA region growing at least 2,704 acres of short rotation woody crops, a large decrease from the 286 farms in 2007. Between 2012 and 2017, statewide data for states within the TVA region shows small increases in the number of farms and acres producing short rotation woody crops, with the exception of North Carolina, Tennessee, and Virginia, which show decreases in this type of crop production (USDA 2019).

In 2012, the Census of Agriculture began recording information on the cultivation of switchgrass, a bioenergy crop that can be directly used as fuel and for producing ethanol. In 2012, it was grown by 18 farms in the TVA region that harvested at least 1,800 acres (USDA 2014). Most of these farms were located in eastern Tennessee and grew switchgrass as part of research studies at the University of Tennessee. Between 2012 and 2017, the number of farms growing switchgrass in Tennessee has decreased from 18 to 3 (USDA 2019).

Three facilities in the TVA region produce ethanol from corn, primarily for use as biofuels with a total production capacity of 263 million gallons per year (Renewable Fuels Association 2018). A large proportion of their corn feedstock is likely grown within the TVA region. Corn grown in the TVA region is also likely used by ethanol producers elsewhere.

<u>Prime Farmland</u> - Prime farmland is land that has the best combination of physical and chemical characteristics for producing food, feed, forage, fiber and oilseed crops, and is available for these uses (USDA 2018b). Prime farmland has the combination of soil properties, growing season, and moisture supply needed to produce sustained high yields of crops in an economic manner if it is treated and managed according to acceptable farming methods. Prime farmland is designated independently of current land use, but it cannot be areas of water, urban, or built-up land.

Approximately 22 percent[2] of the TVA region is classified as prime farmland (NRCS 2018). An additional 4 percent of the TVA region would be classified as prime farmland if drained or protected from flooding.

<u>Forest Management</u> - About 97 percent of the forestland in the TVA region is classified as timberland (USFS 2014), forestland that is producing or capable of producing more than 20 cubic feet of merchantable wood per acre per year and is not withdrawn from timber harvesting by law. About 14 percent of timberland is in public ownership, primarily in national forests. About 20 percent is owned by corporations and the remainder is in non-corporate private ownership. While the majority of corporate timberlands have historically been owned by forest industries, this proportion has decreased in recent years as many forest product companies have sold timberlands due to changing market conditions.

4.5.7.3 Prime Farmlands and Forest Management at Facilities Identified for Potential Future Retirements

The potential decommissioning and deactivation of coal and CT facilities as described in Section 3.2.3. is not expected to affect prime farmland and forest management at each facility. When plant retirement and future land use decisions are made, site-specific analyses will consider the potential impacts on land use, prime farmland, and forest management resources.

4.5.8 Cultural Resources

Cultural resources include prehistoric and historic archaeological sites, districts, buildings, structures, and objects, as well as locations of important historic events that lack material evidence of those events. Cultural resources are considered historic properties if included in, or considered eligible for inclusion in, the National Register of Historic Places (NRHP) maintained by the NPS. The eligibility of a resource for inclusion in the NRHP is based on the Secretary of the Interior's criteria for evaluation (36 CFR § 60.4), which state that significant cultural resources possess integrity of location, design, setting, materials, workmanship, feeling and association, and:

1. are associated with important historical events; or
2. are associated with the lives of significant historic persons; or
3. embody distinctive characteristics of a type, period, or method of construction or represent the work of a master, or have high artistic value; or
4. have yielded or may yield information (data) important in history or prehistory.

[2] This estimate does not include about 20 counties for which soil survey information is incomplete or not available.

4.5.8.1 Regulatory Framework for Cultural Resources

Because of their importance to the Nation's heritage, historic properties are protected by several laws. Federal agencies, including TVA, have a statutory obligation to facilitate the preservation of historic properties, stemming primarily from the National Historic Preservation Act (NHPA; 16 U.S.C. §§ 470 *et seq*.). Other relevant laws include the Archaeological and Historic Preservation Act (16 U.S.C. §§ 469-469c), Archaeological Resources Protection Act (16 U.S.C. §§ 470aa-470mm) and the Native American Graves Protection and Repatriation Act (25 U.S.C. §§ 3001-3013).

Section 106 of the NHPA requires federal agencies to consider the potential effects of their actions on historic properties and to allow the Advisory Council on Historic Preservation an opportunity to comment on the action. Section 106 involves four steps: 1) initiate the process; 2) identify historic properties; 3) assess adverse effects; and 4) resolve adverse effects. This process is carried out in consultation with the State Historic Preservation Officer (SHPO) of the state in which the action would occur and with any other interested consulting parties, including federally recognized Indian tribes.

Section 110 of the NHPA sets out the broad historic preservation responsibilities of federal agencies and is intended to ensure that historic preservation is fully integrated into their ongoing programs. Federal agencies are responsible for identifying and protecting historic properties and avoiding unnecessary damage to them. Section 110 also charges each Federal agency with the affirmative responsibility for considering projects and programs that further the purposes of the NHPA, and it declares that the costs of preservation activities are eligible project costs in all undertakings conducted or assisted by a federal agency.

4.5.8.2 Archaeological Resources

Human occupation in the TVA region began at the end of the Ice Age with the Paleo-Indian Period (13,500 – 11,000 years before present, or “B.P.”). In the Tennessee Valley, prehistoric archaeological chronology is generally broken into four broad time periods: following the Paleo-Indian Period are the Archaic (11,000 – 3,000 B.P.), Woodland (3,000 – 1,100 B.P.), and Mississippian (1,100 – 500 B.P.) periods. Archaeological sites from all these periods, as well as from the more recent historic period, are very numerous throughout the TVA region. They occur on a variety of landforms and in a variety of environmental contexts. Sites are rarely found on steep slopes, with the exception of rockshelters, which have been used throughout the prehistoric and historic periods and often contain artifacts and features with value to archaeology and history. Areas affected by construction, mining, civil works projects and highways, for example, tend to lack significant archaeological resources due to modern ground disturbing activities.

The most reliable information about the locations of archaeological sites is produced during Phase I archaeological surveys conducted for compliance with Section 106. Numerous surveys have been conducted along reservoir shorelines, within reservoirs, and on power plant reservations. However, large areas remain that have not been surveyed. Some TVA transmission line and many highway corridors have also been surveyed. But outside of TVA reservoirs and power plant reservations, the density of surveys is low and relatively little is known about archaeological site distributions.

The earliest documentation of archaeological research in the region dates back to the 19th century when entities such as the Smithsonian Institute and individuals such as Cyrus Thomas undertook some of the first archaeological excavations in America to document the history of Native Americans (Guthe 1952). TVA was a pioneer in conducting archaeological investigations during the construction of its dams and reservoirs in the 1930s and early 1940s (Olinger and Howard 2009). Since then, TVA has conducted numerous archaeological surveys associated with permitting actions, power plants, and transmission system construction and maintenance. These surveys, as well as other off-reservoir projects, have identified more than 2,000 sites, including over 250 within or in the immediate vicinity of TVA transmission line rights-of-way. A large proportion of these sites have not been evaluated for NRHP eligibility. The number of eligible or potentially eligible for listing on the NRHP is unknown.

Archaeological survey coverage and documentation in the region varies by state. Each state keeps records of archaeological resources in different formats. While digitization of this data is under way, no consistent database is available for determining the number of archaeological sites within the TVA region. Survey coverage on private land has been inconsistent and is largely project-based rather than focusing on high-probability areas, so data is unlikely to be representative of the total population of archaeological sites. Based on a search through TVA's data and reports of archaeological surveys on reservoirs, TVA estimates that over 11,000 archaeological sites have been recorded on TVA reservoir lands, including submerged lands. Significant archaeological excavations have occurred as a result of TVA and other Federal projects and have yielded impressive information regarding the prehistoric and historic occupation of the Southeastern U.S. Notable recent excavations and related projects in the region include those associated with the Townsend, Tennessee highway expansion; Shiloh Mound on the Tennessee River in Hardin County, Tennessee; the Ravensford site in Swain County, North Carolina; and documentation of prehistoric cave art in Alabama and Tennessee.

4.5.8.3 Historic Structures

Historic architectural resources are found throughout the TVA region and can include houses, barns and public buildings. Many historic structures in the region have been either determined eligible for listing or have been listed in the NRHP. However, historic architectural surveys have been conducted in only a fraction of the land area within the region.

Over 5,000 historic structures have been inventoried in the vicinity of TVA reservoirs and power system facilities. Of those evaluated for NRHP eligibility, at least 85 are included in the NRHP and about 250 are considered eligible or potentially eligible for listing.

TVA power system facilities listed in the NRHP prior to 2016 include the Ocoee 1, Ocoee 2, Great Falls, and Wilson dams and hydroelectric plants. Wilson Dam is also listed as a National Historic Landmark.

Shawnee Fossil Plant was listed in the NRHP in 2016.It generates electricity through coal-fired, steam-generating furnaces that powered a series of ten turbo-generator units. The first unit at the plant began operation in 1953 and the final unit came online in 1956. The NRHP boundary contains 684 acres with a total of 33 resources. Nineteen resources are considered contributing resources, including the powerhouse, which anchors the historic district. The remaining contributing resources are original support buildings and structures that facilitate the transfer of coal, water, and the resultant electricity through the facility. Smaller storage buildings and maintenance facilities which date to the original construction of the plant are also considered contributing. Fourteen resources were erected after the close of the Period of Significance (1965) and are considered noncontributing (National Park Service 2016).

In 2017, as part of a multiple property submission evaluating the TVA hydroelectric system, 22 additional hydroelectric projects were listed in the NRHP (National Park Service 2017). These projects are Chickamauga, Douglas, Fort Loudoun, Nottely, Kentucky, Cherokee, Hiwassee, Chatuge, Apalachia, Fontana, Watauga, Melton Hill, Tellico, Nickajack, Ocoee No. 3, Watts Bar, Boone, Fort Patrick Henry, Tims Ford, Normandy, Pickwick Landing, and South Holston. The Blue Ridge, Norris, and Guntersville dams have been determined in consultation with SHPOs to be eligible or potentially eligible for the NRHP.

Based on a TVA-wide inventory of facilities, it is TVA's opinion that Browns Ferry Nuclear Plant is eligible for listing in the NRHP, but TVA has not consulted with the SHPO on its eligibility. The various SHPOs have agreed with TVA that the Paradise, Allen (now retired), Cumberland, Kingston and Gallatin Fossil Plants in Tennessee are not eligible.

Allen CT Plant, located southwest of Memphis, Tennessee, was completed in 1972. Colbert Combustion Turbine Plant, located in Tuscumbia, Alabama, was completed in 1972. Construction of the Gallatin Combustion Turbine Plant, located adjacent to the Gallatin Fossil Plant was begun in 1975 and completed in 2000. Johnsonville Combustion Turbine

Plant, was initially completed in 1975, and four more CT units were added in 2000. These three plants have not yet reached the 50-year mark to be eligible for survey and assessment, and they likely would not be eligible for the NRHP under Criteria Consideration G (properties that have achieved significance within the last 50 years).

The switch houses at several TVA substations are also likely eligible for listing, and some of the oldest transmission lines are potentially eligible for listing.

4.5.8.4 Traditional Cultural Properties

The TVA region is a diverse cultural landscape that held special meaning to its past inhabitants and to their descendants. Some of these places can be considered Traditional Cultural Properties (TCP). A TCP is defined as a property that is eligible for inclusion on the NRHP because of its association with cultural practices or beliefs of a living community that (a) are rooted in that community's history, and (b) are important in maintaining the continuing cultural identity of the community (Parker and King 1998). Similarly, a cultural landscape is defined as "a geographic area, including both cultural and natural resources and the wildlife or domestic animals therein, associated with a historic event, activity, or person or exhibiting other cultural or aesthetic values" (Birnbaum 1994). TVA does not make public sensitive information regarding the location or other information regarding sacred sites or TCPs identified by consulting tribes. Some examples of TCPs within the study area include mound sites, segments of the Trail of Tears, and stacked stone features. The Trail of Tears consisted of many routes and sub-routes that were traveled by Native Americans during their removal from their ancestral homelands. Segments of the Trail of Tears cross TVA transmission lines at approximately 278 locations (TVA 2018h). Stacked stone features often appear as single or a group of cylindrically stacked limestone. The origin and purpose of these stone features is uncertain, but a resolution passed by the United South and Eastern Tribes, Inc. (USET), in 2007, recommended that all federal agencies involved in the Section 106 process consider stacked stone features that cannot be conclusively linked to a historic origin to be a TCP under NRHP Criterion A (USET 2007).

4.6 Availability of Renewable Energy Resources

The alternative strategies being evaluated include the potential for increased reliance on renewable generating resources. TVA includes all renewable resources in its definition of renewable energy, including hydroelectric generation. This assessment of the availability of renewable resources does not include TVA's existing hydroelectric facilities and considers renewable resources in the context of many state renewable portfolio standards to include solar, wind, small hydroelectric (see Volume I Section 5.2.2) and upgrades to existing large hydroelectric plants, biomass (including biogas), and geothermal energy. Geothermal generation using currently available and near-term emerging technologies is not considered further because of the lack of a developable resource in the TVA region (Augustine 2011).

Following is an assessment of the availability of potential renewable resources for generating electricity in and near the TVA region.

4.6.1 Wind Energy Potential

The suitability of the wind resource in an area for generating electricity is typically described in terms of wind power classes ranging from Class 1, the lowest, to Class 7, the highest (Elliott et al. 1986). The seven classes are defined by their average wind power density (in units of watts/m^2) or equivalent average wind speed for a specified height above ground. Areas designated Class 3, corresponding to a windspeed of at least 6.4 meters/second (m/s; 14.3 mph) or greater at a height of 50 meter (m) above ground usually have adequate wind for most commercial wind energy developments.

Early regional assessments of wind energy potential were based on wind turbines with a 50-m hub height (i.e., the height of the rotor hub above ground) and focused on ridgetop sites in the eastern part of the TVA region. Raichle and Carson (2008) presented the results of a detailed wind resource assessment at the 50-m height in the southern Appalachian Mountains. Measured annual wind speeds at nine representative privately owned sites ranged from 4.4 m/s on the Cumberland Plateau in northwest Georgia to 7.3-7.4 m/s on sites in the Blue Ridge Mountains near the Tennessee/North Carolina/Virginia border. Two sites in the Cumberland Mountains and one site in the Blue Ridge Mountains were categorized as Class 3 and two sites in the Blue Ridge Mountains were categorized as Class 4. The Class 3 and Class 4 sites had capacity factors of 28 to 36 percent and an estimated energy output of 2.8 to 3.5 GWh per year for each MW of installed capacity. All sites had significantly less wind during the summer than during the winter and significantly less wind during the day than at night during all seasons. Due to the configuration of ridge tops within this area in relation to prevailing wind directions, potential wind projects would likely be linear in extent and relatively small. These conditions describe the only operating windfarm in the TVA region; this facility (see Section 2.4) is located in the Cumberland Mountains.

More recent wind assessments have shifted from a power class rating to increased focus on wind speed and potential capacity factor, and to higher elevations of 80 m (262 feet) and 100 m (328 feet) above ground, tower heights more representative of recently installed wind turbines (Wiser and Bolinger 2018). This re-evaluation showed an increased potential for wind generation in the western portion of the TVA region (Figure 4-19, Figure 4-20). Based on windspeed and windfarm performance data available at that time, the 2010 Eastern Wind Integration and Transmission Study conducted by the National Renewable Energy Laboratory (NREL 2011) estimated a wind potential of 1,247 MW in the TVA region, with an expected annual energy generation value between 3,500 and 4,000 GWh. The DOE Wind Energy Technologies Office currently lists Tennessee's potential wind capacity at 116,000 MWs at 80 meters (USDOE 2018).

Current 80-meter and 100-meter wind speed maps also show the greater potential for wind energy development in the upper Midwest and the Great Plains, where TVA currently acquires most of its wind energy (see Section 2.4). The acquisition of additional wind energy from these areas, as well as from within the TVA PSA, is among the energy resource options considered in this IRP (see Volume I Section 5.2.2).

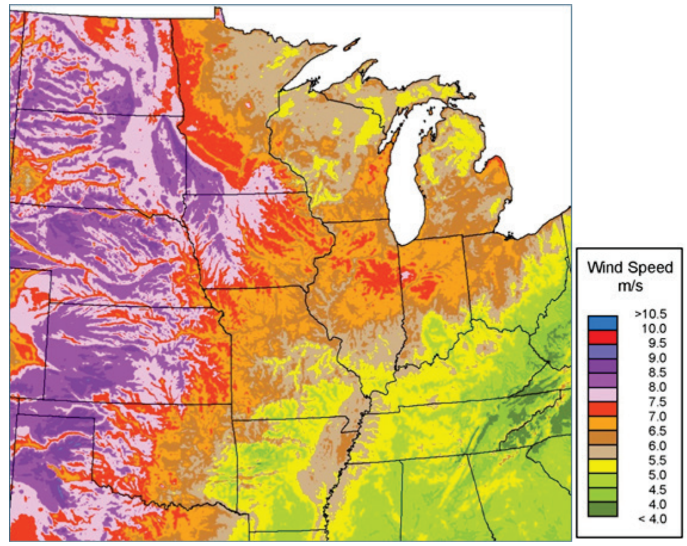


Figure 4-19: Wind resource potential of the eastern and central U.S. at 80 m above ground. Source: Adapted from NREL (2011).

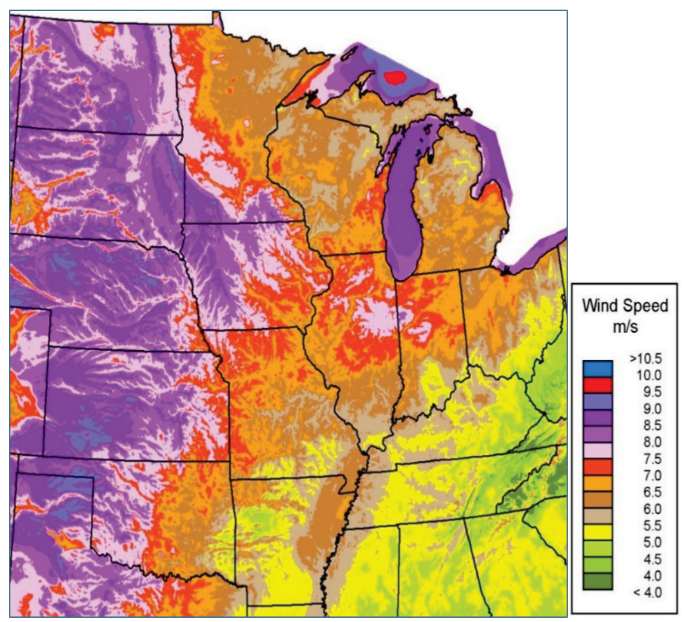


Figure 4-20: Wind resource potential of the eastern and central U.S. at 100 m above ground. Source: Adapted from NREL (2013).

4.6.2 Solar Energy Potential

Solar energy resource potential is a function of average daily solar insolation (see Section 4.3) and is expressed as kWh/m^2/day (available energy (kWh) per unit area (square meters, m^2) per day). Solar resource measurements are reported as either direct normal radiation (no diffuse light) or total radiation (a combination of direct and diffuse light). Diffuse or scattered light, which is common in eastern North America, is caused by cloud cover, humidity, or particulates in the air. Solar PV panels are capable of generating with both direct and diffuse light sources. These measurements do not incorporate losses from converting PV-generated energy (direct current) to alternating current or the reduced efficiency of some PV panels at high temperatures. Figure 4-21 shows the regional solar generation potential for flat plate PV panels; all current and foreseeable solar generation in the TVA region is PV as concentrated solar technologies are not economically feasible due to high amounts of diffuse light. The PV potential assumes flat-plate panels are oriented to the south and installed at an angle from horizontal equal to the latitude of the location. More detailed, state-specific maps are available at NREL (2017). The TVA region has between 4.1 and 4.8 kWh/m^2/day of available solar insolation for flat-plate PV panels, with the potential greatest in the southwestern portion of the region and decreasing towards the northeast. Most of the larger (i.e., >1 MW capacity) utility-scale solar facilities operating, under construction, or proposed in the TVA region are in areas with between 4.5 and 4.8 kWh/m^2/day of insolation.

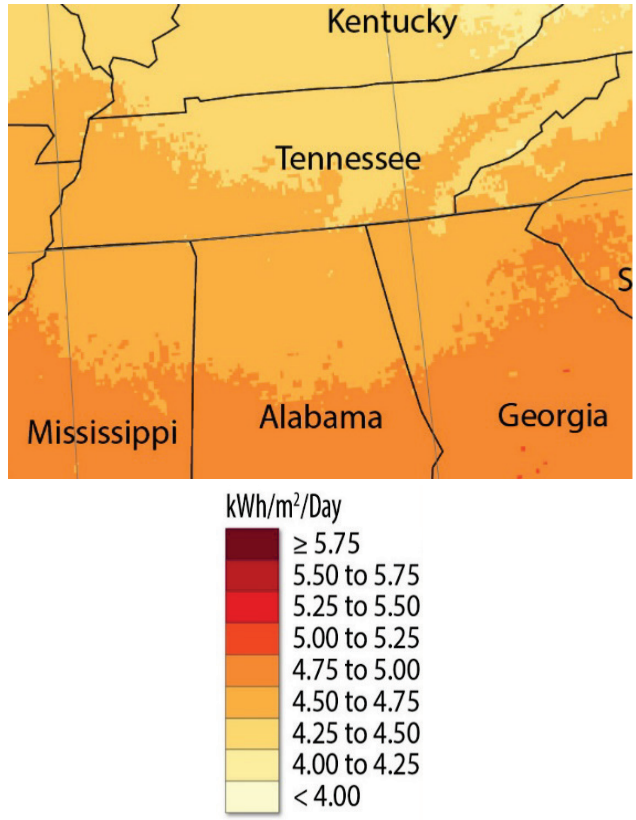


Figure 4-21: Solar photovoltaic generation potential in the TVA region. Source: Adapted from NREL (2018).

Because PV is the most abundant and easily deployable renewable resource, it is difficult to accurately assess a feasible potential total value for the TVA region. Denholm and Margolis (2007) studied the land area of each state necessary to meet the state's entire electrical load by PV generation. To determine the annual PV generation per unit of module power, hourly insolation values were used for 2003–2005 from 216 sites in the lower 48 states. Net PV energy density (the annual energy produced per unit of land area) for each state was calculated using the weighted average of three distinctive PV technologies (polycrystalline silicon, monocrystalline silicon and thin film) which vary in their generating efficiency. Various panel orientations including fixed positions and 1- and 2-axis tracking were included. Tracking panels (i.e., on mounts that pivot to follow the sun) produce more energy per unit area than fixed panels although their initial installation costs are higher.

The resulting state-level solar electric footprint shows that achieving all of the electrical load is theoretically possible (Figure 4-22). Because PV generation is variable depending on time of day and cloud cover, a scaling factor of 1.23 was applied to compensate for losses associated with back-up battery storage. Generating all of the region's electricity by PV is not a practical goal unless very inexpensive energy storage devices become widely available. Therefore, the conclusion of this analysis is not to assign a specific theoretical solar potential but to point out that the solar resource in the TVA region is plentiful. Relative to other states, the seven TVA region states ranked between 14th (Alabama) and 29th (Kentucky) in PV energy density (Denholm and Margolis 2007). Mississippi ranked 18th and Tennessee ranked 27th.

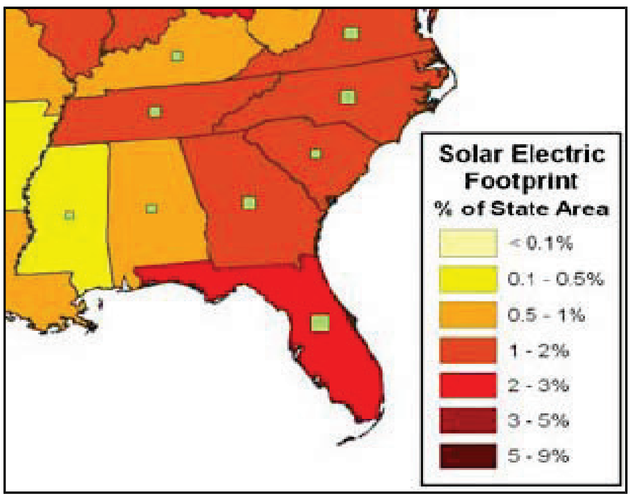


Figure 4-22: Solar electric footprint of southeastern states (2003-2005). Source: Adapted from Denholm and Margolis (2007).

Gagnon et al. (2016) examined the technical potential of PV systems installed on rooftops. Technical potential includes the number and area of rooftops (dependent in large part on population density), geographic location, system, topographic, and land-use constraints, and system performance, but not projected costs. Across most of the TVA region, between 80 and 90 percent of small buildings (e.g., single family homes) were technically suitable for PV systems. For the TVA region states, the proportion of 2013 electricity sales that could be provided by small building, rooftop PV ranged from a low of 16.0 percent for Kentucky to 23.5 percent for North Carolina. With the inclusion of rooftop PV on medium and large buildings, the proportion of 2013 electricity sales that could be provided by rooftop solar ranged from 25.2 percent for Kentucky to 33.8 percent in Georgia.

4.6.3 Hydroelectric Energy Potential

Hydroelectric generation (excluding the Raccoon Mountain pumped storage facility) presently accounts for about 10 percent of TVA's generating capacity (see Section 2.3.5). TVA has gradually increased this capacity by upgrading the hydro turbines and associated equipment. To date, this program has increased TVA's hydro generating capacity by about 15 percent. This capacity increase would qualify as renewable energy under most renewable portfolio standards.

Hall et al. (2006) surveyed the potential for development of low power (<2 MW) and small hydro (between 2 and 60 MW) projects in ways that would not require the stream to be obstructed by a dam, such as partial stream diversion through a penstock to a conventional turbine and unconventional ultra-low head and in-stream kinetic energy turbines (see Volume I Section 5.2.2.5). Feasibility criteria, in addition to the water energy resource, included site accessibility, load or transmission proximity, and land use or environmental constraints that would inhibit development. The study identified numerous small hydro and low power sites with an estimated total feasible capacity of 1,770 MW. The study did not evaluate the hydrokinetic potential of sites with little or no elevation difference and thus likely underestimates this potential resource.

Hadjerioua et al. (2012) surveyed the nation-wide potential for hydroelectric generation of at least 1 MW capacity at existing dams lacking hydroelectric generators. The potential of each dam was determined from regional precipitation and runoff, stream flow data and characteristics of the individual dams. Within the Tennessee River watershed, the survey identified a potential capacity of 38.5 MW and potential generation of 144 GWh/year. This total includes six TVA dams with a total potential capacity of 27.5 MW and potential generation of 103 GWh/year. Non-power dams elsewhere in the TVA PSA have a potential capacity of about 135 MW; most of these dams are in the Tennessee-Tombigbee, Green River (Kentucky), Tallahatchie River and Green River (Mississippi) drainages and are operated by the USACE.

A second recent study by Kao et al. (2014) surveyed the nationwide potential for hydroelectric generation on undeveloped (i.e., without dams) stream reaches. The total potential capacity in the Tennessee River watershed, assuming the new hydroelectric projects are operated with run-of-river flows, was 1,363 MW and the potential generation was about 8,000 GWh/year. The potential capacity of other watersheds within the TVA PSA is less than that of the Tennessee River watershed. The incorporation of environmental attributes such as protected land designation (e.g., National Parks, Wild and Scenic Rivers, wilderness areas), presence of species listed under the ESA, and recreational uses substantially reduces this potential.

4.6.4 Biomass Fuels Potential

NREL (Milbrandt 2005, NREL 2014) analyzed geographic patterns in the availability of biomass suitable for power generation. These analyses included the solid biomass resources of crop residues, forest residues, primary and secondary mill residues, urban wood waste and dedicated energy crops, and biogas. Biogas is methane produced by the biological breakdown of organic matter in the absence of oxygen. Feedstocks for biogas can come from a variety of sources, including landfills, livestock and poultry manure management, wastewater treatment, and various other industrial and commercial organic wastes and byproducts. If not used for generating power, much biogas would otherwise be burned in open flares. Its use for generating power can replace fossil fuels, therefore resulting in a net reduction in GHG emissions. TVA currently purchases power generated from methane at several landfills across the region (see Section 2.4).

Many TVA region counties had a total biomass resource potential of over 100,000 tons/year; these counties are concentrated in Kentucky, western Tennessee, Mississippi and Alabama (Figure 4-23, Figure 4-24). The total potential biomass resource for the TVA region was estimated in 2010 to be approximately 36 million tons/year. This equates to a potential of up to 47,000 GWh[3] of annual biomass energy generation. ‘

The TVA region biomass resource potential for each resource type is shown in Figure 4-25.

[3] Based on assumed heating values for agricultural crops and wood residues of 7,200–8,570 Btu/lb and for methane of 6,400–11,000 Btu/lb, depending on feedstock type. Assumed generating unit heat rates are 13,500 Btu/kWh for crop and wood residues and 12,500 Btu/kWh for methane.

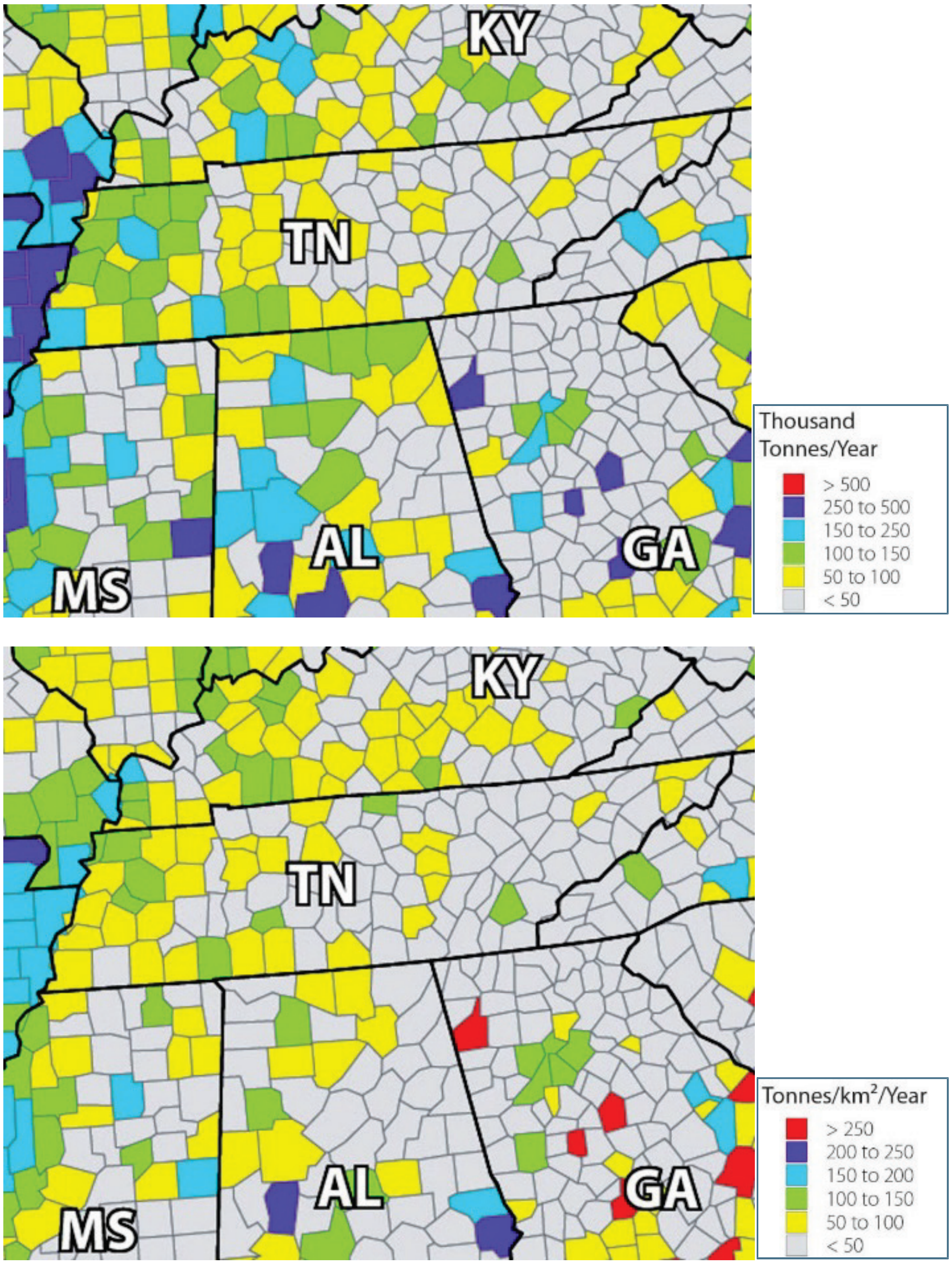


Figure 4-23: Total solid biomass resources in metric tons potentially available in the TVA region by county (top) and per square kilometer by county (bottom). Source: Adapted from NREL (2014).

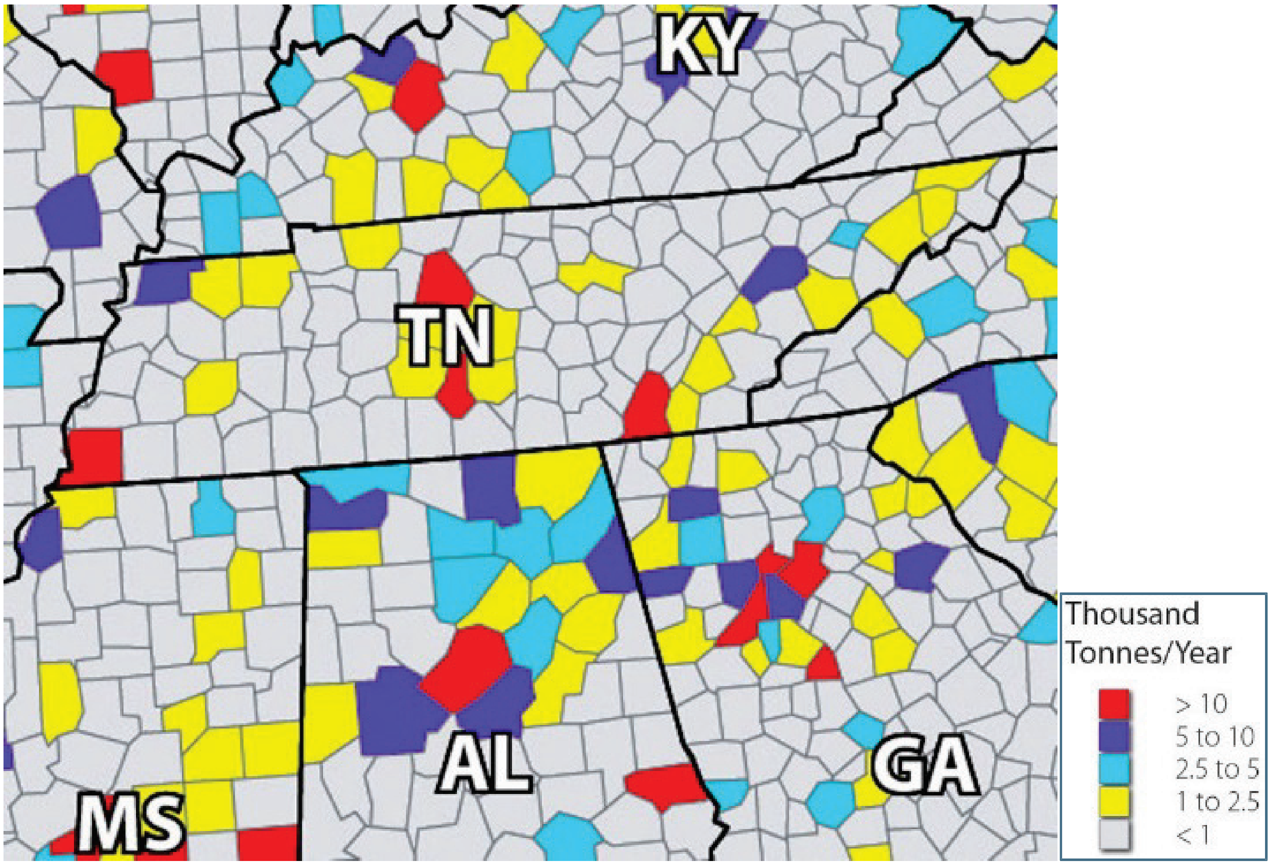


Figure 4-24: Total biogas (methane) resources in metric tons potentially available in the TVA region by county. Source: Adapted from NREL (2014).

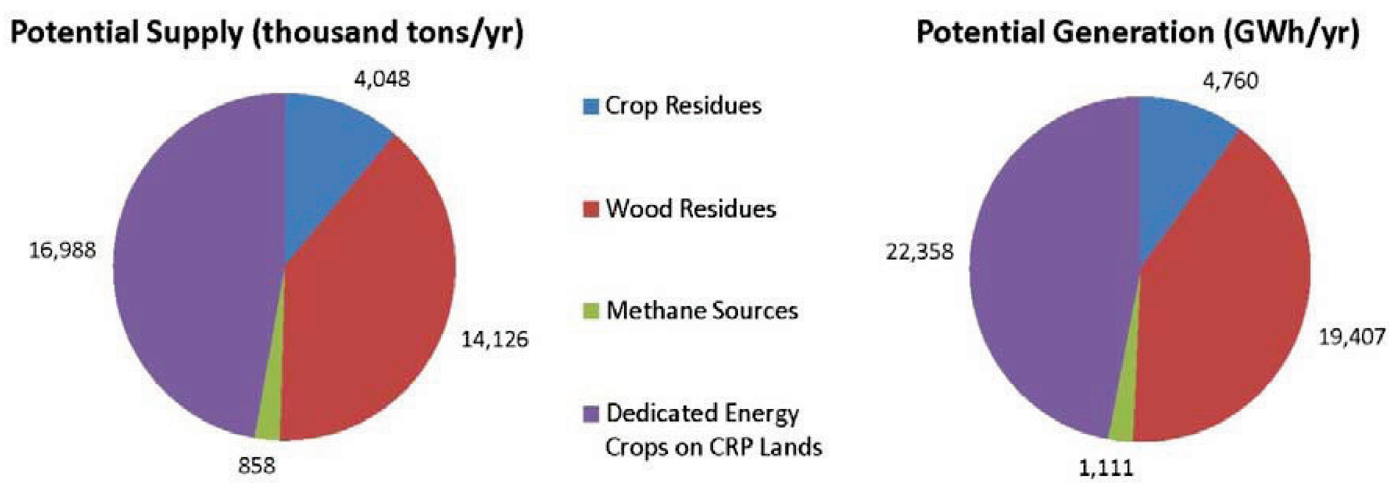


Figure 4-25: TVA region potential biomass resource supply (left) and generation (right). Source: Adapted from Milbrandt (2005) and NREL (2014).

Forest residues consist of logging residues and other removable material left after forest management operations and site conversions, including unused portions of trees cut or killed by logging and left in the woods. Mill residues consist of the coarse and fine wood materials produced by mills processing round wood into primary wood products (primary mill residues) and residues produced by woodworking shops, furniture factories, wood container and pallet mills and wholesale lumberyards (secondary mill residues) (Milbrandt 2005). Crop residues are plant parts that remain after harvest of traditional agricultural crops; the amount available was adjusted to account for the amount left in fields for erosion control and other purposes. Methane sources include landfills, domestic wastewater treatment plants, and emissions from farm animal manure management systems.

Dedicated energy crops are crops grown specifically for use as fuels, either by burning them or converting them to a liquid fuel, such as ethanol, or a solid fuel, such as wood pellets or charcoal. They can include traditional agricultural crops, non-traditional perennial grasses and short rotation woody crops. Traditional agricultural crops grown for fuels include corn, whose kernels are fermented to produce ethanol and soybeans, whose extracted oil can be converted to biodiesel. Sorghum is also a potential fuel feedstock. Non-traditional perennial grasses suitable for use as fuel feedstocks include switchgrass (*Panicum virgatum*) and miscanthus, also known as E-grass (*Miscanthus x giganteum*, a sterile hybrid of *M. sinensis* and *M. sacchariflorus*) (Dale et al. 2010). Short rotation woody crops are woody crops that are harvested at an age of 10 years or less. Trees grown or potentially grown for short rotation woody crops in the TVA region include eastern cottonwood, hybrid poplars, willows, American sycamore, sweetgum and loblolly pine (UT 2008; Dale et al. 2010). Plantations of these trees are typically established from stem cuttings or seedlings. With the exception of loblolly pine, these trees readily re-sprout from the stump after harvesting. As described in Section 4.5.7, the area of short rotation woody crops in the TVA region is small. Milbrandt (2005) analyzed the potential production of dedicated energy crops on Conservation Reserve Program lands, a voluntary program that encourages farmers to address natural resource concerns by removing land from traditional crop production. Growing dedicated energy crops on conservation reserve lands reduces their impact on food production.

The estimate of 36 million potential tons/year does not consider several important factors and may be optimistic. The analysis assumes that all of the biomass is available for use without regard to current ownership and competing markets. Growth in use of biomass will likely result in increased competition for biomass feedstock and reduce the feasibility of some biomass.

TVA has commissioned studies of the biomass potentially available for fueling its coal-fired generating plants. A 1996 study (ORNL 1996) addressed the potential supply of short rotation woody crop and switchgrass biomass grown on crop and pasture lands. The potential supply is greatly influenced by the price paid for biomass, which influences its profitability relative to the profitability of conventional crops. With higher prices, larger amounts of more productive farmland would likely be converted from food production to biomass production, and the western portion of the TVA region has the greatest potential for producing large energy crop supplies.

In a more recent study, Tillman (2004) surveyed the availability of woody biomass for cofiring at eight TVA coal-fired plants (all except Bull Run, Cumberland, and Gallatin) then in operation. Potential sources included producers of primary and secondary mill residues as described above. These sources produced about 433,000 dry tons/year (approximately 7,153,000 Million British Thermal Units (MBtu)/yr) of potential biomass fuels within economical haul distances of TVA coal-fired plants. The most abundant material type was sawdust (about 57 percent of the total) and only about 2 percent of the biomass was not already marketed. At a 2004 price of $1.25–1.50/MBtu, sufficient biomass would be available to support 75–80 MW of generating capacity and the annual generation of 300,000–450,000 MWh of electricity. The availability of woody biomass has likely changed since 2004 because of the closure of some major wood product mills in the region and other forest industry developments.

4.7 Solid and Hazardous Wastes

This section focuses on the solid and hazardous wastes produced by the construction and operation of generating plants and transmission facilities. Wastes typically produced by construction activities include vegetation, demolition debris, oily debris, packing materials, scrap lumber and domestic wastes (garbage). Non-hazardous wastes typically produced by common facility operations include sludge and demineralizers from water treatment plant operations, personal protective equipment, oils and lubricants, spent resins, desiccants, batteries and domestic wastes. In 2016, TVA facilities produced approximately 23,000 tons of non-hazardous solid waste. This quantity decreased to approximately 18,750 tons in 2017. The amount of waste produced at any one facility, however, can vary significantly from year to year due to maintenance, decommissioning, and asset improvement activities. In an effort to reduce waste generation, especially hazardous waste, TVA has incorporated into its procedures waste minimization efforts including reuse and recycling, substitution of less hazardous products and chemical traffic control.

Hazardous, non-radiological wastes typically produced by common facility operations include paint and paint solids, paint thinners, discarded out-of-date chemicals, parts washer liquids, sand blast grit, chemical waste from cleaning operations and broken fluorescent bulbs. The amount of these wastes generated varies with the size and type of facility (Table 4-12). The large increase in tons from coal plants between 2016 and 2017 was due to boiler cleaning at the Paradise Plant. Hazardous wastes, wastes requiring special handling under the Toxic Substances Control Act (TSCA) and universal waste (see explanations below) generated from routine facility operations are generally shipped to Waste Management's Emelle, Alabama, facility for disposal.

Table 4-12: Annual quantities (in tons) of hazardous wastes generated by routine operations at TVA facilities, 2015-2017.

	Type of Facility					
Year	Coal Plant	Nuclear Plant	Hydroelectric Plant	Natural Gas Plant	Other	Total
2015	1.65	3.76	1.42	0.03	0.28	7.14
2016	1.21	1.40	0.14	0.02	0.22	2.99
2017	16.06	1.63	0.57	0.04	0.05	18.35
Annual Average	6.31	2.26	0.71	0.03	0.18	9.49

Hazardous wastes are defined by RCRA to include those that meet the regulatory criteria of ignitability, corrosively, reactivity, or toxicity. They can include such materials as paints, solvents, corrosive liquids and discarded chemicals. Wastes regulated under the TSCA that are typically encountered at TVA sites include polychlorinated biphenyls (PCBs), historically used in insulating fluids in electrical equipment. PCB items are typically shipped to Trans Cycle Industries in Pell City, Alabama, or handled through Clean Harbor's Tucker, Georgia, facility.

Used oil, if not recycled is considered a waste. Used oils include gear oils, greases, mineral oils and an assortment of other petroleum- and synthetic-based oils. The majority of TVA's used oil, approximately 35,000 kilograms, is recycled annually by TVA. Used oil containing 50 or greater parts per million (ppm) PCB is regulated by TSCA and must be disposed of as PCB-contaminated oil.

Universal wastes are a subset of hazardous wastes that are widely available, easily recyclable, and generally pose a relatively low threat. However, these wastes can contain materials that cannot be released into the environment. This classification includes batteries, pesticides, fluorescent bulbs and equipment containing mercury. In 2017, approximately 27.4 tons of universal waste were generated and recycled by TVA.

Coal-fueled generating plants produce large quantities of ash and other coal combustion solid wastes and nuclear plants produce radioactive wastes. These wastes are described in more detail below.

4.7.1 Coal Combustion Solid Wastes

The primary solid wastes produced by coal combustion are fly ash, bottom ash, boiler slag, char, spent bed material and FGD residue. The properties of these wastes (also known as CCRs or coal combustion products) vary with the type of coal plant, the chemical composition of the coal, and other factors. Ash and slag are formed from the noncombustible matter in coal and small amounts of unburned carbon. Fly ash is composed of small, silt- and clay-sized, mostly spherical particles carried out of the boiler by the exhaust gas. Bottom ash is heavier and coarser with a grain size of fine sand to fine gravel and falls to the bottom of the boiler where it is typically collected by a water-filled hopper. Boiler slag, a coarse, black, granular material, is produced in cyclone furnaces when molten ash is cooled in water. Ash and slag are primarily composed of silica (SiO_2), aluminum oxide (Al_2O_3), and iron oxide (Fe_2O_3). Spent bed material is produced in fluidized bed combustion boilers (e.g., the now retired Shawnee Fossil Plant Unit 10).

FGD residue is formed in FGD systems (scrubbers) by the interaction of sulfur in the flue gas with finely ground limestone or slaked lime. TVA's currently operating FGD systems use limestone as the reagent to bond with the sulfur, producing hydrated calcium sulfate ($CaSO_42H_2O$), also known as synthetic gypsum. The recently installed FGD systems at the Gallatin Fossil Plant and on Shawnee Fossil Plant Units 1 and 4 use slaked lime as the reagent and produce calcium sulfite ($CaSO_3$). Unlike the other plants with FGD systems that segregate the ash and FGD residue waste streams, the CCRs at Gallatin and Shawnee are combined in a single dry waste stream.

During 2017, TVA produced approximately 2.5 million tons of CCRs, with approximately 46 percent being gypsum, 29 percent being fly ash, and the remaining 25 percent bottom ash, boiler slag, and dry scrubber product (Table 4-13). Of the 2.5 million tons, 1.0 million tons, or 40 percent, were utilized or marketed. From 2013 to 2016, on average, TVA utilized or marketed approximately 1.2 million tons of CCRs per year, 30 percent of the total CCRs produced during this time. Thus the total quantity of CCRs utilized or marketed decreased in 2017, but the proportion utilized or marketed increased (29 to 40 percent). The decreased quantity utilized or marketed is largely due to reduced total production of CCRs resulting from coal plant retirements. TVA fly ash is utilized as a replacement for Portland cement in ready mix concrete and also as structural fill. TVA gypsum is used to produce wallboard and also in cement. The uses for TVA boiler slag include abrasives and blasting agents. It should be noted that opportunities for reuse of the combined fly ash and FGD residue CCR produced at Gallatin and Shawnee are currently very limited.

CCRs are regulated by 40 CFR Parts 257 and 261, also known as the CCR Rule. This rule regulates the disposal of CCR as solid waste under the subtitle D of RCRA.

Table 4-13: TVA coal combustion residual production and utilization, 2014-2017.

Material	CCR in Tons							
	2014		2015		2016		2017	
	Production	Utilization	Production	Utilization	Production	Utilization	Production	Utilization
Fly Ash	1,454,706	416,922	1,124,402	291,806	911,078	280,071	740,912	286,609
Bottom Ash	294,199	-	247,553	23	218,760	6,660	239,044	4,810
Boiler Slag	485,275	347,265	389,616	285,411	353,850	257,927	143,610	69,338
Gypsum	2,446,508	608,156	2,122,196	729,181	1,882,784	707,837	1,181,731	667,921
Dry Scrubber Product	-	-	-	-	211,840	-	235,801	-

The CCRs that are not sold for reuse are stored in landfills and impoundments at or near coal plant sites. As of early 2019, TVA operates six coal-fired plants. Two of the six facilities (Bull Run and Kingston) have been converted to dry storage and disposal, while three more facilities (Cumberland, Gallatin, and Shawnee) are projected to complete the conversion by October 2020. Proposed CCR management activities, as well as activities that are currently underway, are described in more detail below in Section 4.7.3.

4.7.2 Nuclear Waste

The nuclear fuel used for power generation produces liquid, gaseous, and solid radioactive wastes ("radwaste") that require storage and disposal. These wastes are categorized as high-level waste and low-level waste based on the type of radioactive material, the intensity of its radiation, and the time required for decay of the radiation intensity to natural levels.

High-Level Waste – About 99 percent of high-level waste generated by nuclear plants is spent fuel, including the fuel rod assemblies. Nuclear fuel is made up of small uranium pellets placed inside long tubular metal fuel rods which are grouped into fuel assemblies and placed in the reactor core. In the fission process, uranium atoms split in a chain reaction yielding heat. Radioactive fission products, the nuclei left over after the atom has split, are trapped and gradually reduce the efficiency of the chain reaction. Consequently, the oldest fuel assemblies are removed and replaced with fresh fuel at about 18-month intervals. Because nuclear plants normally operate continuously at full load, spent fuel production varies little from year to year. The seven operating nuclear units produce about 700 tons of high-level waste per year.

After it is removed from the reactor, spent fuel is stored at the nuclear plants in pools (steel lined, concrete vaults filled with water) inside the plant. The spent fuel pools were originally intended to store spent fuel onsite until a monitored retrievable storage facility and a permanent repository were built by the Department of Energy as directed by the Nuclear Waste Policy Act of 1982. Because these facilities have not yet been built, the storage capacity of the spent fuel pools at Watts Bar, Sequoyah and Browns Ferry nuclear plants has been exceeded. TVA, like other utilities, now stores spent fuel at all three nuclear plants in above-ground dry storage casks constructed of concrete and metal and placed on concrete pads inside of the plant security perimeter.

Low-Level Waste – Low-level waste consists of items that have come into contact with radioactive materials. At nuclear plants, these wastes consist of solids such as filters, spent resins (primarily from water filtration systems), sludge from tanks and sumps, cloth and paper wipes, plastic shoe covers, tools and materials; liquids such as tritiated waste (i.e., containing tritium), chemical waste, and detergent waste; and gases such as radioactive isotopes created as fission products and released to the reactor coolant. Nuclear plants have systems for collecting these radioactive wastes, reducing their volume, and packaging them for interim onsite storage and eventual shipment to approved processing and storage facilities.

Dry active wastes, which typically have low radioactivity, are presently shipped to a processor in Oak Ridge, Tennessee, for compaction and then to a processor in Clive, Utah, for disposal. Wet active wastes with low radioactivity are shipped to the Clive processor. Other radioactive wastes are currently shipped to and stored at the Sequoyah plant. Table 4-14 lists the amounts of low level waste produced at TVA nuclear plants between 2010 and 2017.

Table 4-14: Low-level radioactive waste generated at TVA nuclear plants (cubic feet).

	2010	2011	2012	2013	2014	2015	2016	2017
Browns Ferry	50,656	49,898	69,480	85,599	57,123	67,609	62946	81251
Sequoyah	7,995	13,148	8,063	15,284	33415	31590	36695	16094
Watts Bar	9,781	14,543	8,212	9,450	14,906	24,112	8,140	4,065
Total	68,432	77,589	85,755	110,333	105,444	123,311	107,781	101,410

Definition: Low-level radioactive waste includes class A, B and C radioactive waste as reported to the NRC.

Mixed Waste – Mixed Waste is a classification of waste that is dually regulated as radioactive and contains some other components regulated by additional environmental regulations (i.e., RCRA or TSCA). Examples of mixed waste, usually generated during maintenance activities, include lead paint chips, cleanup debris, resin, transformers, and unpunctured aerosol cans. Because of the dual regulation, it is extremely difficult to find a properly permitted outlet for disposal of this material. Table 4-15 shows the mixed waste sent for disposal from TVA sites during 2010–2017.

Table 4-15: Mixed waste generated at TVA nuclear plants and other facilities (kg).

	2010	2011	2012	2013	2014	2015	2016	2017
Browns Ferry	0	0	101	0	0	0	0	4645
Sequoyah	0	0	86	731	0	0	0	2.3
Watts Bar	0	0	0	0	0	0	0	0
Power Service Shops	0	0	1,066	0	0	0	0	0
Total	0	0	1,253	731	0	0	0	4,647

4.7.3 Solid and Hazardous Wastes at Facilities Considered for Potential Retirement

Potential retirement of coal and CT plants would primarily result in a decrease in solid and hazardous waste produced. Currently, CCRs constitute the majority of waste produced at these facilities. Appendix B shows actual and average CCR production at each coal-fired plant between 2012 and 2018. Appendix B also shows projected CCR production at these facilities from 2019 to 2030, should the facilities not be retired. CT plants produce very small quantities of solid waste during normal operation and therefore these wastes are not further described here.

4.7.3.1 Cumberland Fossil Plant

Cumberland disposes of a wide range of solid wastes including refuse, sanitary wastes, contaminated environmental media, scrap metals, non-hazardous wastewater treatment plant sludge, non-hazardous air pollution control wastes, various nonhazardous industrial wastes (e.g., CCRs), and other materials. The primary solid wastes that result from the operation of Cumberland are collectively known as CCR. The primary CCR waste streams at Cumberland are fly ash, bottom ash and gypsum. From 2012 to 2018, Cumberland produced between 412,200 and 606,500 tons of ash per year. During that same time, Cumberland generated between 695,600 and 987,600 tons of gypsum per year. TVA has historically managed storage of CCR materials generated at Cumberland in four CCR units: the Dry Ash Stack, Gypsum Storage Area, Bottom Ash Pond, and Main Ash Pond (including Stilling Pond).

In response to the CCR Rule, TVA published closure plans for each Cumberland CCR unit. The Dry Ash Stack and Gypsum Storage Area have a landfill permit approved under the Tennessee state regulations, which also includes a closure plan. The CCR Rule closure plans for the Dry Ash Stack and Gypsum Storage Area align with the state permitted closure plan, and reflect closure of these units in-place. Similarly, the closure plans reflect closure of the Bottom Ash Pond and Main Ash Pond (including Stilling Pond) in-place. Under these plans, each impoundment would undergo dewatering, waste stabilization, and capping with a geosynthetics-soil matrix.

In May 2018, TVA issued a final EIS (TVA 2018f) for the actions described in the preceding paragraph as well as for the construction and operation of a bottom ash dewatering facility, an onsite CCR landfill, and process water basins at Cumberland. Construction of the on-site CCR landfill is ongoing. In order to accommodate construction of process water basins within the footprint of the Main Ash Pond/Stilling Pond, the preferred alternative for closure of these units in the EIS is a combination of closure-in-place and closure-by-removal.

The CCR units at Cumberland are subject to Order No. OGC15-0177 entered by the Tennessee Department of Environment and Conservation (TDEC) in 2015 (TDEC Order). The TDEC Order outlines a process for the investigation, assessment, and remediation of any unacceptable risks associated with CCR units at all TVA coal-fired power plant sites in Tennessee, except Gallatin. The process will result in a determination of the final closure methodology for the CCR units at Cumberland and any other necessary corrective actions.

4.7.3.2 Gallatin Fossil Plant

Solid waste generated at Gallatin is similar to that described above for Cumberland. From 2015 to 2018, Gallatin produced between 226,400 and 286,700 tons of ash per year. Calcium sulfite production began in 2015 with the startup of the FGD system; since then this FGD byproduct is combined with ash into a single CCR waste stream. CCRs are managed in five CCR units (landfills and surface impoundments): North Rail Loop Landfill, Ash Pond A, Ash Pond E, Bottom Ash Pond, and Middle Pond A.

In response to the CCR Rule, TVA published closure plans for each Gallatin CCR unit. The North Rail Loop Landfill has a landfill permit approved under the Tennessee state regulations, which also includes a closure plan. The North Rail Loop Landfill is currently under development with Cell 1 operational. Closure of the North Rail Loop Landfill is expected to be accomplished by leaving CCR in place and applying a final cover system that meets the CCR Rule closure in-place performance standards, as well as applicable state standards. Potential closure methodologies for the ponds are the subject of an EIS that TVA began preparing in late 2018. TVA recently entered into a settlement agreement in a lawsuit filed by the State of Tennessee and TDEC concerning the ponds at Gallatin. Under this settlement agreement, TVA will close Ash Pond A, Middle Pond A, Bottom Ash Pond, and Ash Pond E by removing the ash to a lined permitted landfill or to a beneficial reuse facility, or some combination of the two. In the ongoing EIS, TVA is considering these various closure methodologies for these units.

4.7.3.3 Kingston Fossil Plant

Kingston disposes of a wide range of solid wastes similar to that described above for Cumberland. From 2012 to 2018, Kingston generated between 114,100 and 195,800 tons of coal ash per year. During that same time, Kingston generated between 127,800 and

225,000 tons of gypsum per year. CCRs are managed in three CCR units (landfills and surface impoundments): the Peninsula Disposal Area, the Sluice Trench and Area East of the Sluice Trench, and the Stilling Pond.

In response to the CCR Rule, TVA published closure plans for each Kingston CCR unit. The Peninsula Disposal Area has a landfill permit approved under the Tennessee state regulations, which also includes a closure plan.The closure plans reflect closure of the Peninsula Disposal Area in place via engineered cover systems consisting of a 40-mil thick textured high-density polyethylene (HDPE) geomembrane and double-sided geocomposite drainage layer, protective cover soil layer, and vegetative soil cover. Under its closure plan, the Stilling Pond would be dewatered, stabilized, filled and graded, and capped with a low-permeability final cover. In-place closure of the Sluice Trench was completed in September 2017. The area encompassing the Sluice Trench consisted of two separate cap systems that will require minimal maintenance. In-place closure of the Area East of the Sluice Trench is scheduled to be completed in 2019. The CCR units at Kingston are subject to the TDEC Order, and the process under that order will result in a determination of the final closure methodology for the CCR units at Kingston and any other necessary corrective actions.

4.7.3.4 Shawnee Fossil Plant

Solid waste generated at Shawnee is similar to that described above for Cumberland. From 2012 to 2018, Shawnee generated between 215,800 and 266,500 tons of coal ash per year. Calcium sulfite production began in 2017 with the completion of the FGD systems on Units 1 and 4; this scrubber byproduct is combined with ash into a single CCR waste stream. CCRs are managed in two CCR units (landfills and surface impoundments): the Consolidated Waste Dry Stack, and the Ash Pond 2 (Main Ash Pond and Stilling Pond).

In 2015, in response to the CCR Rule, TVA began an evaluation of converting ash handling processes at Shawnee from wet sluicing to dry handling. In December 2017, TVA issued a final EIS on CCR management at (TVA 2018e). The EIS analyzed closing both the SWL and Ash Pond 2, as well as building and operating a new lined landfill to store dry CCR waste produced by SHF in the future. The preferred Alternative B included construction of an onsite CCR landfill, closure-in-place of Ash Pond 2 with a reduced footprint, and closure-in-place of the SWL. On January 16, 2018, TVA issued a record of decision (ROD) to implement construction of the new dry CCR landfill, and elected to further consider the alternatives regarding the closure of the SWL and Ash Pond 2 before making a decision.

In April 2018, TVA issued a draft supplemental EIS (SEIS) to further analyze the alternatives for closure of the SWL and Ash Pond 2. The new preferred alternative in the SEIS is generally consistent with the preferred alternative proposed in the 2017 EIS; however the SEIS proposed that ash in the northwest corner of Ash Impoundment 2 would not be removed and consolidated. Instead, both the SWL and Ash Impoundment 2 would be closed-in-place and regraded with materials redistributed within the existing facilities or using borrow material from the Shawnee East Site (as needed) to establish appropriate drainage and stability. New storm water outfalls would be installed along the perimeter of the facilities to outlet at elevations at or above the 100-year flood elevation.

4.8 Socioeconomics

This section describes social and economic conditions in the TVA PSA and near vicinity. It presents and compares qualitative and quantitative data from varying geographies in order to characterize the regional human population and associated demographics, sociocultural factors, and economics. Depending on availability and comparability, the census data derive from the U.S. Census Bureau (USCB) 2010 decennial census (2010 Census), 5-year estimates of the 2012 – 2016 American Community Survey (2016 ACS), and the 2000 – 2010 and the 2010 – 2017 estimates of the USCB Population Estimates Program (2010 PEP and 2017 PEP). These data were obtained utilizing USCB American FactFinder, TIGER Products, and Population and Housing Unit Estimates (USCB 2018a, 2018b, 2018c). Spatial data for figures were obtained through

USCB TIGER Products. Other quantitative and qualitative data were gathered from TVA staff, US Bureau of Economic Analysis (USBEA), regional commissions, counties and communities, and other relevant sources, as cited within each subsection.

Generally, when census data are presented, information on the TVA PSA as a whole is given as a baseline for comparison to smaller parts of the PSA. The TVA PSA considered for socioeconomics consists of 180 counties and two independent cities in seven states, including all counties in Tennessee and portions of Alabama, Georgia, Kentucky, Mississippi, North Carolina, and Virginia (see Appendix C for a complete list of counties considered). Smaller areas are defined as relevant to the topic and may consist of metropolitan statistical areas (MSAs), urban or rural areas, counties, or census tracts.

Where relevant, information from USCB Division 6, East South Central, is employed for comparative purposes. Division 6 includes the majority of the TVA PSA, consisting of Alabama, Kentucky, Mississippi, and Tennessee (USCB 2018d). USCB Division 6 data may be more comparable to the TVA PSA than that of USCB Region 3, the South, because of similarities in population densities, demographics, sociocultural characteristics, and economics. For many topics, U.S.-wide data are also employed due to their usefulness in understanding how the TVA PSA compares with the rest of the nation.

4.8.1 Population and Demographics

Population and various demographic data are presented in this subsection. First, population change for the TVA PSA between 2010 and 2017 are compared with that for Division 6 and the U.S. Then, population variation across the TVA PSA and among its most populous MSAs is discussed. The most current population estimates, the 2017 PEP, informed this analysis. Finally, demographic variables for the TVA service are compared with those of Division 6 and the nation.

4.8.1.1 Population

As shown in Table 4-16, the estimated population of the TVA PSA was 9.8 million in July 2010 and almost 10.3 million by July 2017, a 4.4 percent increase (2017 PEP). Between 2002 and 2010, the rate of increase was about 9.2 percent, greater than the 7.2 percent increase of Division 6 or the 7.6 percent increase of the U.S. as a whole (2010 PEP). In more recent years, the rate of increase has been declining. The 2010 to 2017 rate of increase for the TVA PSA (4.4 percent) was greater than the Division 6 rate of 3.1 percent and less than the national rate of 5.3 percent (2017 PEP). Based on TVA estimates, the annual rate of population growth in the TVA PSA is expected to decline to about 0.5 percent by 2043.

Population varies greatly among the counties in the TVA PSA (Figure 4-26). The larger population concentrations tend to be located along major river corridors: the Tennessee River and its tributaries from northeast Tennessee through Knoxville and Chattanooga into north Alabama; the Nashville area along the Cumberland River; and the Memphis area on the Mississippi River. Low population counties are scattered around the region, but most are in Mississippi, the Cumberland Plateau in Tennessee, and the Highland Rim in Tennessee and Kentucky.

An increasing proportion of the total population of the TVA PSA, 66.5 percent in 2010 and an estimated 67.6 percent in 2017, lives in USCB-defined metropolitan statistical areas[4] (MSAs; Table 4-16). Two of these areas were estimated to have populations greater than one million in 2017: Nashville, 1.9 million, and Memphis, almost 1.4 million. The Knoxville and Chattanooga MSAs were estimated to have populations of approximately 877,000 and 557,000, respectively. These four MSAs accounted for nearly 46 percent of the TVA PSA's population based on the 2017 PEP.

Table 4-16: Population data for the TVA PSA, TVA MSAs, Division 6, and U.S.

Area	2010 Population [a]	2017 Population [b]	% Increase 2010 – 2017	% of TVA PSA Pop., 2017
United States	309,338,421	325,719,178	5.3	--
Division 6	18,459,846	19,719,178	3.1	--
TVA PSA	9,810,629	10,246,104	4.4	--
MSAs in TVA PSA				
Bowling Green, KY	159,309	174,835	9.7	1.7
Chattanooga, TN-GA	529,196	556,548	5.2	5.4
Clarksville, TN-KY	261,619	285,042	9.0	2.8
Cleveland, TN	115,913	122,317	5.5	1.2
Dalton, GA	142,315	144,440	1.5	1.4
Decatur, AL	153,949	151,867	-1.4	1.5
Florence-Muscle Shoals, AL	147,260	147,038	-0.2	1.4
Huntsville, AL	419,279	455,448	8.6	4.5
Jackson, TN	130,031	129,235	-0.6	1.3
Johnson City, TN	199,010	202,053	1.5	2.0
Kingsport-Bristol-Bristol, TN-VA	309,494	306,659	-0.9	3.0
Knoxville, TN	838,748	877,104	4.6	8.6
Memphis, TN-AR	1,326,280	1,348,260	1.7	13.2
Morristown, TN	114,219	118,081	3.4	1.2
Nashville- Davidson-Murfreesboro-Franklin, TN	1,675,757	1,903,045	13.6	18.6
TVA MSA TOTALS	6,522,379	6,921,972	6.1	67.6

Sources:
a 2010 PEP
b 2017 PEP

[4] The Memphis MSA has two counties outside the TVA PSA, Crittenden County, Arkansas and Tunica County, Mississippi.

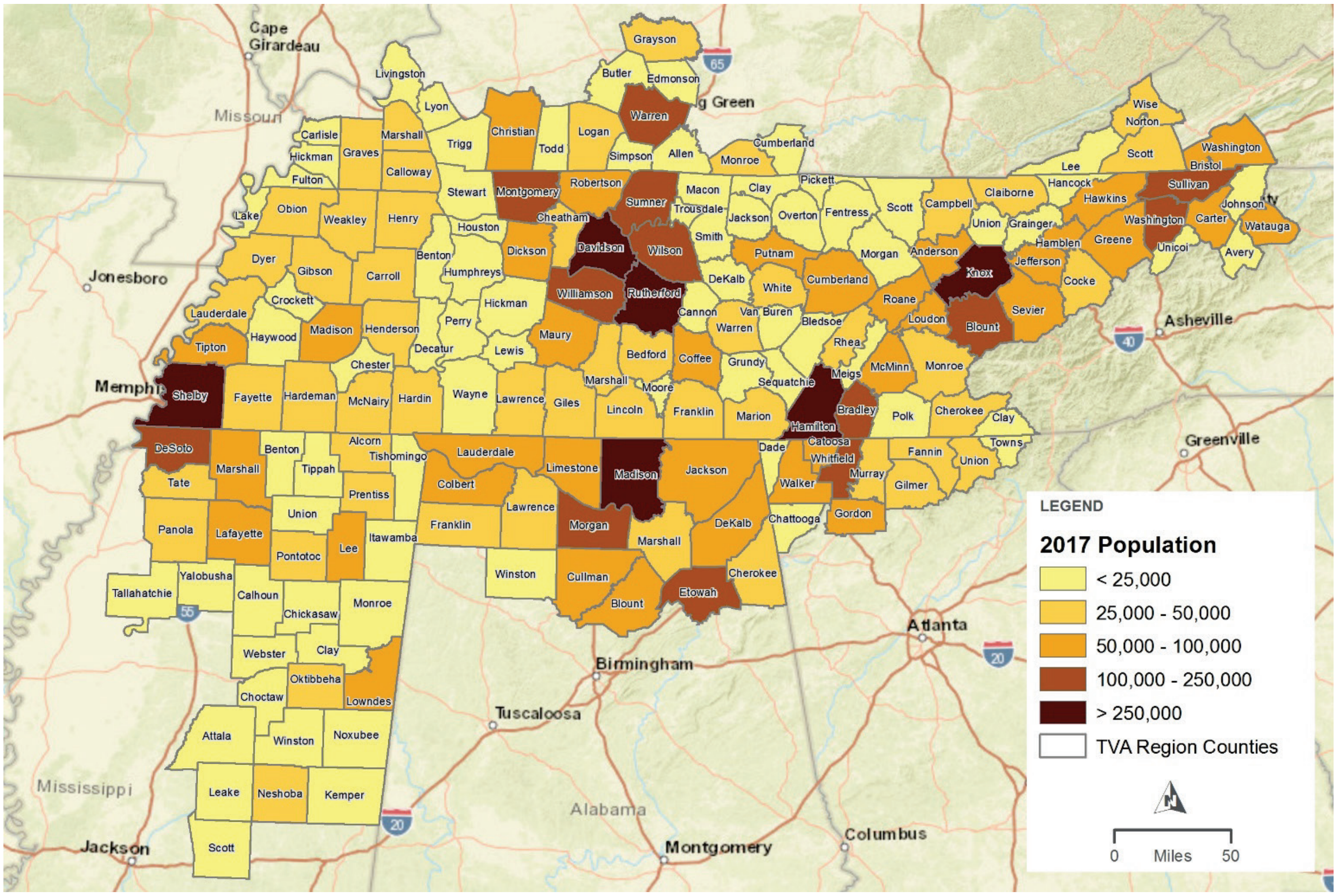


Figure 4-26: Variation in population of counties in the TVA PSA.

While the proportion of the region's population living in metropolitan areas was estimated by the 2017 PEP to be lower than the national average of about 85 percent, the proportion has been increasing, and this trend appears likely to continue in the future. A substantial part of this increase is likely to follow the pattern of increases in the physical size of metropolitan areas as growth expands from the central core of these areas. Conversely, several lifestyle and economic concerns, including commuting time and costs and proximity to social amenities, have led to increased residential populations in the urban core areas of several cities in the TVA PSA, including the largest cities.

4.8.1.2 Demographics

As shown in Table 4-17, the 2016 ACS estimated the median age in the TVA PSA to be 40.8 years, an increase from the median age of 37.9 years when compared to the 2010 Census. The TVA PSA also has a higher percentage of people over 65 years of age than in Division 6 or the nation as a whole. The percentage of people identifying themselves as White alone was 78.7 percent, with the remaining 21.3 percent of people identifying themselves as another race or more than one race (including White). The White alone percentage is greater than that of Division 6 and the U.S., where the percentages were estimated to be 71.3 percent and 73.4 percent, respectively, in the 2016 ACS.

Table 4-17: Demographics of the TVA PSA, Division 6, and U.S.

Geography	Median Age	% White Alone	% Age 65 or More	% High School or Higher
United States	37.7	73.4	14.5	87.0
Division 6	37.5	71.3	14.9	85.6
TVA PSA	40.8	78.7	15.3	84.7

Sources: 2016 ACS Data Profile (DP) 05 and High Sampling (S) 1501

Of the TVA PSA population 25 years old or older, the 2016 ACS estimated that approximately 85 percent hold a high school diploma, equivalency diploma, or higher degree, as shown in Table 4-17. This percentage is lower than in Division 6 and the U.S. as a whole, where 86 and 87 percent of the populations 25 years old or older, respectively, were estimated to hold high school diplomas, the equivalent, or higher degrees, as shown in Table 4-17.

4.8.2 Sociocultural Characteristics

This subsection describes historical and cultural characteristics of USCB Division 6, which encompasses the majority of TVA's PSA (USCB 2018c). The USCB regions and divisions were developed based on "practice and tradition" rather than under any statute or legislation (USCB 1994). Division 6 overlaps the central portion of the culture region known as the South or Southeast. Culture region is a social science concept based on the idea that human culture is formed through the relationships created by people in close proximity and such associations are often related to the geography, climate, resources, population density, and history of an area (Beck et al. 2009).

Distinctions between urban and rural areas across the TVA PSA are also described in this subsection. USCB-defined urban areas are densely developed areas that encompass residential, commercial, and other non-residential land uses (USCB 2016). USCB differentiates two types of urban areas: urbanized areas and urban clusters. Urbanized areas are those consisting of 50,000 or more people, while urban clusters are areas having between 2,500 and 49,999 people. Due to availability, completeness, and comparability, data used for this discussion derive from the 2010 Census.

4.8.2.1 Historical and Cultural Characteristics

Rural lifestyles dominated the Southeast until the mid- to late twentieth century. Earlier in the century, the predominant rural lifestyle, along with high unemployment and poverty rates, extensive flooding, and lagging electrification influenced the passage of the Tennessee Valley Authority Act of 1933 (TVA Act) that created TVA. The TVA Act was part of President Roosevelt's program to assist the nation during the Great Depression (TVA 2018i). The act directed TVA to "provide for the agricultural and industrial development of [the Tennessee Valley]," among other purposes. Flood control and the development of fertilizers were TVA programs designed to assist farmers of the region. Electrification by TVA was intended to help modernize rural communities and encourage economic development. While the Tennessee Valley region has substantially modernized since passage of the TVA Act, rural traditions continue to influence Southeastern culture, including its values, attitudes, music, language, class and race distinctions, and political and religious views (Beck et al. 2009).

Much of the TVA PSA is included in the Appalachian region, which generally straddles the ridgeline of the Appalachian Mountains (ARC 2018a). The Appalachian Regional Commission (ARC) was created in 1965 "to address the persistent poverty and growing economic despair of the Appalachian Region" (ARC 2018b). The ARC service territory extends beyond the Appalachian Mountains to include northern Alabama and a large portion of the TVA PSA in Mississippi. When ARC was formed, Appalachia, to which the region is often referred, was heavily dependent on farming, natural resource extraction, and heavy industries, and the region had a 31-percent poverty rate. More recently, the region has incorporated manufacturing and professional service industries into its economy, and poverty rates have declined to around 17 percent, approximately 4 percent higher than the nation as estimated in the 2016 ACS. Forty-two percent of the population of the Appalachian region is considered rural, as compared with 20 percent of the overall U.S. population.

Portions of the TVA PSA in Mississippi are included in the Mid-South Delta subregion of the South, which generally surrounds the Mississippi River in Arkansas, Louisiana, and Mississippi (Beaulieu and Littles 2009). The subregion is characterized by dependence on natural resources that are integrally linked to cultural heritage and local economies. Similar to many other areas of the South, the Mid-South Delta subregion is distinguished by its sociocultural divisions based on class and race.

Similar to the Mid-South Delta subregion is the Mid-South subregion of the South, which encompasses portions of western and central Tennessee and Kentucky. Inhabitants of western portions of this subregion have strong cultural connections to the Mississippi River. Rural areas of the Mid-South are generally characterized by the predominance of farming traditions. According to the USDA Census of Agriculture, approximately 68,050 farms on nearly 11 million acres were active across Tennessee in 2012 (USDA 2018c). Since 2002, the age of active farmers has increased, while the numbers of new farmers has declined. However, active farmers enjoy an increasing market value for their products.

Resource extraction, especially in relation to coal, remains an important aspect of the economies in portions of the Appalachian region and the Mid-South subregion (USEIA 2018b). Many people in these areas have been employed in coal extraction for decades and often have generational connections to coal mining whether or not they are currently involved in the industry (Carley et al. 2018). These facts have influenced personal identities as well as the broader culture in these areas. In interviews conducted among Appalachian coal mining communities, Carley et al. 2018 found that "[c]oal was frequently framed as the common bond—or identity—that held the entire community together." Interview participants conveyed that these cultural connections are associated with "location, landscape, and personal networks" and that the potential loss of such connections can lead to intense feelings of grief that make choosing different occupations or home locations difficult.

Coal mining areas in the TVA PSA are in northern Alabama, eastern Tennessee, and extreme eastern Kentucky, and the southern portion of the Illinois Basin coalfield in western Kentucky (USEIA 2018c). TVA has not recently purchased coal from Alabama or Tennessee; recent purchases have been from the Illinois Basin coalfield in western Kentucky, southwestern Indiana, and southern Illinois, the Powder River Basin in Wyoming and Montana, and the Uinta Basin in Colorado and Utah (see Section 2.3.1). The Red Hills plant in east-central Mississippi, from which TVA purchases power, is supplied by a nearby lignite mine.

4.8.2.2 Urban-Rural Distinctions

In 2010, the TVA PSA included 160 separate USCB-designated urban areas, 141 of these being smaller urban clusters and 19 being larger urbanized areas. Urban areas composed approximately 1.5 percent of the TVA PSA and contained nearly 59 percent of the population (Figure 4-27; USCB 2010). This is compared with the U.S. as a whole, where approximately 80.7 percent of the population resided within approximately 3.1 percent of the total land area in 2010 (Ratcliffe et al. 2016). Across Division 6, approximately 60 percent of the population lived in urban areas.

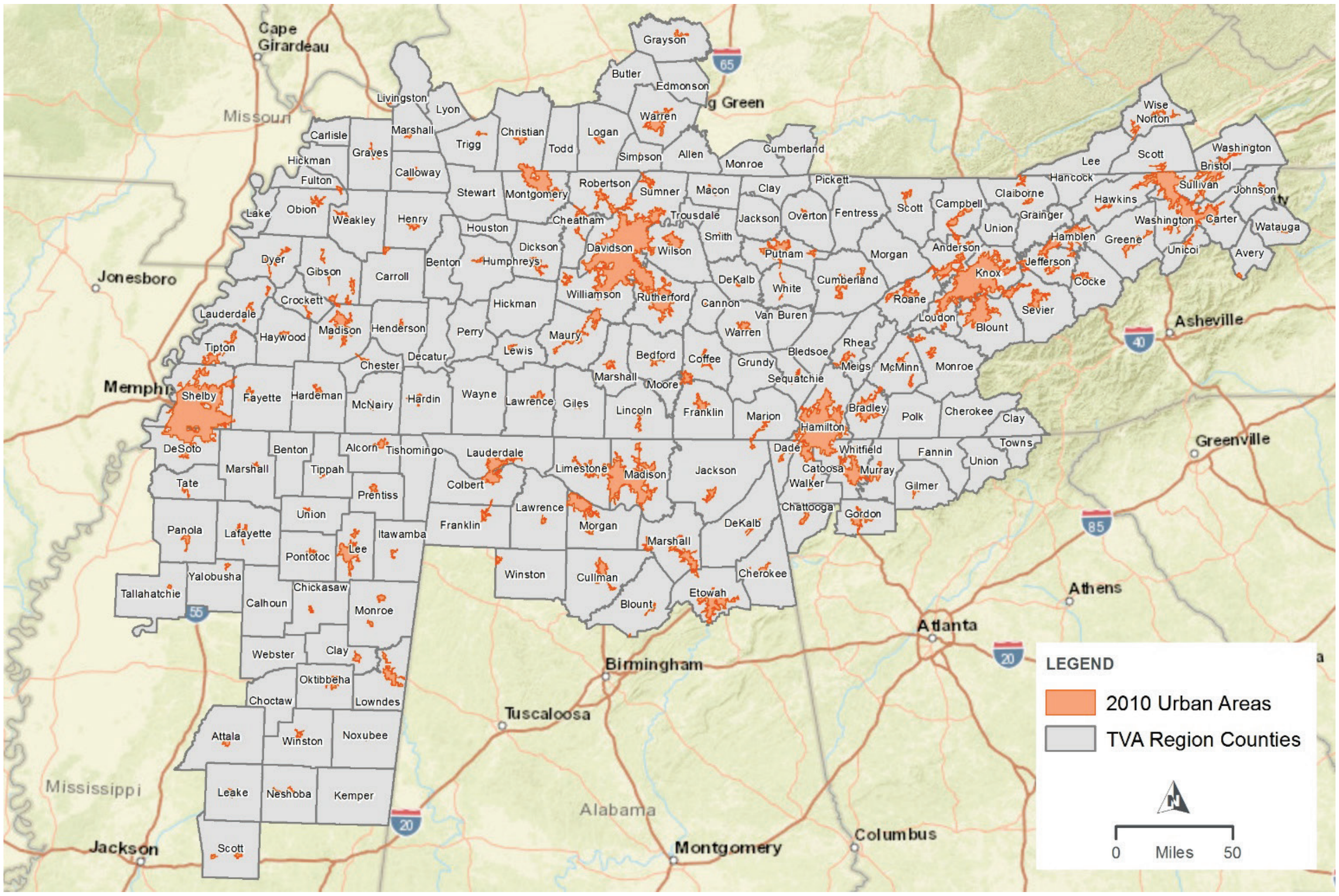


Figure 4-27: Urban and rural areas in the TVA PSA.

USCB considers all portions outside of designated urban areas to be rural areas (USCB 2016). In 2010, over 98 percent of the TVA PSA was considered rural, accounting for almost 42 percent of the population in the TVA PSA (see Figure 4-27). Nineteen percent of the U.S. population was considered rural in the same year (Ratcliff et al. 2016; USCB 2010).

According to the 2016 ACS, the three most populous counties in or partially within the TVA PSA were Shelby, Davidson, and Knox counties, Tennessee (Table 4-18). All of these counties had a population greater than 430,000 residents, and less than 11 percent of the land area of these counties was considered rural in the 2010 Census (USCB 2010). Nashville and portions of its metropolitan area encompass Davidson County, Tennessee, and Shelby County is primarily composed of the City of Memphis. Knox County is largely composed of the Knoxville metropolitan area. The population of Davidson County increased by 6.6 percent between 2010 and 2016, while Knox and Shelby increased by 3.7 and 1.0 percent, respectively.

According to the 2016 ACS data, the three least populous counties in or partially within the TVA PSA were Pickett County, Tennessee, and Carlisle and Hickman counties, Kentucky (Table 4-18). The entirety of these counties was considered rural areas in 2010, as defined by the USCB (USCB 2010). The population of Pickett County increased by approximately 0.4 percent between 2010 and 2016, while Carlisle and Hickman counties declined in population by 2.9 and 4.3 percent, respectively.

Table 4-18: Population data for the most/least populous counties in the TVA PSA.

Geography	2010 Population [a]	% Urban Population, 2010 [b]	2016 Population [c]	% Increase 2010 – 2016
Shelby County, TN	927,644	97.2	936,990	1.0
Davidson County, TN	626,681	96.6	667,885	6.6
Knox County, TN	432,226	89.1	448,164	3.7
Pickett County, TN	5,077	0	5,096	0.4
Carlisle County, KY	5,104	0	4,954	-2.9
Hickman County, KY	4,902	0	4,691	-4.3

Sources:
a 2010 Census DP01. Note that 2010 Census population data reported in April 2010, rather than the 2010 PEP mid-year estimates, were used in order to maintain comparability with urban and rural data, which were obtained during the 2010 Census.
b 2010 County Rurality Level
c 2012 – 2016 ACS 5-Year Estimates

4.8.3 Economics

In this subsection, major industries and employment and income data are presented for the TVA PSA, as compared with Division 6 and the U.S. TVA's contribution to state revenues through its tax equivalent payments is also provided.

4.8.3.1 Regional Economy

Based on the 2016 ACS, the top three industries for employment in the TVA PSA and Division 6, listed by rank highest to lowest, were: 1) educational services, health care, and social assistance industries; 2) manufacturing; and 3) retail trades. For the U.S., these were: 1) educational services, health care, and social assistance industries; 2) the retail trades; and 3) professional, scientific, management, administrative, and waste management industries.

In the TVA PSA and Division 6, the economy depends more on manufacturing than the U.S. as a whole. While the relative importance of manufacturing has been declining for a number of years, both nationally and regionally, in the TVA PSA, manufacturing jobs still employ almost 14 percent of the civilian working population, second among industrial sectors. Factors contributing to the high proportion of manufacturing include location with good access to markets in the Northeast, Midwest, Southwest, and the rest of the Southeast; good transportation; relatively low wages and cost of living; right-to-work laws; and abundant, relatively low-cost resources including land and electricity.

While the types of manufacturing industries vary considerably across the TVA PSA, there has been a continuing shift from non-durable goods, such as apparel, to durable goods, such as automobiles. In 1990, about 48 percent of manufacturing jobs were in durable goods. That share has increased to about 53 percent and this increase is expected to continue. Nondurable goods manufacturing peaked about 1993; the most notable decline has been in apparel and other textile products, which has declined from about 13 percent of regional manufacturing in 1990 to less than 2 percent. Nationally, there has been a slight increase in the share of non-durable goods, from about 40 percent in the year 2000 to a little more than 41 percent.

TVA plays an important role in the regional economy. This is evidenced by low cost, reliable power benefitting industrial customers and economic growth, as well as the amount of capital investment in the TVA PSA. Capital investments include investments in the overall power system such as funding for new and existing generating plants and general system improvements. Table 4-19 shows the amount of capital investment by

TVA for fiscal years 2012 through 2018. With the exception of 2015, TVA capital investment has increased during this period.

Table 4-19: TVA capital Investment between 2012 and 2018.

Fiscal Year	Capital Investment (in billions of U.S. dollars)
2012	$5.9
2013	$5.0
2014	$8.5
2015	$7.8
2016	$8.3
2017	$8.3
2018 (through April)	$9.3
Total	$53.1

Source: TVA Region Performance Highlights, 2012 – 2018

4.8.3.2 TVA-Contributions to State Economies and Revenues

TVA produces approximately 90 percent of the electricity generated in Tennessee, a state that ranks 31st in the nation for total energy production, and eighth in the nation for production of hydroelectric power (USEIA 2018b). TVA operations at Browns Ferry Nuclear Plant near Athens, Alabama is the major reason Alabama ranks fourth in the nation for nuclear power production (USEIA 2018d).

As required in the TVA Act, TVA makes tax equivalent payments, also known as payments in lieu of taxes, to states where TVA sells electricity or owns power system assets; these states are the seven TVA PSA states and Illinois, where TVA owns coal reserves. TVA also makes payments directly to local governments where TVA owns power facilities. The tax equivalent payments total 5 percent of gross proceeds from the sale of power in the prior fiscal year, with some exclusions.

Each state regulates how the payments are distributed to governmental entities across the state. In most of the eight states, the apportionment of funds is determined by the existence of TVA property and/or its value in proportion to the total value of TVA property in the state. Exceptions to this are in Alabama, Illinois, and Virginia. Illinois divides the majority of its funds among areas with TVA coal reserves. Rather than basing the distribution on the value of TVA property within its jurisdiction, Alabama and Virginia distribute payments to counties or cities receiving power services from TVA. Table 4-20 shows the amount of tax equivalent payments to states for TVA fiscal years 2015 through 2018.

Table 4-20: Tax equivalent payments by TVA to states where TVA produces power or acquired lands.

Geography	Tax Equivalent Payments (in millions of U.S. dollars, rounded)			
State	2015	2016	2017	2018
Alabama	$102.6	$94.2	$87.0	$87.5
Georgia	$9.1	$8.9	$8.4	$8.5
Illinois	$0.4	$0.4	$0.3	$0.4
Kentucky	$32.0	$35.1	$34.4	$36.2
Mississippi	$25.0	$40.3	$38.6	$39.7
North Carolina	$2.9	$2.8	$2.8	$2.8
Tennessee	$350.6	$351.9	$344.0	$347.4
Virginia	$1.3	$1.3	$1.2	$1.2

Sources: Illinois Department of Revenue 2017; TVA 2015d, 2016f, 2018j, 2018k

4.8.3.3 Employment

Based on 2016 ACS data, the potential working population in the TVA PSA, defined as people aged 16 years or more who are considered in the labor force, was estimated to be almost 4.8 million. Approximately 7.7 percent of this population was unemployed, slightly lower than the unemployment rates for Division 6 and somewhat higher than that for the U.S as a whole. There is considerable geographic variation in unemployment rates with adjacent counties sometimes having large differences. However, based on the 2016 ACS, the counties with the highest unemployment rates were concentrated in east-central Mississippi, in non-urban counties near the Mississippi River, and in the northern Cumberland Plateau in Tennessee. Unemployment rates across the TVA PSA range from a low of 3.7 percent in Williamson County, Tennessee, in the Nashville area, to a high of 18.2 percent in Hardeman County, Tennessee, a rural county east of Memphis.

As shown in Table 4-21, overall, the TVA PSA was similar to Division 6 in percentages of people employed in various occupations as estimated by the 2016 ACS. While slightly less of its population was employed in management, business, science, and the arts than in the region or nation as a whole, the TVA PSA has a slightly higher percentage of employees in production, transportation, and material moving fields.

Table 4-21: Employment in occupations in the TVA PSA, Division 6, and U.S.

Geography	% Employed in:				
	Mgt., Business, Science, and Arts	Service	Sales and Office	Natural Res., Construction, Maint.	Production, Transportation, Material Moving
United States	37.0	18.1	23.8	8.9	12.2
Division 6	33.3	17	24.1	9.5	16.2
TVA PSA	32.9	16.8	24.1	9.4	16.8

Source: 2016 ACS S2405

TVA fosters job growth throughout its PSA by forming partnerships with economic development organizations. TVA Economic Development works with these organizations to attract new companies and support existing ones. TVA provides site selection services, incentives, and research and technical assistance to help new and existing businesses to operate in the Tennessee Valley (TVA 2018l). As shown in Table 4-22, job growth has moderated.

Table 4-22: TVA-assisted jobs between 2012 and 2018.

Fiscal Year	No. of Jobs
2012	48,000
2013	52,000
2014	60,300
2015	76,200
2016	72,100
2017	70,000
2018 (through April)	45,700

Source: TVA Region Performance Highlights 2012 – 2018

TVA employs a total of 5,189 people at 52 generating facilities throughout its PSA. Browns Ferry Nuclear Plant, near Athens, Alabama, accounts for just over 25 percent of the total number of TVA plant employees. Two other facilities, Watts Bar Nuclear Plant near Spring City in East Tennessee, and Sequoyah Nuclear Plant near Soddy-Daisy, Tennessee (north of Chattanooga), together account for an additional 36 percent of the total number of employees). The number of power plant employees has decreased in recent years as coal plants have been retired.

4.8.3.4 Income

Based on November 2018 USBEA estimates, derived in part from USCB data, per capita income in the TVA PSA is $42,578. This was approximately 1.9 percent higher than the Division 6 per capita income ($41,766) and 17.6 percent lower than that of the U.S. as a whole ($51,640). However, there was wide variation within the TVA PSA. Three counties had incomes above the national average, in descending order: Williamson County, Tennessee; Davidson County, Tennessee; and Fayette County, Tennessee. As previously indicated, Williamson and Davidson counties are within the Nashville metropolitan area. Fayette County, Tennessee, is within the Memphis metropolitan area.

Per capita income was below that in Division 6 and the nation in 166 counties and two independent cities in the TVA PSA, reflecting that higher per capita income concentrates in few areas in the TVA PSA. Figure 4-28 illustrates the differences in per capita income rates of TVA-region counties.

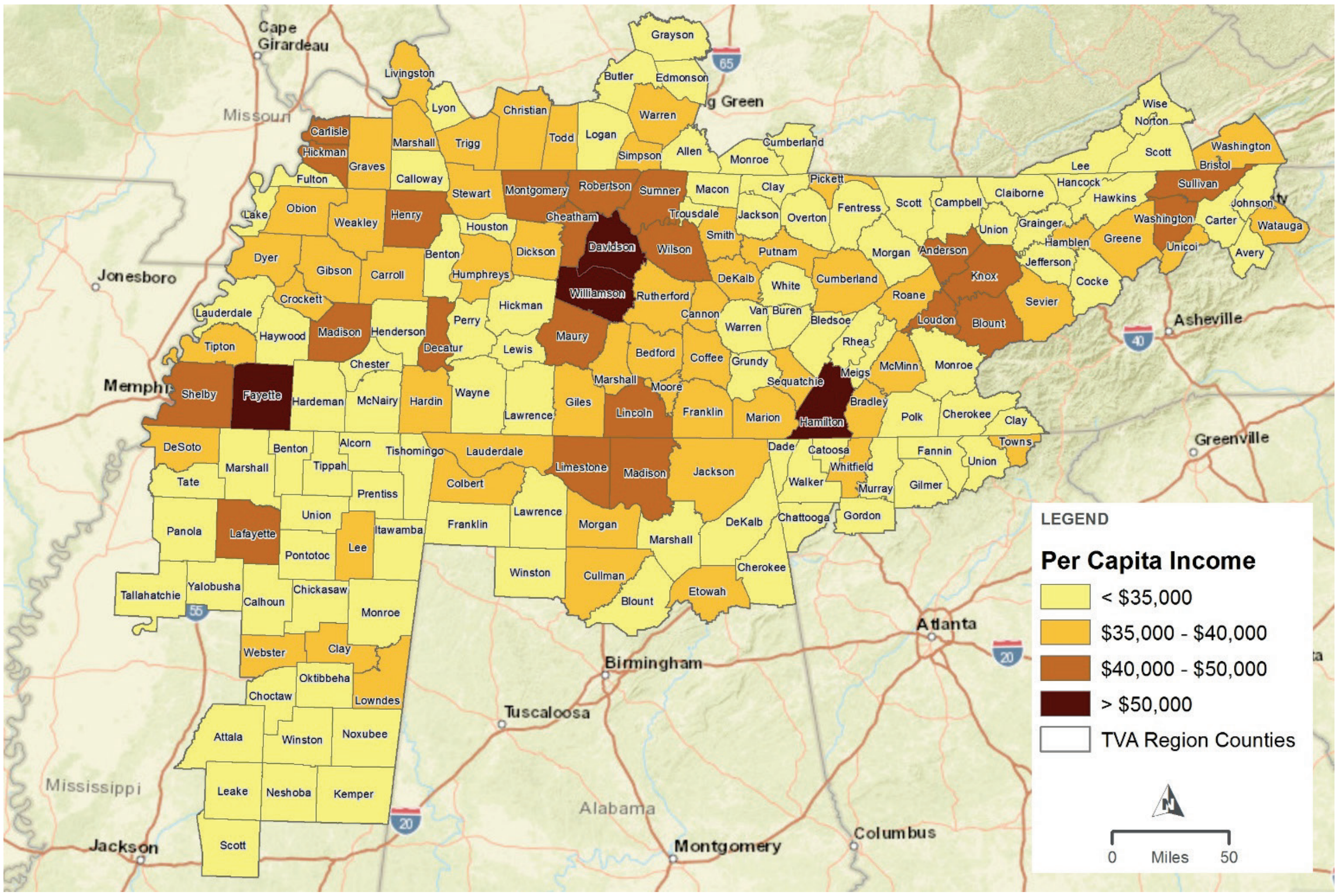


Figure 4-28: Per capita incomes of TVA PSA counties.

4.8.4 Socioeconomic Conditions at Facilities Identified for Future Retirement

Social and economic characteristics surrounding eight TVA plants identified for full or partial retirement during the 20-year IP study period are described in this section. The analyses for the four CT plants consider in detail labor market areas within a 5-mile radius surrounding each plant, as these plants employ few people. Counties within a 20-mile radius of each coal plant serve as the area for analyses of these plants, as they employ many more people. Data for associated states are included in each section for comparison purposes.

4.8.4.1 Allen Combustion Turbine Plant

The labor market area for Allen CT plant (herein, Allen) is defined as Shelby County, Tennessee, where the facility is located, and adjacent Crittenden County, Arkansas.

Population data for Allen-affected counties and associated states are provided in Table 4-23, based on the 2010 Census, 2016 ACS, and state data. From 2010 to 2016, population growth for both affected counties was less than the growth estimated for the associated states, and Crittenden County recorded population losses over that period. Based on the 2016 ACS and state population projections for 2025, both affected counties are expected to grow in population between 2016 and 2025, with Crittenden County likely to increase at rates substantially greater than Arkansas as a whole. Shelby County will likely grow at a lower rate than Tennessee as a whole.

Table 4-23: Population change and projections for Allen-affected counties.

Geography	2010 Census	2016 ACS Estimate	% Change (2010 – 2016)	2025 Projected Population	% Projected Change (2016 – 2025)
Tennessee	6,346,105	6,548,009	3.2	7,148,217	9.2
Shelby County, TN (Allen)	927,644	936,990	1.0	968,453	3.4
Arkansas	2,915,919	2,968,472	1.8	3,151,005	6.1
Crittenden County, AR	50,902	49,511	-2.7	59,113	19.4

Sources: 2010 Census; 2016 ACS; Tennessee Department of Health 2018; U.S. Department of Health and Human Services 2018; University of Arkansas 2003

Other demographic characteristics of the Allen-affected counties are summarized in Table 4-24, based on the 2010 Census and the 2016 ACS. The populations of the affected counties were less rural and younger than the populations of associated states. In Shelby County, there were higher percentages of people who were at least high school graduates and lower percentages of noninstitutionalized adults aged 18 to 64 years with disabilities than across Tennessee. In Crittenden County, higher percentages of people maintained the same residence between 2015 and 2016 than Arkansas as a whole.

Table 4-24: Demographic characteristics for Allen-affected counties.

Geography	% Rural Population	Median Age	% High School or Higher	% Noninst. Labor Force w/ Disability	% Diff. House 1 Yr. Ago
Tennessee	66.4	38.5	86.0	13.6	14.7
Shelby County, TN (Allen)	2.8	35.1	87.1	11.3	16.4
Arkansas	64.9	41.1	85.2	15	15.5
Crittenden County, AR	20.9	34.7	81.8	16.6	15.4

Sources: 2010 Census; 2016 ACS

Table 4-25 summarizes 2016 ACS data on employment and income for the affected counties. Both Allen-affected counties had higher percentages of people in the labor force and higher unemployment rates than their respective states. Based on data from the U.S. Bureau of Labor Statistics (USBLS), total employment in Shelby County was estimated by the USBLS to be 420,439 in 2017. Based on USBEA estimates and as shown in Table 4-25, per capita income in Crittenden County was lower than Arkansas, while Shelby County had higher per capita incomes than across Tennessee. The Allen average annual salary is approximately 2.4 times higher than the average of per capita income in affected counties, as estimated by the USBEA, and Allen directly employs eight people.

Table 4-25: Employment and income characteristics for Allen-affected counties.

Geography	% of 16+ Civ. Pop. in Labor Force	Unemployment Rate	% Employed in Educ. Svcs., Hlth. Care, and Social Assistance	% Employed in Transpo., Warehousing, and Utilities	Per Capita Income, USBEA
Tennessee	60.8	7.5	22.7	6.3	$45,517
Shelby County, TN (Allen)	65	9.4	23.0	11.8	$47,655
Arkansas	58.1	6.9	24.4	5.4	$41,046
Crittenden County, AR	60.5	9.1	26.3	9.9	$36,589

Sources: 2016 ACS; USBEA 2018

Pertinent civilian employment characteristics for the affected counties are also shown on Table 4-25. Of the affected counties, Shelby County had the highest percentages of civilians employed in utilities, transportation, and related industries, while both affected counties had higher percentages of this type of employment than their respective states. In Shelby County, the largest percentage of civilian workers was employed in educational services, health care, and social assistance (23.0%), followed by transportation, warehousing, and utilities (11.8%). The former category employed the largest percentages of civilian workers in Crittenden County and across Tennessee, as well.

4.8.4.2 Colbert Combustion Turbine Plant

The labor market area for Colbert Combustion Turbine Plant (herein, Colbert) is defined as Colbert County, Alabama, where the facility is located, and Lauderdale County, Alabama.

Population data for the Colbert-affected counties and Alabama are provided in

Table 4-26, based on the 2010 Census, 2016 ACS, and state data. As shown, from 2010 to 2016, population declined in both affected counties, with each having a growth rate lower than the state. Based on the 2016 ACS and state population projections for 2025, both affected counties are expected to grow at rates lower than the rate across Alabama between 2016 and 2025, while Colbert County, where Colbert is located, is predicted to decline in population during that time period.

Table 4-26: Population change and projections for Colbert-affected counties.

Geography	2010 Census	2016 ACS Estimate	% Change (2010 – 2016)	2025 Projected Population	% Projected Change (2016 – 2025)
Alabama	4,779,753	4,841,164	1.3	5,030,870	3.9
Colbert County, AL (Colbert)	54,428	54,377	-0.1	54,026	-0.7
Lauderdale County, AL	92,709	92,641	-0.1	92,914	0.3

Sources: 2010 Census; 2016 ACS; U.S. Department of Health and Human Services 2018; University of Alabama 2018

Other demographic characteristics of the Colbert-affected counties are summarized in
Table 4-27, based on the 2010 Census and the 2016 ACS. The populations of both affected counties were less rural and older than Alabama as a whole. In Colbert County, there were lower percentages of people who were at least high school graduates and higher percentages of noninstitutionalized adults aged

18 to 64 years with disabilities than in Lauderdale County or the state. For the most part, higher percentages of people in Colbert County maintained the same residence between 2015 and 2016 than across the state or in Lauderdale County.

Table 4-27: Demographic characteristics for Colbert-affected counties.

Geography	% Rural Population	Median Age	% High School or Higher	% Noninst. Labor Force w/ Disability	% Diff. House 1 Yr. Ago
Alabama	67.1	38.6	84.8	14.5	14.1
Colbert County, AL (Colbert)	43.9	42.4	83.4	17.4	11.4
Lauderdale County, AL	49.3	41.3	84.9	13.1	15.3

Sources: 2010 Census; 2016 ACS

Table 4-28 summarizes 2016 ACS data on employment and income for the affected counties. Both Colbert-affected counties had lower percentages of people in the labor force and lower unemployment rates than across the state. Based on data from USBLS, total employment in Colbert County was estimated by the USBLS to be 21,889 in 2017. Based on USBEA estimates and as shown in Table 4-28, per capita income in Colbert County was lower than in Alabama, while Lauderdale County exceeded that of the state. The Colbert average annual salary is approximately 2.7 times higher than the average of per capita income in affected counties, as estimated by the USBEA, and Colbert directly employs six people.

Table 4-28: Employment and income characteristics for Colbert-affected counties.

Geography	% of 16+ Civ. Pop. in Labor Force	Unemployment Rate	% Employed in Educ. Svcs., Hlth. Care, and Social Assistance	% Employed in Transpo., Warehousing, and Utilities	Per Capita Income, USBEA
Alabama	57.6	8.3	22.5	5.3	$40,805
Colbert County, AL (Colbert)	54.0	7.5	19.9	5.9	$37,602
Lauderdale County, AL	56.0	7.6	21.3	7.5	$36,448

Sources: 2016 ACS; USBEA 2018

Pertinent civilian employment characteristics for the affected counties are also shown on Table 4-28. Of the Colbert-affected counties, Lauderdale County had the highest percentage of civilians employed in utilities, transportation, and related industries, and this was a higher percentage of this type of employment than the state. In Colbert County, the largest percentage of civilian workers was employed in educational services, health care, and social assistance (19.9 percent), followed by manufacturing (18.5 percent). These industries employed the largest percentages of civilian workers in the other affected county and the state, as well.

4.8.4.3 Gallatin Combustion Turbine Plant and Gallatin Fossil Plant

The area of analysis for Gallatin Fossil Plant and Gallatin Combustion Turbine Plant (herein, Gallatin) is defined as Sumner County, Tennessee, where both facilities are located, and Davidson, Macon, Robertson, Rutherford, Smith, Trousdale, and Wilson counties, Tennessee. The discussion for these plants was combined due to being in the same physical location; however, the 20-mile labor market area for Gallatin serves as the area for analysis given its larger expanse. However, employee numbers and average salaries are presented for Gallatin Combustion Turbine Plant only, due to its proposed retirement in the near-term.

Population data for the Gallatin-affected counties and Tennessee as a whole are provided in Table 4-29, based on the 2010 Census, 2016 ACS, and state data. As shown, from 2010 to 2016, population growth in half the affected counties was less than the growth estimated for Tennessee, while growth in Sumner County exceeded that of the state. Based on the 2016 ACS and state population projections for 2025, only one affected county is predicted to grow at rates less than the state, while the other seven counties, including Sumner County, will likely grow at rates substantially greater than Tennessee as a whole.

Table 4-29: Population change and projections for Gallatin-affected counties.

Geography	2010 Census	2016 ACS Estimate	% Change (2010 – 2016)	2025 Projected Population	% Projected Change (2016 – 2025)
Tennessee	6,346,105	6,548,009	3.2	7,148,217	9.2
Sumner County, TN (Gallatin/GCT)	160,645	172,786	7.6	205,787	19.1
Davidson County, TN	626,681	667,885	6.6	750,296	12.3
Macon County, TN	22,248	22,924	3.0	25,575	11.6
Robertson County, TN	66,283	67,905	2.4	76,459	12.6
Rutherford County, TN	262,604	290,289	10.5	376,248	29.6
Smith County, TN	19,166	19,176	0.1	20,473	6.8
Trousdale County, TN	7,870	7,970	1.3	9,098	14.2
Wilson County, TN	113,993	125,616	10.2	155,219	23.6

Sources:2010 Census; 2016 ACS; Tennessee Department of Health 2018; US Department of Health and Human Services 2018

Other demographic characteristics of the Gallatin-affected counties are summarized in Table 4-30, based on the 2010 Census and the 2016 ACS. The populations of three affected counties, excluding Sumner County, were more rural than the population of their respective states. In six affected counties, including Sumner County, the populations were more aged than that of the state. In three of the affected counties, not including Sumner County, there were lower percentages of people who were at least high school graduates and higher percentages of noninstitutionalized adults aged 18 to 64 years with disabilities than across the state. Higher percentages of people in five affected counties, excluding Sumner County, maintained the same residence between 2015 and 2016 than across the state.

Table 4-30: Demographic characteristics for Gallatin-affected counties.

Geography	% Rural Population	Median Age	% High School or Higher	% Noninst. Labor Force w/ Disability	% Diff. House 1 Yr. Ago
Tennessee	66.4	38.5	86.0	13.6	14.7
Sumner County, TN (Gallatin)	27.9	39.5	89.3	10.9	15.2
Davidson County, TN	3.4	34.2	87.5	10.4	18.2
Macon County, TN	79.6	39.6	75.7	18.4	13.1
Robertson County, TN	53.2	38.5	86.5	13	12.5
Rutherford County, TN	17.0	32.9	90.8	8.8	17.6
Smith County, TN	82.9	41.2	82.7	17.1	10.7
Trousdale County, TN	100.0	39.0	79.3	15.8	9.0
Wilson County, TN	38.5	40.3	89.8	10.8	13.2

Sources: 2010 Census; 2016 ACS

Table 4-31 summarizes 2016 ACS data on employment and income for the affected counties. Sumner County and four other Gallatin-affected counties had higher percentages of people in the labor force than Tennessee. The same five counties and two additional counties had lower unemployment rates than the state as a whole. Based on data from USBLS, total employment in Sumner County was estimated by the USBLS to be 92,939 in 2017. Based on USBEA estimates and as shown in

Table 4-31, per capita income was higher in Sumner County and three other affected counties than across Tennessee. The Gallatin CT facility average annual salary is approximately 2.4 times higher than the average of per capita income in affected counties, as estimated by the USBEA, and Gallatin CT facility directly employs eight people. Gallatin Fossil Plant directly employs 174 people.

Table 4-31: Employment and income characteristics for Gallatin-affected counties.

Geography	% of 16+ Civ. Pop. in Labor Force	Unemployment Rate	% Employed in Educ. Svcs., Hlth. Care, and Social Assistance	% Employed in Transpo., Warehousing, and Utilities	Per Capita Income, USBEA
Tennessee	60.8	7.5	22.7	6.3	$45,517
Sumner County, TN (Gallatin/GCT)	65.7	5.3	20.9	6.2	$46,998
Davidson County, TN	69.9	6.2	24.1	4.4	$63,063
Macon County, TN	57.6	6.8	18.3	6.8	$33,041

Geography	% of 16+ Civ. Pop. in Labor Force	Unemployment Rate	% Employed in Educ. Svcs., Hlth. Care, and Social Assistance	% Employed in Transpo., Warehousing, and Utilities	Per Capita Income, USBEA
Robertson County, TN	65.9	7.4	18.8	5.0	$40,463
Rutherford County, TN	70.0	6.1	21.1	6.2	$39,968
Smith County, TN	57.2	4.2	19.4	6.7	$36,759
Trousdale County, TN	60.7	8.0	28.3	9.2	$31,893
Wilson County, TN	65.3	5.4	18.6	6.0	$47,335

Sources: 2016 ACS; USBEA 2018

Pertinent civilian employment characteristics for the affected counties are also shown on

Table 4-31. Of the affected counties, Trousdale County, had the highest percentage of civilians employed in utilities, transportation, and related industries, while three affected counties, excluding Sumner County, had higher percentages of this type of employment than their respective states. In Sumner County, the largest percentage of civilian workers was employed in educational services, health care, and social assistance (20.9 percent), followed by the retail trade (12.9 percent). These industries employed the largest percentages of civilian workers in five other affected counties and the state.

4.8.4.4 Johnsonville Combustion Turbine Plant

The labor market area for Johnsonville Combustion Turbine Plant is defined as Humphreys County, Tennessee, where the facility is located, and Benton County, Tennessee.

Population data for the Johnsonville-affected counties and Tennessee as a whole are provided in Table 4-32, based on the 2010 Census, 2016 ACS, and state data. As shown, from 2010 to 2016, population declined in both affected counties, whereas the state grew. Based on the 2016 ACS and state population projections for 2025, this trend is predicted to continue, with both affected counties expected to grow at rates less than the state between 2016 and 2025.

Table 4-32: Population change and projections for Johnsonville-affected counties.

Geography	2010 Census	2016 ACS Estimate	% Change (2010 – 2016)	2025 Projected Population	% Projected Change (2016 – 2025)
Tennessee	6,346,105	6,548,009	3.2	7,148,217	9.2
Humphreys County, TN (Johnsonville)	18,538	18,216	-1.7	18,336	0.7
Benton County, TN	16,489	16,173	-1.9	15,669	-3.1

Sources: 2010 Census, 2016 ACS; Tennessee Department of Health 2018; US Department of Health and Human Services 2018

Other demographic characteristics of the Johnsonville-affected counties are summarized in Table 4-33, based on the 2010 Census and the 2016 ACS. The populations of both affected counties were more rural and older than the population of the state as a whole. The county populations also had lower percentages of people who were at least high school graduates and higher percentages of noninstitutionalized adults aged 18 to 64 years with disabilities than across the state. Higher percentages of people in affected counties maintained the same residence between 2015 and 2016 than statewide.

Table 4-33: Demographic characteristics for Johnsonville-affected counties.

Geography	% Rural Population	Median Age	% High School or Higher	% Noninst. Labor Force w/ Disability	% Diff. House 1 Yr. Ago
Tennessee	66.4	38.5	86.0	13.6	14.7
Humphreys County, TN (Johnsonville)	82.5	41.7	83.2	19.1	12.8
Benton County, TN	78.5	46.6	81.7	21.6	8.5

Sources: 2010 Census; 2016 ACS

Table 4-34 summarizes 2016 ACS data on employment and income for the affected counties. Both Johnsonville-affected counties had lower percentages of people in the labor force and higher unemployment rates than the state as a whole. Based on data from USBLS, total employment in Humphreys County was estimated by the USBLS to be 8,462 in 2017. Based on USBEA estimates and as shown in Table 4-34, per capita income in both Johnsonville-affected counties was lower than across Tennessee. The Johnsonville average annual salary is nearly 3.0 times higher than the average of per capita income in affected counties, as estimated by the USBEA, and Johnsonville directly employs 28 people.

Table 4-34: Employment and income characteristics for Johnsonville-affected counties.

Geography	% of 16+ Civ. Pop. in Labor Force	Unemployment Rate	% Employed in Educ. Svcs., Hlth. Care, and Social Assistance	% Employed in Transpo., Warehousing, and Utilities	Per Capita Income, USBEA
Tennessee	60.8	7.5	22.7	6.3	$45,517
Humphreys County, TN (Johnsonville)	51.8	8.0	24.3	7.8	$38,686
Benton County, TN	49.3	11.1	22.1	9.4	$29,022

Sources: 2016 ACS; USBEA 2018

Pertinent civilian employment characteristics for the affected counties are also shown on Table 4-34. Both affected counties had higher percentages of civilians employed in utilities, transportation, and related industries than the state. In Humphreys County, the largest percentage of civilian workers was employed in educational services, health care, and social assistance (24.3 percent), followed by manufacturing (20.2 percent). These industries employed the largest percentages of civilian workers in the other affected county and the state, as well.

4.8.4.5 Cumberland Fossil Plant

The labor market area for Cumberland Fossil Plant is defined as Stewart County, Tennessee, where the facility is located, and Bention, Dickson, Henry, Houston, Humphreys, and Montgomery counties, Tennessee, and Christian and Trigg counties, Kentucky.

Population data for the Cumberland-affected counties and associated states are provided in

Table 4-35, based on the 2010 Census, 2016 ACS, and state data. As shown, from 2010 to 2016, population growth in all affected counties except Montgomery County was less than the growth estimated for the associated states. Seven of the nine Cumberland-affected counties, including Stewart County, recorded population losses over that period. Of the Cumberland-affected counties, only Dickson and Montgomery counties recorded population gains over that period. While the populations of associated states are projected to increase between 2016 and 2025, seven of the Cumberland-affected counties are expected to increase over the same period, and two of these counties are projected to grow at greater rates than their respective states, as demonstrated in Table 4-35.

Table 4-35: Population change and projections for Cumberland-affected counties.

Geography	2010 Census	2016 ACS Estimate	% Change (2010 – 2016)	2025 Projected Population	% Projected Change (2016 – 2025)
Tennessee	6,346,105	6,548,009	3.2	7,148,217	9.2
Stewart County, TN (Cumberland)	13,324	13,257	-0.5	13,320	0.5
Benton County, TN	16,489	16,173	-1.9	15,669	-3.1
Dickson County, TN	49,666	50,926	2.5	57,196	12.3
Henry County, TN	32,330	32,291	-0.1	32,616	1.0
Houston County, TN	8,426	8,234	-2.3	8,144	-1.1
Humphreys County, TN	18,538	18,216	-1.7	18,336	0.7
Montgomery County, TN	172,331	189,709	10.1	233,603	23.1
Kentucky	4,339,367	4,411,989	1.7	4,886,381	10.8
Christian County, KY	73,955	73,936	-0.0	73,999	0.1
Trigg County, KY	14,339	14,267	-0.5	14,482	1.5

Sources: 2010 Census; 2016 ACS; Kentucky State Data Center 2016; Tennessee Department of Health 2018; U.S. Department of Health and Human Services 2018

Other demographic characteristics of the Cumberland-affected counties, as compared with associated states, are summarized in

Table 4-36, based on the 2010 Census and the 2016 ACS. The populations of affected counties were generally more rural and older than the state populations. The exceptions for this were in Montgomery and Christian counties, where the populations were less rural and younger than the associated states. In all but three counties, excluding Stewart County, there were lower percentages of people who were high school graduates or higher than the associated states. All seven Tennessee counties had higher percentages of noninstitutionalized adults aged 18 to 64 years with disabilities than across the state. For the most part, higher percentages of people in affected counties maintained the same residence between 2015 and 2016 than their associated states. The exceptions to this were Houston and Montgomery counties.

Table 4-36: Demographic characteristics for Cumberland-affected counties.

Geography	% Rural Population	Median Age	% High School or Higher	% Noninst. Labor Force w/ Disability	% Diff. House 1 Yr. Ago
Tennessee	66.4	38.5	86.0	13.6	14.7

Geography	% Rural Population	Median Age	% High School or Higher	% Noninst. Labor Force w/ Disability	% Diff. House 1 Yr. Ago
Stewart County, TN (Cumberland)	100.00	43.4	86.3	17.8	11.3
Benton County, TN	78.5	46.6	81.7	21.6	8.5
Dickson County, TN	67.8	40.0	83.6	15.6	11.9
Henry County, TN	66.8	45.1	84.3	21.2	12.5
Houston County, TN	100.0	43.5	76.9	23.3	14.8
Humphreys County, TN	82.5	41.7	83.2	19.1	12.8
Montgomery County, TN	19.7	30.3	92.2	14	21.6
Kentucky	41.6	38.6	84.6	15.8	15.1
Christian County, KY	28.6	28.3	86.0	15.1	14.7
Trigg County, KY	79.4	45.1	84.2	14.0	9.9

Sources: 2010 Census; 2016 ACS

Cumberland Fossil Plant directly employs 329 people. Table 4-37 summarizes 2016 ACS data on employment and income for the Cumberland-affected counties. All affected counties had lower percentages of people in the labor force than their respective states. Seven counties, including Stewart County, where Cumberland is located, had unemployment rates above that of the associated states. Based on data from USBLS, total employment in Stewart County was estimated to be 4,926 in 2017. Based on USBEA estimates, per capita income in all affected counties was lower than that of their respective state.

Table 4-37: Employment and income characteristics for Cumberland-affected counties.

Geography	% of 16+ Civ. Pop. in Labor Force	Unemployment Rate	% Employed in Educ. Svcs., Hlth. Care, and Social Assistance	% Employed in Transpo., Warehousing, and Utilities	Per Capita Income, USBEA
Tennessee	60.8	7.5	22.7	6.3	$45,517
Stewart County, TN (Cumberland)	49.0	8.7	20.0	6.9	$39,523
Benton County, TN	49.3	11.1	22.1	9.4	$33,164
Dickson County, TN	58.0	5.6	21.5	5.9	$39,055
Henry County, TN	53.2	7.9	20.9	8.0	$40,839
Houston County, TN	50.0	7.4	20.8	6.4	$32,297
Humphreys County, TN	51.8	8.0	24.3	7.8	$38,686
Montgomery County, TN	57.1	8.2	22.9	5.4	$40,633
Kentucky	59.0	7.6	24.0	6.0	$40,597

Geography	% of 16+ Civ. Pop. in Labor Force	Unemployment Rate	% Employed in Educ. Svcs., Hlth. Care, and Social Assistance	% Employed in Transpo., Warehousing, and Utilities	Per Capita Income, USBEA
Christian County, KY	48.4	10.4	21.4	4.1	$37,622
Trigg County, KY	54.5	10.1	26.2	10.3	$36,130

Sources: 2016 ACS; USBEA 2018

Pertinent civilian employment characteristics for the affected counties are also shown on Table 4-37. Of the affected counties, Trigg County had the highest percentage of civilians employed in utilities, transportation, and related industries, while Stewart County and six other affected counties exceeded state percentages for this type of employment. All counties except Dickson and Montgomery counties had higher percentages of civilians employed in mining and related industries than the associated states. These industries employed the largest percentages of civilian workers in both associated states and eight of the nine affected counties.

4.8.4.6 Kingston Fossil Plant

The labor market area for Kingston Fossil Plant is defined as Roane County, Tennessee, where Kingston is located, and Anderson, Cumberland, Knox, Loudon, McMinn, Meigs, Monroe, Morgan, Rhea, and Scott counties, Tennessee.

Population data for the Kingston-affected counties and Tennessee are provided in

Table 4-38, based on the 2010 Census, 2016 ACS, and state data. As shown, from 2010 to 2016, population growth in all except three affected counties was less than the growth estimated for the state. Three of the 11 affected counties, including Roane County, recorded population losses over that period. Based on state population projections for 2025, only three of the affected counties are projected to grow at greater rates than across Tennessee, and Roane County is expected to decline in population, as shown in

Table 4-38.

Table 4-38: Population change and projections for Kingston-affected counties.

Geography	2010 Census	2016 ACS Estimate	% Change (2010 – 2016)	2025 Projected Population	% Projected Change (2016 – 2025)
Tennessee	6,346,105	6,548,009	3.2	7,148,217	9.2
Roane County, TN (Kingston)	54,181	52,983	-2.2	52,247	-1.4
Anderson County, TN	75,129	75,545	0.6	78,454	3.9
Cumberland County, TN	56,053	57,895	3.3	63,521	9.7
Knox County, TN	432,226	448,164	3.7	491,829	9.7
Loudon County, TN	48,556	50,637	4.3	56,835	12.2
McMinn County, TN	52,266	52,606	0.7	54,415	3.4
Meigs County, TN	11,753	11,804	0.4	12,445	5.4
Monroe County, TN	44,519	45,482	2.2	48,124	5.8
Morgan County, TN	21,987	21,688	-1.4	22,211	2.4

Geography	2010 Census	2016 ACS Estimate	% Change (2010 – 2016)	2025 Projected Population	% Projected Change (2016 – 2025)
Rhea County, TN	31,809	32,461	2.1	33,990	4.7
Scott County, TN	22,228	22,029	-0.9	22,053	0.1

Sources: 2010 Census; 2016 ACS; Kentucky State Data Center 2016; **Tennessee Department of Health 2018**; US Department of Health and Human Services 2018

Other demographic characteristics of the Kingston-affected counties, as compared with Tennessee, are summarized in

Table 4-39, based on the 2010 Census and the 2016 ACS. The populations of six affected counties, including Roane County, were more urban than the state population, and the populations of eight affected counties, also including Roane County, were older. In all but two counties, including Roane County, there were lower percentages of people who were high school graduates or higher than across Tennessee. All except one affected county had higher percentages of noninstitutionalized adults aged 18 to 64 years with disabilities than the state as a whole. For the most part, higher percentages of people in affected counties maintained the same residence between 2015 and 2016 than the state. The exceptions for this are in Cumberland, Knox, Rhea and Monroe counties.

Table 4-39: Demographic characteristics for Kingston-affected counties.

Geography	% Rural Population	Median Age	% High School or Higher	% Noninst. Labor Force w/ Disability	% Diff. House 1 Yr. Ago
Tennessee	66.4	38.5	86.0	13.6	14.7
Roane County, TN (Kingston)	51.0	46.3	85.8	20.9	10.2
Anderson County, TN	34.7	43.3	85.5	18.9	13.2
Cumberland County, TN	60.9	50.1	83.6	21.5	15.4
Knox County, TN	10.9	37.3	90.6	13.0	16.0
Loudon County, TN	40.6	47.2	85.3	16.4	11.9
McMinn County, TN	60.3	42.9	83.2	16.1	13.8
Meigs County, TN	100.0	43.9	78.9	22.5	8.3
Monroe County, TN	76.1	43.1	79.1	21.9	17.2
Morgan County, TN	99.9	41.1	79.8	20.4	14.5
Rhea County, TN	68.0	40.3	75.9	21.9	17.2
Scott County, TN	80.6	38.8	77.3	24.5	10.8

Sources: 2010 Census; 2016 ACS

Kingston Fossil Plant directly employs 254 people. Table 4-40 summarizes 2016 ACS data on employment and income for the Kingston-affected counties. All affected counties had lower percentages of people in the labor force than across the state. Nine counties, including Roane County, where Kingston is located, had unemployment rates above the state. Based on data from USBLS, total employment in

Roane County was estimated by the USBLS to be 22,140 in 2017. Based on USBEA estimates, per capita income in Roane County and eight other counties was lower than that of Tennessee. Only Knox and Loudon counties had per capita incomes higher than the state.

Table 4-40: Employment and income characteristics for Kingston-affected counties.

Geography	% of 16+ Civ. Pop. in Labor Force	Unemployment Rate	% Employed in Educ. Svcs., Hlth. Care, and Social Assistance	% Employed in Transpo., Warehousing, and Utilities	Per Capita Income, USBEA
Tennessee	60.8	7.5	22.7	6.3	$45,517
Roane County, TN (Kingston)	52.1	9.3	22.1	6.8	$39,763
Anderson County, TN	49.0	7.4	21.1	5.1	$40,847
Cumberland County, TN	46.3	8.8	21.7	5.8	$36,038
Knox County, TN	56.1	6.2	24.7	4.7	$48,160
Loudon County, TN	42.3	7.5	19.1	6.5	$46,183
McMinn County, TN	52.8	8.6	19.2	4.4	$35,084
Meigs County, TN	46.9	12.5	16.0	8.2	$33,347
Monroe County, TN	50.7	11.5	21.0	5.0	$32,283
Morgan County, TN	42.2	8.6	21.0	7.6	$28,699
Rhea County, TN	56.7	8.0	17.2	9.9	$34,267
Scott County, TN	49.0	13.4	21.7	8.0	$28,721

Sources: 2016 ACS; USBEA 2018

Pertinent civilian employment characteristics for the affected counties are also shown on Table 4-40. Of the affected counties, Rhea County had the highest percentage of civilians employed in utilities, transportation, and related industries, while six counties, including Roane County, exceeded state percentages for this type of employment. In Roane County, the largest percentage of civilian workers was employed in educational services, health care, and social assistance (22.1 percent), followed by the retail trade (13.9 percent). The former category likewise employed the largest percentage of civilian workers in the state and six of the remaining ten affected counties, while manufacturing employed the largest percentages of workers in four of the affected counties.

4.8.4.7 Shawnee Fossil Plant

The labor market area for Shawnee Fossil Plant is defined as McCracken County, Kentucky, where Shawnee is located, and all counties within a 20-mile radius of Shawnee, consisting of Ballard, Carlisle, Graves, Livingston, and Marshall counties, Kentucky, and Johnson, Massac, Pope, Pulaski, and Union counties, Illinois.

Population data for the Shawnee-affected counties and associated states are provided in Table 4-41, based on the 2010 Census, 2016 ACS, and state data. As shown, from 2010 to 2016, population growth in all affected counties except, Johnson County, was less than the growth estimated for the associated states. Nine of the affected counties, including McCracken County, recorded population losses over that period. Of the Shawnee-affected counties, only Graves and Johnson counties recorded small population gains over that period. While the populations of associated states are projected to increase between 2016 and 2025, only five of the 11 Shawnee-affected counties are expected to increase over the same period, and two of these counties are projected to grow at greater rates than their respective states, as shown in Table 4-41.

Table 4-41: Population change and projections for Shawnee-affected counties.

Geography	2010 Census	2016 ACS Estimate	% Change (2010 – 2016)	2025 Projected Population	% Projected Change (2016 – 2025)
Kentucky	4,339,367	4,411,989	1.7	4,886,381	10.8
McCracken County, KY (Shawnee)	65,565	65,292	-0.4	65,487	0.3
Ballard County, KY	8,249	8,216	-0.4	8,097	-1.4
Carlisle County, KY	5,104	4,954	-2.9	4,604	-7.1
Graves County, KY	37,121	37,379	0.7	38,243	2.3
Livingston County, KY	9,519	9,353	-1.7	8,889	-5.0
Marshall County, KY	31,448	31,213	-0.7	31,060	-0.5
Illinois	12,830,632	12,851,684	0.2	13,263,662	3.2
Johnson County, IL	12,582	12,866	2.3	13,889	8.0
Massac County, IL	15,429	14,883	-3.5	15,438	3.7
Pope County, IL	4,470	4,255	-4.8	4,314	1.4
Pulaski County, IL	6,161	5,792	-6.0	5,079	-12.3
Union County, IL	17,808	17,458	-2.0	17,130	-1.9

Sources: 2010 Census; 2016 ACS; Illinois Department of Public Health 2015; Kentucky State Data Center 2016

Other demographic characteristics of the Shawnee-affected counties, as compared with associated states, are summarized in Table 4-42, based on the 2010 Census and the 2016 ACS. The populations of affected counties were generally more rural and older than the state populations. The exceptions to this were in McCracken County, where Shawnee is located, and Massac County, where the populations were less rural than the associated states. In all but three counties, excluding McCracken County, there were lower percentages of people who were high school graduates or higher than the associated states. Livingston County, Kentucky, and all five Illinois counties had higher percentages of noninstitutionalized adults aged 18 to 64 years with disabilities than their respective states. For the most part, higher percentages of people in affected counties maintained the same residence between 2015 and 2016 than their associated states. The exception to this was Johnson County, Illinois.

Table 4-42: Demographic characteristics for Shawnee-affected counties.

Geography	% Rural Population	Median Age	% High School or Higher	% Noninst. Labor Force w/ Disability	% Diff. House 1 Yr. Ago
Kentucky	41.6	38.6	84.6	15.8	15.1
McCracken County, KY (Shawnee)	27.8	42.4	87.8	13.3	12
Ballard County, KY	100	42.9	86.2	10.6	8.2

Geography	% Rural Population	Median Age	% High School or Higher	% Noninst. Labor Force w/ Disability	% Diff. House 1 Yr. Ago
Carlisle County, KY	100	42.4	81.8	11.2	7.5
Graves County, KY	69.4	40.3	81.7	14.4	6.9
Livingston County, KY	95.4	46.5	82.5	18.8	7.2
Marshall County, KY	85.9	44.8	85.9	14.4	8.1
Illinois	51.1	37.4	88.3	8.5	12.7
Johnson County, IL	100	42.9	83.4	13.8	12.8
Massac County, IL	50.5	44	85	18.3	9.2
Pope County, IL	100	50.6	87.2	26.4	7.7
Pulaski County, IL	100	43.5	82.7	20.6	7.8
Union County, IL	65.9	43.7	85.6	15.5	7.2

Sources: **2010 Census; 2016 ACS**

Shawnee Fossil Plant directly employs 241 people. Table 4-43 summarizes 2016 ACS data on employment and income for the Shawnee-affected counties. All affected counties had lower percentages of people in the labor force than their respective states. Five counties, excluding McCracken County, where Shawnee resides, had unemployment rates above that of the associated states. Based on data from USBLS, total employment in McCracken County was estimated by the USBLS to be 27,835 in 2017. Based on USBEA estimates, per capita income in all affected counties except McCracken and Carlisle counties was lower than their respective states.

Table 4-43: Employment and income characteristics for Shawnee-affected counties.

Geography	% of 16+ Civ. Pop. in Labor Force	Unemployment Rate	% Employed in Educ. Svcs., Hlth. Care, and Social Assistance	% Employed in Transpo., Warehousing, and Utilities	Per Capita Income, USBEA
Kentucky	59.0	7.6	24.0	6.0	$40,597
McCracken County, KY (Shawnee)	57.9	5.1	25.2	6.8	$48,797
Ballard County, KY	55.1	5.3	21.4	6.2	$36,849
Carlisle County, KY	56.7	7.9	20.7	8.1	$42,704
Graves County, KY	57.6	8.4	23.5	6.4	$36,685
Livingston County, KY	54.4	5.1	23.7	11.5	$36,412
Marshall County, KY	54.2	6.8	23.1	7.9	$39,039
Illinois	65.4	8.2	22.9	6	$54,203
Johnson County, IL	43.8	8.9	31.8	5.9	$32,881

Geography	% of 16+ Civ. Pop. in Labor Force	Unemployment Rate	% Employed in Educ. Svcs., Hlth. Care, and Social Assistance	% Employed in Transpo., Warehousing, and Utilities	Per Capita Income, USBEA
Massac County, IL	51.6	7.8	22.8	9.6	$36,835
Pope County, IL	40.3	8.5	26.9	8.1	$28,262
Pulaski County, IL	48.1	11.9	29.7	10.2	$36,215
Union County, IL	55.9	6.3	31.7	7.2	$41,756

Sources: 2016 ACS; USBEA 2018

Pertinent civilian employment characteristics for the affected counties are also shown on Table 4-43. Of the affected counties, Livingston County had the highest percentage of civilians employed in utilities, transportation, and related industries, and Mccracken County and all other affected counties except one exceeded state percentages for this type of employment. All counties except McCracken and Marshall counties had higher percentages of civilians employed in mining and related industries than across their respective states. In McCracken County, the largest percentage of civilian workers was employed in educational services, health care, and social assistance (25.2 percent), followed by the retail trade (13.1 percent). The former category employed the largest percentages of civilian workers in all other affected counties and both associated states.

4.9 Environmental Justice

Environmental justice-related impacts are analyzed in accordance with E.O. 12898 to identify and address as appropriate disproportionately high and adverse human health or environmental effects of federal programs, policies, and activities on minority populations and low-income populations. While TVA is not subject to this E.O., it routinely considers environmental justice impacts in its NEPA review processes.

Council of Environmental Quality (CEQ) guidance for applying E.O. 12898 under NEPA directs identification of minority populations when either the minority population of the affected area exceeds 50 percent or the minority population percentage of the study area is meaningfully greater than the minority population percentage in the general population or other appropriate unit of geographic analysis (CEQ 1997). The CEQ guidance also specifies that low-income populations are to be identified using the annual statistical poverty threshold from the USCB Current Population Reports Series P-60 on Income and Poverty. The USCB-provided 2016 poverty threshold for an individual was $12,228 and the official poverty rate for the U.S. as a whole in 2016 was 12.7 percent (USCB 2017).

CEQ defines minority populations as people who identify themselves as Asian or Pacific Islander, American Indian or Alaskan Native, Black (not of Hispanic origin), or Hispanic. Due to necessarily including one of these minorities, those indicating two or more races are also considered minorities. Minority and low-income populations may be groups of people living in geographic proximity or scattered groups or individuals sharing common conditions. In addition, the CEQ guidelines direct identification of groups demonstrating differential patterns of consumption of natural resources among minority and low-income populations.

The TVA PSA considered for environmental justice consists of 180 counties and two independent cities in seven states, including all counties in Tennessee and portions of Alabama, Georgia, Kentucky, Mississippi, North Carolina, and Virginia (see Appendix C for a complete list of counties considered). Following CEQ guidance, those counties with a minority population that exceeds that of the TVA PSA as a whole are presented as the portions of the TVA PSA where the chance for disproportional environmental and human health effects may be the greatest. Minority populations were identified using 2012 – 2016 ACS 5-year census estimates (2016 ACS) compiled in DP 5 for each of the 182 counties or independent cities in the TVA PSA. Per CEQ guidelines, low-income populations were defined as those with poverty rates above the TVA PSA average rate of 19.71 percent. These populations were identified using the 2016 ACS results compiled in Demographic Profile 3 for each of the counties and independent cities. Additional low-income populations were identified at the census tract level using poverty rates reported in 2016 ACS DP 3 for each of the counties and independent cities. Additional low-income populations were identified at the census tract level using the same census data source.

Where relevant, TVA PSA-wide environmental justice data is compared with information from USCB Division 6, East South Central. Division 6 includes the majority of the TVA PSA, consisting of Alabama, Kentucky, Mississippi, and Tennessee (USCB 2018d).

4.9.1 Low-Income Populations

Based on the 2016 ACS, the percentage of the overall TVA PSA population living below the poverty level was 19.71 percent. Eighty-two counties and two independent cities in the TVA PSA had poverty rates above the PSA average, as illustrated in Figure 4-29; the 2016 ACS estimates for per capita income and the percentage of the population living in poverty for PSA counties are included in Appendix D-1.

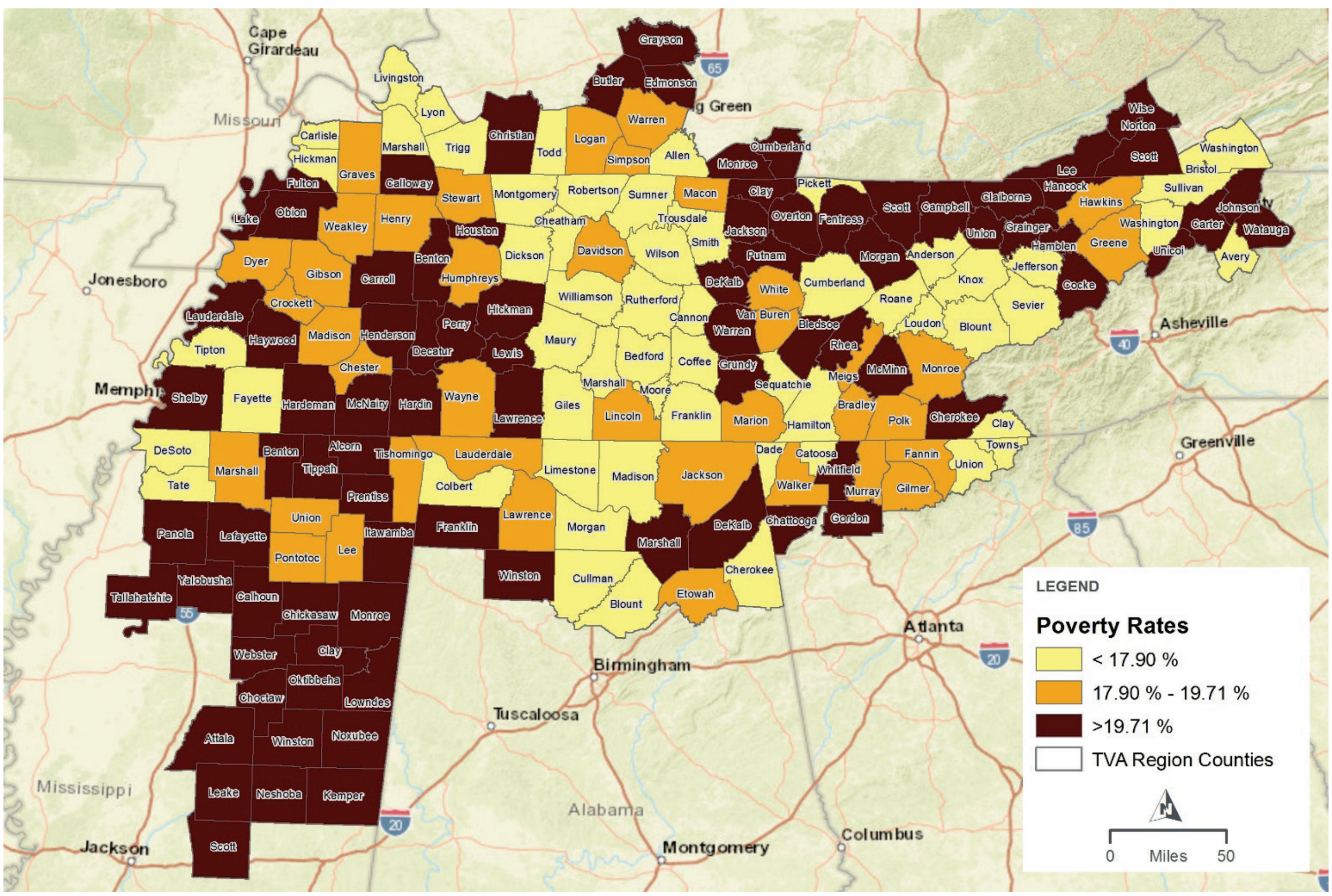


Figure 4-29: Poverty rates (proportion of population with annual income below $12,228) of Counties in the TVA PSA.

A total of 900 census tracts in 174 counties or independent cities and seven states had poverty rates above the TVA PSA average. Low-income census tracts are in all but eight counties of the TVA PSA. The per capita income levels and poverty rates from the 2016 ACS are included in Appendix D-2.

4.9.2 Minority Populations

Based on the 2016 ACS data, the minority population in the TVA PSA is estimated to be 21.3 percent. Eight counties in the PSA had minority populations that exceeded 50 percent, well above the average in the PSA as a whole (Figure 4-30). These included Haywood and Shelby counties in Tennessee and Clay, Kemper, Marshall, Noxubee, Panola, and Tallahatchie counties in Mississippi. The minority percentages of each are shown in Table 4-44 in comparison with those of Division 6 and the TVA PSA as a whole. In these areas, the African-American population composed the highest percentage of the population, averaging almost 55 percent. An additional 31 counties had a minority population greater than the TVA PSA average. All of the counties with minority percentages higher than the TVA PSA as a whole are listed in Appendix D-3.

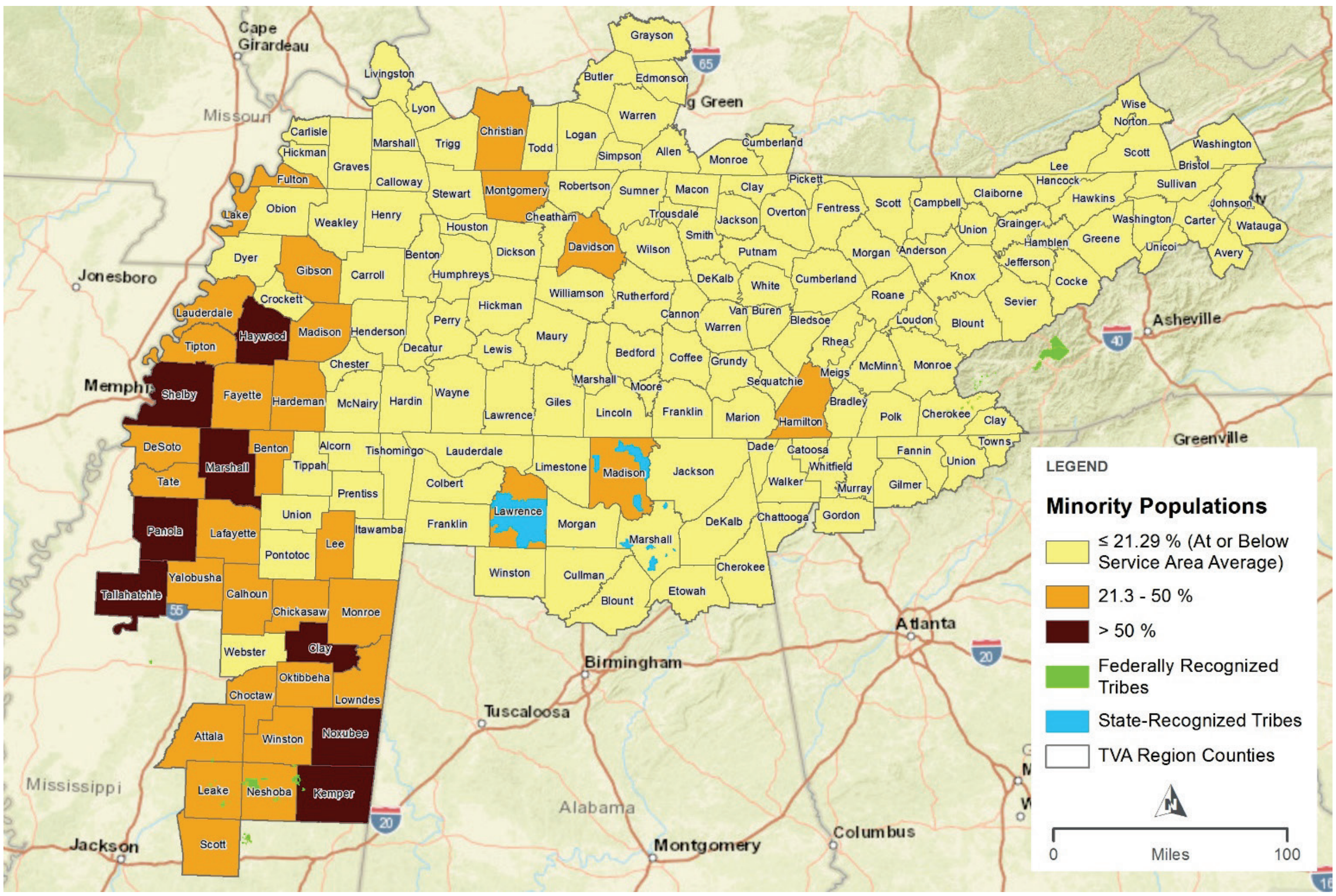


Figure 4-30: Minority populations at the county level in the TVA PSA.

Table 4-44: Counties in the TVA PSA with minority populations cxceeding 50 percent.

Geography	2016 Pop.	2016 Minority %	% African American	% Am. Indian / AK Native	% Asian	% Native Hawaiian / Other Pacific Islander	% Some Other Race	% Two or More Races	% Hispanic
Division 6	18,790,354	25.3	21.4	1.0	1.7	0.1	1.3	1.8	4.0
TVA PSA	10,042,431	21.3	17.0	1.1	1.8	0.1	1.2	1.9	5.2
TVA PSA Counties									
Noxubee County, MS	11,098	69.9	69.2	0.5	0.0	0.0	0.2	0.0	4.0
Kemper County, MS	10,128	64.5	60.8	3.7	0.0	0.0	0.0	0.5	1.5
Tallahatchie County, MS	14,776	62.3	46.7	0.6	1.6	0.4	13.3	0.4	15.2
Shelby County, TN	936,990	60.4	54.2	0.7	2.9	0.2	3.0	1.7	6.0
Clay County, MS	20,147	59.5	58.4	0.4	0.7	0.0	0.1	0.3	1.3
Haywood County, TN	18,129	54.0	51.1	0.6	0.2	0.5	2.6	1.1	4.2
Panola County, MS	34,319	51.5	51.0	0.2	0.1	0.1	0.2	1.0	1.6
Marshall County, MS	36,196	50.8	48.4	0.7	0.1	0.0	1.8	1.1	3.4

Source: 2016 ACS DP05

Three state-designated tribal statistical areas (SDTSA) are extant in the TVA PSA in northern Alabama and considered part of the minority population (USCB 2012). These consist of the Cherokee Tribe of Northeast Alabama SDTSA in Jackson County, Echota Cherokee SDTSA in Cullman, Lawrence, and Madison counties, and United Cherokee Ani-Yun-Wiya Nation SDTSA in Marshall County. Their locations are shown on Figure 4-30.

4.9.3 Federally Recognized Tribes

Two federally recognized tribes currently maintain reservations within the TVA PSA: the Eastern Band of Cherokee Indians (EBCI) in southwestern North Carolina and the Mississippi Band of Choctaw Indians (MBCI) in east central Mississippi, as shown on Figure 4-30. These sovereign nations are part of the minority population in the TVA PSA. Detailed USCB data is provided in an effort to better characterize these tribal populations and anticipate potential risks.

The EBCI is composed of 14,000 tribal members, while the resident population of the EBCI reservation, located in Cherokee, Graham, Jackson, and Swain counties, North Carolina, was estimated to be 9,613 for the period between 2012 and 2016 (EBCI 2016; USCB 2012). The ancestors of EBCI members either never made the journey to resettle in Oklahoma, which was mandated by the federal government in the Indian Removal Act of 1830, or made the trip and eventually returned to their homeland in and around western North Carolina (EBCI 2016).

Based on the 2016 ACS, the EBCI resident population had a median age of 32 years old, with approximately 37 percent between the ages 25 and 54 (USCB 2012). Within the population 25 years old and older, approximately 80 percent was estimated to be high school graduates or higher, and 11.4 percent was estimated to hold a bachelor's degree or higher. Of the civilian population 18 years old and older, almost 7 percent was classified as military veterans.

Approximately 97 percent of the EBCI population 16 years old or older in the labor force was employed, making the unemployment rate approximately 3.1 percent. Over 40 percent of the civilian employed population was employed in service occupations. According to the 2016 ACS data, the median household income was $32,379 and 25.3 percent of the resident population earned income amounts below the poverty level during the year prior to the estimates being made. Nearly 74 percent of occupied housing units was estimated to be owner-occupied, and the median housing unit value was $105,100. Over 66 percent of the civilian noninstitutionalized population had health insurance, with approximately one-third (33.6 percent) uninsured.

The MBCI reservation is located on 35,000 acres in east central Mississippi, in portions of Attala, Carroll, Kemper, Leake, Neshoba, Newton, and Winston counties (MBCI 2016). Approximately 10,000 people comprise the MBCI tribal membership, while the resident population of the MBCI reservation was estimated to be 7,735 for the period between 2012 and 2016 (MBCI 2016; USCB 2012). The ancestors of MBCI members were among a small percentage of Choctaws who did not relocate to Oklahoma when required to do so by the Indian Removal Act of 1830 (MBCI 2016).

Based on 2016 ACS estimates, the age groups between 5 and 9 years old and 24 and 34 years old composed the largest percentage of the MBCI resident population (over 28 percent), contributing to a relatively young median age of 25.3 years old (USCB 2012). Within the population 25 years old and older, approximately 70 percent was estimated to hold a high school diploma or higher, and 2.7 percent, to have completed a four-year college degree or higher. Approximately 2.6 percent of the civilian population 18 years old and older was military veterans.

The unemployment rate among the MBCI resident population was estimated at approximately 13.7 percent. The largest occupational group for the MBCI resident population was service occupations, which employed approximately 47.6 percent of the civilian working population. The median household income was $35,732, and 33.5 percent of the resident population and 28.9 percent of families were estimated as having income amounts below the poverty level for the year prior to the estimates being made. The median housing unit value was $67,000, and almost 70 percent of occupied units were owner-occupied. Approximately 33.5 percent of the resident population was uninsured, with approximately two-thirds (66.5 percent) estimated to have health insurance.

4.9.4 TVA Programs Benefiting Minority and Low-Income Populations

In partnership with local power companies, TVA offers several programs directed at or involving low-income or minority populations in its PSA. These are summarized in this subsection.

The eScore residential energy efficiency program provides a customized path for making a residence energy efficient (see Section 2.5.1) and provides rebates for purchases of energy efficient appliances. Demographic information collected on over 70,000 participants in the program indicated that just under 40 percent of participants had household incomes under $50,000 and of that percent, nearly one in five were renters. Nearly 20 percent of participants were also over age 65.

TVA launched the Extreme Energy Makeovers program in 2015 using mitigation funds from the USEPA Air Agreements funds. The program provided $42 million in grants to seven LPC teams to upgrade over 3,475 homes in low-income communities. These grants provide weatherization upgrades for electrically-heated, single family homes at no cost to income-qualified participants and achieved around 36 percent energy savings for less than $10 per square foot. With the average age of participating homes 58 years, upgrades included HVAC, ductwork, insulation and other measures to reduce energy consumption and energy costs. The teams included LPCs and local community partners (including resource agencies, local municipal offices) to develop community-based projects that best served the low-income residents within the LPC service area. Teams included Knoxville, TN (Knoxville Extreme Energy Makeover), Huntsville, AL (Huntsville Extreme Energy Makeover), Cleveland, TN, North Georgia, GA, Oak Ridge, TN, Columbus, MS, and 4-County, MS. This project ended in 2017.

TVA continues to examine ways to develop a sustainable, Valley-wide low-income weatherization program through the Home Uplift initiative. Home Uplift includes seven pilots to develop program and technical tools to support larger efforts to serve more residents. TVA has invested $5 million over two years to Home Uplift projects in Memphis, Chattanooga, Nashville, Knoxville, Huntsville, 4-County, MS, and West Kentucky to weatherize over 1,000 homes. Another objective of the pilots is to create a pool of participants for longer-term study on the non-energy benefits of home weatherization. This 2-year study will help quantify the health benefits of improved home with the objective of seeking local, state, federal and private community funding for future weatherization.

Other programs led by LPCs in partnership with TVA focus on economically-disadvantaged residents. For example, low-income Memphis, Light, Gas and Water (MLGW) residential customers have been recipients of various program benefits such as home weatherization grants and loans (DNV GL 2018). One such program, the Max Impact (MI) home weatherization loan program, provided on-bill financed low-interest loans up to $2,500 for home weatherization improvements for households with maximum annual incomes of $50,000. Another program is Share the Pennies – MLGW's Round up program where customers' bills are rounded to the next whole dollar, with the funds generated being used to weatherize qualified homes. With a $1 million dollar grant in 2018, TVA matches MLGW's investment dollar-for-dollar to increase the impact on participant's homes. MLGW offers several other program options for low-income, elderly, disabled, and other qualifying customers including grants, educational programs, pre-payment programs, budget billing (whereby payments are spread over a 12-month period), payment moratoriums, and home improvement initiatives.

TVA and the State of TN Weatherization Assistance Program (WAP) have partnered since 2008 to provide training for auditors and energy savings kits to WAP clients. These kits include direct install items such as LED light bulbs and educational materials. In 2018, TVA developed and launched a new technical tool to streamline the field and administrative processes which enabled full utilization of federal funding for low-income weatherization in Tennessee.

TVA also offers some grant assistance and special programming for areas termed Special Opportunities Counties (SOC). Only counties with the lowest per capita personal income, the highest percentage of residents below the poverty level, and the highest average annual unemployment rates are eligible for the SOC program. The list of eligible counties is updated annually. Figure 4-31 shows the counties considered SOC in 2018.

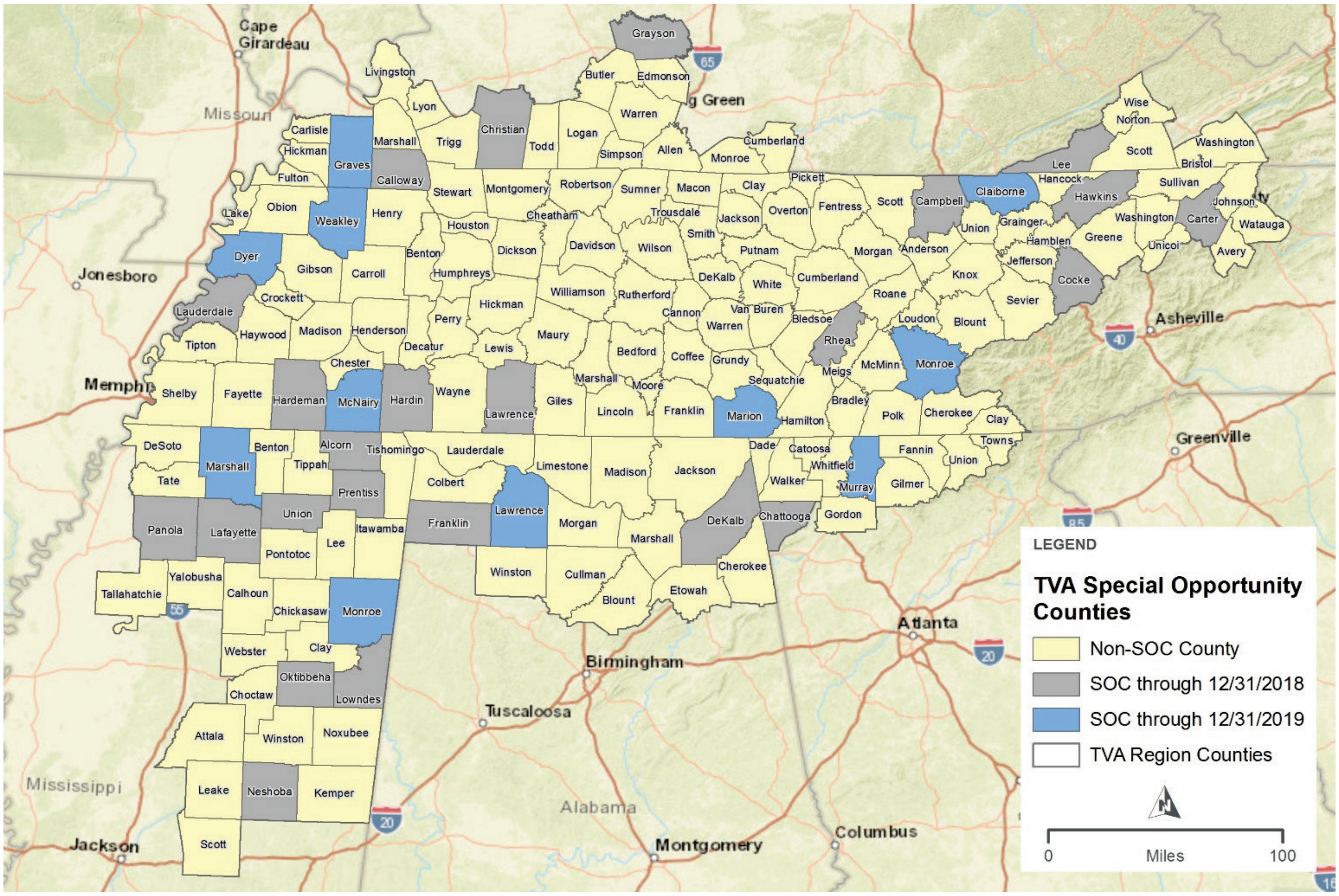


Figure 4-31: 2018 Special Opportunities Counties, as designated by TVA.

4.9.5 Environmental Justice Communities near TVA Power Plants

Demographic indicators for potential environmental justice concerns were obtained for a 3-mile radius surrounding TVA power plants, including the eight plants identified in the IRP for full or partial retirement over the 20-year study period. Indicators considered herein include minority, low-income, and linguistically isolated population percentages, as well as population percentages for children under 5 years of age and adults over 64 years of age. These data derive from the USEPA's EJSCREEN database, which utilizes the most current ACS 5-year estimates (USEPA 2018e), as shown in Table 4-45. For comparison purposes, EJSCREEN data is also provided for associated states and the nation as a whole.

Table 4-45: Environmental justice demographic indicators for selected TVA power plants.

Geography / Plant	% Minority Pop.	% Low-Income Pop.	% Linguistically Isolated Pop.	% Pop. Under Age 5	% Pop. Over Age 64
US	38	34	4	6	14
Alabama	34	39	1	6	15
Bellefonte Nuclear	34	37	0	2	22
Colbert CT	16	26	0	2	21
Kentucky	15	39	1	6	15

Geography / Plant	% Minority Pop.	% Low-Income Pop.	% Linguistically Isolated Pop.	% Pop. Under Age 5	% Pop. Over Age 64
Shawnee Fossil	13	44	0	5	21
Mississippi	43	45	1	6	14
Ackerman CC	17	35	0	5	26
Caledonia CC	12	31	0	6	13
Magnolia CC	34	43	0	4	26
Southaven CC	74	48	1	7	13
Tennessee	25	38	1	6	15
Allen CC, CT	100	67	0	8	22
Cumberland Fossil	10	52	0	4	21
Gallatin Fossil, CT	6	18	3	6	13
John Sevier CC	9	51	0	6	17
Johnsonville CT	5	30	0	4	18
Kingston Fossil	7	39	0	5	21
Lagoon Creek CC	42	48	0	6	14
Sequoyah Nuclear	4	24	0	6	14
Watts Bar Nuclear	2	39	0	4	15

EJSCREEN data for the 18 plants considered in this analysis indicate that three plant locations have minority percentages that are higher than their associated states. These consist of the Allen CT and Lagoon Creek CC plants in Tennessee, and Southaven CC in Mississippi. Both Allen and Southaven CC are located in the Memphis metropolitan area, while Lagoon Creek CC is in Brownsville, Tennessee, approximately 60 miles northeast of Memphis. The same plant locations, along with John Sevier CC, located in the Appalachian region of northeastern Tennessee, demonstrate higher percentages of low-income populations than their associated states. Ten of the 18 plants have higher percentages of the population over the age of 64 than their respective states. This is reflective of the overall higher median age of the TVA PSA, as discussed in Section 4.8.1.2. For the most part, data indicate that the numbers of people under age 5 or considered linguistically isolated surrounding the plant locations are not significant in comparison with associated states. Appendix D-3 presents ethnicity percentages for each county in the TVA PSA, including those in which the 18 plants are located (see also Figure 1-1).

5 Anticipated Environmental Impacts

This chapter describes the anticipated environmental impacts of the alternative strategies and their associated portfolios. It first describes the general process Tennessee Valley Authority (TVA) uses to site new power facilities. It then describes the potential environmental impacts of the continued operation of TVA's generating facilities, facilities from which TVA purchases power through Power Purchase Agreements (PPAs), and the generating facilities that TVA is likely to own or purchase power from in the future. The chapter then describes the environmental impacts of distributed energy resources (DER), energy efficiency (EE) programs, and demand response (DR) programs. These are followed by a description of the environmental impacts of the construction and upgrading of the transmission system necessary to support future generating facilities. Finally, this chapter describes potential mitigation measures and commitment of resources.

5.1 Facility Siting and Review Processes

When planning new generating facilities, TVA uses several criteria to screen potential sites. Generating facilities are often needed in specific parts of the TVA power service area in order to support the efficient operation and reliability of the transmission system. Once a general area is identified, sites are screened by numerous engineering, environmental and financial criteria.

Specific screening criteria include regional geology and local terrain; proximity to major highways, railroads and barge access; proximity to major natural gas pipelines; proximity to high-voltage transmission lines; land use and land ownership; regional air quality; sources of process water; the presence of floodplains; proximity to parks and recreation areas; potential impacts to endangered and threatened species, wetlands, and historic properties; and potential impacts to minority and low-income populations. Through this systematic process, TVA attempts to minimize the potential environmental impacts of the construction and operation of new generating facilities.

New transmission facilities are typically required to transmit power between two defined points or to improve transmission capacity and/or reliability in a defined area. As with generating facilities, potential transmission line routes, substation locations, and switching station locations are screened by numerous engineering, environmental and financial criteria. Specific screening criteria include slope; the presence of highways, railroads and airports; land use and land ownership patterns; proximity to occupied buildings, parks and recreation areas; and potential impacts to endangered and threatened species, wetlands and historic properties. TVA also provides for and encourages participation by potentially affected landowners in this screening process.

TVA is not directly involved in the siting and operation of natural gas pipelines that may have to be built to serve new natural gas plants. Instead, TVA purchases natural gas service from contractors who are responsible for constructing and operating the pipeline. Construction and operation of a natural gas pipeline are subject to various state and federal environmental requirements depending on how and where constructed. If a pipeline is built specifically to serve TVA, TVA would evaluate the potential environmental impacts and take steps to ensure any associated impacts are acceptable.

The results of the site screening process, as well as the potential impacts of the construction and operation of the generating and transmission facilities at the screened alternative locations, are described in comprehensive environmental review documents made available to the public. During this environmental review process, TVA consults with the appropriate State Historic Preservation Officer on the potential impacts to historic properties and, as necessary, with the USFWS on the potential impacts to endangered and threatened species and their designated critical habitats.

Independent power producers (IPPs), from whom TVA purchases power under long-term PPAs, typically use a site screening process similar to the TVA process described above for new generating facilities. Depending on the location of the facility, approval by state and/or local authorities may also be necessary. The action by TVA of entering into a long-term PPA is subject to the requirements of the National Environmental Policy Act (NEPA) and other environmental laws and regulations, and TVA conducts comprehensive environmental reviews of generating facilities that IPPs propose to construct in order to provide power to TVA under long-term PPAs. TVA's criteria for approving a PPA typically include the requirement that, pending the outcome of the environmental review, TVA determines that the proposed facility is "environmentally acceptable" and would not result in significant environmental impacts.

5.2 Environmental Impacts of Supply-Side Resource Options

Because the locations of most future generating facilities are not known, this impact assessment focuses on impact areas that are generally not location-specific. These impact areas are described below.

Air Quality – The potential impacts to air quality are described by the direct emissions of the sulfur dioxide (SO_2), nitrogen oxide (NO_x), and mercury (Hg) and are quantified by the amounts emitted per unit of electricity generated and the total amounts emitted under each of the alternative strategies and portfolios during the 20-year planning period.

Greenhouse Gases (GHG) – As previously recommended by Council of Environmental Quality (CEQ 2016), GHG emissions are assessed for both the direct emissions of CO_2, from the combustion of non-renewable carbon-based fuels, and for the life cycle GHG emissions, which include direct and indirect emissions of CO_2, methane, nitrous oxide (N_2O), and other greenhouse gases. Life cycle GHG emissions include emissions from the construction, operation, and decommissioning of generating facilities; the extraction or production, processing and transportation of fuels; and the management of spent fuels and other wastes. Because life cycle GHG emissions have not been specifically determined for TVA's generating facilities, the estimates used in this assessment are based on published life cycle assessments (LCAs, e.g., Dolan and Heath 2012, Warner and Heath 2012, NETL 2016). Both direct CO_2 emissions and life cycle GHG emissions are quantified by the amount emitted per unit of electricity generated and the total amount emitted under each of the alternative strategies and portfolios during the 20-year planning period. Where distinguishable and unless otherwise stated, the LCA values described below do not include impacts associated with the transmission and distribution of the electricity generated by the various facilities. Life cycle GHG emissions are standardized to the 100-year global warming potentials adopted by the IPCC Fourth Assessment Report (Forster et al. 2007) or, for more recent LCAs, the IPCC Fifth Assessment Report (Myrhe et al. 2013)

Water Resources – The impacts of water pollutants discharged from a generating facility are highly dependent on site- and facility-specific design features, including measures to control or eliminate the discharge of water pollutants, which are not addressed here. The impacts of the process water used and consumed by a thermal generating facility (primarily for cooling) depend on the characteristics of the source area of water withdrawals and of the water bodies where process water is discharged. The quantities of process water used and consumed are indicators of the magnitude of these impacts. Facilities with open-cycle cooling systems withdraw and discharge large quantities of water. Facilities with closed-cycle cooling systems use less water but consume (typically by evaporation) a large proportion of it. Water use and consumption are quantified by the volumes used and consumed per unit of electricity generated and the total volumes used and consumed under each of the alternative strategies and portfolios. These water quantities are described for the TVA system as a whole, as well as by major river basin and whether from surface or groundwater sources.

Solid Waste – The potential for impacts from the generation and disposal of solid wastes are assessed by the quantities of coal ash, scrubber sludge (i.e., synthetic gypsum and related materials produced by flue gas desulfurization systems), and high-level radioactive waste (spent nuclear fuel). These are quantified by the amounts produced per unit of electricity generated and the total amounts under each of the alternative strategies and portfolios.

Fuel Consumption – The amount of fuel consumed relates to the potential impacts of the extraction or production, processing, and transportation of fuels. Fuel consumption is quantified by the amount consumed per unit of electricity generated and the total amount consumed under each of the alternative strategies and portfolios. In addition to coal, coal plants equipped with scrubbers or circulating fluidized bed boilers use limestone ($CaCO_3$) or slaked lime ($Ca(OH)_2$) as a reagent to reduce SO_2 emissions. The quantity of limestone or lime consumed is a function of the quantity and the SO_2 content of coal consumed. As with coal, the quarrying, processing and transportation of limestone and lime affects air, water and land resources.

Land Requirements – Land requirements for the alternative strategies and portfolios are quantified by both the facility land requirements and life cycle land requirements. These land requirements are indicators of the potential for impacts to land-based resources such as vegetation, wildlife, many endangered and threatened species, cultural resources such as archaeological sites and historic structures, land use, prime farmland, visual/aesthetic resources, recreation, and to aquatic resources from runoff and sedimentation. While this analysis assumes that the potential for impact increases with the land area affected, the kind of impact and its potential severity will vary depending on site-specific conditions and locations, as well as on the type of facility.

The facility land requirement is the land area permanently disturbed by the construction of the generating unit. It does not include adjacent lands that are part of the facility site and maintained in a natural or semi-natural state as buffers or exclusion zones. Facility land requirements were determined from a variety of sources, including characteristics of TVA facilities, both existing and under development; characteristics of comparable facilities recently constructed or proposed elsewhere in the country; and various published reports on this topic. The facility land requirement given for each strategy and portfolio is the total acreage permanently disturbed by the construction of new generating facilities during the planning period.

The life cycle land requirement is a measure of the land area transformed during the life cycle of a generating facility, expressed in terms of units of area per amount of electricity generated. This land includes the facility site; adjacent buffer areas; lands used for fuel extraction or production, processing, and transportation; and land used for managing spent fuels and other wastes. Some of the land areas, such as the facility site, are transformed for decades while others, such as some minelands, are transformed for shorter time periods. These differing time periods are considered in the development of the LCA. The estimates used in the following descriptions are based on published LCAs (e.g., Fthenakis and Kim 2009, Jordaan et al. 2017). Published life-cycle land requirement information is not available for some of the generating and storage facilities under consideration. For some other facilities, the available published information is based on facilities with substantial differences from current or proposed TVA facilities in important components such as the length of natural gas pipelines and therefore not readily applicable to TVA facilities.

Life cycle land requirements can also be expressed with a land-use metric that accounts for the total surface area occupied by the materials and products used by a facility, the time the land is occupied, and the total energy generated over the life of the facility (Spitzley and Keoleian 2005, AEFPERR 2009). The rank order by energy technology reported for a sample of U.S. facilities, from the smallest to the largest land requirements, is natural gas, coal, nuclear, wind, solar PV, conventional hydroelectric, and biomass. The large land requirements for hydroelectric include the reservoirs, which typically have other uses. The biomass land requirements are based on the use of dedicated woody or non-woody crops; the use of forest residues would also result in a somewhat lower land requirement. Biomass generation using landfill gas, mill residues, or other byproducts has a much smaller life cycle land requirement than biomass generation using other fuel. Relatively few LCAs address this type of land-use metric.

Following is a discussion of the environmental attributes of the generation options. Environmental characteristics of new supply-side resources selected in the capacity expansion plans are listed in Table 5-1. A few of the environmental characteristics listed in Table 5-1 are dependent on their location and on the detailed facility design and are difficult to quantify without more detailed engineering analyses. The various types of generating facilities are described in Section 5.2 of Volume I and Section 2.3 of Volume II. It is important to note there are comprehensive environmental laws and regulations that address almost all activities associated with the construction and operation of new industrial facilities, particularly energy generation facilities. This regulatory umbrella ensures the environmental impacts associated with energy resources are acceptable and in general, public health and the environment are adequately protected.

Table 5-1: Environmental characteristics of new supply-side resources included in alternative strategies.

	Summer Net Dependable Capacity, MW	Summer Full-Load Heat Rate, Btu/kWh	Storage Efficiency	SO2 emissions, lbs/MWh	NOx emissions, lbs/MWh	HG emissions, lbs/MWh	CO2 emissions, tons/GWh	GHG life cycle emissions, tons CO2-eq/GWh	Process water use, gallons/MWh	Process water consumption, gallons/MWh	Facility land requirement, permanently disturbed acres	Facility land requirements, acres/MW
Aeroderivative Combustion Turbine 6x (GE LMS 100)	576	9,350		0	0.337	0	547		0	0	45	0.0781
Combustion Turbine 3x (7FA)	703	10,132		0	0.365	0	593		0	0	68	0.0967
Combustion Turbine 4x (7FA)	934	10,132		0	0.365	0	593		0	0	68	0.0728
Combined Cycle 2x1	1,062	6,520		0	0.078	0	382		250	195	80	0.0502
Combined Cycle 2x1 Supplemental Duct Firing	120	8,656		0	0.104	0	507		250	195	0	0
Small Modular Reactors	600	10,046		0		0			1164	665	375	0.6250
Compressed Air Energy Storage	330	4,700	70%	0	0.169	0	275		0	0	80	0.2424
Utility-Scale Battery Storage	100		88%	0	0	0	0		0	0	4	0.1600

	Summer Net Dependable Capacity, MW	Summer Full-Load Heat Rate, Btu/kWh	Storage Efficiency	SO2 emissions, lbs/MWh	NOx emissions, lbs/MWh	HG emissions, lbs/MWh	CO2 emissions, tons/GWh	GHG life cycle emissions, tons CO2-eq/GWh	Process water use, gallons/MWh	Process water consumption, gallons/MWh	Facility land requirement, permanently disturbed acres	Facility land requirements, acres/MW
Utility-Scale Tracking Solar (20 Year PPA)	34 (50)*			0	0	0	0		0	0	365	7.300

5.2.1 Fossil-Fueled Generation

5.2.1.1 Coal – Existing Facilities

TVA currently operates 26 coal-fired generating units at 6 plant sites (see Section 2.3.1). Flue gas desulfurization (FGD) systems for SO_2 control and selective catalytic reduction (SCR) systems for NO_x emissions control have been installed at 19 of these units. The plants with these FGD and SCR systems include TVA's largest coal units and total about 7,000 MW of generating capacity. The remaining coal-fired units use other methods to reduce SO_2 and NO_x emissions including the use of low-sulfur coal, low-NO_x burners, and selective non-catalytic NO_x reduction systems.

While the life cycle GHG emissions for TVA coal plants have not been calculated, several studies have calculated these emissions for comparable coal plants. Spitzley and Keoleian (2005) found an emission rate of 1,060 tons CO_2-eq/GWh[4] for pulverized coal boilers without advanced emissions control systems, comparable to seven of the Shawnee units. NETL (2010a) calculated a life cycle GHG emission rate of 1,226 tons CO_2-eq/GWh (1,112 kg/MWh) for a pulverized coal plant equipped with an electrostatic precipitator, SCR, and scrubber, comparable to Kingston, Gallatin, and two Shawnee units. For a supercritical pulverized coal plant (SCPC) equipped with an electrostatic precipitator, FGD and SCR, comparable to Bull Run, Cumberland and Paradise Unit 3, NETL (2010b) calculated a life cycle GHG emission rate of 1,045 tons CO_2-eq/GWh (948 kg/MWh).

The largest source of life cycle GHG emissions from coal plants similar to TVA's is CO_2 from coal combustion, which typically accounts for between 80 and 90 percent of GHG emissions (Kim and Dale 2005, Odeh and Cockerill 2008, Cuéllar-Franca and Azapagic 2015). The next highest source is methane emissions from coal mining; these emissions are higher for underground than surface mines. Methane emissions from underground mining of Illinois Basin coal, which accounted for 39 percent of TVA's 2017 coal supply and 46 percent of the 2018 coal supply, are several times those from mining Powder River Basin (PRB) coal (NETL 2014). This difference is attributable to both the higher methane content of bituminous coals (such as Illinois Basin coal), and to the greater rate of PRB coal bed methane recovery and utilization as part of the natural gas supply. Coal preparation and transport typically account for less than 1 percent of GHG emissions (NETL 2010b). Other GHG sources include limestone mining and transport, lime processing for FGD systems using slaked lime such as the systems at Gallatin and on two Shawnee units. GHG emissions from plant construction, decommissioning and other processes are relatively small.

All TVA coal plants, except Paradise, use only open-cycle cooling and thus have high water use rates but low water consumption rates (see Section 4.4). Paradise uses closed-cycle cooling much of the year causing lower water use and higher water consumption rates. As a result, the amount of heat discharged to the Green River at Paradise is relatively low.

The Red Hills plant in Mississippi burns lignite coal from an adjacent surface mine. Relative to the average for TVA's coal plants, the Red Hills CO_2 emission rate is high due to the low heat rate of the plant and low fuel energy content. Like the TVA coal plants with FGD systems, Red Hills uses limestone to reduce SO_2 emissions. The plant occupies about 320 acres and its fuel cycle disturbs about 275 acres/year, equivalent to 0.09 acre/GWh of energy generated. It uses groundwater in a closed-cycle cooling system with no discharges to receiving water bodies.

Coal mining has the potential to adversely impact large areas, depending on the mining method and area being mined. The impacts are greatest from surface mining, particularly by mountain- top removal, in Appalachia (U.S. Environmental Protection Agency (USEPA) 2005, Palmer et al. 2010). In recent years TVA has greatly reduced its use of coal from Appalachian surface mines and currently uses no coal from this source. Impacts from surface mining include removal of forests and other plant communities, disruption of wildlife habitat, alteration of streams and associated aquatic communities, and long-term alterations of the mine area topography. Impacts from underground mining are typically less than those of surface mining.

Coal plants produce large quantities of ash and, if equipped with FGD systems, calcium-based residues (see Section 4.7). Although some of these coal combustion residuals (CCRs) are recycled for a range of beneficial uses, large quantities are typically permanently stored in impoundments or landfills at or near coal plants. These facilities can occupy tens to hundreds of acres.

5.2.1.2 Coal – New Facilities

The new coal facilities available for selection during the portfolio modeling are an integrated gasification combined cycle (IGCC) plant with and without carbon capture and sequestration (CCS), and two configurations of supercritical pulverized coal (SCPC) plants with and without CCS (see Volume 1 Section 5.2.2). The environmental impacts of constructing and operating an IGCC plant without CCS, the Mesaba Energy Project, are described in USDOE (2009). The environmental impacts of constructing and operating IGCC plants with CCS are described for the FutureGen plant in USDOE (2007) and for the Kemper County, Mississippi, IGCC Project in USDOE (2010). Life cycle impacts of SCPC and IGCC plants with and without CCS are described by Odeh and Cockerill (2008), NETL (2010b, 2012), and Cuéllar-Franca and Azapagic (2015). Life cycle GHG emissions of SCPC plants with CCS vary according to the technology used to capture CO_2, with emissions from plants utilizing oxy-fuel combustion up to about a quarter lower than plants utilizing post-combustion capture (Cuéllar-Franca and Azapagic 2015).

Relative to conventional SCPC coal plants, emissions of priority air pollutants from an IGCC plant without CCS are low, especially for SO_2. Projected life cycle GHG emissions for an IGCC plant without CCS are comparable to or somewhat higher than those of a SCPC plant (NETL 2012, Cuéllar-Franca and Azapagic 2015). Assuming a 90 percent carbon capture rate, adding CCS to a new SCPC plant would reduce life cycle GHG emissions from approximately 1,045 to 283 tons CO_2-eq/GWh, and adding CCS to an IGCC plant would reduce life cycle GHG emissions to about 190 to 242 tons CO_2-eq/GWh (NETL 2012, Cuéllar-Franca and Azapagic 2015). For both SCPC and IGCC plants, adding CCS increases the proportion of life cycle GHG emissions attributable to coal mining and processing from about 8 percent to 41–43 percent.

New SCPC and IGCC plants are assumed to have closed-cycle cooling systems. Adding CCS to a SCPC plant increases water consumption by the generating facility by about 70 percent to around 920 gallons/MWh (NETL 2010b). For an IGCC plant, CCS raises water consumption by around 25 percent to 413 gallons/MWh (NETL 2012). Other estimates for IGCC plants with CCS, closed-cycle cooling systems, and zero liquid discharge include 469 gallons/MWh for the Kemper County plant (USDOE 2010) and 655 gallons/MWh for the FutureGen plant (USDOE 2007). Instead of the fly ash, bottom ash, and scrubber sludge produced by a SCPC plant, IGCC plants produce a glassy, inert slag during the gasification process. The projected slag production rate for the FutureGen plant, using Illinois Basin coal, is 47.3 tons/GWh (USDOE 2007).

Projected facility surface land requirements for IGCC plants with CCS include 200 acres for the 275-MW FutureGen plant (USDOE 2007) and 550 acres for the 582-MW Kemper plant (USDOE 2010). The average land requirement for these two plants is 0.84 acres/MW. The 1,200-MW Mesaba IGCC plant, without CCS, is projected to occupy 300 acres (USDOE 2009). The IGCC plant without CCS option considered in this IRP process is assumed to require 400 acres and the IGCC plant with CCS option is assumed to require 450 acres. The difference is due to the land requirements for CCS components, particularly CO_2 pipelines and injection wells. Published life cycle land requirements are not available and would vary with the type of coal being used, mining method, CCR disposal method, and distance from the generating facility to the carbon sequestration site.

TVA's SCPC plants occupy land areas of 730 to 3,000 acres, with an average of 0.83 acres/MW. Recently constructed SCPC and advanced ultra-supercritical plants in the U.S. (John W. Turk, Jr. in Arkansas, Longview in West Virginia, Sandy Creek in Texas, and Prairie State in Illinois) occupy an average of 0.91 acres/MW. Based on these averages, and because the correlation between plant land area and capacity is weak, a new 800-MW SCPC plant is assumed to occupy 725 acres and a new 1,600-MW SCPC is assumed to occupy 1,100 acres. Due to the land requirements for CCS components, adding CCS to the SCPC plants is assumed to require an additional 50 acres.

Life cycle land requirements for coal plants without CCS range from about 0.037 to 0.099 acres/GWh (Fthenakis and Kim 2009). The type of mining of the coal used to fuel a coal plant is the largest source of variation, with surface mining affecting a larger land area. The time required to reclaim the mined area also affects the life cycle land requirements.

5.2.1.3 Natural Gas – Existing Facilities

The construction and operational impacts of TVA's recently constructed frame-type combustion turbine (CT) and combined cycle (CC) plants (e.g., Lagoon Creek CT, John Sevier CC, Paradise CC, Allen CC) are described in several EISs and environmental assessments (e.g., TVA 2000, TVA 2010a, TVA 2013b, TVA 2014b). Natural gas-fired plants do not emit SO_2 or mercury, and direct emissions of NO_x (usually controlled by water or steam injection and/or SCR systems) and CO_2 are low relative to other fossil plants. CT plants require minimal amounts of process water.

TVA's CC plants use closed-cycle cooling, as do most other CC plants elsewhere. The average land area for TVA CT plants is about 90 acres (0.153 acres/MW). TVA CC plants occupy an average of about 87 acres (0.108 acres/MW).

Life cycle GHG emissions have not been calculated for TVA's gas-fired plants. NETL (2016) reported life cycle GHG emissions of about 514 and 560 tons CO_2-eq/GWh for U.S. fleet CC plants operated in baseload and load-following modes, respectively. For advanced class combustion turbines, similar to those at TVA's newest CC plants, NETL (2016) reported life cycle GHG emission rates of 497 tons CO_2-eq/GWh. The life cycle GHG emissions for the U.S. fleet of CT plants was reported by NETL (2016) to be 747 tons CO_2-eq/GWh. This emission rate is probably close to that of the TVA CT plants which are comprised of a mix of older, lower capacity turbines and more recent, higher capacity advanced class turbines.

About 20 to 22 percent of the GHG emissions from CC and CT plants reported by NETL (2016) results from the extraction, processing and transport of natural gas. These emissions are dominated by methane. The natural gas supply analyzed in this study was based on the 2012 U.S. mix of domestic sources, including 34 percent "conventional" gas sources (23 percent onshore, 5 percent offshore, and 6 percent associated) and 66 percent "unconventional" gas sources (20 percent tight, 39 percent shale, and 6 percent coal bed methane) (NETL 2016). The GHG emission rate during gas production and transport to gas plants averaged

12.7 grams CO_2-eq/megajoule (MJ, equivalent to 948 BTU) of natural gas.

GHG emission rates were somewhat higher for unconventional tight (21.0 grams CO_2-eq/MJ), Barnett shale (12.4 grams CO_2-eq/MJ), and Marcellus shale (14.5 grams CO_2-eq/MJ) gas production than for conventional onshore (10.3 grams CO_2-eq/MJ gas production. When the full life-cycle GHG emissions are considered, including those from combustion in the power plant, the differences between attributable to the gas source are minimal and less than 1 percent of total life-cycle GHG emissions (Heath et al. 2014).

One of several areas of concern over the environmental impacts of shale gas production by hydraulic fracturing has been over fugitive emissions of methane. Hydraulic fracturing, used in the production of shale and "tight" gas, as well as coal-bed methane, involves the injection of pressurized fluids (predominantly water with gels and chemical additives) and sand into the well borehole to fracture the gas-bearing rock formation and increase its permeability. Howarth et al. (2011) suggested that high methane emissions during shale gas production resulted in higher overall GHG emissions than coal. Other studies have shown the life cycle carbon footprint of electricity generation from shale gas is similar to (Weber and Clavin 2012) or somewhat (11 percent) greater than (Hultman et al. 2011) generation from conventional gas. Even when accounting for higher emissions from the use of shale gas, Hultman et al. (2011) and NETL (2014) concluded that electricity generation from shale gas had a much lower GHG emissions than generation from coal.

In a review of published studies, Heath et al. (2014) found GHG emission rates were somewhat higher for unconventional tight (21.0 grams CO_2-eq/MJ), Barnett shale (12.4 grams CO_2-eq/MJ), and Marcellus shale (14.5 grams CO_2-eq/MJ) gas production than for conventional onshore (10.3 grams CO_2-eq/MJ gas production. When the full life-cycle GHG emissions are considered, including those from combustion in the power plant, the differences attributable to the gas source are minimal and less than 1 percent of total life-cycle GHG emissions.

Several other areas of concern over the environmental impacts of shale gas production have been identified and the risk to water resources is the subject of numerous studies. In a Congressionally mandated study of the impact of fracking on water resources, USEPA (2016a) identified the following areas of concern: water withdrawals in times or areas of low water availability; spills that result in large volumes or high concentrations of chemicals reaching groundwater resources; leakage of gas or injected liquids from wells into groundwater resources; injection of hydraulic fracturing fluids directly into groundwater resources; discharge of inadequately treated wastewater into surface water resources; and the disposal of wastewater into unlined pits, resulting in contamination of groundwater resources. An assessment of the frequency and severity of the resulting impacts was limited by data gaps and uncertainties in the available data. Vengosh et al. (2014) identified additional risks to water resources and recommend several mitigation measures to reduce these risks. Some of these measures have been the subject of various regulatory and industry initiatives.

Other areas of risk include decreased air quality, induced seismicity (earthquakes) from hydraulic fracturing and disposal of fracturing fluids and produced water by deep injection, habitat loss and fragmentation, noise and light pollution, public health, and socioeconomic and community effects. Some of these risk areas are not as well-known as those related to water resources and methane emissions (Small et al. 2014, Souther et al. 2014). Recently published studies have shown an increase in earthquakes in the central U.S. attributable to the deep underground injection of wastewater. Much of this wastewater is saline produced water from oil and gas wells. Relatively few induced earthquakes are directly attributable to hydraulic fracturing (Rubenstein and Mahani 2015, Weingarten et al. 2015).

5.2.1.4 Natural Gas – New Facilities

The new natural gas facilities available for selection during the portfolio modeling are three configurations of reciprocating internal combustion engine (RICE) generating sets, three configurations of aeroderivative CT plants, two configurations of frame-type CT plants, three configurations of CC plants without carbon capture and storage, and a CC plant with CCS (see Volume 1 Section 5.2.2). The CT and CC plant configurations are based on advanced F-class combustion turbines. The environmental characteristics of these plants are generally similar to those of existing recent gas plants characterized above by NETL (2016), although the new frame-type F-class turbines are somewhat more efficient and thus have somewhat lower emission rates. Land area requirements for frame-type CT and CC plants are based on those of TVA's newest frame-type CT and CC plants, which show little correlation between land area and capacity. Land area requirements for RICE and aeroderivative CT plants are based on published reports or calculated from aerial photographs of existing plants elsewhere in North America. Little published data on the life cycle impacts, including life cycle GHG emissions, of these plants is available. The GHG life cycle emission rate of the aeroderivative CTs is likely about 10 percent lower than that of the frame-type 7FA CTs given the approximately 10 percent lower heat rate and higher efficiency of the aeroderivative CTs.

Fthenakis and Kim (2009) estimated a life cycle land requirement of approximately 0.076 acres/GWh for a natural gas-fired plant using gas from conventional sources. Jordaan et al. (2017) found a life cycle land requirement of 0.153 acres/GWh in an analysis of several CC and CT plants in Texas fueled by natural gas from the Barnett Shale area in Texas. The largest contributor to the land requirement was the pipeline infrastructure, which accounted for about 74 percent of the land requirement. Gathering pipelines, which connect well sites with transmission pipelines, were the largest component of the pipeline infrastructure. The power plant was also a large contributor to the land requirement, with lower efficiency CT plants requiring more land than higher efficiency CC plants.

5.2.2 Nuclear Generation

5.2.2.1 Nuclear – Existing Facilities

The impacts of operating TVA's existing nuclear plants are described in previous EISs and other reports (e.g., TVA 2007b). Nuclear power generation does not directly emit regulated air pollutants or GHGs. The largest variable in life cycle GHG emissions of a nuclear plant, aside from the operating lifetime, electrical output, and capacity factor, are related to the uranium fuel cycle and include the uranium concentration in the ore, the type of uranium enrichment process, and the source of power for enrichment facilities. Almost all past uranium enrichment in the U.S. used the energy-intensive gaseous diffusion process largely powered by fossil fuels. No gaseous diffusion enrichment facilities are currently operating or likely to operate in the U.S. in the future. Commercial enrichment by the centrifuge process began in the U.S. at a plant in New Mexico in 2010. This process, widely used outside the U.S., can require less than 3 percent the energy of the gaseous diffusion process.

Construction of other U.S. centrifuge process enrichment plants is currently on hold. Laser enrichment processes would further reduce energy requirements; commercial development of this technology in the U.S. has slowed due to the recent low demand for nuclear fuel. The use of highly enriched uranium from surplus U.S. Department of Energy (USDOE) inventories diluted to commercial reactor fuel also reduces GHG emissions.

The life cycle GHG emissions of TVA's nuclear plants have not been determined. In a recent international survey of nuclear electric generation life cycle studies, Warner and Heath (2012) reported a median GHG emission rate of 13.2 tons CO_2-eq/GWh (12 grams CO_2-eq/kWh) and an interquartile range (the 75th percentile value minus the 25th percentile value) of 18.7 tons CO_2-eq/GWh. Boiling water reactors, such as TVA's Browns Ferry plant, tend to have slightly higher life cycle GHG emissions than pressurized water reactors such as TVA's Sequoyah and Watts Bar plants. Fthenakis and Kim (2007) reported life cycle GHG emissions of 17.6 to 60.6 tons CO_2-eq/GWh for U.S. nuclear plants. Part of the difference in emission rates between the 2012 international survey and the 2007 U.S. study is the greater U.S. reliance on the more energy-intensive gaseous diffusion enrichment process. Fthenakis and Kim (2007) predicted a decrease in life cycle GHG emissions to about 13.2

tons CO_2-eq/GWh with exclusive use of centrifuge enrichment.

TVA's nuclear plants occupy an average of 1,114 acres each and about 80 percent of this area is developed. Life cycle land metrics have not been determined for TVA's nuclear plants.

Fthenakis and Kim (2009) estimated a life cycle land transformation of 0.023 acres/GWh for nuclear power. About half of this transformed land is the power plant site. Due to the evolving approach to the long-term disposal of spent fuel, the land required for offsite spent fuel disposal is excluded from this estimate. Use of the Yucca Mountain, Nevada, site for long-term disposal would increase the estimate by about a third.

5.2.2.2 Nuclear – New Facilities

The new nuclear generation options available for selection during the portfolio modeling are a 1,260-MW pressurized water reactor, a 1,117-MW advanced pressurized water reactor (characterized by the AP1000 design), and a 600-MW multiple unit small modular reactor (see Volume 1 Section 5.2.2.1). The impacts of constructing and operating a one- or two-unit pressurized water reactor nuclear plant at the Bellefonte site in northeast Alabama are described in a 1974 EIS (TVA 1974).

In 2008, TVA completed an environmental report (TVA 2008b) for a combined license application to the Nuclear Regulatory Commission for the construction and operation of a two-unit AP1000 nuclear plant on the Bellefonte site adjacent to two partially built pressurized water reactors. Most operational impacts would be comparable to those of TVA's existing nuclear plants with the exception of water use and water consumption. A new advanced pressurized water reactor would operate with closed cycle cooling; water use would be relatively low and water consumption relatively high compared to TVA's other thermoelectric plants. The environmental impacts of constructing and operating similar advanced pressurized water reactors at other sites in the U.S. have been described in EISs issued by the Nuclear Regulatory Commission. These include, for example, Vogtle Units 3 and 4 in Georgia and V. C. Summer Units 2 and 3 in South Carolina (NRC 2018a).

The impacts of constructing and operating a small modular reactor (SMR) plant would be generally similar to those of TVA's existing nuclear plants and the other new nuclear generation options, but proportionately less due to the lower capacity of the small modular reactor plant. These impacts have recently been described by NRC in the April 2019 Final EIS (NRC 2019) for a new SMR plant at TVA's Clinch River Site in Roane County. The use of modular construction for major plant components would reduce construction impacts at the plant site compared to a conventional pressurized water or advanced pressurized water reactor.

5.2.3 Renewable Generation

TVA's current renewable energy portfolio is dominated by the hydroelectric facilities at its dams and power purchase agreements for wind energy. Power purchase agreements for solar generation are a small but rapidly growing component of the portfolio (see Sections 3.3 and 3.4). Following is an overview of the environmental impacts of renewable generation from hydroelectric, wind, solar, and biomass facilities.

5.2.3.1 Hydroelectric – Existing Facilities

Impacts of the operation of TVA's hydroelectric facilities are described in the *Reservoir Operations Study* (TVA 2004). Hydropower generation does not directly emit GHGs and its life cycle GHG emissions are among the lowest of the various types of generation. Although not studied for TVA facilities, reported GHG emission rates from other hydroelectric facilities vary greatly and are frequently greatest shortly after the reservoir is initially filled. These emissions are primarily methane from the decomposition of flooded biomass. Scherer and Pfister (2016) modeled GHG emissions from hydroelectric reservoirs based on measured GHG emissions from a variety of reservoirs with different characteristics. The best predictors of GHG emissions were the ratio of reservoir area to electricity generation, the age of the reservoir, and the local maximum temperature. Reservoir productivity has also been identified as a predictor of GHG emissions (Deemer et al. 2016). Calculated GHG emissions from 15 TVA hydroelectric reservoirs ranged from -5 kg CO_2-eq/KWh for Apalachia (indicating this small, run-of-river reservoir is a carbon sink rather than a carbon source) to 32 kg CO_2-eq/KWh for Fontana to 208 kg CO_2-eq/kWh for Kentucky (Scherer and Pfister 2016). Their average of 74 kg CO_2-eq/kWh is lower than the U.S. average of 148 kg CO_2-eq/kWh. Hydroelectric reservoirs are frequently constructed to serve multiple purposes, including flood control, navigation, water supply and recreation; these purposes other than hydropower offset some of the GHG emissions. Scherer and Pfister (2016) considered these multiple uses in their analysis and adjusted their estimates according to the ranking of hydropower among the multiple purposes of each reservoir. Consequently, their estimates reflect emissions attributable to the reservoir's hydropower use.

5.2.3.2 Hydroelectric – New Facilities

Under all the alternatives, TVA would continue to modernize its hydroelectric units as part of its normal maintenance activities. The impacts of these upgrades have been described in environmental assessments for many facilities (e.g., TVA 2005a). While the upgrades generally do not change the volume of water used on a daily cycle, they can increase the rate of water passing through the turbines and result in small, periodic increases in downstream velocities. A potential consequence of the increased velocity is increased downstream bank erosion, which TVA mitigates as necessary by protecting stream banks with riprap or other techniques. Other environmental impacts of hydro modernization are minimal and there is typically no additional long-term conversion of land.

Two options for new hydroelectric generation involve adding turbines to existing TVA hydroelectric dams. One option is adding a 40-MW turbine to a main-stem dam where water is regularly spilled (passed over the dam through floodgates during high flow periods) to utilize the energy potential in the spilled water. The other option is adding a 30-MW turbine where there is adequate existing space for the turbine. Both of these would be relatively major construction projects, although most construction activities would occur on the dam reservations.

An additional option for new hydroelectric generation is the development of run-of-river generating facilities. Run-of-river facilities could include the addition of turbines to existing, non- power dams and in-stream turbines not requiring a dam. One type of run-of-river generating facility is adding turbines to existing run-of-river dams, such as old mill dams. The construction of the generating facilities could result in major modifications to the dams and transmission upgrades, and at some sites would require additional land. The dams would continue to operate in a run-of-river mode, which would lessen some potential environmental impacts. Provisions for fish passage, however, could be required at some dams. See Section 5.2.2.5 of Volume I for descriptions of potential sites. Other run-of-river projects would use very small or no reservoirs. One class of these would divert part of the stream flow into a raceway to a downstream generator without totally blocking the stream channel. Potential environmental impacts include alterations of the streambed and stream banks, removal of riparian vegetation, and, for at least a short stretch of the stream, reduction of stream flow (Electric Power Research Institute (EPRI) 2010). Another type of run-of-river facility is in-stream generators mounted on the streambed or suspended from a barge or other structure. These could interfere with boating and other recreational uses of the stream. At this time, their potential impacts on fish and other aquatic life are poorly known, although a few studies have suggested they are not significant. Land requirements vary with the type of run-of-river facility and for this analysis are assumed to be 0.5 acres/MW. Life-cycle GHG emissions from all of the new hydroelectric options would be low because, with the possible exception of very small reservoirs for some run-of-river projects, the options do not include the construction of new reservoirs.

5.2.3.3 Wind – Existing Facilities

A significant portion of TVA's renewable generation portfolio is wind generation from the Cumberland Mountains of Tennessee, the upper Midwest, and the Great Plains (Table 3-6). TVA currently purchases power from eight wind farms with a total of 757 turbines. The hub heights of these turbines range from 78–100 m and the rotor diameters range from 77–100

m. TVA completed environmental assessments for wind farms in Tennessee and Kansas (TVA 2011b, 2011c).

Impacts of wind farm construction include the clearing and grading of access roads and turbine sites and excavation for turbine foundations and electrical connections. Denholm et al. (2009) reported an average direct permanent impact area of 0.74 acres/MW, and a direct average temporary impact area of 1.73 acres/MW. These impact areas average somewhat smaller in mid-western croplands and somewhat larger in Great Plains grasslands/herbaceous areas and forested Appalachian ridges. A review of wind farms supplying TVA purchased power (Table 2-6) showed that their average direct impact area is close to that of Denholm et al. (2009).

The total wind farm area tends to be much larger than the direct impact areas and nationwide averages 84 acres/MW or a capacity density of 1 MW/82 acres (Denholm et al. 2009). This density, while low relative to most other types of electrical generation, varies greatly due to different leasing practices by wind farm developers. Using a different analysis technique that incorporated capacity factor, Miller and Keith (2018) calculated an energy density of 1MW/494 acres for windfarms constructed between 1998 and 2016. A very small proportion of this wind farm area is directly disturbed and most land-use practices can continue on the remainder of the area. Land clearing and road and transmission line development for wind farms can, however, result in habitat fragmentation. Operational impacts include turbine noise, which can be audible for distances of a quarter mile or more, and the visual impacts of the turbines which can dominate the skyline. Operating turbines can also cause shadow flicker, the flickering effect caused when rotating wind turbine blades periodically cast shadows through constrained openings such as the windows on neighboring properties. The scale of the problem depends on a number of factors such as turbine height, wind speed and direction, position of the sun, distance from the turbine, local terrain and amount of cloud cover; modeling tools have been developed to quantify shadow flicker associated with existing and proposed windfarms. Shadow flicker has been reported to cause headaches and increase stress for some individuals.

Impacts to biological resources include habitat fragmentation, displacement of wildlife that avoid tall structures, and mortality of birds and bats from collision with turbines. Bats can also die from trauma induced by air pressure changes caused by the rotating turbines (BLM 2005, Baerwald et al. 2008). Loss et al. (2013) and Erickson et al. (2014) compiled information on bird collision mortality at wind farms across North America. Loss et al. (2013) estimated mean annual mortality rates of 6.86 birds/turbine (3.86 birds/MW) for the eastern U.S. (including Tennessee and Illinois) and 2.92 birds/turbine (1.81 birds/MW) for the Great Plains (including Iowa and Kansas). This study also found an increase in mortality rate with turbine hub height. Erickson et al. (2014) estimated annual mortality rates for songbirds (passerines) of 2.58–3.83 birds/MW for the eastern U.S. (including Tennessee) and 2.15–3.96 birds/MW for the Plains region (including Illinois, Iowa, and Kansas). In comparing total estimated wind farm mortality of individual species of songbirds with their estimated continent-wide populations, Erickson et al. (2014) concluded less than 0.045 percent of the entire population of each species suffered mortality from collisions with turbines.

While the impacts of bird mortality are probably not significant in most areas, the impacts of bat mortality have a greater potential for concern. The highest annual bat mortality rates, 20.8–69.6 bats/turbine (14.9–53.3 bats/MW) have been reported at wind farms on forested ridges in the eastern U.S. (Arnett et al. 2008, Hayes 2013). Annual rates at Midwest wind farms (i.e., much of the potential MISO area) are lower, between 2.0 and 7.8 bats/turbine (2.7–8.7 bats/MW). Very limited bat mortality information is available from wind farms in the southern Great Plains (i.e., much of the potential Southwest Power Pool (SPP) and high voltage direct current (HVDC) wind resource areas), where one study found a mortality rate of 1.2 bats/turbine/year (0.8/MW) (Arnett et al. 2008, USDOE 2015). Common patterns detected in bat mortality studies include the following: 1) most fatalities occur in later summer and early fall; 2) most fatalities are of migratory, foliage- and tree-roosting species; and 3) most fatalities occur on nights with low wind speed (<6 meters/second) and 4) fatalities increase immediately before and after the passage of storm fronts (Arnett et al. 2008).

The U.S. Fish and Wildlife Service has developed guidelines (USFWS 2012) for the siting, development, and operation of wind farms. These voluntary guidelines include preliminary site screening, detailed site characterization studies, post-construction studies, and potential impact reduction and mitigation measures. Reducing the operation of wind turbines during periods of low wind speeds at night during seasons when bats are most active has been shown to be an effective measure for reducing bat mortality while having minimal effect on power generation (Arnett et al. 2011).

Wind turbines produce no direct emissions of air pollutants or GHGs. In a recent international survey of land-based, utility-scale wind power generation life cycle studies, Dolan and Heath (2012) found a median GHG emission rate of 12 tons CO_2-eq/GWh (11 grams CO_2-eq/KWh) and an interquartile range (the 75th percentile value minus the 25th percentile value) of 11 tons CO_2-eq/GWh. The largest contributor to variation in the life cycle GHG emission rate was the turbine capacity factor.

5.2.3.4 Wind – New Facilities

The EIS for the Plains & Eastern Clean Line Transmission Project (USDOE 2015b) describes the potential impacts of constructing and operating this HVDC transmission line. TVA was a cooperating agency in the development of this EIS, which also programmatically describes the potential impacts of constructing and operating wind farms in the Oklahoma and Texas Panhandle area from which TVA could purchase power under the HVDC and SPP wind power options. Most of the potential HVDC wind farm area is rangeland. Potential wind farm sites in other portions of the SPP service area are also dominated by rangeland. Potential wind farm sites in the MISO area are primarily agricultural land with an increasing proportion of rangeland in the Dakotas.

TVA anticipates the developers of wind farms will follow USFWS guidelines on windfarms (USFWS 2012). Land area requirements, based on the direct permanent impact area, are conservatively assumed to be 1 acre/MW for wind farms in the TVA service area and 0.8 acre/MW for wind farms elsewhere. Larger areas are affected by the noise and visual impacts of wind turbines, as well as shadow flicker.

5.2.3.5 Solar – Existing Facilities

TVA operates 14 small solar PV installations. TVA also purchases energy generated from numerous PV facilities up to 101 MW_{DC} in size (see Section 2.4).

TVA assessed the potential impacts of small PV facilities in a programmatic environmental assessment (TVA 2014c) and the impacts of larger solar facilities in other EAs listed in Section 1.3.4. Most completed ground-mounted PV facilities have been constructed on previously cleared areas, frequently pasture, hayfield, or crop land, and most have required little grading to smooth or level the site. Several have been constructed on land classified under the Farmland Protection Policy Act as prime farmland. Although the construction and operation of the PV facility usually eliminates agricultural production on the area, it typically does not adversely affect soil productivity or the ability to resume agricultural production once the PV facilities are removed (NCCETC 2017). The construction of the PV facility frequently affects local scenery, but this affect is often minor because of the low profile of the PV components and vegetative screening, either existing or planted as part of the PV facility development.

PV facilities produce no direct emissions of air pollutants or GHGs. In a recent international survey of crystalline silicon power generation life cycle studies, Hsu et al. (2012) found a median GHG emission rate for chrystalline silicon PV panels of 50 tons CO_2-eq/GWh (45 grams CO_2-eq/KWh) and an interquartile range (the 75th percentile value minus the 25th percentile value) of 11 tons CO_2-eq/GWh (10 g/kWh). These rates are based an annual solar insolation of 1,700 kWh/m^2/year, within the range of 1,460–1,825 kWh/m^2/year (4–5 kWh/m^2/day) found across most of the TVA region (see Figure 4-21, Section 4.6.2). The largest contributor to variation in the life cycle GHG emission rate was the insolation level. Facilities using thin-film PV panels based on cadmium-telluride (CdTe), which are often used in large utility-scale PV facilities, have a life cycle

GHG emission rate of 22 tons CO_2-eq/GWh (20 grams CO_2-eq/kWh; Kim et al. 2012). Few PV facilities using thin-film PV panels had been built in the TVA service area; some currently proposed large-capacity PV facilities would use thin-film PV panels.

Land requirements for PV facilities vary greatly and depend on the type of installation. Building- mounted systems require no additional land. Ground-mounted systems may be on canopies that provide shelter and thus, do not negatively impact land use. Land requirements for stand-alone ground-mounted systems vary with the type of mounting system. Fixed systems (with panels that do not move to track the movement of the sum) require less land than those with 1- or 2-axis tracking. The generation by tracking systems, however, is greater than from fixed systems. Ong et al. (2013) surveyed land requirements of U.S. PV projects between 1 and 20 MW capacity. Fixed-tilt systems required an average of 5.5 acres/MW_{AC} and single-axis tracking systems required an average of 6.3 acres/MW_{AC}. Based on the analysis of Ong et al. (2013) and a review of 13 operating and proposed PV facilities in the TVA service area, as well as 23 PV facilities elsewhere in the Southeast, new ground-mounted PV facilities are assumed to require 6.1 acres/MW_{DC} (7.2 acres/MW_{AC})[5] for fixed-tilt systems and 7.3 acres/MW_{DC} (8.6 acres/MW_{AC}) for single-axis tracking systems.

5.2.3.6 Solar – New Facilities

The impacts of new solar generating facilities included in the capacity expansion plans are expected to be similar to those described above for existing facilities. New building-mounted PV facilities, likely to be constructed as distributed energy resources, would not require additional land and would have few other impacts. Future utility-scale PV facilities in the TVA region are likely to be multi-MW in size. An increasing proportion of recently constructed and proposed multi-MW solar facilities in the TVA region use single-axis tracking systems. These systems require relatively flat ground and can be built on brownfield, cropland, or other greenfield sites. An increasing proportion of PV facilities have been and are expected to be constructed on cropland, where the amount of grading required to prepare the site is low relative to other land types.

Some of the impacts of developing solar facilities on agricultural and forested land could be reduced by developing solar facilities on sites that had been previously heavily disturbed, including brownfield sites. Numerous such potentially suitable sites occur across the TVA service area. To date, such sites comprise less than 3 percent of the land area occupied by TVA solar facilities. This proportion is unlikely to greatly increase as such sites infrequently provide the large, continuous area sought by developers of utility-scale solar facilities. Many brownfield sites also have restrictions on penetrating the ground surface, which increases solar construction costs.

The development of a solar facility on an agricultural site typically eliminates the agricultural production at least for the duration of facility operations, except in limited circumstances where the site is grazed by sheep or other livestock as a means of managing vegetation growth. Such grazing is, at present, rarely used in the TVA region. The conversion of the site to a solar facility, with a permanent grass and herbaceous vegetative cover, can reduce the runoff of silt and agricultural chemicals that often occurs from cropland. The maintenance of a permanent vegetative cover, particularly when composed of native plant species, can also increase local wildlife diversity (Beatty et al. 2017).

5.2.3.7 Biomass – Existing Facilities

TVA purchases electricity generated from landfill gas and wood waste (see Section 2.4). The environmental impacts of this generation are, overall, beneficial due to the avoidance of methane emissions and utilization of residues at wood and grain processing plants. The generating facilities have typically been built on heavily disturbed landfill or other industrial sites and occupy small land areas.

[5] The DC to AC conversion is based on a 0.85 derate factor as used by Ong et al. (2013).

5.2.3.8 Biomass – New Facilities

The alternative strategies include the two options for new biomass generation, a 115-MW dedicated biomass facility, and a 124-MW repowered coal unit. Under the repowered coal unit option, TVA would convert one or more of its existing smaller coal-fired units, such as at the Shawnee Fossil Plant, to exclusively burn biomass. The conversion would require changes to the boilers, changes to or replacement of the boiler coal feed system, and construction of a biomass fuel receiving and processing facility. The land requirements for these vary and are plant-specific. Most of the components could likely be sited on the existing plant reservations on areas previously disturbed by other plant operations. Life cycle land requirements would increase over those of a coal facility if there are multiple, dispersed fuel sourcing areas. Emission rates would likely be similar to those of a new dedicated biomass facility described below. Water use and consumption rates would be somewhat less than those of the coal unit.

Potential fuels for the biomass-fueled generating facilities include forest wood (trees harvested for use as biomass feedstock), forest residues, mill residues, wood waste, and dedicated biomass crops. These fuels and their availability in the TVA region are described in Section 4.6.4.

A dedicated biomass facility could be constructed at one of TVA's existing or former plant sites or at a greenfield site. Plant capacity for biomass generating facilities can be limited due to fuel delivery constraints and plants larger than 50 MW are uncommon (EPRI 2014). A few larger plants have been proposed or begun construction in recent years. The amount of fuel consumed per unit of generation varies with the type of biomass, its moisture content, and the plant technology (e.g., stoker boiler, circulating fluidized bed boiler, or gasification). Fuel consumption rates reported at several dedicated facilities range from 2–5 tons/MWh (Wiltsee 2000, EPRI 2014). Facility land requirements vary; reported values include 17 acres for a 36- MW plant, 31 acres for a 40-MW plant, 39 acres for a 50-MW plant, and 200 acres for a 100- MW plant (Wiltsee 2000, EPRI 2010). This impact analysis assumes 100 acres are required for a 115-MW plant. Life cycle land requirements vary greatly with the fuel feedstock. They are relatively small for mill residues and waste wood. For biomass fuel crops, land requirements would be high and likely among the highest ofany of the resource options under consideration.

Biomass-fueled generating plants emit no mercury and only minimal amounts of SO_2; NO_x emissions vary with the type of facility and NO_x emission reduction systems are typically required. Biomass-fueled generating plants are frequently described as being carbon neutral because the CO_2 they emit is not of fossil origin. Plants used as biomass fuel feedstock takeup (sequester) CO_2 from the atmosphere during photosynthesis; this CO_2 is then emitted to the atmosphere when they are burned. The CO_2 emission rate from the combustion of biomass for generating electricity is typically higher than for fossil fuels (EPRI 2014) due to the low energy content of biomass fuels and the low efficiency (high heat rate) of biomass generating plants.

The issue of whether biomass-fueled power generation is carbon neutral, however, is controversial as the combustion of forest-derived biomass emits a large pulse of CO_2 that can require decades to be sequestered by growing trees (Walker et al. 2010). Consequently, there is a lag time of many years for the CO_2 emitted by the combustion to be sequestered by new forest growth. In April 2018, the USEPA, after years of deliberation, issued a policy statement that forest biomass would be treated as carbon neutral in any future regulatory actions when used for energy generation at stationary sources (e.g., electric generating plants; USEPA 2018f). This determination is based on the assumption that the forest biomass was harvested from a managed forest and the harvested area is not converted to a non-forest use. The issue, however, remains controversial (e.g., Science News Staff 2018) and the USEPA, in the policy statement, acknowledged that its scientific advisors were divided on the issue and that the statement was issued, in part, in response to Congressional direction and recent Executive Orders.

Aside from direct CO_2 emissions, GHGs are emitted during several process steps of biomass- fueled power generation. Many published studies of life cycle GHG emissions from electrical generation with biomass fuels assume that combustion of biomass does not result in the direct emission of CO_2 and therefore, some studies have concluded that life cycle GHG emissions are negative. Spath and Mann (2004), for example, calculated a life cycle GHG emission rate of -452 tons CO_2-eq/GWh for a 60-MW direct-fired boiler using wood waste. Spitzley and Keoleian (2005) reported rates of 58 tons CO_2-eq/GWh for a 50-MW direct-fired boiler fueled with willow grown as an energy crop. In a survey of published LCAs, EPRI (2013) found a median GHG emission rate of 39 tons CO_2-eq/GWh (35 grams CO_2-eq/KWh) and an interquartile range (the 75th percentile value minus the 25th percentile value) of 33 tons CO_2-eq/GWh (30 g/kWh) for direct combustion biomass generating facilities. Facilities burning mill and forest residues had lower life cycle GHG emission rates than those burning dedicated woody and herbaceous crops. These differences are largely attributable to increased energy inputs for crop production, including fertilizer applications (EPRI 2013). These life cycle GHG emission estimates do not include emissions resulting from any land use conversion associated with fuel acquisition.

The harvesting and transportation of trees for use as fuel can result in adverse environmental impacts. These impacts are similar to those that can result from harvesting trees for other purposes. Potential impacts include the modification or loss of wildlife habitat, sedimentation, reduction in soil fertility, loss of old growth forest, change in forest type and understory vegetation, altered scenery, and competition with other wood-using industries. The severity of these impacts varies with the use of appropriate best management practices, the proportion or quantity of trees harvested from a stand, whether the harvested stand is a plantation, post- harvest site treatment and other factors.

5.2.4 Energy Storage

5.2.4.1 Existing Facilities

TVA's Raccoon Mountain facility occupies about 1,050 acres and utilizes approximately 386,470 gallons of water per MWh of generation. Denholm and Kulcinski (2004) analyzed life cycle GHG emissions of pumped storage facilities. The construction, operation (excluding pumping), and decommissioning of the facility produce life cycle GHG emissions of approximately 5.5 tons of CO_2-eq/GWh of storage capacity, a small proportion of the total life cycle GHG emissions. GHG emissions from generation are a function of the GHG intensity of the electricity used in the pumping mode. Based on the 80 percent efficiency of energy conversion at Raccoon Mountain and 5 percent transmission loss factor (a function of distance from the energy source and load center), GHG emissions are approximately 1.3 times the energy source emissions. At TVA's 2017 CO_2 intensity of 426 tons/GWh, the operation of Raccoon Mountain, as well as that of a future pumped storage facility, would emit about 554 tons of CO_2/GWh. This emission rate will decrease with the reduction in CO_2 intensity occurring under the action alternatives.

Although Raccoon Mountain uses a large volume of water, none of this water is consumed except for the small quantity that evaporates from the upper storage reservoir.

5.2.4.2 New Facilities

The operational impacts of a new 850-MW pumped storage plant are expected to be similar to those of the Raccoon Mountain plant. Construction impacts would include the construction of the upper reservoir, excavation of the powerhouse and the tunnel connecting the upper and lower reservoirs, and construction of the discharge structure in the lower reservoir. If the lower reservoir is an existing reservoir, dredging of the discharge area and construction of an enclosure around the discharge structure would likely be required. If a new lower reservoir is required, additional impacts would result from the construction of the dam and reservoir and diversion of existing streams around or into the reservoirs. These impacts could be substantial. A new pumped storage plant is assumed to operate with an efficiency of 81 percent.

Because there are few operating compressed air energy storage (CAES) plants, information on their environmental impacts is limited. Based on a TVA study of potential CAES facility configurations in northeast Mississippi during the 1990s, a 330-MW CAES facility would require about 80 acres for the air injection/withdrawal wells, connecting pipelines, and the CAES plant. Operation of the plant would require about 2,300 gallons per minute of water to operate the plant cooling system. A portion of this water would likely be provided by well air/water separators. The plant is assumed to operate with an efficiency of 70 percent.

The utility-scale battery storage facility is assumed to resemble current systems using lithium-ion batteries. Such facilities typically consist of batteries, supervisory and power management system, HVAC system, and fire prevention system in modular shipping-style containers on a concrete pad with spill containment. Other components include electrical switching equipment and transformers. They are often constructed in association with a wind or solar generating facility or adjacent to an existing substation.

The impacts of constructing and operating a utility-scale lithium-ion battery storage facilities in association with southern California solar facilities have been described by County of Imperial (2016 and BLM (2018). NYSPSD and NYSERDA (2018) describes the environmental impacts of the State of New York's initiative to deploy at least 1,500 MW of energy storage by 2025. The New York EIS reviewed various types of battery storage, including lithium-ion, as well as thermal and flywheel storage technologies. The land area required for battery storage facilities is typically only a few acres and construction-related impacts are minimal. Operational impacts are also minimal with adherence to typical mitigation measures including RCRA regulations and best management practices.

Several analyses of the life cycle impacts of the use of lithium-ion batteries in electric vehicles are available, relatively few had addressed utility-scale battery storage facilities. Baumann et al. (2017) found life-cycle CO_2 emissions of lithium-ion batteries of between 0.45 and 0.51 kilograms $CO_{2\text{-eq}}$/kWh of storage capacity for different types of lithium-ion batteries powered by the European electricity mix. Life-cycle emissions of the batteries when powered by PV-generated electricity were considerably lower, 0.13 to 0.20 kilograms $CO_{2\text{-eq}}$/kWh of storage capacity. These values were for batteries operated to shift the time of availability of energy. Their CO_2 emissions varied when operated to provide other grid services. Vandepaer et al. (2017) reported life-cycle CO_2 emissions of 101.8 grams $CO_{2\text{-eq}}$/Wh of storage capacity for a 6-MWh grid-connected lithium-ion battery and 130.7 grams $CO_{2\text{-eq}}$/Wh for a 75-kWh lithium-ion battery in distributed grid configuration. Both of these batteries were powered by wind energy and used for electric time shifts. In each of these studies, As illustrated by these studies, life cycle CO_2 emissions vary greatly with the source of the energy used to charge them. The construction of lithium-ion batteries is alwo relatively energy-intensive, and has the potential to produce several pollutants (Vandepaer et al. 2017).

5.3 Environmental Impacts of Energy Efficiency and Demand Response Resource Options

The sources of environmental impacts from the proposed expansion of TVA's EEDR programs under the alternative strategies include the following:

- The reduction in or avoidance of generation (collectively reduction") resulting from energy efficiency measures. This reduction is incorporated into the alternative strategies and portfolios assessed in Section 5.5.
- The change in the type of generation due to changes from on-peak to off-peak energy use resulting from demand response programs. This change in load shape, and the resulting change in peak demand, is incorporated into the alternative strategies and portfolios assessed in Section 5.5. Historically, most demand response has been in emergency situations and shifted the time of electrical use with little net change in use and little environmental impact. More widespread employment of demand response is likely to result in a small net reduction in electrical use and the associated impacts from its generation (Huber et al. 2011).
- The impacts of the generation of renewable electricity by end users participating in the

Green Power Providers, biodiesel generation, and non-renewable clean generation programs are included in the discussion Section 5.5.

- The generation of solid waste resulting from building retrofits and the replacement of appliances, heating and air conditioning (HVAC) equipment, and other equipment to reduce energy use.
- Adverse impacts to historic buildings from building retrofits that result in changes in their external appearance and associated historic integrity.

Building retrofits to reduce energy use, such as replacing windows and doors, produce solid wastes which are often disposed of in landfills. The disposition of old appliances, HVAC equipment, water heaters, and other equipment varies across the region with the local availability of recycling facilities. Old refrigerators and HVAC equipment may also contain hydro chloroflourocarbon refrigerants ("freon") whose use and disposal is regulated due to their harmful effects on stratospheric ozone ("the ozone layer") and because of their high global warming potential. To reduce these harmful effects, HVAC contractors are required to reclaim and recycle these refrigerants from HVAC equipment being replaced.

The activities associated with building retrofits and other residential, commercial, and industrial EE measures are unlikely to have disproportionately high adverse impacts on low income and minority populations. Household energy efficiency efforts can result in reductions of cold-related illnesses and associated stress by making it easier for residents to heat their homes. Reduced ventilation rates, can, however, adversely affect indoor air quality. In a review of this topic, Maidment et al. (2014) concluded that household EE measures have a net positive impact on health and the benefits are greatest for low income populations. Due to the structure of the EE programs, however, low-income residents frequently have less ability to participate in them. Most EE programs require that participating individuals and organizations pay a portion of the costs of their energy efficiency measures. Low-income residents typically have a reduced ability to pay these costs. In addition, many low-income residents live in rental housing and there are few EE programs targeting rental single-family and multi-family housing.

Programmatic environmental reviews of EE programs have been conducted by USDOE (2015a) for the Hawai'i Clean Energy Program and by the Rural Utilities Service (USDA 2012) for their Energy Efficiency and Conservation loan program. USDOE (2015a) concluded that EE programs would result in beneficial impacts from reduction of GHG emissions and the potential for adverse impacts from EE actions is low with adherence to applicable regulations and best management practices. The Rural Utility Service (USDA 2012) identified a few areas of concern including the potential presence of lead-based paint and asbestos containing material which would be mitigated with adherence to applicable regulations. The potential for adverse impacts to historic properties was low but some EE activities resulting in the modification of the exterior of buildings would require additional project-specific reviews.

5.4 Environmental Impacts of Transmission Facility Construction and Operation

As described in Chapter 3 of Volume I, all of the alternative strategies would require the construction of new or upgraded transmission facilities. Following is a listing of generic impacts of these construction activities (Table 5-2). This listing was compiled by reviewing the EISs (e.g., TVA 2005b), environmental assessments (e.g., TVA 2013c), and other project planning documents for TVA transmission construction activities completed from 2005 through mid-2018. A total of 298 projects was included in this review. Thirty-nine projects involved construction or expansion of a new or existing substation or switching station. One-hundred forty-three projects, including some of the substation/switching station projects, involved the construction of new transmission lines totaling about 623 miles in length. One-hundred twenty-eight projects involved modifications to existing transmission lines.

Table 5-2: Generic impacts of transmission system construction activities determined from a review of project planning documents of 298 transmission construction projects*, 2005-2018.

	Transmission Lines	Substations and Switching Stations
Land Use Impacts		
Land requirements	Average of 13.1 acres/line mile, range 3.5 – 39	Average of 10.8 acres, range 1 – 73 Median for 500 kV: 49.5 acres
		Median for <500 kV: 5.5 acres
Floodplain fill	0	Average of 0.1 acres, range 0 – 4 5% affected floodplains
Prime farmland converted	0	Average of 6.9 acres, range 0 – 29.1 64% affected prime farmland
Land Cover Impacts		
Forest cleared	Average of 5.5 acres/line mile for new lines, range 0 – 30.5	Average of 4.5 acres, range 0 – 50 29% cleared forest
Wetland Impacts		
Area affected	Average of 0.9 acres/line mile for new line, range 0 – 22.2, 55% affected wetlands	Average of 0.1 acres, range 0 – 1.8 15% affected wetlands
	Average of 0.9 acres/line mile of existing line, range 0 – 18.3, 52% affected wetlands	
Forested wetland area cleared	Average of 0.3 acres/line mile of new line, range 0 – 6.3, 48% affected forested wetlands	-
	Average of 0.02 acres/line mile of existing line, range 0 – 0.5, 17% affected forest wetlands	
Stream Impacts		
Stream crossings	Average of 2.9 per mile of new line, range 0 – 50, 76% crossed streams	n/a
	Average of 1.5 per mile of existing line, range 0 – 5.6, 64% crossed streams	
Forested stream crossings	Average of 1.0 per mile of new line, range 0 – 17.6, 48 crossed forested streams	n/a
	Average of 0.1 per mile of existing line, range 0 – 2.5, 8% crossed forested streams	
Endangered and Threatened Species	32 (11%) of 256 projects affected federally listed endangered or threatened species, or species proposed or candidates for listing 63 (22%) of 290 projects affected state-listed endangered, threatened, or special concern species	
Historic Properties	41 (14%) of 288 projects affected historic properties	
Parks and Public Lands	40 (16%) of 249 projects affected parks and public lands	

*Note: Because some project planning documents did not contain all of the environmental data, the sample sizes for the various categories differ.

The anticipated amount of construction of new or upgraded transmission facilities varies among the alternative strategies. All new generating facilities would require connections to the transmission system, either directly or through an interconnection with an LPC. The length of connecting transmission lines and the need for new substations and switching stations depend on the location and capacity of the facilities. The retirement of generating facilities, such as coal plants, can also result in the need for new or upgraded transmission facilities in order to maintain adequate power supply and reliability. The importation of wind energy from outside the TVA region would likely require transmission facility construction. Potential impacts of transmission facility construction associated with the HVDC wind resource option are described in a 2015 EIS (USDOE 2015b).

5.5 Environmental Impacts of Alternative Strategies and Associated Capacity Expansion Plans

While the total amount of energy generated during the 2019-2038 planning period is, by design, similar across the alternative strategies for each scenario, the manner in which this energy is generated varies across strategies (Figures 3-3, 3-4). This is a result of the differences between the alternative strategy designs and the constraints on different energy resources and targets as described in Section 3.2 and Volume I Section 6.1.2. The environmental impacts, averaged across scenarios, are generally greater for Strategies A and B than for Strategies C, D, and E. An exception to this is for land use, where the land required for new energy resources is greatest for Strategies C, D, and E due to their larger amounts of new solar capacity. Within each strategy, the environmental impacts are generally greater for Scenario 3 and lowest for Scenario 5.

Alternative Strategies:
- A – Base Case (No Action)
- B – Promote DER
- C – Promote Resiliency
- D – Promote Efficient Load Shape
- E – Promote Renewables

Scenarios:
- 1 – Current Outlook
- 2 – Economic Downturn
- 3 – Valley Load Growth
- 4 – Decarbonization
- 5 – Rapid DER Adoption
- 6 – No Nuclear Extensions

Following is a discussion of the impacts of each alternative strategy and the Target Power Supply Mix (the preferred alternative) on air quality, greenhouse gas emissions and climate change, water withdrawals and water use, waste generation, fuel consumption, facility land requirements, and TVA-region economics over the 20-year, 2019-2038 planning period. These impact discussions have been revised to incorporate TVA's decision in early 2019 to retire the coal-fired Paradise Fossil Plant Unit 3 in 2020 and Bull Run Fossil Plant in 2023. These retirements have been incorporated into the Strategy A – Base Case Strategy (see Section 3.3) and resulted in varying degrees of changes in the impacts of the alternative strategies. For impacts most closely associated with coal-fired generation, the early retirements reduced the differences between the alternative strategies.

The bar charts and time-series graphs illustrate the average of the values for the six scenarios for each alternative strategy. The whisker bars on the bar charts show the range of the values of the six scenarios associated with each strategy. Appendix E lists the values for each combination of alternative strategy and scenario. Additional bar charts in the following sections illustrate the potential impacts of the Target Power Supply Mix; these show both the ranges associated with Scenario 1 – Current Outlook and the extended ranges associated with other scenarios and the sensitivity analyses. Because of the lack of published information applicable to the full suite of TVA's current and proposed future energy resources, life cycle impacts of the alternative strategies are not quantified in the following sections.

5.5.1 Air Quality

All alternative strategies and the Target Power Supply Mix will result in significant long-term reductions in total emissions and emission rates of sulfur dioxide (SO_2), nitrogen oxides (NO_x), and mercury (Table 5-3, Figures 5-1, 5-2, 5-3; Appendix E). A large portion of these reductions, especially for SO_2 and mercury, result from the full or partial retirement of coal plants. The retirement of Paradise in 2020 and Bull Run in 2023 account for the similarity in emissions through 2023 portrayed in Figures 5-1, 5-2, and 5-3. After 2023, emission trends diverge due to increased differences between the strategies. Overall coal generation stays relatively steady or slightly increases during much of this period in most cases, including under the Current Outlook scenario, due to increasing natural gas prices relative to coal prices. Additional coal retirements occur late in the planning period in several cases and these are reflected in the late-term decreases in emissions. The effects on air quality from the partial and entire retirement of CT and coal facilities are included in the following discussion.

The increase in emissions of SO_2 and mercury in 2031 to 2033 is due to fewer regularly scheduled coal plant outages during this period and, under Scenario 6, the retirement of a Browns Ferry Nuclear Plant unit in 2033. This increase is followed by sharp decreases in 2034 in SO_2 and mercury, largely resulting from the retirement of the seven Shawnee units that lack modern emission controls. NOx emissions also decrease in 2034 due to the Shawnee retirements. Late in the planning period the emission trends for SO_2 again converge. Within each strategy, there is a large variation in emissions among the associated scenarios (Figures 5-4, 5-5, 5-6) and this variation is much larger than the differences between the strategies. Emissions are greatest under Scenario 3, followed closely by Scenario 6 and lowest under Scenario 5, followed closely by Scenario 4.

The overall reductions in emissions under each strategy, averaged across the associated scenarios, show relatively little variation (Table 5-3). Emission reductions under Strategy A, the No Action Alternative, are somewhat less than those of the other strategies for SO_2 and NOx and noticeably less for mercury. The largest reductions for SO_2 and mercury occur under Strategy C, which has the least amount of coal-fired generation. NOx reductions, however, are greatest for Strategies C, D and E; this is largely due to fossil-fueled generation being displaced by the larger amounts of renewable generation under these strategies.

Emissions under the Target Power Supply Mix and the Current Outlook scenario tend to be in the upper range of all of the scenarios associated each alternative strategy. The lowest levels of emissions under the Target Power Supply Mix are associated with the sensitivities analyzed for increased increased coal plant operating costs, expanded energy efficiency market depth, and doubled carbon penalty.

The reductions in SO_2, NOx and mercury emissions will continue recent trends in emissions of these air pollutants. By 2038, TVA emissions of SO_2 will have decreased since 1995 by about 99.3 percent under all alternative strategies. This would result in further small decreases in regional ambient concentrations of SO_2 and sulfate (a component ofacid deposition), regional haze, and fine particulates. TVA emissions of NOx will also have decreased since their 1995 peak by about 99 percent under all strategies. Although this continued decrease will likely result in reductions in regional NOx and ozone concentrations, the air quality effect may be small as TVA emissions make up an increasingly small proportion of regional NOx emissions.

Table 5-3: Average total, annual, and 2019-2038 percent reduction of emissions of SO2, NOx, and mercury by alternative strategy and the Target Power Supply Mix.

	Alternative Strategy						
	A – No Action	B	C	D	E	Target Power Supply Mix	
						Current Outlook Range	Extended Range
SO_2							
Total emissions 2019-2038, tons	168,821	169,130	157,935	160,060	159,430	205,468 – 212,791	89,733 – 212,791
Annual emissions, tons	8,441	8,457	7,987	8,002	7,972	10,273 – 10,640	4,487 – 10,640
Percent reduction 2019-2038	62.1	62.0	65.2	63.6	63.1	21.2 – 23.9	21.2 – 66.8
NOx							
Total emissions 2019-2038, tons	158,940	158,531	157,244	152,983	153,360	179,993 – 182,994	113,585 – 182,994
Annual emissions, tons	7,947	7,927	7,862	7,649	7,668	9,000 – 9,147	5,679 – 9,147
Percent reduction 2019-2038	60.7	60.7	57.1	63.3	62.0	22.9 – 24.1	22.9 – 52.1
Mercury							
Total emissions 2019-2038, pounds	3,703	3,710	3,524	3,619	3,597	4,617 – 4,866	1,733 – 4,866
Annual emissions, pounds	185	186	176	181	180	231 – 243	87 – 243
Percent reduction 2019-2038	26.0	25.4	33.5	29.1	28.1	2.4 – 7.4	2.4 – 65.2

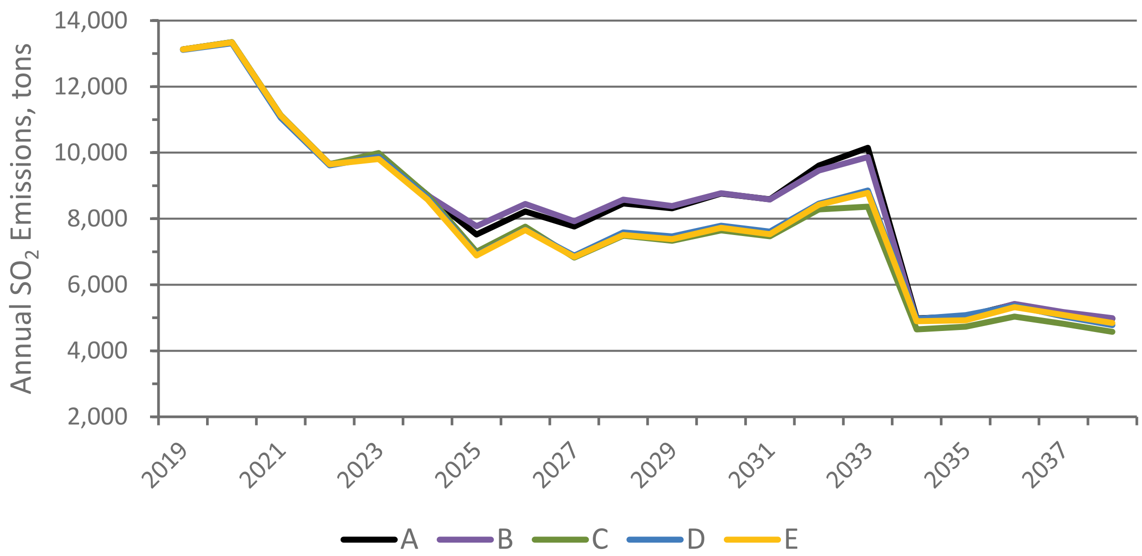


Figure 5-1: Trends in emissions of sulfur dioxide (SO_2) by alternative strategy based on averages of the six scenarios.

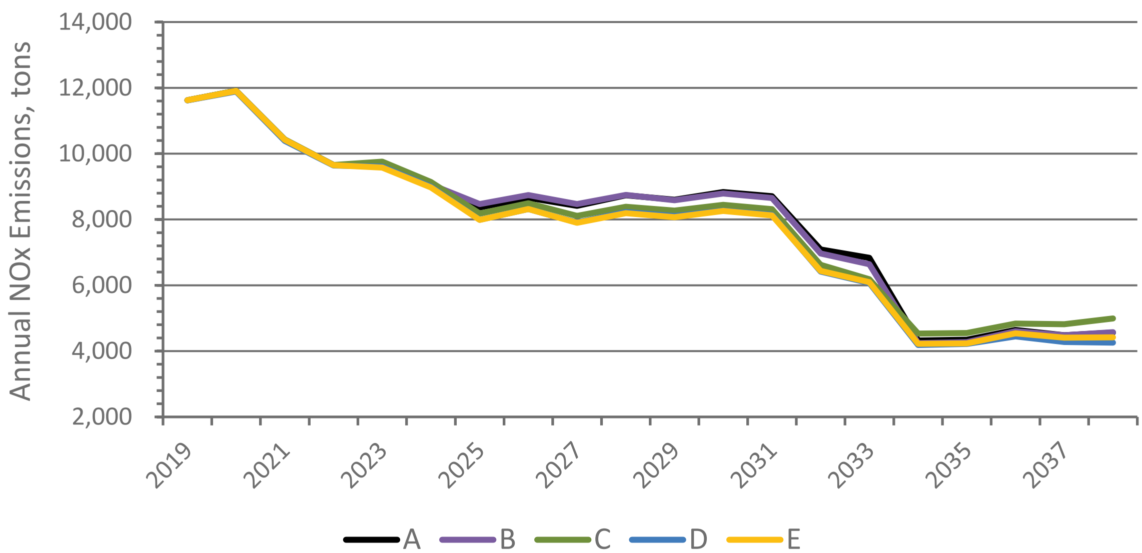


Figure 5-2: Trends in emissions of nitrogen oxides (NOx) by alternative strategy based on averages of the six scenarios.

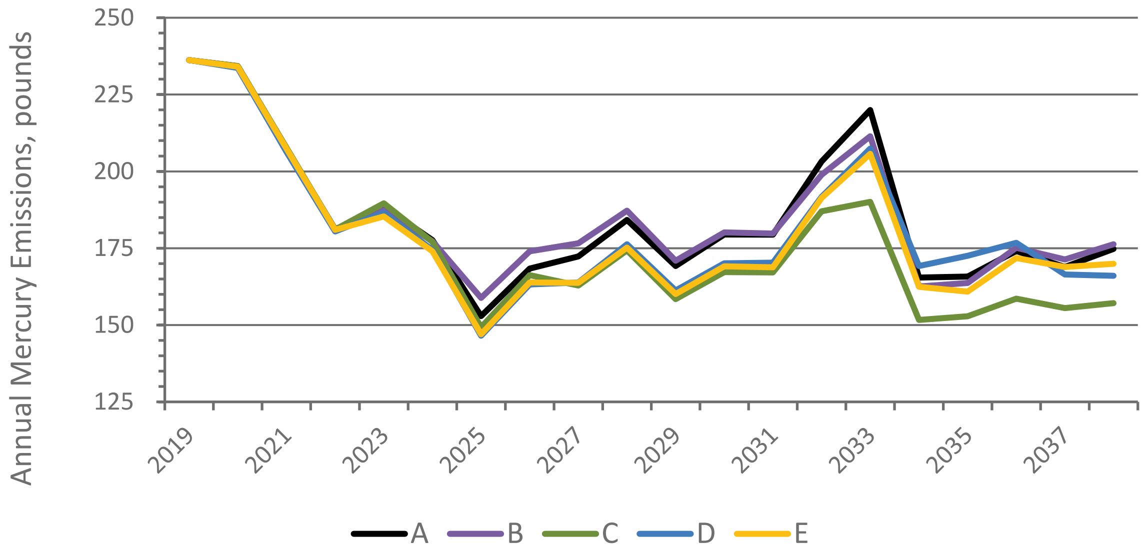


Figure 5-3: Trends in emissions of mercury by alternative strategy based on averages of the six scenarios.

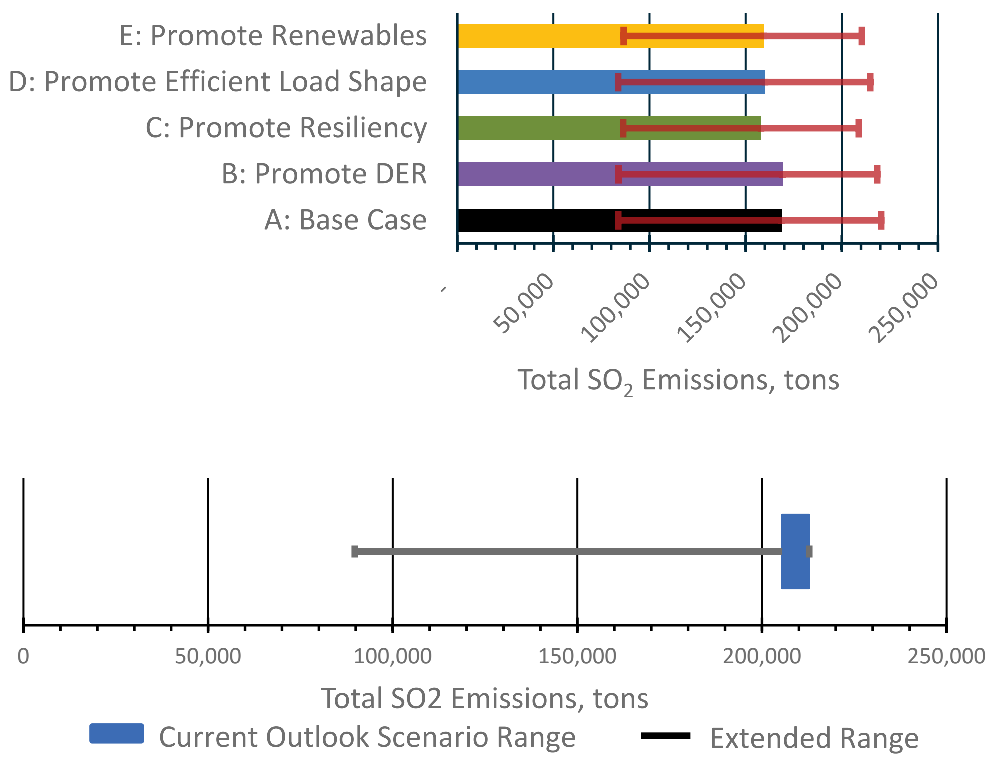


Figure 5-4: Average 2019–2038 total emissions of sulfur dioxide (SO_2) by alternative strategy (top) and for the Target Power Supply Mix (bottom). The error bars in the top chart indicate the maximum and minimum values for the scenarios associated with each alternative strategy.

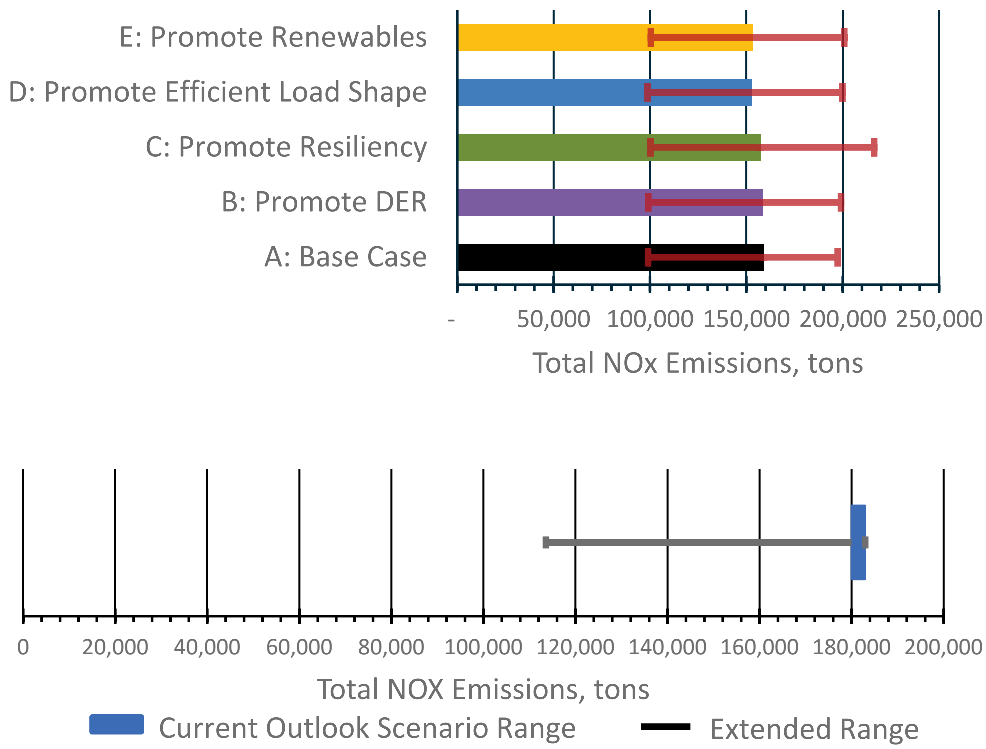
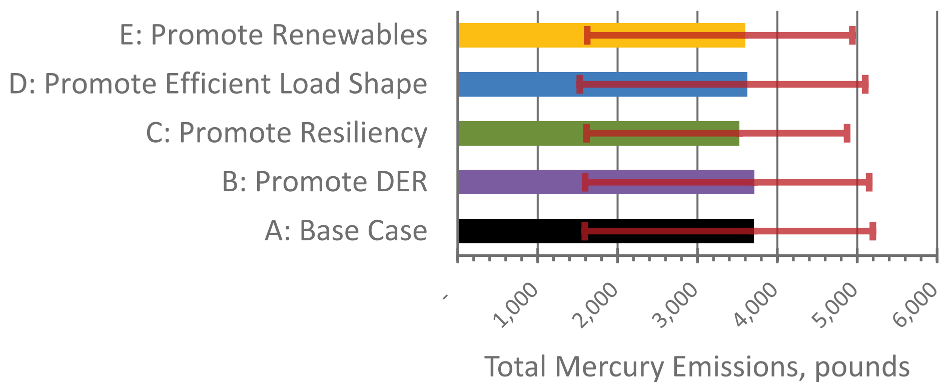


Figure 5-5: Average 2019–2038 total emissions of nitrogen oxides (NOx) by alternative strategy (top) and for the Target Power Supply Mix (bottom). The error bars in the top chart indicate the maximum and minimum values for the scenarios associated with each alternative strategy.



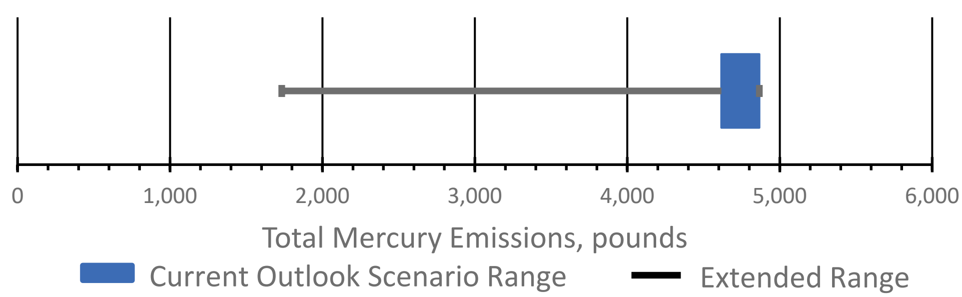


Figure 5-6: Average 2019–2038 total emissions (left) of mercury by alternative strategy (top) and for the Target Power Supply Mix (bottom). The error bars in the top chart indicate the maximum and minimum values for the scenarios associated with each alternative strategy.

5.5.1.1 Impacts of Potential Facility Retirements

The changes in emissions of air pollutants that would result from the near-term retirement of the CT units listed in Section 3.2.3 were determined by modeling the future operation of the TVA generating assets with and without the retirement of the CT units by the end of 2020. This analysis is based on TVA's current power supply plan as reflected by Strategy A – Base Case (updated to include the Paradise and Bull Run retirements) and Scenario 1 – Current Outlook. The peaking generation currently provided by the CTs would be replaced by other peaking resources. During the decade following the retirements, i.e., 2021–2030, annual average system-wide emissions of SO_2 would decrease by 1.6 percent, NOx emissions would decrease by 0.7 percent, and mercury emissions would decrease by 2.1 percent. SO_2 and mercury emissions are produced by coal units and not natural gas-fired units. With the retirement of the CTs, more energy efficiency measures would be implemented sooner than otherwise; this, along with reduced electrification results in reduced energy demand and small reductions in coal- and gas-fired generation.

5.5.2 Climate and Greenhouse Gases

Total and annual direct emissions of CO_2, as well as CO_2 emission rates – also referred to as CO_2 intensity – decrease under all alternative strategies and the Target Power Supply Mix (Table 5-4; Figures 5-7, 5-9; Appendix E). The variation among the strategies for both CO_2 emissions and emissions rates is relatively small and much less than the variation among the scenarios associated with each strategy (Figures 5-8, 5-10).

Table 5-4: Average CO_2 emissions and emissions rates, percent emissions changes, and percent emission rate changes by alternative strategy and the Target Power Supply Mix.

	Alternative Strategy						
	A – No Action	B	C	D	E	Target Power Supply Mix	
						Current Outlook Range	Extended Range
Total CO_2 emissions 2019-2038, million tons	772	766	758	758	759	847 – 865	588 – 996
Annual CO_2 emissions, thousand tons	38,610	38,316	37,915	37,931	37,945	42,328 – 43,230	29,392 – 49,805
Percent CO_2 emissions change, 2019-2038	-21.4	-22.4	-24.4	-24.8	-24.1	-7.6 to -9.5	+6.4 to -37.2
CO_2 emissions rate, lbs/MWh	488	485	479	480	480	532 – 543	409 – 543
Percent CO_2 change reduction, 2019-2038	-26.2	-27.0	-29.4	-29.0	-28.4	-8.3 to -10.0	-8.3 to -31.0

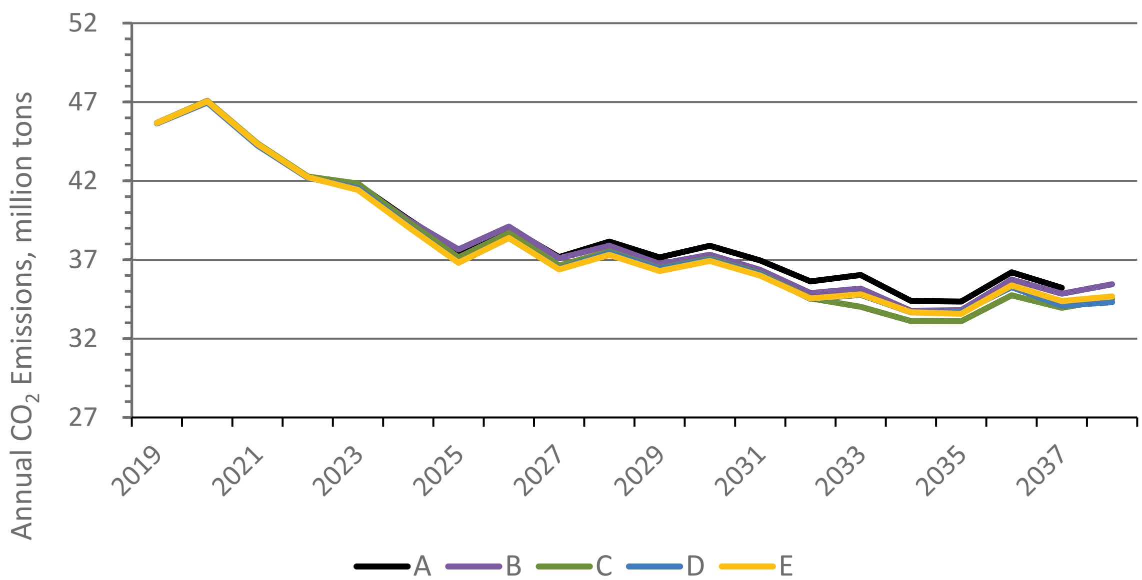


Figure 5-7: Trends in emissions of CO_2 by alternative strategy based on averages of the six scenarios.

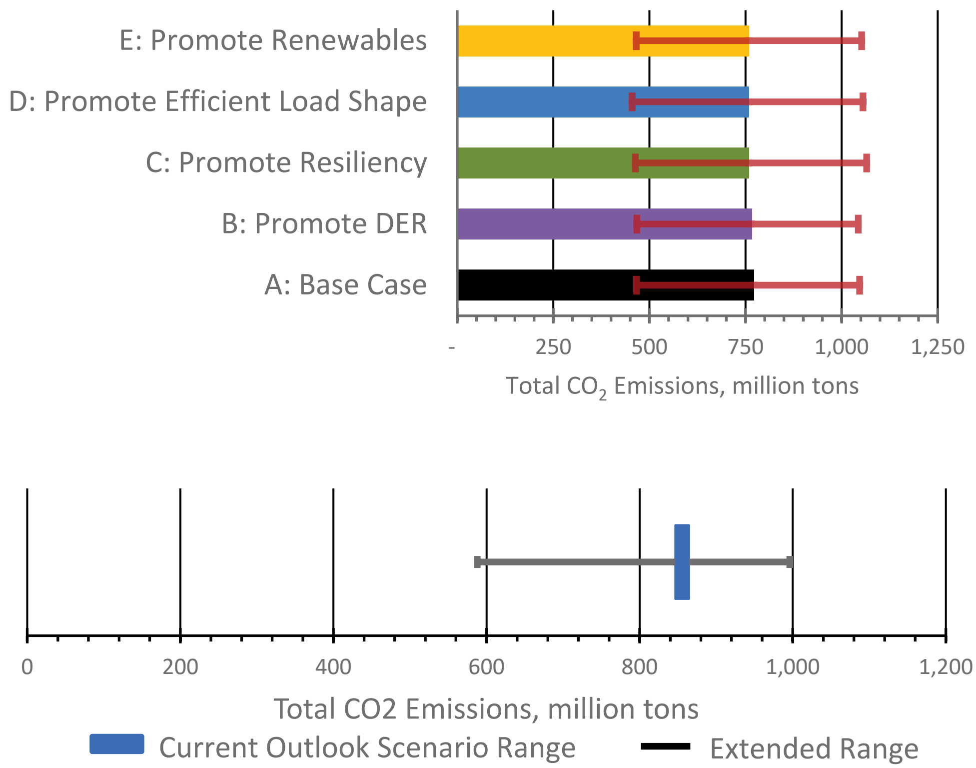


Figure 5-8: Average 2019–2038 total emissions of CO_2 by alternative strategy (top) and for the Target Power Supply Mix (bottom).The error bars in the top chart indicate the maximum and minimum values for the scenarios associated with each alternative strategy.

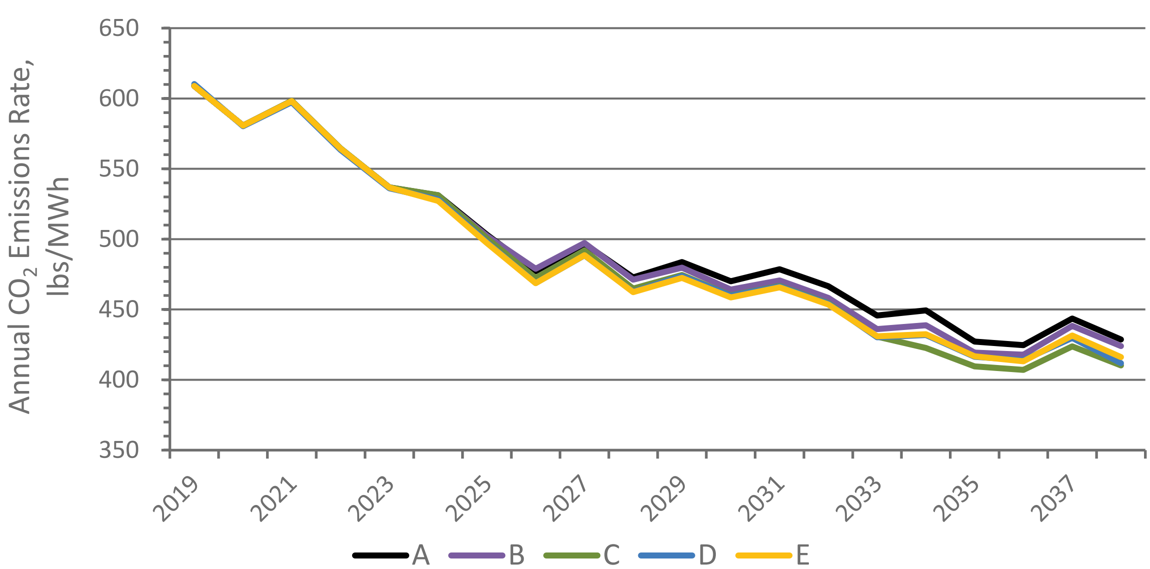


Figure 5-9: Trends in CO_2 emissions rate by alternative strategy based on averages of the six scenarios.

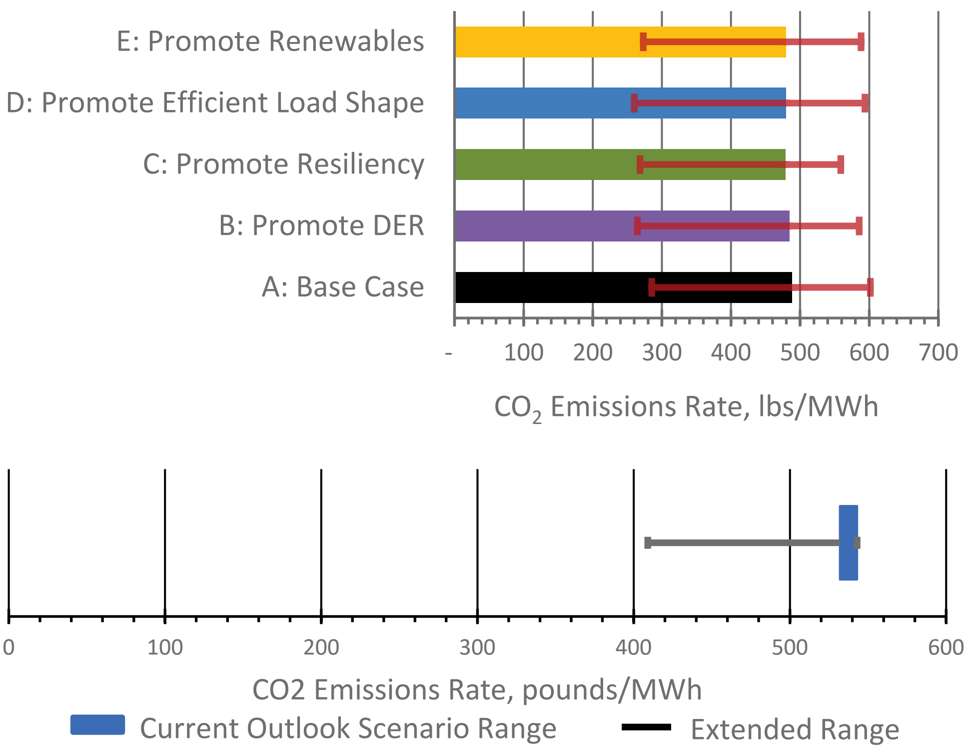


Figure 5-10: Average 2019–2038 CO_2 emissions rates by alternative strategy (top) and for the Target Power Supply Mix (bottom). The error bars in the top chart indicate the maximum and minimum values for the scenarios associated with each alternative strategy.

Strategy A has the greatest CO_2 emissions and CO_2 emissions rate and the least reductions. Strategy C has the lowest CO_2 emissions and emission rates. Within each strategy, Scenario 3 has the highest CO_2 emissions and emission rates, followed closely by Scenarios 1 and 6. Scenario 5 has the lowest rate, followed closely by Scenario 4. The overall trends for both CO_2 emissions and emission rates are very similar, with the percent reductions somewhat greater for emission rates. All strategies show a small increase in 2020 followed by a decline through 2025 driven largely by coal plant retirements. Emissions then increase in 2026; this increase is due to increased coal generation resulting from fewer than average regularly scheduled coal plant maintenance outages during the year. The decrease in 2033 is due to the expiration of the PPA with the Red Hills lignite-fueled plant, which has relatively high CO_2 emissions, under all scenarios and other coal retirements under some scenarios. Between 2035 and 2038, the strategies show overall increases in CO_2 emissions and emission rates. These increases are largely due to increased fossil-fueled generation following the retirement of the three Browns Ferry Nuclear Plant units under Scenario 6.

CO_2 emissions under the Target Power Supply Mix and the Current Outlook scenario tend to be in the upper range of all of the scenarios associated with each strategy. The lowest CO_2 emissions under the Target Power Supply Mix are associated with the sensitivity for a doubled carbon penalty and high gas price.

5.5.2.1 Impacts of Potential Facility Retirements

The change in CO_2 emissions that would result from the near-term retirement of the CT units listed in Section 3.2.3 were determined in the same manner as described in Section 5.5.1.1 for other air pollutants. During the decade following the CT retirements, i.e., 2021–2030, annual average system-wide emissions of CO_2 would decrease by 0.6 percent.

5.5.2.2 GHG Emissions, Climate Change, and Adaptation

In addition to the forecast reductions in GHG emissions from power generation, TVA has specific targets related to GHG emissions (TVA 2017f). These include a 31 percent reduction in Scope 1 and Scope 2 GHG emissions by 2025 and a 21 percent reduction in Scope 3 GHG emissions by 2025. Scope 1 GHG emissions are direct emissions from applicable sources owned or controlled by TVA, including vehicles. Scope 2 GHG emissions are indirect emissions from the generation of power used by TVA. Scope 3 GHG emissions are from sources not owned or controlled by TVA but related to TVA activities and include, among other things, business travel, employee commuting and contracted waste disposal. At the end of fiscal year 2016, Scope 1 and 2 GHG emissions had been reduced by 22.2 percent and TVA was on track to meet the 2025 target. Scope 3 emissions were reduced by 24.5 percent by the end of 2016. Additional TVA targets include reducing the energy intensity of buildings by 2.5 percent annually through 2025, relative to a 2015 baseline, and increasing the proportion of renewable energy to at least 30 percent of total electric energy consumed by 2025.

All alternative strategies and the Target Power Supply Mix will result in the continued, significant, long-term reductions in CO_2 emissions from the generation of power marketed by TVA. By the end of the planning period, CO_2 emissions will have been reduced by between approximately 67 percent (Strategy A) and 69 percent (Strategy C) from 1995, and between approximately 64 percent (Strategy A) and 67 percent (Strategy C) since 2005. For the Target Power Supply Mix under the Current Outlook scenario, CO_2 emission reductions will range from 62 to 63 percent since 1995 and from 59 to 60 percent since 2005. Depending on future conditions considered in the sensitivity analyses, the CO2 emission reductions could be as high as 74 percent since 1995 and 72 percent since 2005.

The climate change impacts of GHG emissions, including CO_2 emissions, have been recently described in the Fourth National Climate Assessment (USGCRP 2018). Chapter 19 of this assessment focuses on the Southeast US, where the predicted impacts include increases in temperature and extreme precipitation and, in urban areas, more frequent and longer summer heat waves, increased risk of vector-borne diseases, reduced air quality, and stresses on infrastructure. Other impacts include changes to ecosystems and agriculture from altered precipitation and temperature regimes and the continued northward movement of tropical and subtropical species, including problematic invasive species, and increased wildfire risk. Some of these impacts are likely to be greatest on low-income and vulnerable populations, particularly in rural areas. Other climate assessments, including the recent Intergovernmental Panel on Climate Change Special Report on Global Warming of 1.5° (IPCC 2018), describe impacts worldwide. This report states that global net human-caused emissions of CO_2 would need to fall by about 45 percent from 2010 levels by 2030 and reach "net zero" by 2050 in order to limit global warming to 1.5°C, a threshold at which many of the widespread impacts of greater warming could be avoided.

The reduction in CO_2 emissions will have small but beneficial impacts on the potential for associated climate change. The actual effects on climate in the TVA region and elsewhere would be small and difficult to quantify. In its Climate Adaptation Action Plan (TVA 2016g), TVA identified the following climate change risks relevant to the TVA power system:

- Increased demand for power due to increased cooling-season temperatures
- Altered reservoir operations and hydropower generation due to increased demands for water and altered precipitation patterns and evaporative losses
- Effects of changing runoff and water temperatures
- Increased frequency of extreme weather events, including extreme precipitation events and drought
- Increased temperatures and number of days exceeding 95°F
- Increased geographic and temporal variation in rainfall
- Increased ozone and particulate matter ($PM_{2.5}$) concentrations.

Recent and projected trends in temperature and precipitation in the TVA region are described above in Section 4.3 and, for the larger southeastern U.S., in USGCRP (2018). Projected trends from climate change models include increases in average temperature, the number of days over 95°F, and the number of nights over 75°F, and decreases in number of days below 32°F. Predicted trends in precipitation have greater uncertainty and include increases in winter, spring and fall precipitation, and an increase in the frequency of heavy precipitation events.

The EPRI and TVA (2009) report described the effects of the forecast climate change based on the 2007 IPCC report in the TVA region. The effects are likely to be relatively modest over the next decade and increase in magnitude by mid-century. Potential effects on water resources include increased water temperatures, increased stratification of reservoirs, reduced dissolved oxygen levels, and increased water demand for crop irrigation. Potential effects on agriculture include increased plant evapotranspiration, altered pest and pathogen regimes, changes in the types of crops grown, and increased demand for electricity by confined livestock and poultry operations.

Potential effects on forest resources include increased tree growth, altered disturbance regimes, changes in forest community composition with declines in species currently at the southern limit of their ranges, and expansion of the oak-hickory and oak-pine forest types. Potential effects on fish and wildlife include range retractions and expansions, altered community composition, loss of cool to cold aquatic habitats and associated species such as brook trout, and increased threats to many endangered and threatened species.

The modeled higher air temperatures, the associated higher water temperatures, and the altered precipitation patterns that could result from climate change likely would affect the operation of TVA generating facilities. One likely effect is an increase in the demand for electricity. Warmer summer temperatures would result in more electricity used for air conditioning; this increase would likely be greater than the reduction in electricity used for space heating resulting from warmer winter temperatures. TVA's coal and nuclear plants predominantly use open-cycle cooling and discharge heated water to the river system (see Section 4.4.3). NPDES permits, required for the discharge of cooling water into rivers and reservoirs, prescribe the maximum temperature of discharged water. Warmer gross river and reservoir temperatures would make meeting thermal discharge limits more difficult. The NRC also sets safety limits at nuclear plants on the maximum temperature of intake water used in essential auxiliary and emergency cooling systems. When cooling water intake temperatures are high, power plants must reduce power production (derate) or use cooling towers (if available) to reduce the temperature of the discharged water and avoid non-compliance with thermal limits. If intake temperatures reach their limits, NRC requires the plants to shut down. Consequently, elevated water temperatures can reduce thermal generation by causing forced deratings, additional use of cooling towers (which reduces net generation), and/or nuclear plant shutdown.

Increased air and water temperatures also influence the operation of thermal power plants with cooling towers. TVA's CC plants and the Red Hills lignite-fueled plant use cooling towers as the primary cooling systems and its nuclear plants use cooling towers as auxiliary cooling systems. Increased condenser cooling water temperatures reduce the efficiency of power generation. Hotter, more humid air also reduces evaporation potential and the performance of cooling towers. A 1993 TVA study (Miller et al. 1993) analyzed the relationships between extreme air and water temperatures and power plant operations based on historical meteorological and operational data.

In the upper Tennessee River drainage, for each 1°F increase in air temperature from April through October, water temperatures increased by 0.25°F to almost 0.5°F, depending upon year and location in the TVA reservoir system. In general, air temperature effects cascade down the reservoir system. In the Tennessee River system, for both closed- and open-cycle plants in Tennessee (on or upstream of Chickamauga Reservoir) and in Alabama (on Wheeler Reservoir), this study found that the incremental impacts to operations from increased temperature were greatest during hot-dry years. Operation of most thermal power plants in the

TVA power system was resilient to temperature increases during cold-wet and average meteorological years. The dominant meteorological variables affecting thermal plant performance were water temperature, and, for plants using cooling towers, humidity.

Changes in the operation of the Tennessee River system implemented in the ROS (TVA 2004) provide TVA flexibility to adapt to some climate change impacts while minimizing the effects on thermal generation. The analyses in the ROS were based on historical conditions and assume unusually high air temperatures and/or changes in precipitation last a relatively short time and are not long-term changes (cf. Milly et al. 2008). TVA recently installed additional cooling capacity at the Browns Ferry Nuclear Plant and further adaptation, such as the installation of increased cooling capacity at other thermal plants, may be necessary in the future given the forecast long-term increases in temperature.

While water resources are relatively abundant in the TVA service area, climate stressors could change that abundance, either locally or region-wide, leading to impacts and the need for adaptive measures by other sectors of the economy, as well as other aspects of the energy system (EPRI and TVA 2009). Increased precipitation during storms will increase flood risk, expand flood hazard areas, increase the variability of stream flows (i.e., higher high flows and lower low flows) and increase the velocity of water during high flow periods, thereby increasing erosion. These changes will have adverse effects on water quality and aquatic ecosystem health. Climate change also has the potential to affect outdoor recreation, including reservoir and stream-based recreation.

A 2014 Government Accountability Office report described a number of measures to help reduce climate-related risks and adapt the nation's energy systems to weather and climate-related impacts (USGAO 2014). These measures generally fall into two categories—hardening and resiliency. Hardening involves making physical changes that improve the durability and stability of specific pieces of infrastructure—for example, elevating and sealing water-sensitive equipment—making it less susceptible to damage. In contrast, resiliency measures allow energy systems to continue operating after damage and allows them to recover more quickly; for example, installing back-up generators to restore electricity more quickly after severe weather events. TVA is continually evaluating the need for, and where necessary, implementing measures to increase the hardening and resiliency of its power system.

To more specifically explore the potential effects of future variation in climate on the power system, TVA conducted a sensitivity analysis that incorporated predicted changes in temperature and precipitation described by the U.S. Global Change Research Program in USEPA (2016b). The analyzed changes include hotter and dryer summers, warmer and wetter winters, and an overall 3°F increase in average annual temperature (see Volume I Sections 8.2.8 and 8.2.9). Under these future conditions, the TVA power system would change from having both summer and winter peak demand periods to summer peaking. Coal and nuclear generation would decrease due to reduced summer cooling capacity, combustion turbine (CT) capacity additions would occur sooner, and an additional 2,100 MW of solar capacity would be added. Annual CO_2 emissions would be reduced by about 1 to 3 percent compared to the range of the Target Power Supply Mix and the Current Outlook scenario.

5.5.3 Water Resources

The coal-fired, nuclear, and natural gas-fired CC plants comprising most of TVA's energy supply require water to operate plant cooling systems and, particularly for coal plants, other plant processes. For each of these generating plants, the required quantity of water is directly proportional to the amount of power they generate (see Section 4.7). CT plants have very low water requirements and wind and solar generating facilities do not require water to operate. Potential impacts to water resources, with the exception of discharges of cooling water, are generally greater from coal-fired generation than from other types of generation due to the various liquid waste streams from coal-fired plants and the potentially adverse water quality impacts from coal mining and processing. Under all alternative strategies, TVA would continue to comply with the Clean Water Act by meeting State water quality standards and through compliance with NPDES permit requirements.

The volume of water used by thermal generating facilities, (i.e., nuclear, coal, and CC facilities) decreases between 2019 and 2038 under all alternative strategies (Figure 5-11). The decreases, averaged across the scenarios associated with each strategy, range from 9.3 percent for Strategy B to 12.7 percent for Strategy C. Strategy C has the lowest water use during most of the planning period due to its relatively high amount of renewable generation that replaces thermal generation. Water use changes are minimal under the Target Power Supply Mix and the Current Outlook scenario, ranging from an increase of 1.6 percent to a decrease of 0.2 percent. Under the extended range of the Mix, water use could decrease by as much as 20 percent.

The annual average volume of water used varies by less than 3 percent among the strategies, much less than the variation among the scenarios associated with each strategy (Figure 5-12). Cumberland Fossil Plant and the Sequoyah and Browns Ferry Nuclear Plants use the most cooling water and the water use trends closely track the generation by these plants. Water use generally decreases late in the planning period due to retirements of coal plants under several scenarios. Temporary spikes in water use occur due to projected timing of maintenance and refueling outages. The decreases late in the planning period are largely due to coal retirements and the retirement of the three Browns Ferry units beginning in 2033 under Scenario 6. The replacement generation has lower water use rates.

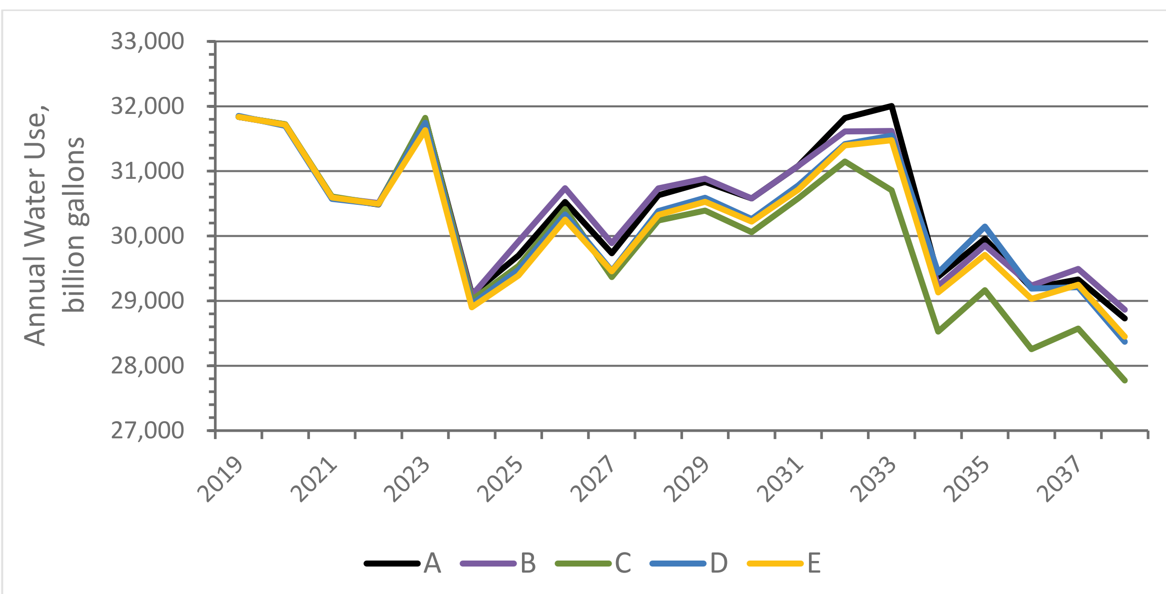


Figure 5-11: Trends in water use by alternative strategy based on averages of the six scenarios.

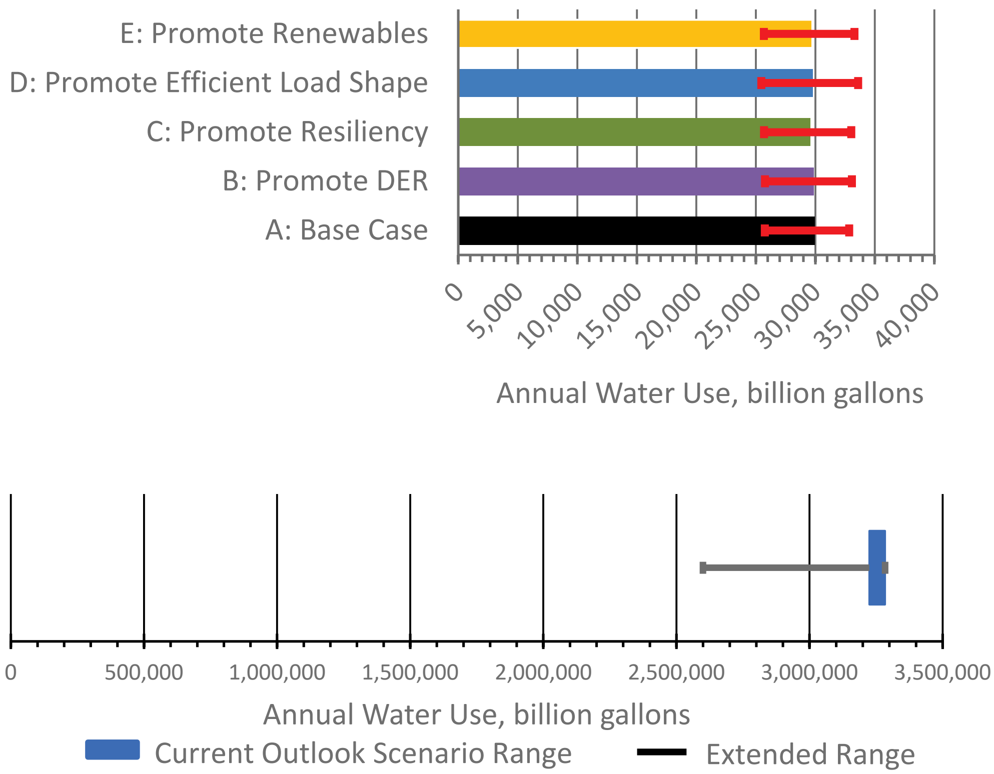


Figure 5-12: Average annual 2019–2038 water use by the alternative strategy (top) and for the Target Power Supply Mix (bottom). The error bars in the top chart indicate the maximum and minimum values for the scenarios associated with each alternative strategy.

The reductions in water use would result in localized beneficial impacts to aquatic ecosystems. The volume of water used by hydroelectric facilities is not included in Figures 5-11 and 5-12.

Figures 5-13 and 5-14 show the 2019–2038 trends and annual averages of water consumption by alternative strategy. The volume of water consumed is the quantity of water withdrawn from a water body, including both surface and groundwater sources, and evaporated in the closed-cycle cooling systems of thermal generating facilities instead of being discharged to a water body. This volume is typically less than 2 percent of the total quantity of water used under each alternative strategy. The reductions, averaged across scenarios associated with each alternative strategy, range from 10.9 percent under Strategy A to 12.7 percent under Strategy C. The variation in average annual water consumption (Figure 5-14) among alternative strategies is small and much less than the variation among the scenarios associated with each strategy. Scenario 3 consistently has the highest water consumption and Scenario 5 has the lowest water consumption. Water consumption changes are minimal under the Target Power Supply Mix and the Current Outlook scenario, ranging from an increase of 1.4 percent to a decrease of 0.2 percent. Under the extended range of the Mix, water use could decrease by as much as 20 percent. The reductions in water consumption would have beneficial impacts; these impacts would generally be small and vary with the characteristics of the source area of the water withdrawal.

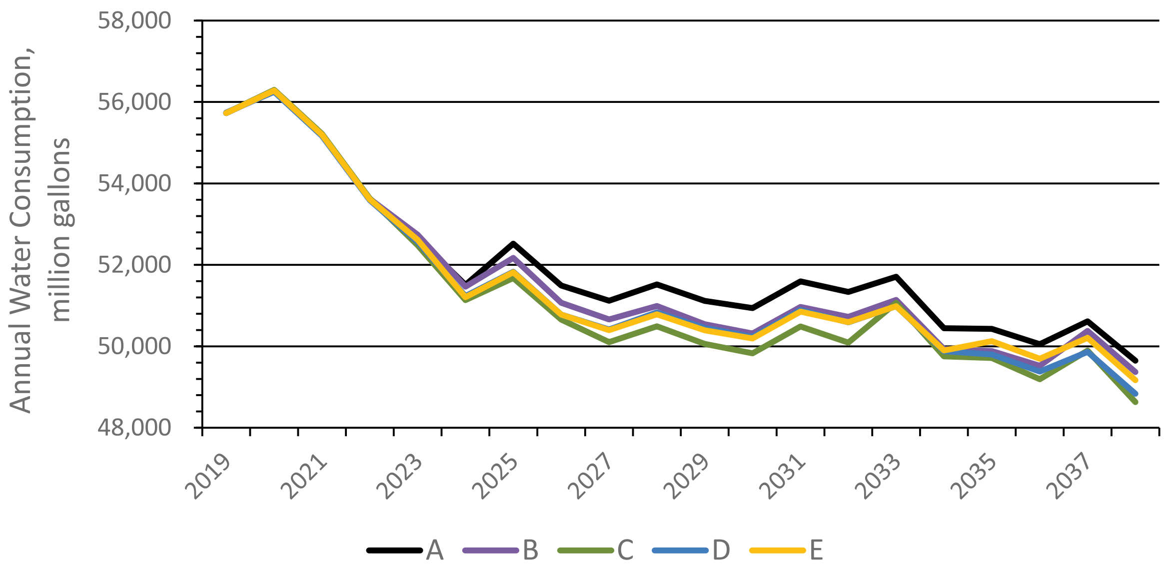
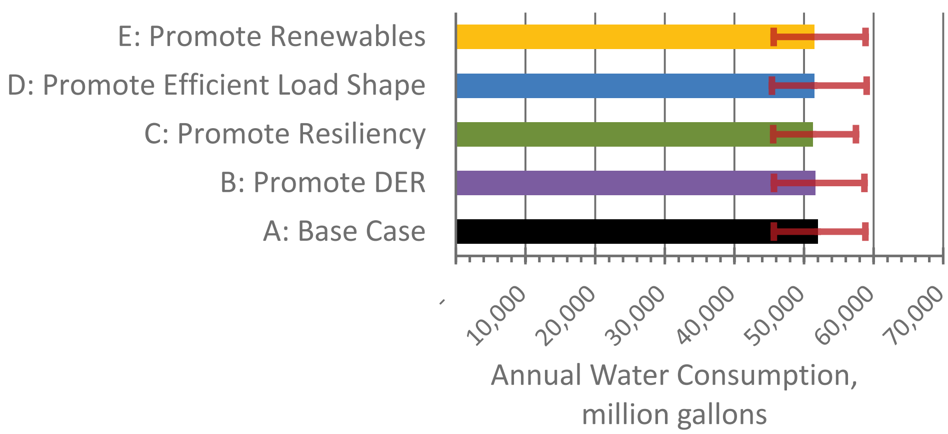


Figure 5-13: Trends in average annual water consumption by alternative strategy based on averages of the six scenarios.



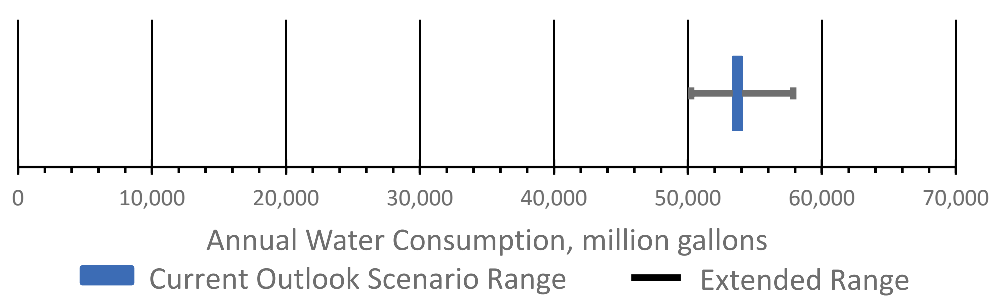


Figure 5-14: Average annual 2019–2038 water consumption by alternative strategy (top) and for the Target Power Supply Mix (bottom). The error bars in the top chart indicate the maximum and minimum values for the scenarios associated with each alternative strategy.

Figure 5-15 shows 2019-2038 water consumption by major river basin. A majority of the thermal plants providing power to TVA and consuming water are located in the Tennessee River basin and this accounts for its high volume of water consumption. Almost all of the water consumed in the Tennessee, Cumberland, Ohio, and Green River basins is from surface water sources. Groundwater sources are primarily used in the Mississippi, Pearl, and Tombigbee River basins.

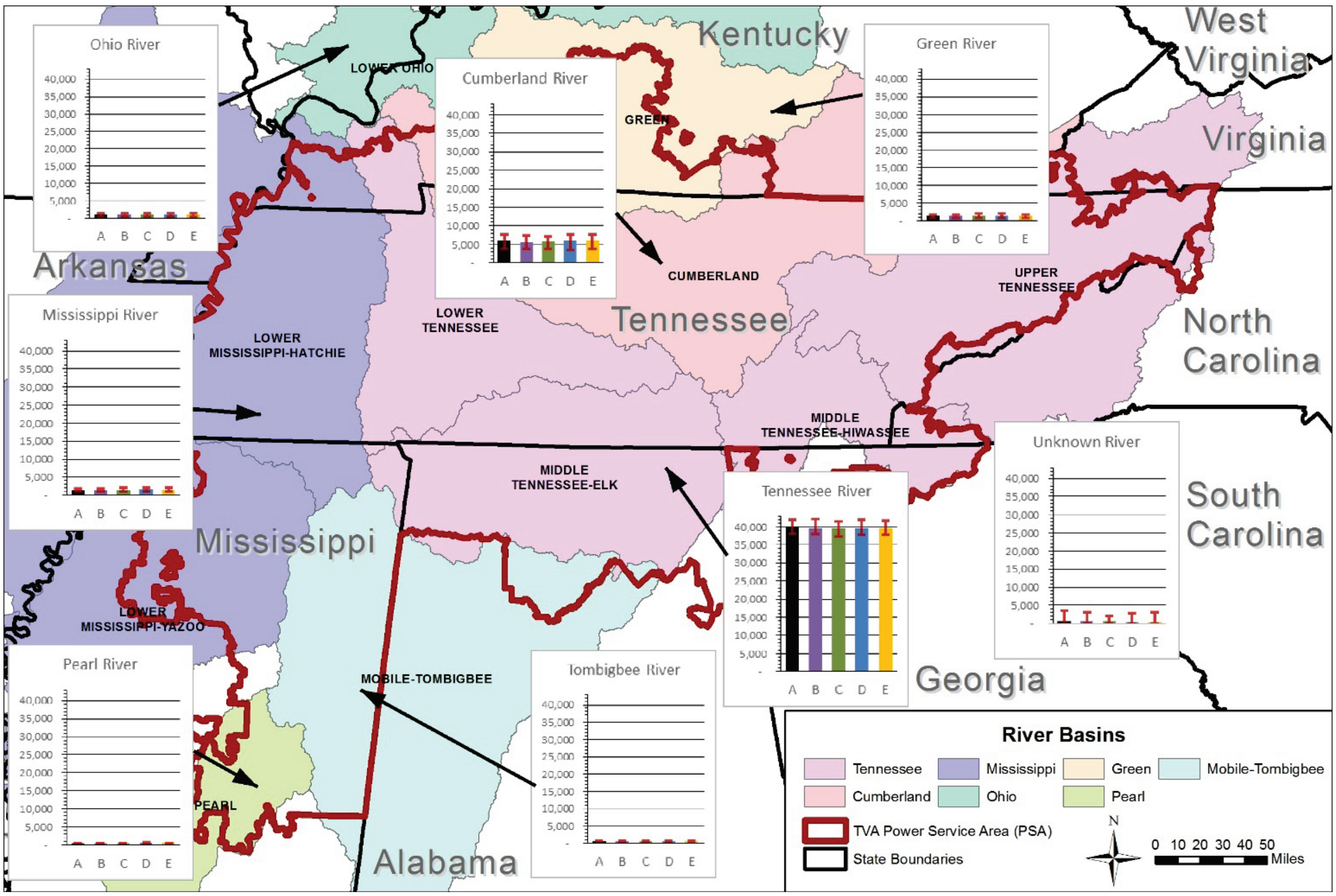


Figure 5-15: Water consumption by alternative strategy and major river basin. The error bars indicate the maximum and minimum values for the scenarios associated with each alternative strategy.

The error bars indicate the maximum and minimum values for the scenarios associated with each alternative strategy. Unknown River refers to future generating facilities whose locations are presently unknown.

5.5.3.1 Impacts of Potential Facility Retirements

The following section describes the water resources impacts from the retirement of the facilities discussed in Section 3.2.3. The retirement of coal plants (Cumberland, Gallatin, Kingston, and Shawnee) would cease coal burning operations and result in a substantial reduction of water withdrawals and wastewater discharges, including thermal discharges, into the adjacent rivers described in Section 4.4.2.4.

TVA would implement all of the planned actions related to the current and future management and storage of CCRs at these facilities, which have either been reviewed or will be in subsequent NEPA analysis.

Upon closure and repurposing of impoundments and landfills, it is expected that most discharge would cease. The remaining discharge flows would come from raw cooling water, fire protection water, main station sumps/unwatering sumps, storm water flows, and from ponds and landfills until closed. Decreased discharge flows would impact the adjacent rivers by decreasing any impacts of thermal discharges as well as the constituent concentrations of the discharges. Surface water discharges would be expected to see direct, indirect, and cumulative beneficial impacts due to the decrease in metals loading.

The elimination of withdrawals of cooling water as a result of cessation of coal-burning operations would reduce impingement and entrainment impacts, and have other beneficial impacts from reduced water consumption. Long-term, direct, and minor beneficial impacts to the aquatic life communities in the adjacent rivers would occur.

Because facility buildings, structures, and facilities would remain in place until a decision regarding future use of the site is made, there would be a long-term potential for direct discharges of chemicals, hazardous waste, and solid waste, including but not limited to friable asbestos releases, to receiving streams through sump discharges, storm water releases, and directly to adjacent surface waters. Periodic inspections and maintenance of the remaining facilities would be performed as needed to ensure that any contaminated equipment would not impact surface water quality. The implementation of best management practices, protocols to respond to on-site spills prior to discharge, and site clean-up would help to reduce the potential for any releases to surface waters.

With the use of proper best management practices and compliance with all federal, state, and local regulations and guidelines, surface water impacts associated with direct, indirect or cumulative impacts would be expected to be temporary and minor.

Additionally, surface water flow, underseepage, and groundwater migration from impoundments to surface waters would be reduced subsequent to closure. Closure work would be done in compliance with applicable regulations, permits, and best management practices; therefore, potential direct and indirect impacts of the potential retirements on surface waters would be negligible. However, long-term effects from contaminated groundwater may persist after closure of impoundments, but are regulated under the CCR Rule and applicable state regulatory programs to protect human health and the environment. Applicable federal and state monitoring requirements would be followed after retirement of each facility. A more detailed discussion of groundwater quality at each of the coal plants considered for retirement is presented in Section 4.4.1.4.

The potential retirement of CTs at Allen (20 turbines), Colbert (8 turbines), Gallatin (4 turbines), and Johnsonville (16 turbines) plants would have no effect on water resources, including groundwater. CTs require no cooling water, and therefore, operation and/or retirement of CTs does not affect surface water at these facilities.

5.5.4 Fuel Consumption

The major fuels used for generating electricity would continue to be coal, enriched uranium and natural gas in all of the alternative strategies. Coal-fired generation and coal consumption under the alternative strategies closely track CO_2 emissions illustrated above in Figure 5-7. The variation in coal consumption among the alternative strategies is relatively small (Figure 5-16). Coal consumption by the lignite-fueled Red Hills Power Project, from which TVA acquires all of the power generated, is predicted to remain relatively constant at about 4.5 million tons/year until 2032 when TVA's PPA expires under all combinations of strategies and scenarios. It is not included in Figure 5-16. Under the Target Power Supply Mix and the Current Outlook scenario, 2019-2038 coal consumption would be near the upper range of coal consumption under the five alternative strategies (Figure 5-16). Depending on future conditions as defined by the other scenarios and sensitivity analyses, coal consumption would be somewhat greater with much higher future natural gas prices but up to about two-thirds less under conditions of increased coal plant operating costs and restrictions on CO_2 emissions.

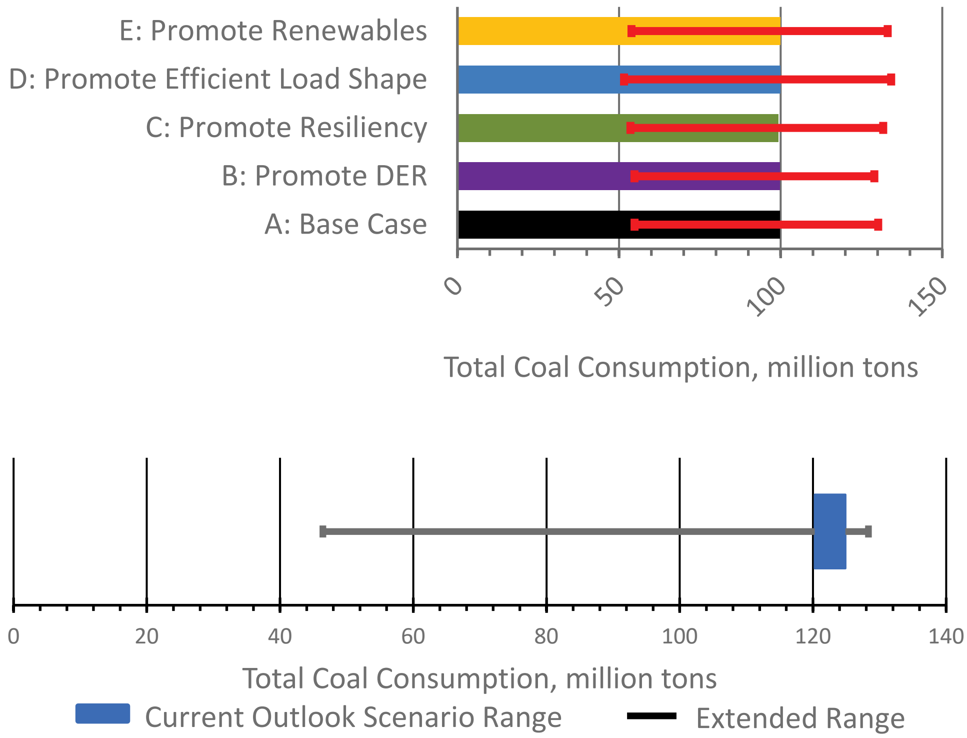


Figure 5-16: Average total 2019–2038 coal consumption by TVA plants by alternative strategy (top) and for the Target Power Supply Mix (bottom). The error bars in the top chart indicate the maximum and minimum values for the scenarios associated with each alternative strategy.

Although the future sources of coal purchased by TVA cannot be accurately predicted, the anticipated decrease in coal consumption would reduce the adverse impacts associated with coal mining. The majority of coal used by TVA in the future is likely to continue to be from the Illinois and Powder River Basin coalfields.

TVA presently uses about 154 tons/year of enriched uranium in its nuclear plants. Use of enriched uranium remains relatively constant throughout most of the planning period for all strategies. Under Scenario 6, the three Browns Ferry Nuclear Plant units would be retired between 2033 and 2036, resulting in a decrease in the use of uranium late in the planning period. Under Strategy C, this decrease would be partially offset by the use of uranium in the two small modular reactors constructed to replace approximately one of the Browns Ferry units.

Environmental impacts from producing the nuclear fuel include land disturbance, air emissions (including the release of radioactive materials), and discharge of water pollutants from uranium mining, processing, tailings disposal, and fuel fabrication. The magnitude of these impacts is difficult to predict with certainty due to the great variability in potential sources for nuclear fuel. Any future use of surplus highly enriched uranium would also reduce overall uranium fuel cycle impacts as it would reduce the need for uranium mining and enrichment.

About 297 billion standard cubic feet (SCF) of natural gas were used in 2018 by TVA gas-fueled generating facilities and by gas facilities from which TVA purchased power under PPAs. Natural gas consumption during the 2019-2038 planning period varies little between the alternative strategies (Figure 5-17 and Figure 5-18). Across the strategies, gas consumption is consistently highest under Scenario 3 and lowest under Scenario 5, with Scenario 5 volumes less than half those of Scenario 3. Under the Target Power Supply Mix and the Current Outlook scenario, total natural gas consumption would be close to the averages of the five alternative strategies. Under the conditions defined by the other scenarios and sensitivity analyses, total gas consumption could be up to about 50 percent greater than under the Current Outlook.

Figure 5-17: Trends in average annual natural gas consumption by alternative strategy based on averages of the six scenarios. The volume is based on the heat content of 1,033 Btu/cubic foot of natural gas used by the electric power sector in 2017 (USEIA 2018e).

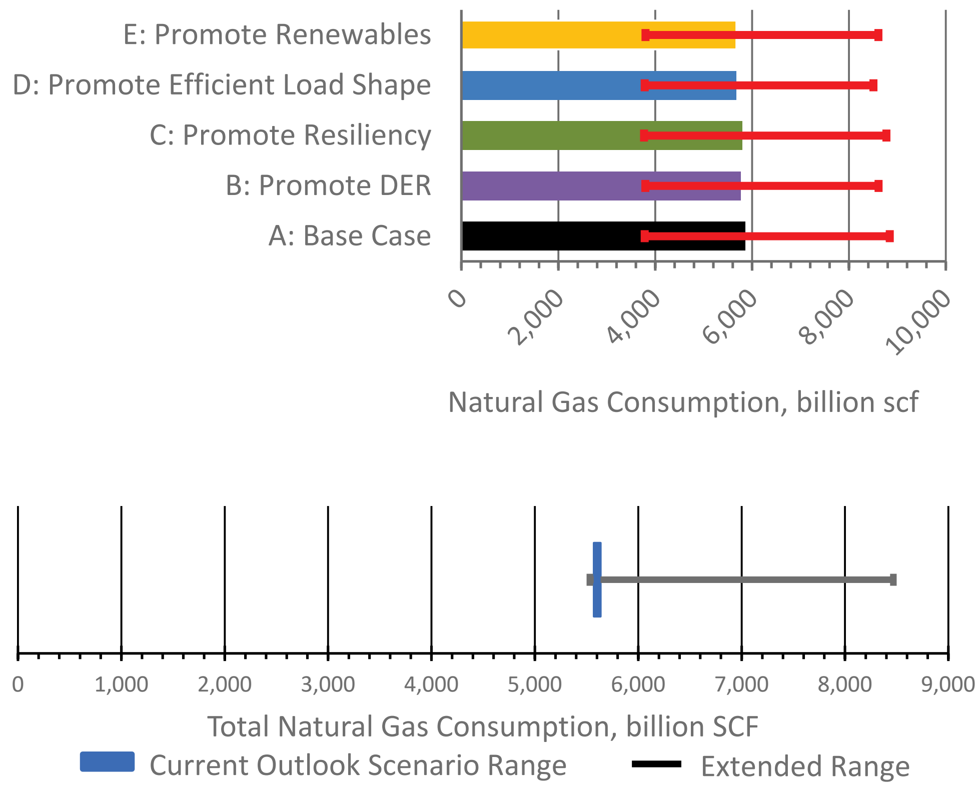


Figure 5-18: Average total 2019–2038 natural gas consumption by alternative strategy(top) and for the Target Power Supply Mix (bottom). The error bars in the top chart indicate the maximum and minimum values for the scenarios associated with each alternative strategy.

5.5.4.1 Coal Combustion Solid Wastes

All alternative strategies and the Target Power Supply Mix will result in long-term reductions in the production of CCRs due to the retirement of coal plants/units (Figure 5-19). CCR production closely tracks coal generation and decreases early in the planning period with the retirement of the Paradise and Bull Run coal plants. Another large decrease occurs between 2030 and 2034 when additional coal plants are retired under many strategies and scenarios. The PPA for the Red Hills plant, which produces a large quantity of ash relative to its generation, also expires during this period. The quantity of CCR produced during the 2019-2038 planning period shows little variation between alternative strategies (Figure 5-20). It varies much more between the scenarios associated with each strategy and is greatest with Scenario 3 and lowest with Scenario 5.

Under the Target Power Supply Mix and the Current Outlook scenario, total CCR production would be around 45 million tons, at the upper end of the range of the five alternative strategies. Depending on future conditions as defined by the other scenarios and sensitivity analyses, this quantity of CCR could be reduced by as much as half. The long-term reduction in future CCR production under all alternative strategies and the Target Power Supply Mix would reduce the environmental impacts resulting from CCR management.

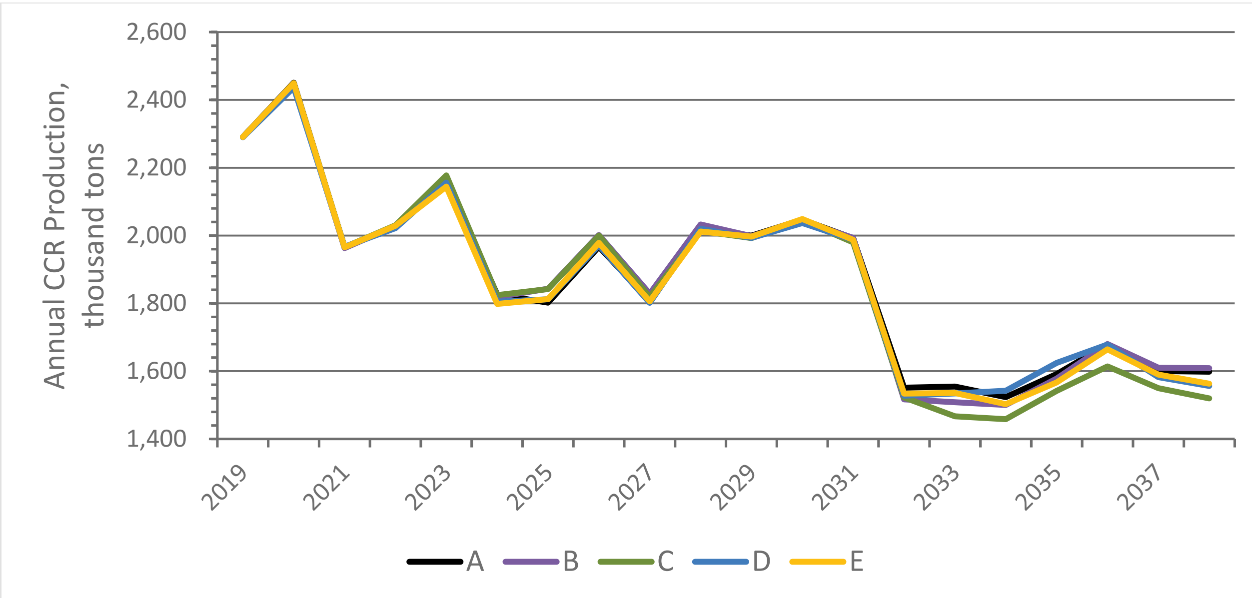
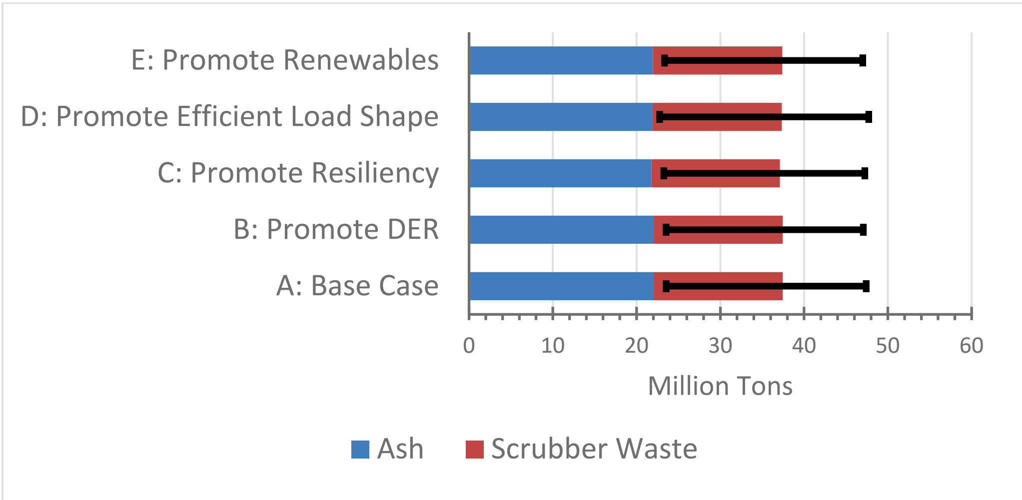


Figure 5-19: Trends in average annual coal combustion residual (combined ash and FGD residue) alternative strategy based on averages of the six scenarios.



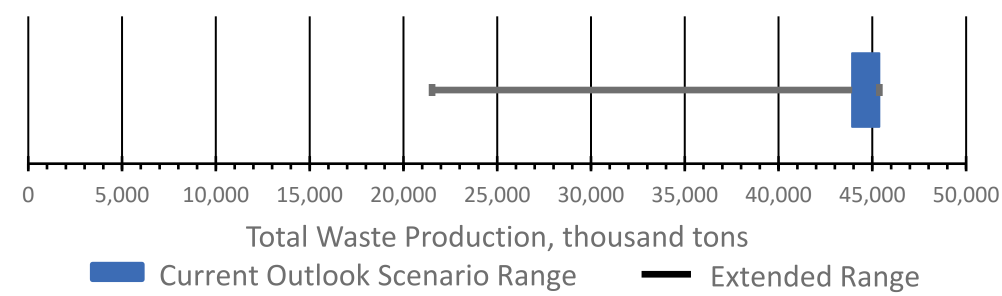


Figure 5-20: Total average 2019–2038 coal combustion residual production by alternative strategy (top) and for the Target Power Supply Mix (bottom). The error bars in the top chart indicate the maximum and minimum values for the scenarios associated with each alternative strategy.

TVA has increased the proportion of CCRs produced at its coal plant that is marketed for beneficial use (Section 4.7.1). This effort reduces many of the environmental impacts of managing CCRs in landfills. In accordance with the USEPA's 2015 CCR rule, TVA is taking several actions related to its management of CCRs as described in Section 4.7.1. The construction-related and long-term environmental impacts of many of these actions are described in EAs and EISs listed in Section 1.3.2.

5.5.4.2 Nuclear Waste

The trends in the production of high-level waste, which is primarily spent nuclear fuel and other fuel assembly components, parallel those of nuclear fuel requirements and are very similar for all alternative strategies. TVA anticipates continuing to store spent fuel on the nuclear plant sites in spent fuel pools and dry casks until a centralized facility for long-term disposal and/or reprocessing is operating. TVA has recently constructed additional dry cask storage capacity to store more spent fuel on its nuclear plant sites. The production of low-level nuclear waste is expected to remain relatively constant.

5.5.4.3 Impacts of Potential Facility Retirements

The following section describes the solid and hazardous waste impacts that could occur if TVA retires the facilities discussed in Section 3.2.3. The retirement of coal plants (Cumberland, Gallatin, Kingston, and Shawnee) would cease coal burning operations and no additional CCR solid wastes would be produced. Residual ash and coal dust would be washed from equipment and areas and managed through the ash handling system. TVA would implement supplemental mitigation measures at Cumberland and Kingston for the CCR units at those site as determined to be required pursuant to the 2015 TDEC Order as well as closure plans approved by TDEC, which could include additional monitoring, assessment, corrective action programs, or other actions deemed appropriate.

Any lighting ballasts containing would be removed and properly disposed offsite during preliminary activities after power termination and during the early stages of demolition. Other materials that are removed and typically recycled in early retirement activities include used oils, glycols, and refrigerants. Consumer commodities (lubricants, aerosols, cleaners, etc.) are reused if possible, or sent for disposal if an outlet cannot be found. Laboratory chemicals would be evaluated for reuse or disposal on a case-by-case basis. Fuels would be used elsewhere or sent for recycling. Bulk chemicals/materials are typically recycled, or disposed as applicable. Mercury devices, batteries, light bulbs and e-waste are recycled.

Asbestos-containing materials in building structures and systems would be remediated as necessary to be protective of environment and worker health and safety, but full abatement would not occur until demolition activities are initiated.

Given that TVA would manage the removal and disposal of solid and hazardous wastes in accordance with local, state, and federal regulations, and recycle these wastes to the maximum extent possible, retirement of the coal facilities would improve the overall quality of environmental media.

CT plants produce very small quantities of solid waste during normal operation and therefore the potential retirement of the CT units at Allen, Colbert, Gallatin, and Johnsonville would not affect solid and hazardous wastes.

5.5.5 Land Resources

TVA's existing power plant reservations have a total area of about 25,000 acres. This total does not include conventional hydroelectric plants, most of which are closely associated with multi-purpose dams and reservoirs, or the approximately 1600-acre Bellefonte site. Many of the power plant reservations have large, relatively undisturbed areas and the actual area disturbed by facility construction and operation (the "facility footprint") totals about 18,000 acres. Much of the relatively undisturbed area on plant sites is forested and relatively little of it is considered prime farmland. The generating facilities from which TVA purchases power under PPAs (excluding hydroelectric plants) have a total area of about 4,300 acres; about 1,900 acres of this is occupied by solar facilities operating in late 2018.

Land requirements for new generating and storage facilities, excluding behind-the-meter distributed energy resources, were determined from the capacity expansion plans and the resource type- and facility-specific land requirements given in Section 5.2. For long-term natural gas PPAs, half of the facilities were assumed to be existing and half new. Where the indicated capacities translated to fractional facilities, the number of facilities was rounded up to the nearest whole number. Behind-the-meter solar facilities are assumed to be mostly building-mounted and would not result in additional land requirements. A small portion of these facilities could be ground-mounted; most of these are assumed to be on developed commercial or industrial sites and would result in minimal additional land requirements.

The partial and/or entire retirement of CT and coal plants would not result in any immediate changes in land use. After facilities are retired, TVA would conduct a comprehensive review of the long-term management of the plant site, including the potential reuse or demolition of plant buildings and redevelopment of the site.

Land requirements for new generating and storage facilities, averaged across scenarios, range from about 41,900 acres for Strategy B to 59,100 acres for Strategy D (Figure 5-22). The land requirement for Strategy E is very close to that of Strategy D, and both Strategy D and Strategy E have little variation across scenarios. Strategy B has the largest variation in land requirements across scenarios, with the land requirement for Scenario 3 about three times the land requirement for Scenario 2 (Figure 5-21, Figure 5-22). Land requirements vary by less than two percent among the scenarios associated with both Strategy D and Strategy E. Scenario 3 has the largest land requirement for all strategies except Strategy C, where the land requirement for Scenario 6 is slightly larger than that for Scenario 3. The land requirement for the Target Power Supply Mix under the Current Outlook scenario ranges from 33,145 to 59,034 acres. Under the Growth scenario and with relaxation of the annual and total limits on solar capacity additions, land requirements could total about 103,427 acres. This additional acreage would be occupied by solar facilities.

For all combinations of strategies and scenarios (Figure 5-22), at least 97 percent of the land required for new generating and storage facilities is for utility-scale, single-axis tracking solar facilities. Relative to other types of generation, solar PV facilities have a high land requirement in relation to their generating capacity. Smaller land areas would be occupied by natural gas-fired and storage facilities. The selected storage facilities are utility-scale batteries, which have relatively small land requirements and are often located at existing power plants or substations. Under some sensitivities incorporated into the extended range of the Target Power Supply Mix, up to 175 MW of hydroelectric generating capacity could be added. The land area necessary for developing new reservoirs or expanding existing reservoirs is not included in the Target Power Supply Mix land requirements illustrated in Figure 5-21.

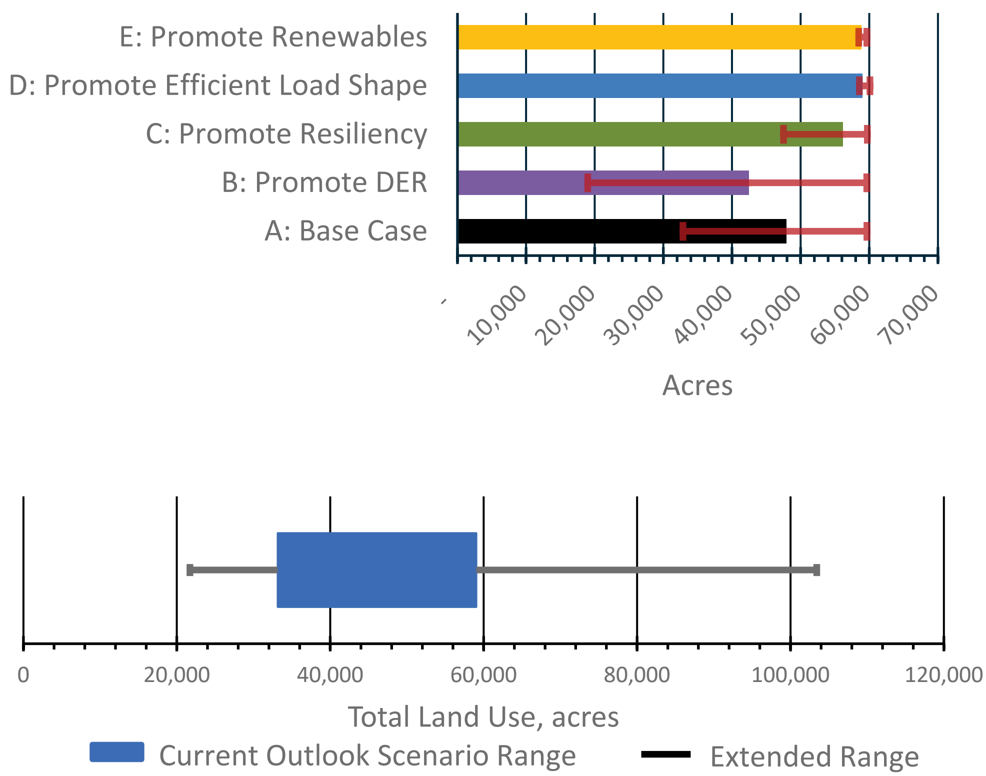


Figure 5-21: Average total land area for all new generating facilities by alternative strategy (top) and for the Target Power Supply Mix (bottom). The error bars in the top chart indicate the maximum and minimum values for the scenarios associated with each alternative strategy.

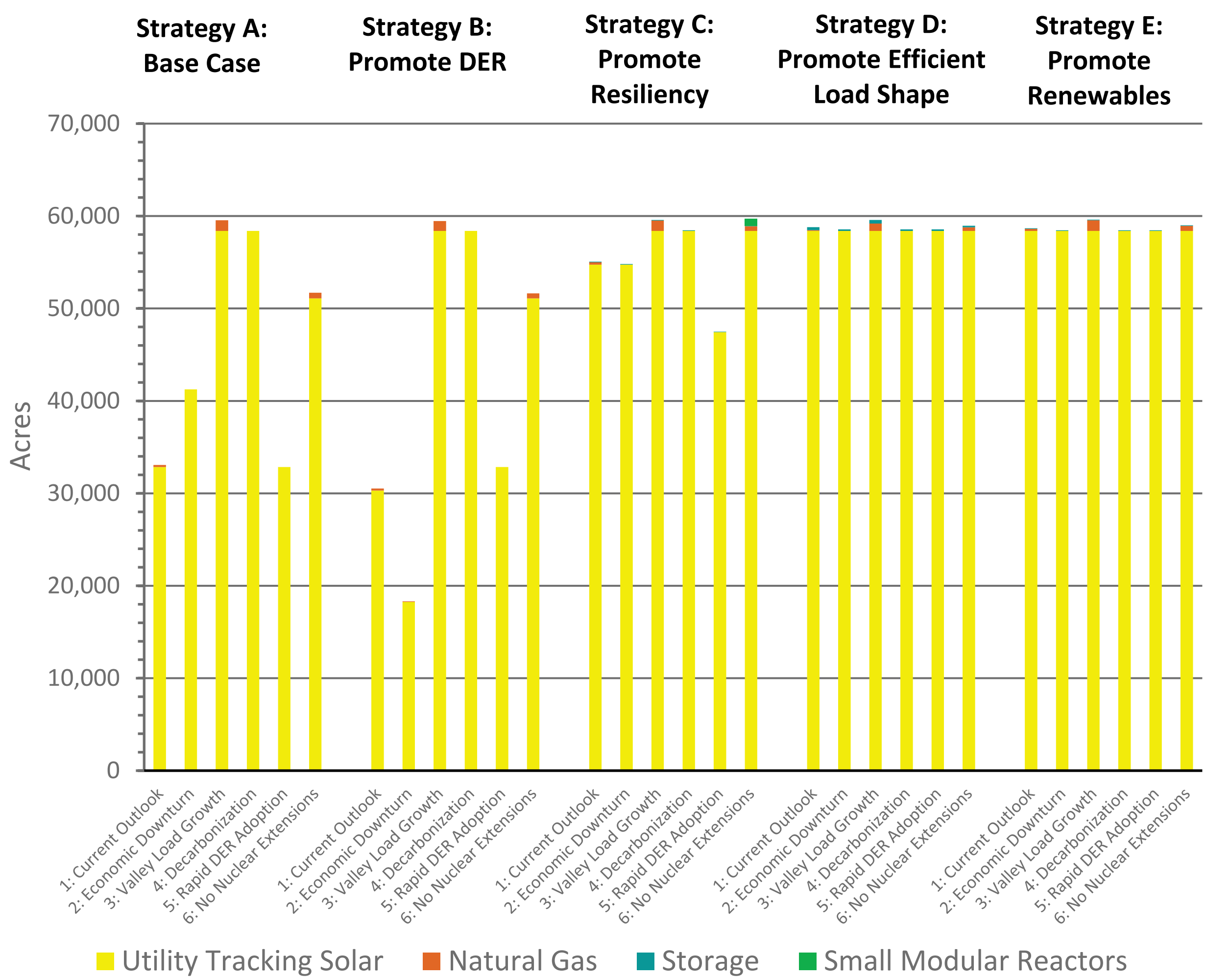


Figure 5-22: Land requirements for new generating facilities by type of generation, alternative strategy, and scenario.

Over 90 percent of the land area occupied by utility-scale solar facilities constructed in the TVA service area to date was previously in agricultural use as either cropland or pasture. Most of the remaining land area was previously forested. The majority of these solar facilities have been in western Tennessee and northwest Alabama; solar proposals recently received by TVA indicate a continued interest in developing solar facilities in these areas as well as in Mississippi. The preference for this region is due to the presence of large tracts of relatively flat land in large ownerships and its better solar resource relative to the rest of the TVA region (see Section 4.6.2).

Despite the large land requirements of utility-scale solar facilities, which typically displace agricultural operations including grazing or, to a much smaller extent forest, the impacts of solar facilities on the land are low relative to other types of generating facilities. The construction of solar facilities typically does not require extensive excavation and solar facilities have little associated permanent or semi-permanent infrastructure that hinders restoration of the site after the facility is dismantled. See Sections 5.2.3.5 and 5.2.3.6 for a more detailed discussion of the impacts of constructing and operating solar facilities. While the approximately 18,300–58,400 acres occupied by new solar facilities under the portfolios shown in Figure 5-22 is a large land area, it comprises 0.03–0.10 percent of the TVA service area. The potential maximum land area under the Target Power Supply Mix, with the addition of 14,000 MW of solar generating capacity by 2038, is about 0.17 percent of the TVA service area. Most existing solar facilities, solar facilities under development, and proposed solar facilities are in rural areas where the rate of land use change has been low; consequently the cumulative impact of these facilities on land use is insignificant. The cumulative impacts of future solar development on land use will be greater, particularly if utility-scale solar development remains concentrated in northwest Alabama, southwest Tennessee, and Mississippi.

The land requirements illustrated in Figure 5-21 and Figure 5-22 only include those for the generating and storage facility footprints and associated access roads. They do not include undisturbed portions of the power plant reservations or the land area needed for extraction (e.g., mining, drilling), processing, and transportation of fuels or long-term disposal of wastes.

5.5.5.1 Impacts on Potential Facility Retirements

Parks and managed areas are located on and in the vicinity of the eight generating plants considered for full or partial retirement. Before implementing a specific resource option, TVA will conduct a review of its potential impacts to land use. This review will, as appropriate, focus on resource- and/or site-specific land use issues such as impacts on parks and managed areas. Redevelopment of retired plant sites is beyond the scope of the IRP, and would be assessed on a site-specific basis with public and agency input.

5.5.6 Socioeconomics

Potential socioeconomic impacts of the alternative strategies were assessed by the real per-capita income and non-farm employment metrics described in Volume I, Section 6.3. These metrics were calculated using the PI+ Model by Regional Economic Models, Inc. This model is described in detail in Volume 1, Appendix J. The numerous inputs to the model include employment, wage, income, and population data, costs associated with the energy resource options, and labor and capital requirements. Real per-capita income reflects the general economic well-being of area residents and the net effect of each strategy's change in expenditures and electricity bills. Increases in TVA expenditures to operate the power system stimulate the area economy in select areas, but can also increase all customers' electricity bills and reduce their discretionary income. These impacts tend to be generally offsetting.

Changes in real per-capita income and employment are described for the TVA service area. Because the IRP is programmatic and does not address the future siting and construction of generating facilities, site-specific analyses of socioeconomic impacts, including potential site- specific disproportionate impacts to minority and low-income populations, are not possible at this time. An exception to this is the projected retirement of generating facilities, where some local area-specific impacts are described below.

The differences in annual real per capita income and employment of residents of the TVA service area were compared to Strategy A for each scenario (Tables 5-5, 5-6). The differences in real per capita income are small; averaged across scenarios, there would be no change under Strategies B and E and small decreases under Strategies C and D. The small magnitude of the changes are due in large part to the small proportion of the TVA region's economy (about $440 billion in 2018) comprised by TVA revenues ($11.2 billion in 2018). The real per capita income metric does not reflect the effects of TVA expenditures outside its service area which are mostly for fuels and purchased power. Most of the fuel used to supply power to TVA is purchased from sources outside the service area; the major exceptions to this are coal from Muhlenberg County, Kentucky. and Choctaw County, Mississippi. None of the portfolios include significant new PPAs from sources outside the service area and the current out-of-area PPAs for wind energy expire in the early 2030s. Under the Target Power Supply Mix, wind energy generated outside of the TVA service area could be added depending on future trends in cost and demand.

Table 5-5: Changes in real per capita income by alternative strategy relative to Strategy A – Base Case.

Strategy	Scenario 1	2	3	4	5	6	Strategy Average
A: Base Case	--	--	--	--	--	--	--
B: Promote DER	0.00%	0.00%	0.01%	0.00%	0.00%	0.00%	0.00%
C: Promote Resiliency	-0.01%	0.00%	-0.01%	0.00%	0.00%	-0.03%	-0.01%
D: Promote Efficient Load Shape	-0.01%	-0.02%	-0.04%	-0.02%	-0.02%	-0.01%	-0.02%
E: Promote Renewables	0.00%	0.00%	-0.01%	0.00%	-0.01%	0.00%	0.00%

Table 5-6: Changes in employment by alternative strategy relative to Strategy A – Base Case.

Strategy	Scenario 1	2	3	4	5	6	Strategy Average
A: Base Case	--	--	--	--	--	--	--
B: Promote DER	0.01%	0.00%	0.01%	0.01%	0.10%	0.00%	0.02%
C: Promote Resiliency	0.01%	0.01%	0.01%	0.01%	0.10%	0.01%	0.02%
D: Promote Efficient Load Shape	0.02%	0.01%	0.01%	0.01%	0.11%	0.00%	0.03%
E: Promote Renewables	0.01%	0.01%	0.00%	0.00%	0.10%	0.00%	0.02%

As with real per capita income, the differences in employment between the alternative strategies are small. Strategies B, C, D, and E would all result in small increases in employment. Most of these increases are attributable to Scenario 5: Rapid DER Adoption. Under this scenario, TVA's revenue requirements decrease by about 10 to 12 percent relative to Strategy A, stimulating regional economic growth and associated employment. Smaller increases under other scenarios are due in part to employment increases proportional to population increases.

Before implementing a specific resource option, TVA will conduct a review of its potential socioeconomic impacts. This review will, as appropriate, focus on resource- and/or site-specific socioeconomic issues such as impacts on employment rates, housing, schools, emergency services, water supply and wastewater treatment capacity, and local government revenues including TVA tax equivalent payments.

The construction and/or acquisition of facilities by TVA could increase TVA's tax equivalent payments, also known as payments in lieu of taxes, to states where the facilities are located. The construction of new solar facilities and other energy resources by independent power producers from which TVA purchases power would not affect tax equivalent payments; these facilities would, however, likely pay other taxes to the local communities and states.

5.5.6.1 Impacts of Potential Facility Retirements

The following section describes the socioeconomic impacts that could occur if TVA retires the facilities discussed in Section 3.2.3.

The potential retirement of a CT or coal facility would result in the loss of a local employment option, and people currently employed at these facilities may become temporarily unemployed. The CT facilities employ a relatively small number of people (Allen = 8, Colbert = 6, Gallatin = 8, Johnsonville = 28). While this decrease in employment represents less than 0.01 percent of total employment in the counties in which the facilities are located, minor direct adverse economic impacts to the area surrounding the CT facility could result.

The coal facilities employ more people (Cumberland = 329, Gallatin = 174, Kingston = 254, Shawnee = 241), and the loss of employment would result in a direct adverse economic impact to the surrounding areas . Employees and associated family members may also temporarily or permanently relocate to different locations in the state or beyond for employment or other reasons, and these changes may affect familial and community relations. The retirement of coal facilities would result in indirect employment impacts to associated mining, transportation, and by-product industries, as well as businesses providing other materials and services. Adverse economic impacts could occur within these industries and associated affected counties.

TVA would help offset this employment loss by placing some interested employees in available positions across the TVA PSA. As described in Section 4.8.4, there are several other fields in the vicinity of the CT and coal facilities, including educational services, health care, and social assistance; manufacturing; transportation; retail trade; and warehousing. Employees at these facilities may find alternative employment in these other industries. However, the average annual salary is approximately 2.4 to 3.0 times higher than the average of per capita income in affected counties. For Allen CT facility and Johnsonville CT facility, the proximity to more urbanized areas such as Memphis and Nashville, TN may help offset the need for employees and associated family members to relocate. Therefore, the potential retirement of these facilities would result in minor, direct, adverse socioeconomic impacts.

The potential retirement of these facilities would also adversely affect TVA's tax equivalent payments, also known as payments in lieu of taxes, to each state where the facility is located. Each state regulates how the payments are distributed to governmental entities across the state. The potential retirement of CT plants would have a negligible adverse effect on payments to Tennessee and Alabama (where the CT plants are located). The potential retirements of coal plants or the Browns Ferry nuclear plant would have a greater adverse effect. Before implementing a specific resource option, TVA will conduct a review of its potential socioeconomic impacts, including local government revenues from TVA tax equivalent payments.

5.5.7 Environmental Justice

All of the capacity expansion plans associated with the alternative strategies and scenarios include the construction and operation of new generating facilities and, for many plans, new energy storage facilities. The potential impacts on minority and low-income populations from the construction and operation of these facilities, whose locations are, with a few exceptions, not known at this time and will be determined in future environmental analyses. The potential impacts of the retirement of generating facilities on low-income and minority populations are described below in Section 5.5.8.1.

Future rate increases could affect low-income populations more than other populations. Low-income populations also have limited ability to participate in energy efficiency programs that could reduce their future power bills. TVA is working with the local power companies to develop programs benefiting low-income homeowners and renters. Strategies B – Promote DER and D – Promote Efficient Load Shape include energy efficiency programs targeting low income customers.

5.5.7.1 Impacts of Facility Retirements

Demographic indicators for potential environmental justice concerns were obtained using EJSCREEN for a 3-mile radius surrounding TVA power plants, including the eight facilities being considered for full or partial retirement (see Section 4.9.5). Allen CT Plant has minority percentages and low-income population percentages higher than the state of Tennessee. Allen CT Plant, Colbert CT Plant, Shawnee Fossil Plant, Cumberland Fossil Plant, and Johnsonville CT Plant have higher percentages of the population over the age of 64 compared to their respective states.

The potential retirement of these facilities would not result in significant environmental justice-related impacts. TVA would help offset this employment loss by placing some interested employees in available positions across the TVA PSA. Because of the lack of significant environmental impacts as described in Section 5.5.7, no disproportionate impacts to disadvantaged populations are projected. Minor positive indirect effects to minority and low-income populations may occur due to beneficial changes to local air quality from coal facility retirements.

5.6 Potential Mitigation Measures

As previously described, TVA's siting processes for generation and transmission facilities, as well as practices for modifying these facilities, are designed to avoid and/or minimize potential adverse environmental impacts. Potential impacts are also reduced through pollution prevention measures and environmental controls such as air pollution control systems, wastewater treatment systems, and thermal generating plant cooling systems. Other potentially adverse impacts can be mitigated by measures such as compensatory wetlands mitigation, payments to in-lieu stream mitigation programs and related conservation initiatives, enhanced management of other properties, documentation and recovery of cultural resources, and infrastructure improvement assistance to local communities.

5.7 Unavoidable Adverse Environmental Impacts

The adoption of an alternative strategy for meeting the long-term electrical needs of the TVA region has no direct environmental impacts. The implementation of the strategy, however, would have adverse environmental impacts. The nature and potential significance of the impacts will depend on the energy resource options eventually implemented under the strategy. Resource options in each strategy have associated adverse impacts that cannot be realistically avoided but which can often be minimized.

Under every alternative strategy, TVA would continue to operate most of its existing generating units for the duration of the 20-year planning period. The exceptions are the coal plants/units that would be retired, a few of the older CT units, and, under Scenario 6, the Browns Ferry Nuclear Plant. The operation of the generating units would continue to result in the release of various air and/or water pollutants, depending on the kind of unit, and to generate wastes.

The construction and operation of new generating facilities would unavoidably result in changes in land use unless new facilities are located at existing plant sites. The conversion of land from a non-industrial use to an industrial use would unavoidably affect land resources such as farmland, wildlife habitat and scenery.

5.8 Relationship Between Short-Term Uses and Long-Term Productivity of the Human Environment

The adoption and implementation of a long-term energy resource strategy would have various short- and long-term consequences. These depend, in part, on the actual energy resource options implemented. Option-specific and/or site-specific environmental reviews will be conducted before final implementation decisions are made to use certain energy resources and will examine potential environmental consequences in more detail.

In both the short and long term, TVA would continue to generate electrical energy to serve its customers and the public. The availability of adequate, reliable, low-priced electricity will continue to sustain and increase the economic well-being of the TVA region. The availability of electricity also has been recognized as enhancing public health and welfare.

The generation of electricity has both short- and long-term environmental impacts. Short-term impacts include those associated with facility construction and operational impacts, such as the consequences of exposure to the emission of air pollutants and consequences of thermal discharges. Potential long-term impacts include land alterations for facility construction and fuel extraction, and the generation of nuclear waste that requires safe storage for an indefinite period.

5.9 Irreversible and Irretrievable Commitments of Resources

The continued generation of electricity by TVA will irreversibly consume various amounts of non-renewable fuels (coal, natural gas, diesel, fuel oil, and uranium). The continued maintenance of TVA's existing generating facilities and the construction of new generating facilities will irreversibly consume energy and materials. The siting of most new energy facilities, except for wind and PV facilities, will irretrievably commit the sites to industrial use because of the substantial alterations of the sites and the relative permanence of the structures. The continued generation of nuclear power will produce nuclear wastes; therefore, a site or sites will have to be devoted to the safe storage of these wastes. Any such site would essentially be irretrievably committed to long-term storage of nuclear waste.

The alternative strategies contain varying amounts of EEDR and renewable generation. Reliance on these resources lessens the irreversible commitment of non-renewable fuel resources, but would still involve the irreversible commitment of energy and materials and, depending on the type of renewable generation, the irreversible commitment of generating sites.

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Experience: 32 years TVA experience in nuclear systems engineering, resource planning, price forecasting, and financial analysis
Role: Integrated expansion, production cost, and financial modeling. Application of stochastic and risk analysis

Kyle Lawson (TVA)
Education: M.S. and B.S., Economics;
Experience: 10 years in planning, forecasting, implementation, and measurement of energy efficiency and demand response programs
Role: Energy efficiency and demand response program accomplishments, current programs, and program plans

Ed Liebsch (HDR)
Education: M.S., Meteorology; B.S., Earth Science w/Chemistry Minor
Experience: 38 years in air dispersion analysis, 28 years in air quality permitting and NEPA air quality analysis
Role: Air Quality, Climate and Greenhouse Gases

Tanya Mathur (TVA)
Education: B.S., Electrical Engineering; B.S., Neuroscience
Experience: 14 years in reliability engineering and operations, energy management systems, advanced power applications, transmission reliability and engineering controls, resource planning and fleet strategy
Role: Capacity planning, financial modeling, expansion modeling and analysis; document preparation

Al Myers (HDR)
Education: Completed credits toward B.S. Business Administration
Experience: 22 years in administration
Role: Formatting, editing of EIS and IRP

Charles P. Nicholson (HDR)
Education: Ph.D., Ecology and Evolutionary Biology; M.S., Wildlife Management; B.S., Wildlife and Fisheries Science
Experience: 24 years in NEPA compliance, 17 years in wildlife and endangered species management
Role: Project Manager, NEPA compliance, EIS preparation

Roger Pierce (TVA)
Education: M.B.A.; B.S.M.E., Mechanical Engineering
Experience: 10 years TVA experience in resource planning.
Role: Expansion and production cost modeling

Ashley Pilakowski (TVA)
Education: B.S., Environmental Management
Experience: 7 years in environmental planning and policy and NEPA compliance
Role: TVA Project Manager, TVA NEPA Coordinator, NEPA Compliance

Kim Pilarski-Hall (TVA)
Education: M.S., Geography, Minor Ecology
Experience: 24 years in wetlands assessment, delineation, and mitigation
Role: Wetlands

Erin E. Pritchard (TVA)
Education: M.A., Anthropology
Experience: 24 years in archaeology and cultural

resource management
Role: Cultural Resources

M. Hunter Reed (TVA)
Education: M.B.A; B.S.B.A., Finance and Management of Information Systems
Experience: 7 years TVA experience in resource planning and IT systems engineering
Role: IRP document preparation

Harriet L. Richardson Seacat (HDR)
Education: M.A. and B.A., Anthropology
Experience: 17 years in anthropology, archaeology, history, and NHPA and NEPA documentation
Role: Document preparation, GIS mapping (Socioeconomics and Environmental Justice)

Bob Roth (TVA)
Education: M.S. Economics; B.S. Economics
Experience: 33 years of energy industry experience, with 17 years of utility industry experience in economic and load forecasting, marketing, and rates
Role: Economic forecasting, Socioeconomics, Environmental Justice

Marylee Sauder (TVA contractor)
Education: BA, English and Journalism
Experience: 24 years in corporate communications
Role: IRP project communications

Timothy D. Sorrell (TVA)
Education: M.S., Mechanical Engineering; B.S., Nuclear Engineering; M.B.A.
Experience: 28 years utility experience in forecasting, system planning, commodity trading, nuclear fuel
Role: Economic impact, load forecasting, commodity price forecasting

Miles Spenrath (HDR)
Education: B.S., Environment and Natural Resources
Experience: 6 years in NEPA compliance
Role: Aquatic Life, Vegetation and Wildlife, Endangered and Threatened Species, Wetlands

Preeth Srinivasaraghavan (TVA)
Education: M.E.M., Environmental Management; B.A. Environmental Studies and Political Science
Experience: 3 years experience in wholesale power markets, environmental policy, and resource planning
Role: IRP document preparation

Amanda K. Turk (TVA)
Education: M.S., Environmental Engineering; B.S., Civil Engineering
Experience: 9 years in water supply investigations, watershed hydrology, and surface water quality analysis
Role: Water Supply

E. Blair Wade (HDR)
Education: M.E.M., Environmental Management; B.S., Integrated Sciences and Technology (Environmental Science and GIS)
Experience: 14 years in environmental permitting and NEPA compliance
Role: Assistant Project Manager, NEPA compliance, EIS preparation

A. Chevales Williams (TVA)
Education: B.S., Environmental/Chemical Engineering
Experience: 13 years of experience in water quality monitoring and compliance; 12 years in NEPA planning and environmental services
Role: Surface Water

Carrie C. Williamson, P.E., CFM (TVA)
Education: M.S., Civil Engineering; B.S., Civil Engineering
Experience: 6 years in Floodplains and Flood Risk; 3 years in River Forecasting; 11 years in Compliance Monitoring
Role: Floodplains and Flood Risk

Daniel A. Woolley (TVA)
Education: B.S., Finance
Experience: 11 years of experience in financial and risk analysis and modeling, resource planning
Role: Capacity expansion and financial modeling

Cassandra L. Wylie (TVA)
Education: M.S., Forestry and Statistics; B.S., Forestry
Experience: 30 years in air quality analyses and studying the effects of air pollution on forests
Role: Air Quality

Elizabeth F. Upchurch (TVA)

Education: BA Geography, University of Tennessee
Experience: 15 years Utility Experience. 10 years Project Management and Stakeholder Engagement
Role: Stakeholder Engagement / IRP

Karen R. Utt (TVA)
Education: B.A., Biology; J.D.
Experience: 25 years of experience with environmental compliance, specializing in carbon risk management and climate change adaptation planning
Role: Greenhouse gas and climate change analyses

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8 EIS Recipients

Following is a list of the agencies, organizations, and persons who have received copies of the EIS or notices of its availability with instructions on how to access the EIS on the IRP project webpage.

8.1 Federal Agencies

USDA Forest Service, Region 8, Atlanta, GA
USDA Forest Service, Montgomery, AL
U.S. Environmental Protection Agency, Washington, DC
U.S. Environmental Protection Agency, Region 4, Atlanta, GA
Department of Interior, Washington, DC
U.S. Fish and Wildlife Service, Southeast Region Office, Atlanta, GA
U.S. Fish and Wildlife Service, Frankfort, KY
U.S. Fish and Wildlife Service, Asheville, NC
U.S. Fish and Wildlife Service, Abingdon, VA
U.S. Fish and Wildlife Service, Cookeville, TN
U.S. Fish and Wildlife Service, Gloucester, VA
U.S. Fish and Wildlife Service, Daphne, AL
U.S. Fish and Wildlife Service, Athens, GA
U.S. Army Corps of Engineers, Savannah District
U.S. Army Corps of Engineers, Louisville District
U.S. Army Corps of Engineers, Nashville District
U.S. Army Corps of Engineers, Norfolk District
U.S. Army Corps of Engineers, Memphis District
U.S. Army Corps of Engineers, Mobile District
U.S. Army Corps of Engineers, Wilmington District
U.S. Army Corps of Engineers, Raleigh Regulatory Field Office and Asheville Regulatory Field Office
U.S. Army Corps of Engineers, Vicksburg District
Economic Development Administration, Atlanta, GA
Advisory Council on Historic Preservation

8.2 State Agencies

8.2.1 Alabama

Alabaman Forestry Commission
Department of Agriculture and Industries
Department of Conservation and Natural Resources
Department of Economic and Community Affairs
Department of Environmental Management
Department of Transportation
Alabama Historical Commission
Top of Alabama Regional Council of Governments
North-Central Alabama Regional Council of Governments
Northwest Alabama Council of Local Governments
Decatur-Morgan County Port Authority

8.2.2 Georgia

Department of Natural Resources: Historic Preservation Division
Department of Economic Development
Department of Community Affairs
Department of Natural Resources
Department of Wildlife Resources

8.2.3 Kentucky

Kentucky State Clearinghouse
Kentucky Heritage Council

8.2.4 Mississippi

Northeast Mississippi Planning and Development District
Mississippi Development Authority
Department of Finance and Administration
Department of Environmental Quality
Department of Archives and History: Historic Preservation Division
Natchez Trace Parkway Superintendent

8.2.5 North Carolina

North Carolina State Clearinghouse
Office of Archives and History: Historic Preservation Office

8.2.6 Tennessee

Tennessee State Clearinghouse
Department of Environment and Conservation
Division of Archaeology: State Historic Preservation Office
East Tennessee Development District
Southeast Tennessee Development District
Upper Cumberland Development District
South Central Tennessee Development District

Southwest Tennessee Development District
Northwest Tennessee Development District
Tellico Reservoir Development Agency
Beech River Development Authority
Duck River Development Agency

8.2.7 Virginia

Office of Environmental Review Clearinghouse
Department of Historic Resources

8.3 Federally Recognized Tribes

Absentee Shawnee Tribe of Indians of Oklahoma
Alabama-Coushatta Tribe of Texas
Alabama-Quassarte Tribal Town
Cherokee Nation
The Chickasaw Nation
The Choctaw Nation of Oklahoma
Coushatta Tribe of Louisiana
Delaware Nation
Eastern Band of Cherokee Indians
Eastern Shawnee Tribe of Oklahoma
Jena Band of Choctaw Indians
Kialegee Tribal Town
Mississippi Band of Choctaw Indians
The Muscogee (Creek) Nation
The Osage Nation
Poarch Band of Creek Indians
The Seminole Nation of Oklahoma
Shawnee Tribe
Thlopthlocco Tribal Town
United Keetoowah Band of Cherokee Indians in Oklahoma

8.4 Individuals and Organizations

The following individuals received notification of the availability of the final EIS.

A

Abbott, George, Memphis River Park Partnership, Memphis, TN; Abel, Sandra, Walland, TN; Abkowitz, Kendra, Tennessee Division of Environment and Cnnservation, Nashville, TN; Abrams, Judith, New York, NY; Ackema, Deborah, Climate Reality, Goodlettsville, TN; Ackley, Sandy, Tullahoma, TN; Acosta, Heather, Kingsport, TN; Ada, Corinne, Sierra Club; Adams, Karis, Lexington, TN; Adams, Thomas; Addis, Barbara, Knoxville, TN; Ahmed, Tarik, Knoxville, TN; Akers, Aaron; Akselrad, Kathleen, Hilham, TN; Aldridge, Saundra, Huntsville, AL; Alegre, Joe, Chattanooga, TN; Alexander, Bob; Alexander, Dana, Arlington, TN; Alexander, Tonya, Mount Juliet, TN; Alexiades, V., Knoxville, TN; Alford, Domina; Allen, Joseph, Nashville, TN; Allen, Leanne, Nashville, TN; Allen Burke, Julie; Allison, Dianne, Huntsville, AL; Altun, Rukiye; Ammons, Wayne, Wayne Ammons Group, LLC; Amos, Ashley, Sweetwater, TN; Ananka, Maryia, Chattanooga, TN; Andersen, Susan, Hermitage, TN; Anderson, Betty, Bowling Green, KY; Anderson, Craig, Tranquility Farms, Bowling Green, KY; Anderson, Emery; Anderson, Ranae, Universal Fibers Systems, Bristol, VA; Anderson, Sherry, Clinton, TN; Anderson, Tyler, Vanderbilt University; Andrews, Correna, McCallie School, Chattanooga, TN; Anthony, Kate, Ringgold, GA; Archer, Ward, POA, Memphis, TN; Armbruster, Jay, Knoxville, TN; Armendariz, Al; Armes, Hal, Sardis, MS; Armour, Ellen, Nashville, TN; Armstrong, Kathy, Hermitage, TN; Arnett, Brian, Starkville, MS; Arnett, James, Nashville, TN; Arnoult, Duffy-Marie, Memphis, TN; Arnoult, Leo, Memphis, TN; Arora, Sumesh; Askins, Kelly, Germantown, TN; Atha, Patty, AL; Atkins, John H.; Atkins Jr., John H., Morristown, TN; Atkinson, Eileen, Clarkrange, TN; Austin, Debra, Jefferson City, TN; Austin, Wade, Nashville, TN

B

B., Christine, Gastonia, NC; Baccheschi, Belle, Greeneville, TN; Bagwell, Amy, Germantown, TN; Bailey, Brent; Baird, Holly; Baird, Walter, LaFollette Utilities Board, LaFollette, TN; Baisden, Ronald, Johnson City, TN; Baker, Angie, Brentwood, TN; Baker, Kellie, Franklin, TN; Baker, Kristina, Southaven, MS; Bakewell, Deborah, Brentwood, TN; Bales, Elliott, Hixson, TN; Balog, Amy, Pikeville, TN; Banbury, Scott, Memphis, TN; Barber, Ann, Knoxville, TN; Barham, Kristy, Dyersburg, TN; Barkenbus, Jack; Barnard, Graham, Huntsville, AL; Barnes, Brian, TVA-MCC, Olive Branch, MS; Barnes, Paula, Memphis, TN; Barnes, Rachael, Bristol, TN; Barritt, Jim, Shelbyville, TN; Barros, Deborah, Huntsville, AL; Barton, Mitch; Baty, Steven, Huntsville, AL; Baxter, Michaela, Cookeville, TN; Beasley, Matt, Tennessee Solar Energy Industries Association, TN; Beaver, Amanda, Chattanooga, TN; Beavers, Nancy, Woodlawn, TN; Beck, Charles, Chattanooga, TN; Beckman, Emily, Murfreesboro, TN; Behn, John, Columbia, TN; Behr, Wendy, Nashville, TN; Bell, Janine, Drummonds, TN; Bell, Ramie, Memphis, TN; Bellamy, Flo, Mountain City, TN; Benavides, Caroyln, CBU, Memphis, TN; Benedetti, Caroline, Knoxville, TN; Bennett, Teresa, Livingston, TN; Benshoof, Rob, Nashville, TN; Bentley, Marianne, Nashville, TN; Berlin, Robert, Maryville, TN; Bermel, Colby; Bernstein, Julianne; Berry, Jan, Sierra Club, Greenback, TN; Berry, Parker; Bertin, Hector, Whiteville, TN; Berton, Helene, Oxford, MS; Best, Crystal, NC Department of Administration, Raleigh, NC; Bevels, Terry, Fayetteville, TN; Bias, Latosha, SEEED, Knoxville, TN; Bidwell, Troy, Knoxville, TN; Bielaczyc, Sara, Nashville, TN; Bishop, Ann, Millington, TN; Bishop, Mark, Clinton, TN; Black, Ruth, Cookeville, TN; Blackman, Pat, Owens Cross Roads, AL; Blanco, Karen, Harrison, TN; Blank, Mike; Bledsoe, Debra, Vanderbilt University; Blevins, Laura; Blevins, Vicki, Bristol, TN; Blohm, Bruce, Chattanooga, TN; Bolton, Ben; Bomar, Rob, Lightware Solar, Nashville, TN; Bombay, Katherine, Citizens Climate Lobby, Nashville, TN; Bordenkircher, David, Nashville, TN; Boring, Rita, Mc Donald, TN

Bott, Margaret, Spring City, TN; Boucher, Butterfly, Nashville, TN; Bourassa, Veronica, Evensville, TN; Bowden, Deanna, Brentwood, TN; Bowen, Dianne, Memphis, TN; Bowen, Eleanor, Sierra Club, Bowling Green, KY; Bowen, Nigel, Lakeland, TN; Bowers, Gary, Nashville, TN; Bowers, Joe, Santa Fe, TN; Bowman, Megan, Calhoun, GA; Bowman, Tim, Calhoun, GA; Boxley, Donald, PAG's Across America, Gurley, AL; Boyd, Candace, Knoxville, TN; Boyd, Gail, Hixson, TN; Boyd, Rodney; Bradfield, Susan, Franklin, TN; Bradley, Laura, Oxford, MS; Bradley, Rhonda, Crossville, TN; Bragg, Laurie, Huntsville, AL; Branham, Mary, Knoxville, TN; Brawner, Debbie, Nashville, TN; Bredhold, Wendy; Brehmer, Rebecca, Knoxville, TN; Brennan, Steve; Breon, David, Murfreesboro, TN; Brewer, Leann, Walland, TN; Brice, Logan, University of Wisconsin-Stevens Point, Stevens Point, WI; Brichetto, Joanna, Nashville, TN; Bridges, Nancy, Bowling Green, KY; Briley, David, Metropolitan Government of Nashville-Davidson Co., Nashville, TN; Brinson, Solange, Memphis, TN; Bristow, Mary, Brentwood, TN; Brooks, Janet, Chattanooga, TN; Brooks, Janice, Memphis, TN; Brooks, Karl, Harrison, TN; Brooks, Ralph, Knoxville, TN; Brown, Forrest, Nashville, TN; Brown, Jason, Kingston, TN; Brown, Kathleen M, Summertown, TN; Brown, Nathan, Chattanooga, TN; Brown, Rhonda, Oak Ridge, TN; Brown, Shirley, Maryville, TN; Brown, Steve, Piney Flats, TN; Brown, Tracy, Lenoir City, TN; Brown-Hall, Jennifer, Greeneville, TN; Browning, Leah, Fairview, TN; Bryan, Jillian, Mosheim, TN; Bryson, Linda, Chattanooga, TN; Buchi, Russell, TN Interfaith Power & Light, Nashville, TN; Buckley, Helen, Chattanooga, TN; Buckley, Marguerite, Bristol, TN; Buckner, Randy, Energy Alabama, Toney, AL; Bullock, Bill, Memphis, TN; Burch, Emily, St Louis Blues, Clayton, MO; Burford, Ellen, Senatobia, MS; Burgdorf, Jeri, Nashville, TN; Burks, John, Hixson, TN; Burks, Neely, Nashville, TN; Burleson, Tony, Maryville, TN; Burris, Heather, Rogersville, TN; Bursaw, Chris; Burton, Frances, Vanderbilt University, Nashville, TN; Busby, Chris, Watertown, TN; Butler, David, Hermitage, TN; Buttrey, Natasha, HoneyCombs Salon, Goodlettsville, TN; Byrne, C, Huntsville, AL

C

Cai, Jinliang, Memphis Chamber, Memphis, TN; Caldwell, Tiffany, Amory, MS; Calton, Rhonda, Church Hill, TN; Calton, Valorie, Russellville, TN; Campanelli, Keegan, Vanderbilt SPEAR; Campbell, Jack, Madison, AL; Campbell, James Michael, Spring City, TN; Campbell, Nathan, Tullahoma, TN; Campbell, Shannon, Ringgold, GA; Camper, Stacey, Bowling Green, KY; Canty, Caitlin, Nashville, TN; Capps, Stephanie, Nashville, TN; Caraway, Morgan, Chattanooga, TN; Carlough, Bob, Butler, TN; Carlson-Bancroft, Sally, Nashville, TN; Carney, Jason, Tennessee Solar Energy Association, Knoxville, TN; Carpenter, Jamie, Murfreesboro, TN; Carpenter, Stacy, Nashville, TN; Carr, John, Chapmansboro, TN; Carroll, Sandra, Shelbyville, TN; Carter, Julia, Huntsville, AL; Carter, Karen, Crossville, TN; Carter, Steve, Bell Buckle, TN; Carter, William, ESA, Huntsville, AL; Case, Daniel, Memphis, TN; Casey, Paula, Clifton, TN; Cash-Procell, Gloria, Huntsville, AL; Caskey, Mark, Memphis, TN; Casteel, Mark, Knoxville, TN; Castle, Zachary, Nashville, TN; Cerutti, Chloe, Murfreesboro, TN; Chambers, Nicole, La Vergne, TN; Chance, Sherry, Lebanon, TN; Chandler, Claire, Nashville, TN; Chandler, Gregory, Huntsville, AL; Chandler, Kevin, TVA, Huntsville, AL; Chapdelaine, Perry, Ashland City, TN; Chasteen, Jessica, Kingston, TN; Chatlani, Shalina; Chen, Jin; Cherich, Carol, Clarksville, TN; Chevedden, Judith, Spring Hill, TN; Child, Brian; Childres, Karen, Greeneville, TN; Childress, Don, Harrison Construction, Knoxville, TN; Chorney, Andrew; Christian, Jeff; Christison, Nicole, Murfreesboro, TN; Christmas, Teresa, Bowling Green, KY; Clark, Cory; Clark, Donald, Pleasant Hill, TN; Clark, Lynn; Clarke, Mary, TN Conservation Voters, Nashville, TN; Claudio, Jessica, Hixson, TN; Clausen, Marlene, Chattanooga, TN; Cleek, Rodney; Clelland, Kellie, Memphis, TN; Clement, Micheal; Clevenger, Keith, TEC Tuscaloosa; Cloud, Barbara, Nashville, TN; Cloud, Carolina, Energy Alabama, Madison, AL

Coburn, Madison; Cockerham, John, East Tennessee State University, Johnson City, TN; Cofer, Amber; Cogswell, Deborah, Nashville, TN; Cohen, Armond, Clean Air Task Force, Boston, MA; Cohn, Esther, Nashville, TN; Cole, Mary Ellen; Cole, Matt; Coles, Nathan, Brentwood, TN; Coletta, Carol, Memphis River Park Partnership, Memphis, TN; Collier, Janet, Spring City, TN; Collison, Ken; Comstock, Chuck, Johnson City, TN; Congelosi, Susan, Blowing Rock, NC; Conley, Robert; Connor, Will, Nashville, TN; Cook, Anders, Knoxville, TN; Cook, James, Murfreesboro, TN; Cookston, Gary, Whitwell, TN; Coombs, Joyce, Corryton, TN; Cooper, Suzanne, Nashville, TN; Copeland, William; Coppala, Jeff, Consumer, Knoxville, TN; Coppinger, June, Chattanooga, TN; Cordell, Ruth, Bell Buckle, TN; Corrigan, Dr. Peter L., Starkville, MS; Cosby, Cheryl, TN; Costello, Michael, Knoxville, TN; Cotter, Trey, Chattanooga, TN; Counts, Kristina, Franklin, TN; Courtney, Susan, Andersonville, TN; Cousino, Scott, TVA; Cover, Ann L., United Methodist Creation Care, Nashville, TN; Cowan, Margaret, Bristol, TN; Cox, Maggie, Christ Church Creation Care, Nashville, TN; Cox, Michael, Oakland, TN; Cox, Robin; Craft, Don, Huntsville, AL; Craven, Dorothy, Waterloo, AL; Crawford, Russ, Sierra Club, Nashville, TN; Crawley, Natasha, Chattanooga, TN; Creach, Laurel, Metro Nashville, Nashville, TN; Cripps, Molly; Croft, Keith, Nashville, TN; Cross, Adney, Knoxville, TN; Cross, William, Memphis, TN; Crow, Charles & Dinah, Cumberland City, TN; Crutcher, Buford, Harvest, AL; Cruze, Lynn, Bean Station, TN; Crystal, Howard, Center for Biological Diversity, Washington, DC; Cummings, Lisa, Alvaton, KY; Cunningham, Elizabeth, Cleveland, TN; Cunningham, Steve, Memphis, TN; Curl, Teresa, La Fayette, GA; Curtis, Anne, Chattanooga, TN

D

D., Russanne, TN Interfaith Power & Light, Nashville, TN; Dacus, Chris, Bell Buckle, TN; Dalton, Hunter, Morristown, TN; Daniel, Gail, Camden, TN; Danielson, Deborah, Hunntsville, AL; Danks, Harold, Alicity Group, Chattanooga, TN; Darby, Michael, Knoxville, TN; Dare, Cheryl, Memphis, TN; Davis, Ann, The Climate Reality Project, Memphis, TN; Davis, Joanna, Murfreesboro, TN; Davis, Lauren; Davis, Lynn, McMinnville, TN; Day, Ida, Knoxville, TN; de Jong, Perrin, Center for Biological Diversity, Asheville, NC; Deaderick, Martha, Tennessee Citizens for Wilderness Planning, Kingston, TN; Dean, Jeffrey, Bruceton, TN; Dean, Susan, Monteagle, TN; Decaprio, Alexis, Delano, TN; Delap, Ann, Knoxville, TN; DeLay, Sam, Chattanooga, TN; Deming, Jim, TN Interfaith Power & Light, Nashville, TN; Deshazer, William, Nashville, TN; Detmer, Carol Michler, Murfreesboro, TN; Devine, Jason, Nashville, TN; Dias, Renee, Nashville, TN; Dickerson, Steven, Dickerson Petroleum, Kosciusko, MS; Diedrich, Joe, Cemex, Knoxville, TN; Dishman, Patricia, Nashville, TN; Dobbs, Jamey, Knoxville, TN; Dobson, Mary-Lynn, Rockwood, TN; Dodson, Carolyn, Signal Mtn, TN; Dolby, Len; Dollar, Julie, Chattanooga, TN; Donegan, Shahn, Hermitage, TN; Donegan, Teresa, Lebanon, TN; Donnell, Evans, Nashville, TN; Doochin, Dianne, Nashville, TN; Dornfeld, Robert And Sandra, Athens, TN; Dorsett, Gina, Flintstone, GA; Douglas, Eric, Vanderbilt University; Douglas, Susan, Huntingdon, TN; Dout, Ed, Chickamauga, GA; Dowell, Carleen, Antioch, TN; Doze, Laura; Draper, Jonathan, Nashville, TN; Draper, Karen, Murfreesboro, TN; Dresser, Donald, TN; Drew, Craig, Chattanooga, TN; Driscoll, S; Drummond, Sarah, Knoxville, TN; Drumright, Chris, Murfreesboro, TN; Dube, Margaret, Memphis, TN; Duck, Kyle; Duck, Travis, Vanderbilt University, Austin, TX; Duley, Caroline, Nashville, TN; Duncan, Donna, Lebanon, TN; Duncan, Laura; Dunn, Larry, Cleveland, TN; Dunson, Debra, Spring Hill, TN; Durham, Cody; Dyson, Alfred; Easter, Darrel, Bartlett, TN; Echevarria, Mari T., Knoxville, TN; Echols, Princeton, Memphis, TN; Eckert, Steven; Edmondson, Shawn, Natchez Trace EPA, Houston, MS; Edwards, Madeline, Memphis, TN; Ehlers, Allen, Nashville, TN; Eichbauer, George, Flowery Branch, GA; Elder, Binji, Nashville, TN; Elder, Blake; Elfin, Julie, Knoxville, TN; Elkins, Judy, Puryear, TN; Elliott, Joan, Johnson City, TN; Ellis, Julie, Bowling Green, KY; Ellis, K, SEEED, Knoxville, TN; Ellis, Lynn, Knoxville, TN; Embrey, Dustin, Gurley, AL; Emerson, Jill, Paradoxe Corporation, Jackson, TN; England, Brandon; Erbach, Donald; Essary, Sharon, Knoxville, TN; Estes, Chip; Evans, Sheila, Church Hill, TN; Everhart, Aubrey, Bristol, TN; Ewing, Alexandra, Vanderbilt University, Nashville, TN

F

Faatz, Sharon, Chickamauga, GA; Fabey, Ellen, Sierra Club; Fabish, Zachary, Sierra Club, Washington, DC; Fachilla, Frankie, Nashville, TN; Fairstein, Joel, Oak Ridge, TN; Farmer-Brown, Loretta, Memphis, TN; Faucher, Ian, Vanderbilt University, Nashville, TN; Faulkner, Susan, Nashville, TN; Faust, Ted, Knoxville, TN; Fay, Andrew; Fay, Tony; Fell, Samuel, Estill Springs, TN; Fidler, Gabriel, Maryville, TN; Fingerman, Robert, Monteagle, TN; Finney, Ellen, Franklin, TN; Fisher, Judy, Nashville, TN; Fishman, John, Huntsville, AL; Fister, Alan, Brentwood, TN; Fitzgerald, Amy; Fitzgerald, Marian, Maryville, TN; Fleming, Nick, Nashville, TN; Flessner, Dave; Fletcher, Ashley, Spring Hill, TN; Fletcher, Frank, Memphis Light, Gas, and Water, Memphis, TN; Fletcher, Herman, Sevierville, TN; Foley, Caroline, Vanderbilt University; Forbes, C S, Harriman, TN; Forster, Forrest; Forsythe, Edd; Foster, Rebecca, Nashville, TN; Foster, Rick, Chattanooga, TN; Foster, Tiffany; Fotre, Julian, TN Interfaith Power & Light; Fowler, Ben, Nashville, TN; Fowler, Jacqueline, Knoxville, TN; Fowles, Aaron, Memphis, TN; Franetovich, Pete; Franklin, Kathy, Kingsport, TN; Franklin, Margaret, Collierville, TN; Franklin, Yvette, Knoxville, TN; Frey, Adrienne, Franklin, TN; Friedman, Anjay, SPEAR at Vanderbilt University, Nashville, TN; Frye, Odell, Associated Valley Industries, Ooltewah, TN; Fulcher, Valerie, Virginia Department of Environmental Quality, Richmond, VA; Fuller, Leslie, TN; Furino Sr.

G

Gary, Tazewell, TN; Gafni, Leah, Memphis, TN; Gaines, Jim, News Sentinel; Gallacher, C, Louisville, TN; Gallo, Susan, Chattanooga, TN; Gandulla, Luis, Oak Ridge, TN; Garber, Elizabeth, Nashville, TN; Garcia, Amanda, Southern Environmental Law Center, Nashville, TN; Garcia, Joe, Knoxville, TN; Gardner, Kent, Elizabethton, TN; Gardner, Lindsay, Tennessee Wildlife Federation, Nashville, TN; Garland, Pete, Signal Mountain, TN; Garrett, Gary; Garrett, Robert, Huntsville, AL; Garrone, Angela, Southern Alliance for Clean Energy, Knoxville, TN; Gassel, Elizabeth, Knoxville, TN; Gaudin, Timothy, Hixson, TN; Gayk, David, Knoxville, TN; Gaynor, Bruce, Summertown, TN; Gelbard, E., University, MS; Gemmill, John, Memphis, TN; Gentry, Elizabeth, Knoxville, TN; Gentry, Haley, Vanderbilt University, Nashville, TN; George, Andrea, Vanderbilt University, Nashville, TN; George, David, Memphis, TN; George, Michael & Frances, Athens, TN; Gheorghiu, Iulia; Giagnorio, Corinne, Chattanooga, TN; Gibby, Tiffany; Gibson, Gordon, Knoxville, TN; Gienapp, Jim, The Climate Reality Project, Memphis, TN; Gilbert, Tim; Gill, Evelyn, Knox County Commission, Knoxville, TN; Gillies, Phoenix, Murfreesboro, TN; Glanville, Bruce, USGBC, Lenoir City, TN; Glaser, Pamela, Soddy-Daisy, TN; Glassow, Scott, Vanderbilt University, Nashville, TN; Gochfeld, Deb, Oxford, MS; Goehl, William, Rogersville, TN; Goehler, Lee, Athens, AL; Goetze, Anne, Franklin, TN; Goldberg, Henry, Nashville, TN; Golden, Jim, Knoxville, TN; Golin, Caroline; Good, Tim, Maxam Tire North America Inc, Danvers, MA; Goodson, Chuck, Industrial Lubricant Company, Tyler, TX; Gorenflo, Louise, TN Interfaith Power & Light; Goss, Sandra, Tennessee Citizens for Wilderness Planning, Knoxville, TN; Gourley, Sherry, Smyrna, TN; Graeter, Phillip; Graham, Brian, Arrington, TN; Graham, Michael; Grant, Andrew, Vanderbilt University; Graves, Emily, Memphis, TN; Green, Cooper, Huntsville, AL; Green, Elizabeth, Pigeon Forge, TN; Green, Kathy, Murfreesboro, TN; Green, Patricia, Nashville, TN; Greening, Lorna; Gregg, Judy, Kodak, TN; Gregory, Jessica, Knoxville, TN; Grice, Christine, Huntsville, AL; Griffin, Elroy, Dover, TN; Griffith, Gloria, Mountain City, TN; Grimes, Joyce, North Memphis Recycling Program, Memphis, TN; Gronendyke, Cassandra, Cookeville, TN; Grose, Tom, Nashville, TN; Groton, James, Oak Ridge, TN; Gubbins, Philip, SPEAR, Nashville, TN; Guenst, John, Franklin, TN; Gugino, Jack, Knoxville, TN; Guile, Koryn, Vanderbilt University & Sunrise Movement, Nashville, TN; Guinn, Gerald, Huntsville, AL; Gulick, Leslie, Sparta, TN; Gumbel, Alan, GMAC Workforce, Memphis, TN; Gungor, Deniz, Vanderbilt University; Gunter, Kalita, Erin, TN; Guyot, Shannon, Bartlett, TN

H

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Smith, Colleen, Capital Power Corporation, Boston, MA; Smith, Ian, Memphis, TN; Smith, Karen, Cedar Hill, TN; Smith, Michael, Hendersonville, TN; Smith, R. Steve, A & W Ready Mix, LLC, Kodak, TN; Smith, Sandra, St. Henry Catholic Church, Nashville, TN; Smith, Shana, Martin, TN; Smith, Stephen, Southern Alliance for Clean Energy, Knoxville, TN; Smukowski, Mark; Sneed, Michele, Huntsville, AL; Snell, Barbara, Gallatin, TN; Snook, Lynda, Kingsport, TN; Snyder, John; Sokoloff, Ranan, Carthage, TN; Solomon, Susan B., Nashville, TN; Solsbee, Brian; Sondheim, Steven; Soora, Karthik; Sorensen, Kirk, Flibe Energy, Madison, AL; Sorensen, Quincy, Flibe Energy; Soskel, Norman, Germantown, TN; Soule, Ellena, Vanderbilt SPEAR; Sparkman, Alan, Tennessee Concrete Association, Nashville, TN; Sparks, Cath, Nashville, TN; Spears, Hubert, Oxford, MS; Spence, Kelley, Nashville, TN; Spitalny, Cheri, Chattanooga, TN; Spooner, Megan, Chickamauga, GA; Springston, Tara; Sprouse, Nicholas, Bowling Green, KY; Spry, Richard, Murfreesboro, TN; Stalnaker, Lisa, Knoxville, TN; Stanfill, Mark, Knoxville, TN; Stanley, Joyce, Department of Interior, Atlanta, GA; Stann, Dana, Nashville, TN; Stanton, Ryan; Stayton, Ken, Nashville, TN; Stebbins, Tracy, Starkville, MS; Steele, Martha, Huntsville, AL; Steffek, Thomas, Memphis, TN; Stein, Jeffrey, American Petroleum Institute, Washington, DC; Steiner, Pamela, Ringgold, GA; Steitz, Jim, Gatlinburg, TN; Stephens, Logan; Stephenson, Kenneth, Knoxville, TN; Stephenson, Nathaniel, Knoxville, TN; Stephenson, Tommi, Nashville, TN; Stevens, Catherine, Memphis, TN; Stilson, Brenda, Huntsville, AL; Stokes, Allen, Clinton, TN; Stollberg, Horst, Blountville, TN; Stone, Darby, Harvest, AL; Strader, Bud, Rockwood, TN; Strain, Vivian, Memphis, TN; Straley, David; Stranch, Grace, Nashville, TN; Stratton, Adam; Stribling, Lynda, Philadelphia, MS; Strickland, Clarence; Stump, Kenya; Sturdivant-Wilson, Jara; Sturis, Robin, Crawford, TN; Sugg, Ben, Maryville, TN; Sumner, Michael, Germantown, TN; Surface, Elizabeth, Nashville, TN; Surface, Tom, Experian Health, Nashville, TN; Swartz, Eric, Memphis, TN; Swartz, Kristi; Swearengen, Catherine, Memphis, TN; Sweatt, Sweatt, Cookeville, TN; Swinford, Bonnie, Knoxville, TN; Sykes, Kevin, Madison, TN; Sykes, Sidney

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Whittaker, Nancy, Cordova, TN; Whittle, Alexander, Madison, TN; Wicker, Jessica, Birchwood, TN; Widmer, Leah, Starkville, MS; Wieland, Paul, Huntsville, AL; Wierschem, Rebecca, Knoxville, TN; Wiggins, Kenny, Alcoa, TN; Wiggins, Nick, Wolf River Conservancy, Memphis, TN; Wiggins, Randy; Wilding, Joyce, Kingston Springs, TN; Wilkerson, Bruce, City of Bowling Green and Bowling Green Municipal Utilities; Wilkin, William, Nashville, TN; Wilkins, Matthew, Nashville, TN; Willett, Cynthia, Smyrna, TN; Williams, David, Sierra Club, Elkmont, AL; Williams, Elena, Memphis, TN; Williams, Ernie, Mainstream Green Solutions, Wildersville, TN; Williams, Jeff; Williams, Joan, Elkmont, AL; Williams, John, Nashville, TN; Williams, Linda, Sierra Club, Memphis, TN; Williams, Marilyn, Cullman, AL; Williams, Melissa; Williams, Patricia H, Nashville, TN; Williams, Susan, Halls, TN; Williams, Tamala, Athens, AL; Williams, Thomas, Bowling Green, KY; Williams, Wayne, Knoxville, TN; Williams, William, Clinton, TN; Williams-Mooradian, Kathleen, Nashville, TN; Williamson, Becky; Williamson, John, Nashville, TN; Willis, Christine, US Fish and Wildlife Service, Atlanta, GA; Willis, Phillip; Wilson, Arlene, Nashville, TN; Wilson, Brian, Hixson, TN; Wilson, Harold, Telford, TN; Wilson, John; Wilson, Karen; Wilson, Katy; Wilson, Linda, Eads, TN; Wilson, Martha and Glen, Brentwood, TN; Wilson, Wade, Oneida, TN; Winfield, Charlie, Arlington, TN; Winther, Evelyn, Knoxville, TN; Wohlgemuth, James, Nashville, TN; Wohlgemuth, Jim, Nashville, TN; Wolfe, Vickie, Butler, TN; Woods, Rocquelle, Huntsville, AL; Woody, Ronald; Woolf, Genesis, Mountain City, TN; Wrye, Susan, Nashville, TN; Wuichet, Charlotte, Amory, MS; Wyatt, John, Tellico Plains, TN; Wynn, Steven, Huntsville, AL

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2019 Integrated Resource Plan

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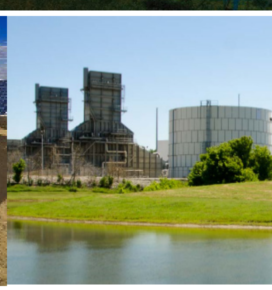

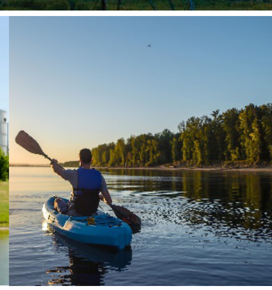

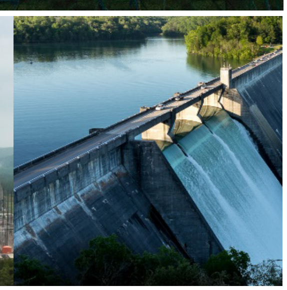

TENNESSEE VALLEY AUTHORITY

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Appendix A - Federally Listed Species near TVA Generation Facilities

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Federally Listed Species near TVA Generation Facilities

Facilities Considered for Retirement

NAME	SCIENTIFIC_NAME	COMMON_NAME	ST_RANK	ST_STATUS	FED_STATUS
Allen					
	Sterna antillarum athalassos	Interior Least Tern	S2S3B	END	LE
	Haliaeetus leucocephalus	Bald Eagle	S3	NMGT	DM
	Charadrius melodus	Piping Plover	<null>	<null>	LT
Apalachia					
	Pityopsis ruthii	Ruth's Golden Aster	S1	END	LE
	Epioblasma florentina walkeri	Tan Riffleshell	S1	END	LE
	Pleuronaia dolabelloides	Slabside Pearlymussel	S2	<null>	LE
	Cryptobranchus alleganiensis	Hellbender	S3	NMGT	PS
	Villosa trabalis	Cumberland Bean	S1	END	LE
Blue Ridge Dam					
	Cryptobranchus alleganiensis	Hellbender	S2	RARE	PS
Browns Ferry					
	Campeloma decampi	Slender Campeloma	S1	SP	LE
Bull Run					
	Dromus dromas	Dromedary Pearlymussel	S1	END	LE
	Lampsilis abrupta	Pink Mucket	S2	END	LE
	Fusconaia cuneolus	Fine-rayed Pigtoe	S1	END	LE
	Cumberlandia monodonta	Spectaclecase	S2S3	<null>	LE
	Cryptobranchus alleganiensis	Hellbender	S3	NMGT	PS
	Hemistena lata	Cracking Pearlymussel	S1	END	LE
	Dromus dromas	Dromedary Pearlymussel	S1	END	LE
	Fusconaia cor	Shiny Pigtoe Pearlymussel	S1	END	LE
	Plethobasus cooperianus	Orange-foot Pimpleback	S1	END	LE
	Plethobasus cicatricosus	White Wartyback	S1	END	LE
Caledonia					
	Lampsilis perovalis	Orange-nacre Mucket	S1	END	LT
	Pleurobema perovatum	Ovate Clubshell	S1	END	LE
Chatuge Dam					
	Cryptobranchus alleganiensis	Hellbender	S2	RARE	PS
	Sarracenia oreophila	Green Pitcher Plant	S1	END	LE
	Haliaeetus leucocephalus	Bald Eagle	S3B,S3N	THR	DM
Cherokee Dam					
	Cumberlandia monodonta	Spectaclecase	S2S3	<null>	LE
	Plethobasus cicatricosus	White Wartyback	S1	END	LE
	Fusconaia cor	Shiny Pigtoe Pearlymussel	S1	END	LE
	Dromus dromas	Dromedary Pearlymussel	S1	END	LE
	Haliaeetus leucocephalus	Bald Eagle	S3	NMGT	DM
Chickamauga Dam					
	Percina tanasi	Snail Darter	S2S3	THR	LT

NAME	SCIENTIFIC_NAME	COMMON_NAME	ST_RANK	ST_STATUS	FED_STATUS
	Lampsilis abrupta	Pink Mucket	S2	END	LE
	Pleurobema plenum	Rough Pigtoe	S1	END	LE
	Plethobasus cooperianus	Orange-foot Pimpleback	S1	END	LE
	Scutellaria montana	Large-flowered Skullcap	S4	THR	LT
Colbert					
	Palaemonias alabamae	Alabama Blind Cave Shrimp	S1	SP	LE
	Myotis grisescens	Gray Bat	S2	SP	LE
	Plethobasus cyphyus	Sheepnose	S1	SP	LE
	Cumberlandia monodonta	Spectaclecase	S1	SP	LE
	Lampsilis abrupta	Pink Mucket	S1	SP	LE
	Pleuronaia dolabelloides	Slabside Pearlymussel	S1	SP	LE
	Pleurobema plenum	Rough Pigtoe	S1	SP	LE
	Cyprogenia stegaria	Fanshell	S1	SP	LE
	Fusconaia cor	Shiny Pigtoe Pearlymussel	S1	SP	LE
	Quadrula cylindrica cylindrica	Smooth Rabbitsfoot	S1	SP	LT
	Dromus dromas	Dromedary Pearlymussel	S1	SP	LE
	Athearnia anthonyi	Anthony's River Snail	S1	SP	LE
	Lemiox rimosus	Birdwing Pearlymussel	S1	SP	LE
	Plethobasus cicatricosus	White Wartyback	S1	SP	LE
	Speoplatyrhinus poulsoni	Alabama Cavefish	S1	SP	LE
	Toxolasma cylindrellus	Pale Lilliput	S1	SP	LE
	Epioblasma brevidens	Cumberlandian Combshell	S1	SP	LE
	Elassoma alabamae	Spring Pygmy Sunfish	S1	SP	LT
	Haliaeetus leucocephalus	Bald Eagle	S4B	SP	DM
Cumberland					
	Haliaeetus leucocephalus	Bald Eagle	S3	NMGT	DM
	Quadrula cylindrica	Rabbitsfoot	<null>	<null>	LT
Douglas Dam					
	Haliaeetus leucocephalus	Bald Eagle	S3	NMGT	DM
	Percina tanasi	Snail Darter	S2S3	THR	LT
Fontana Dam					
	Myotis septentrionalis	Northern Long-eared Bat	S2	SR	LT
	Myotis sodalis	Indiana Bat	S1S2	END	LE
Fort Loudoun Dam					
	Cryptobranchus alleganiensis	Hellbender	S3	NMGT	PS
	Plethobasus cooperianus	Orange-foot Pimpleback	S1	END	LE
	Haliaeetus leucocephalus	Bald Eagle	S3	NMGT	DM
	Percina tanasi	Snail Darter	S2S3	THR	LT
	Lampsilis abrupta	Pink Mucket	S2	END	LE
Ft Patrick Henry Dam					
	Pegias fabula	Little-wing Pearlymussel	S1	END	LE
	Quadrula intermedia	Cumberland Monkeyface	S1	END	LE

NAME	SCIENTIFIC_NAME	COMMON_NAME	ST_RANK	ST_STATUS	FED_STATUS
Gallatin					
	Lesquerella perforata	Spring Creek Bladderpod	S1	END	LE
	Myotis grisescens	Gray Bat	S2	END	LE
	Haliaeetus leucocephalus	Bald Eagle	S3	NMGT	DM
Great Falls Dam					
	Myotis grisescens	Gray Bat	S2	END	LE
	Cryptobranchus alleganiensis	Hellbender	S3	NMGT	PS
	Haliaeetus leucocephalus	Bald Eagle	S3	NMGT	DM
Guntersville Dam					
	Haliaeetus leucocephalus	Bald Eagle	S4B	SP	DM
	Cryptobranchus alleganiensis	Hellbender	S2	SP	PS
	Myotis grisescens	Gray Bat	S2	SP	LE
	Lampsilis abrupta	Pink Mucket	S1	SP	LE
	Cyprogenia stegaria	Fanshell	S1	SP	LE
	Myotis sodalis	Indiana Bat	S2	SP	LE
Hiwassee Dam					
	Myotis septentrionalis	Northern Long-eared Bat	S2	SR	LT
	Myotis sodalis	Indiana Bat	S1S2	END	LE
	Cryptobranchus alleganiensis	Hellbender	S3	SC	PS
John Sevier					
	Haliaeetus leucocephalus	Bald Eagle	S3	NMGT	DM
	Lemiox rimosus	Birdwing Pearlymussel	S1	END	LE
	Fusconaia cuneolus	Fine-rayed Pigtoe	S1	END	LE
	Quadrula intermedia	Cumberland Monkeyface	S1	END	LE
	Villosa perpurpurea	Purple Bean	S1	END	LE
Johnsonville					
	Haliaeetus leucocephalus	Bald Eagle	S3	NMGT	DM
	Lampsilis abrupta	Pink Mucket	S2	END	LE
	Plethobasus cooperianus	Orange-foot Pimpleback	S1	END	LE
	Pleurobema plenum	Rough Pigtoe	S1	END	LE
	Obovaria retusa	Ring Pink	S1	END	LE
	Charadrius melodus	Piping Plover	<null>	<null>	LT
Kentucky Dam					
	Haliaeetus leucocephalus	Bald Eagle	S2	THR	DM
	Lampsilis abrupta	Pink Mucket	S1	END	LE
	Quadrula cylindrica cylindrica	Smooth Rabbitsfoot	S2	THR	LT
	Plethobasus cooperianus	Orange-foot Pimpleback	S1	END	LE
	Plethobasus cyphyus	Sheepnose	S1	END	LE
	Quadrula cylindrica	Rabbitsfoot	<null>	<null>	LT
Kingston					
	Haliaeetus leucocephalus	Bald Eagle	S3	NMGT	DM
	Plethobasus cooperianus	Orange-foot Pimpleback	S1	END	LE
	Erysimum capitatum	Western Wallflower	S1S2	END	PS

NAME	SCIENTIFIC_NAME	COMMON_NAME	ST_RANK	ST_STATUS	FED_STATUS
	Villosa perpurpurea	Purple Bean	S1	END	LE
	Lampsilis virescens	Alabama Lampmussel	S1	END	LE
	Fusconaia cuneolus	Fine-rayed Pigtoe	S1	END	LE
	Erimonax monachus	Spotfin Chub	S2	THR	LT
Magnolia					
	Myotis sodalis	Indiana Bat	S1B	END	LE
Marshall					
	Quadrula cylindrica cylindrica	Smooth Rabbitsfoot	S2	THR	LT
	Plethobasus cyphyus	Sheepnose	S1	END	LE
	Obovaria retusa	Ring Pink	S1	END	LE
	Lampsilis abrupta	Pink Mucket	S1	END	LE
	Plethobasus cooperianus	Orange-foot Pimpleback	S1	END	LE
	Cyprogenia stegaria	Fanshell	S1	END	LE
	Quadrula cylindrica	Rabbitsfoot	<null>	<null>	LT
Melton Hill Dam					
	Myotis grisescens	Gray Bat	S2	END	LE
	Obovaria retusa	Ring Pink	S1	END	LE
	Cyprogenia stegaria	Fanshell	S1	END	LE
	Plethobasus cyphyus	Sheepnose	S2S3	<null>	LE
	Lampsilis abrupta	Pink Mucket	S2	END	LE
	Plethobasus cooperianus	Orange-foot Pimpleback	S1	END	LE
	Cryptobranchus alleganiensis	Hellbender	S3	NMGT	PS
Nickajack Dam					
	Platanthera integrilabia	White Fringeless Orchid	S2	SLNS	LT
	Myotis grisescens	Gray Bat	S2	SP	LE
	Haliaeetus leucocephalus	Bald Eagle	S3	NMGT	DM
	Myotis sodalis	Indiana Bat	S1	END	LE
	Lampsilis abrupta	Pink Mucket	S2	END	LE
	Cyprogenia stegaria	Fanshell	S1	END	LE
	Dromus dromas	Dromedary Pearlymussel	S1	END	LE
	Percina tanasi	Snail Darter	S2S3	THR	LT
	Athearnia anthonyi	Anthony's River Snail	S1	END	LE
Norris Dam					
	Cumberlandia monodonta	Spectaclecase	S2S3	<null>	LE
	Haliaeetus leucocephalus	Bald Eagle	S3	NMGT	DM
	Lampsilis abrupta	Pink Mucket	S2	END	LE
	Dromus dromas	Dromedary Pearlymussel	S1	END	LE
	Fusconaia cuneolus	Fine-rayed Pigtoe	S1	END	LE
	Erimystax cahni	Slender Chub	S1	THR	LT
	Lampsilis virescens	Alabama Lampmussel	S1	END	LE
	Fusconaia cor	Shiny Pigtoe Pearlymussel	S1	END	LE
	Athearnia anthonyi	Anthony's River Snail	S1	END	LE
	Pleurobema plenum	Rough Pigtoe	S1	END	LE

NAME	SCIENTIFIC_NAME	COMMON_NAME	ST_RANK	ST_STATUS	FED_STATUS
	Epioblasma florentina walkeri	Tan Riffleshell	S1	END	LE
	Cyprogenia stegaria	Fanshell	S1	END	LE
	Cryptobranchus alleganiensis	Hellbender	S3	NMGT	PS
	Myotis sodalis	Indiana Bat	S1	END	LE
	Myotis grisescens	Gray Bat	S2	END	LE
	Myotis septentrionalis	Northern Long-eared Bat	S1S2	<null>	LT
Nottely Dam					
	Cryptobranchus alleganiensis	Hellbender	S3	SC	PS
	Myotis septentrionalis	Northern Long-eared Bat	S2	SR	LT
Ocoee No.1 Dam					
	Haliaeetus leucocephalus	Bald Eagle	S3	NMGT	DM
	Percina tanasi	Snail Darter	S2S3	THR	LT
Ocoee No.2					
	Pityopsis ruthii	Ruth's Golden Aster	S1	END	LE
	Haliaeetus leucocephalus	Bald Eagle	S3	NMGT	DM
	Myotis septentrionalis	Northern Long-eared Bat	S1S2	<null>	LT
Ocoee No.3					
	Cryptobranchus alleganiensis	Hellbender	S3	NMGT	PS
	Myotis septentrionalis	Northern Long-eared Bat	S1S2	<null>	LT
	Pityopsis ruthii	Ruth's Golden Aster	S1	END	LE
Paradise					
	Lampsilis abrupta	Pink Mucket	S1	END	LE
	Pleurobema plenum	Rough Pigtoe	S1	END	LE
Pickwick Landing Dam					
	Cyprogenia stegaria	Fanshell	S1	END	LE
	Plethobasus cooperianus	Orange-foot Pimpleback	S1	END	LE
	Plethobasus cicatricosus	White Wartyback	S1	END	LE
	Obovaria retusa	Ring Pink	S1	END	LE
	Lampsilis abrupta	Pink Mucket	S2	END	LE
	Cumberlandia monodonta	Spectaclecase	S2S3	<null>	LE
	Cryptobranchus alleganiensis	Hellbender	S3	NMGT	PS
	Haliaeetus leucocephalus	Bald Eagle	S3	NMGT	DM
	Pleuronaia dolabelloides	Slabside Pearlymussel	S2	<null>	LE
	Plethobasus cyphyus	Sheepnose	S2S3	<null>	LE
Raccoon Mtn Pumped Storage					
	Scutellaria montana	Large-flowered Skullcap	S4	THR	LT
	Haliaeetus leucocephalus	Bald Eagle	S3	NMGT	DM
	Quadrula intermedia	Cumberland Monkeyface	S1	END	LE
	Dromus dromas	Dromedary Pearlymussel	S1	END	LE
	Plethobasus cooperianus	Orange-foot Pimpleback	S1	END	LE
	Myotis grisescens	Gray Bat	S2	END	LE

NAME	SCIENTIFIC_NAME	COMMON_NAME	ST_RANK	ST_STATUS	FED_STATUS
	Platanthera integrilabia	White Fringeless Orchid	S2S3	END	LT
S Holston Dam					
	Erimonax monachus	Spotfin Chub	S2	THR	LT
	Etheostoma marmorpinnum	Marbled Darter	S1	END	LE
	Epioblasma florentina walkeri	Tan Riffleshell	S1	END	LE
Sequoyah					
	Scutellaria montana	Large-flowered Skullcap	S4	THR	LT
	Haliaeetus leucocephalus	Bald Eagle	S3	NMGT	DM
	Dromus dromas	Dromedary Pearlymussel	S1	END	LE
Shawnee					
	Plethobasus cyphyus	Sheepnose	S1	END	LE
	Quadrula cylindrica	Rabbitsfoot	<null>	<null>	LT
	Myotis sodalis	Indiana Bat	S1S2	END	LE
	Plethobasus cooperianus	Orange-foot Pimpleback	S1	END	LE
	Lampsilis abrupta	Pink Mucket	S1	END	LE
Tims Ford Dam					
	Pleuronaia dolabelloides	Slabside Pearlymussel	S2	<null>	LE
	Fusconaia cor	Shiny Pigtoe Pearlymussel	S1	END	LE
	Quadrula intermedia	Cumberland Monkeyface	S1	END	LE
	Ptychobranchus subtentum	Fluted Kidneyshell	S2	<null>	LE
	Epioblasma florentina walkeri	Tan Riffleshell	S1	END	LE
	Fusconaia cuneolus	Fine-rayed Pigtoe	S1	END	LE
	Myotis grisescens	Gray Bat	S2	END	LE
Watauga Dam					
	Haliaeetus leucocephalus	Bald Eagle	S3	NMGT	DM
	Cryptobranchus alleganiensis	Hellbender	S3	NMGT	PS
Watts Bar					
	Haliaeetus leucocephalus	Bald Eagle	S3	NMGT	DM
	Lampsilis abrupta	Pink Mucket	S2	END	LE
	Cyprogenia stegaria	Fanshell	S1	END	LE
	Dromus dromas	Dromedary Pearlymussel	S1	END	LE
	Myotis septentrionalis	Northern Long-eared Bat	S1S2	<null>	LT
	Myotis grisescens	Gray Bat	S2	END	LE
	Pleurobema plenum	Rough Pigtoe	S1	END	LE
	Percina tanasi	Snail Darter	S2S3	THR	LT
	Cryptobranchus alleganiensis	Hellbender	S3	NMGT	PS
	Plethobasus cyphyus	Sheepnose	S2S3	<null>	LE
Watts Bar Dam					
	Myotis septentrionalis	Northern Long-eared Bat	S1S2	<null>	LT
	Myotis grisescens	Gray Bat	S2	END	LE
	Cyprogenia stegaria	Fanshell	S1	END	LE
	Lampsilis abrupta	Pink Mucket	S2	END	LE
	Percina tanasi	Snail Darter	S2S3	THR	LT
	Haliaeetus leucocephalus	Bald Eagle	S3	NMGT	DM

NAME	SCIENTIFIC_NAME	COMMON_NAME	ST_RANK	ST_STATUS	FED_STATUS
	Cryptobranchus alleganiensis	Hellbender	S3	NMGT	PS
	Plethobasus cyphyus	Sheepnose	S2S3	<null>	LE
	Pleurobema plenum	Rough Pigtoe	S1	END	LE
	Dromus dromas	Dromedary Pearlymussel	S1	END	LE
Wheeler Dam					
	Haliaeetus leucocephalus	Bald Eagle	S4B	SP	DM
	Myotis grisescens	Gray Bat	S2	SP	LE
Widows Creek					
	Haliaeetus leucocephalus	Bald Eagle	S4B	SP	DM
	Athearnia anthonyi	Anthony's River Snail	S1	SP	LE
Wilbur Dam					
	Haliaeetus leucocephalus	Bald Eagle	S3	NMGT	DM
	Cryptobranchus alleganiensis	Hellbender	S3	NMGT	PS
Wilson Dam					
	Myotis grisescens	Gray Bat	S2	SP	LE
	Cumberlandia monodonta	Spectaclecase	S1	SP	LE
	Lampsilis abrupta	Pink Mucket	S1	SP	LE
	Plethobasus cyphyus	Sheepnose	S1	SP	LE
	Dromus dromas	Dromedary Pearlymussel	S1	SP	LE
	Fusconaia cuneolus	Fine-rayed Pigtoe	S1	SP	LE
	Fusconaia cor	Shiny Pigtoe Pearlymussel	S1	SP	LE
	Quadrula cylindrica cylindrica	Smooth Rabbitsfoot	S1	SP	LT
	Pleurobema plenum	Rough Pigtoe	S1	SP	LE
	Haliaeetus leucocephalus	Bald Eagle	S4B	SP	DM
	Lampsilis virescens	Alabama Lampmussel	S1	SP	LE
	Athearnia anthonyi	Anthony's River Snail	S1	SP	LE
	Lemiox rimosus	Birdwing Pearlymussel	S1	SP	LE
	Epioblasma triquetra	Snuffbox	S1	PSM	LE
	Epioblasma brevidens	Cumberlandian Combshell	S1	SP	LE
	Cryptobranchus alleganiensis	Hellbender	S2	SP	PS
	Etheostoma wapiti	Boulder Darter	S1	SP	LE

B

Appendix B - Solid and Hazardous Waste

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Month	Bull Run Fossil Plant				Cumberland Fossil Plant				Gallatin Fossil Plant		
	Actual Production Fly Ash (Tons)	Actual Production Bottom Ash (Tons)	Actual Production Gypsum (Tons)	Average Actual Ash Production (Tons)	Actual Production Fly Ash (Tons)	Actual Production Bottom Ash (Tons)	Actual Production Gypsum (Tons)	Average Actual Ash Production (Tons)	Actual Production Dry Scrubber Product (Tons)	Actual Production Bottom Ash (Tons)	Average Actual Ash Production (Tons)
FY12 Total	25,585	6,091	18,496	31,676	407,490	69,701	746,092	477,190	0	0	0
FY13 Total	50,785	12,254	43,157	63,039	495,644	105,861	806,071	601,505	0	0	0
FY14 Total	77,281	18,524	61,822	95,805	487,727	97,137	942,286	584,864	0	0	0
FY15 Total	81,778	30,969	74,133	112,747	519,275	87,284	987,684	606,559	52,934	42,581	95,515
FY16 Total	65,830	15,398	46,713	81,228	396,664	54,257	850,637	450,921	198,818	27,650	226,468
FY17 Total	88,010	28,068	66,148	116,077	253,813	38,591	738,475	292,404	236,487	31,658	268,145
FY18 Total	51,674	17,284	38,428	68,958	341,575	70,634	695,696	412,210	248,308	38,424	286,732
Average	**62,992**	**18,370**	**49,842**	**81,361**	**414,598**	**74,781**	**823,849**	**489,379**	**184,137**	**35,078**	**219,215**

Month	Bull Run Fossil Plant				Cumberland Fossil Plant				Gallatin Fossil Plant		
	Forecasted Production Fly Ash (Tons)	Forecasted Production Bottom Ash (Tons)	Forecasted Production Gypsum (Tons)	Average Forecasted Ash Production (Tons)	Forecasted Production Fly Ash (Tons)	Forecasted Production Bottom Ash (Tons)	Forecasted Production Gypsum (Tons)	Average Forecasted Ash Production (Tons)	Forecasted Production Dry Scrubber Product (Tons)	Forecasted Production Bottom Ash (Tons)	Average Forecasted Ash Production (Tons)
FY19 Total	68,651	7,370	46,567	76,021	222,010	54,823	604,680	276,833	99,885	12,984	112,869
FY20 Total	77,153	8,283	52,335	85,436	193,319	47,738	526,536	241,057	52,063	6,066	58,128
FY21 Total	78,342	8,410	53,142	86,752	169,666	41,897	462,114	211,564	33,862	3,699	37,561
FY22 Total	77,127	8,280	52,317	85,407	188,973	46,665	514,698	235,637	35,295	3,919	39,214
FY23 Total	77,366	8,305	52,479	85,671	304,829	75,274	830,252	380,103	38,354	4,174	42,528
FY24 Total	0	0	0	0	266,126	65,717	724,836	331,842	33,423	3,416	36,839
FY25 Total	0	0	0	0	251,372	62,073	684,651	313,445	35,278	3,916	39,194
FY26 Total	0	0	0	0	229,253	56,611	624,409	285,865	39,455	4,343	43,798
FY27 Total	0	0	0	0	321,522	79,396	875,716	400,918	43,102	4,904	48,006
FY28 Total	0	0	0	0	364,270	89,952	992,148	454,222	68,991	8,667	77,657
FY29 Total	0	0	0	0	399,653	98,689	1,088,518	498,342	76,688	9,635	86,323
FY30 Total	0	0	0	0	391,681	96,721	1,066,806	488,402	104,245	13,654	117,899
Average	**75,728**	**8,130**	**51,368**	**83,857**	**275,223**	**67,963**	**749,614**	**343,186**	**55,053**	**6,615**	**61,668**

Month	Kingston Fossil Plant: Actual Production Fly Ash (Tons)	Kingston Fossil Plant: Actual Production Bottom Ash (Tons)	Kingston Fossil Plant: Actual Production Gypsum (Tons)	Kingston Fossil Plant: Average Actual Ash Production (Tons)	Paradise Fossil Plant: Actual Production U3 Scrubber Sludge (Tons)	Paradise Fossil Plant: Actual Production Sluiced Fly Ash (to Peabody, Estimated Tons)	Paradise Fossil Plant: Actual Production Slag Rejects (Tons)	Paradise Fossil Plant: Average Actual Ash Production (Tons)	Shawnee Fossil Plant: Actual Production Dry Scrubber Product Units 1 & 4 and Fly Ash Units 2-3 & 5-9 (Tons)	Shawnee Fossil Plant: SHF Actual Production Bottom Ash (Tons)	Shawnee Fossil Plant: Average Actual Ash Production (Tons)
FY12 Total	91,619	22,509	127,887	114,128	427,145	Not Measured	278,365	705,510	239,177	27,414	266,591
FY13 Total	148,882	36,163	194,598	185,045	323,660	Not Measured	285,079	608,739	226,599	26,289	252,888
FY14 Total	157,610	38,221	1,225,475	195,831	323,660	Not Measured	285,079	608,739	226,255	25,463	251,718
FY15 Total	136,613	27,198	209,368	163,811	320,820	Not Measured	252,205	573,025	181,564	34,137	215,701
FY16 Total	132,506	15,786	209,018	148,292	319,992	Not Measured	225,621	545,613	206,490	9,080	215,571
FY17 Total	175,814	5,955	224,514	181,769	318,968	Not Measured	80,437	399,405	206,312	34,837	241,149
FY18 Total	116,658	16,463	171,590	133,121	332,636	Not Measured	61,752	394,388	218,660	33,238	251,898
Average	**137,100**	**23,185**	**337,493**	**160,285**	**338,126**	**Not Measured**	**209,791**	**547,917**	**215,008**	**27,208**	**242,216**

Month	Kingston Fossil Plant: Forecasted Production Fly Ash (Tons)	Kingston Fossil Plant: Forecasted Production Bottom Ash (Tons)	Kingston Fossil Plant: Forecasted Production Gypsum (Tons)	Kingston Fossil Plant: Average Forecasted Ash Production (Tons)	Paradise Fossil Plant: Forecasted Production U3 Scrubber Sludge (Tons)	Paradise Fossil Plant: Forecasted Production Sluiced Fly Ash (to Peabody, Estimated Tons)	Paradise Fossil Plant: Forecasted Production Slag Rejects (Tons)	Paradise Fossil Plant: Average Forecasted Ash Production (Tons)	Shawnee Fossil Plant: Forecasted Production Dry Scrubber Product Units 1 & 4 and Fly Ash Units 2-3 & 5-9 (Tons)	Shawnee Fossil Plant: Forecasted Production Bottom Ash (Tons)	Shawnee Fossil Plant: Average Forecasted Ash Production (Tons)
FY19 Total	49,445	12,098	75,295	61,544	125,034	18,972	55,311	199,317	216,344	44,405	260,748
FY20 Total	50,789	12,427	77,341	63,216	0	0	0	0	228,101	46,150	274,250
FY21 Total	50,407	12,334	76,759	62,741	0	0	0	0	181,160	36,549	217,709
FY22 Total	52,816	12,923	80,427	65,739	0	0	0	0	114,958	22,859	137,817
FY23 Total	50,882	12,450	77,482	63,332	0	0	0	0	108,091	22,416	130,507
FY24 Total	16,183	3,960	24,644	20,143	0	0	0	0	115,134	23,612	138,746
FY25 Total	9,755	2,387	14,855	12,142	0	0	0	0	131,087	26,482	157,568
FY26 Total	11,831	2,895	18,015	14,725	0	0	0	0	160,882	31,156	192,038
FY27 Total	12,977	3,175	19,761	16,152	0	0	0	0	198,672	38,983	237,655
FY28 Total	23,061	5,643	35,118	28,704	0	0	0	0	235,108	47,386	282,493
FY29 Total	25,696	6,287	39,129	31,983	0	0	0	0	122,946	19,887	142,833
FY30 Total	35,445	8,673	53,975	44,118	0	0	0	0	97,582	12,416	109,998
Average	**32,441**	**7,938**	**49,400**	**40,378**	**125,034**	**18,972**	**55,311**	**199,317**	**159,172**	**31,025**	**190,197**

C

Appendix C - Socioeconomics

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Appendix C: Counties and Independent Cities in the TVA Service Area as Considered for Socioeconomics and Environmental Justice

State	County and City Name
Alabama	
	Blount County
	Cherokee County
	Colbert County
	Cullman County
	DeKalb County
	Etowah County
	Franklin County
	Jackson County
	Lauderdale County
	Lawrence County
	Limestone County
	Madison County
	Marshall County
	Morgan County
	Winston County
Georgia	
	Catoosa County
	Chattooga County
	Dade County
	Fannin County
	Gilmer County
	Gordon County
	Murray County
	Towns County
	Union County
	Walker County
	Whitfield County
Kentucky	
	Allen County
	Butler County
	Calloway County
	Carlisle County
	Christian County
	Cumberland County
	Edmonson County
	Fulton County
	Graves County
	Grayson County
	Hickman County
	Livingston County
	Logan County
	Lyon County

State	County and City Name
Tennessee	
	Anderson County
	Bedford County
	Benton County
	Bledsoe County
	Blount County
	Bradley County
	Campbell County
	Cannon County
	Carroll County
	Carter County
	Cheatham County
	Chester County
	Claiborne County
	Clay County
	Cocke County
	Coffee County
	Crockett County
	Cumberland County
	Davidson County
	Decatur County
	DeKalb County
	Dickson County
	Dyer County
	Fayette County
	Fentress County
	Franklin County
	Gibson County
	Giles County
	Grainger County
	Greene County
	Grundy County
	Hamblen County
	Hamilton County
	Hancock County
	Hardeman County
	Hardin County
	Hawkins County
	Haywood County
	Henderson County
	Henry County
	Hickman County
	Houston County
	Humphreys County
	Jackson County

Kentucky (continued)

Marshall County
Monroe County
Simpson County
Todd County
Trigg County
Warren County

Mississippi

Alcorn County
Attala County
Benton County
Calhoun County
Chickasaw County
Choctaw County
Clay County
De Soto County
Itawamba County
Kemper County
Lafayette County
Leake County
Lee County
Lowndes County
Marshall County
Monroe County
Neshoba County
Noxubee County
Oktibbeha County
Panola County
Pontotoc County
Prentiss County
Scott County
Tallahatchie County
Tate County
Tippah County
Tishomingo County
Union County
Webster County
Winston County
Yalobusha County

North Carolina

Avery County
Cherokee County
Clay County
Watauga County

Tennessee (continued)

Jefferson County
Johnson County
Knox County
Lake County
Lauderdale County
Lawrence County
Lewis County
Lincoln County
Loudon County
McMinn County
McNairy County
Macon County
Madison County
Marion County
Marshall County
Maury County
Meigs County
Monroe County
Montgomery County
Moore County
Morgan County
Obion County
Overton County
Perry County
Pickett County
Polk County
Putnam County
Rhea County
Roane County
Robertson County
Rutherford County
Scott County
Sequatchie County
Sevier County
Shelby County
Smith County
Stewart County
Sullivan County
Sumner County
Tipton County
Trousdale County
Unicoi County
Union County
Van Buren County
Warren County
Washington County

Virginia

- Lee County
- Scott County
- Washington County
- Bristol city
- Wise County
- Norton city

Tennessee (continued)

- Wayne County
- Weakley County
- White County
- Williamson County
- Wilson County

D

Appendix D – Environmental Justice

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Appendix D1: Environmental Justice

Limited-Income Counties in the TVA Service Area

Geography	Population 16 Years and Older	Per Capita Income	Poverty %
DeKalb County, Alabama	55,542	18,685	19.8
Franklin County, Alabama	24,674	18,193	22.3
Marshall County, Alabama	73,792	21,767	20.5
Winston County, Alabama	19,621	19,299	20.6
Chattooga County, Georgia	20,336	17,381	22.4
Gordon County, Georgia	43,680	20,009	20.6
Butler County, Kentucky	10,272	20,591	24.6
Calloway County, Kentucky	32,008	21,109	24.9
Christian County, Kentucky	54,921	19,962	20.3
Cumberland County, Kentucky	5,530	18,362	22.3
Edmonson County, Kentucky	10,018	20,194	21.9
Fulton County, Kentucky	5,141	18,067	26.7
Grayson County, Kentucky	20,539	20,783	24.2
Monroe County, Kentucky	8,450	19,969	26.1
Alcorn County, Mississippi	29,363	20,006	19.9
Attala County, Mississippi	14,741	20,283	24.4
Benton County, Mississippi	6,682	20,261	22.7
Calhoun County, Mississippi	11,562	17,203	26.3
Chickasaw County, Mississippi	13,523	18,514	27.2
Choctaw County, Mississippi	6,630	18,434	24.5
Clay County, Mississippi	15,763	19,097	26.0
Itawamba County, Mississippi	18,970	19,707	20.2
Kemper County, Mississippi	8,275	14,715	29.9
Lafayette County, Mississippi	43,721	23,833	25.3
Leake County, Mississippi	17,446	18,178	27.1
Lowndes County, Mississippi	46,976	22,143	21.9
Monroe County, Mississippi	28,445	19,905	20.6
Neshoba County, Mississippi	22,077	19,030	22.3
Noxubee County, Mississippi	8,662	16,108	32.4
Oktibbeha County, Mississippi	41,416	20,128	32.6
Panola County, Mississippi	26,449	20,098	22.4
Prentiss County, Mississippi	20,101	18,313	22.7
Scott County, Mississippi	21,581	17,203	26.5
Tallahatchie County, Mississippi	12,083	12,747	28.2
Tippah County, Mississippi	17,100	19,453	23.5
Webster County, Mississippi	7,800	20,722	21.5
Winston County, Mississippi	14,635	21,943	28.3
Yalobusha County, Mississippi	9,893	18,802	21.6
Watauga County, North Carolina	46,619	22,892	31.3
Benton County, Tennessee	13,464	20,504	22.6
Bledsoe County, Tennessee	11,648	18,962	23.7
Campbell County, Tennessee	32,827	19,948	22.4

Appendix D1: Environmental Justice

Limited-Income Counties in the TVA Service Area

Geography	Population 16 Years and Older	Per Capita Income	Poverty %
Carroll County, Tennessee	23,008	19,851	19.8
Carter County, Tennessee	47,053	20,118	23.9
Claiborne County, Tennessee	26,306	19,215	22.3
Clay County, Tennessee	6,446	16,470	24.8
Cocke County, Tennessee	28,719	18,959	26.1
Decatur County, Tennessee	9,507	21,977	20.9
DeKalb County, Tennessee	15,410	25,273	22.2
Fentress County, Tennessee	14,430	17,487	23.3
Grainger County, Tennessee	18,659	19,850	20.2
Grundy County, Tennessee	10,881	16,132	28.0
Hamblen County, Tennessee	50,268	20,642	21.2
Hancock County, Tennessee	5,387	16,351	27.3
Hardeman County, Tennessee	21,396	16,178	23.7
Hardin County, Tennessee	21,132	22,928	22.2
Haywood County, Tennessee	14,404	19,956	21.0
Henderson County, Tennessee	22,140	20,479	20.7
Hickman County, Tennessee	19,678	18,410	22.9
Houston County, Tennessee	6,603	18,256	20.9
Jackson County, Tennessee	9,612	17,675	25.0
Johnson County, Tennessee	15,147	17,834	26.9
Lake County, Tennessee	6,647	13,330	29.2
Lauderdale County, Tennessee	21,611	16,217	24.7
Lewis County, Tennessee	9,571	19,877	20.4
McNairy County, Tennessee	20,929	18,285	23.1
Morgan County, Tennessee	17,938	18,281	23.6
Obion County, Tennessee	24,863	21,650	21.1
Overton County, Tennessee	17,725	19,827	20.0
Perry County, Tennessee	6,346	18,611	28.6
Putnam County, Tennessee	60,866	22,555	24.0
Rhea County, Tennessee	25,802	20,888	22.9
Scott County, Tennessee	17,331	21,011	27.7
Shelby County, Tennessee	725,360	26,963	21.4
Unicoi County, Tennessee	15,004	20,958	21.0
Union County, Tennessee	15,309	19,030	23.5
Warren County, Tennessee	31,668	20,749	20.7
Lee County, Virginia	20,789	17,820	26.1
Scott County, Virginia	18,589	20,935	20.1
Wise County, Virginia	32,904	20,896	21.2
Bristol city, Virginia	13,988	21,865	20.6
Norton city, Virginia	3,200	19,522	26.5
	Averages	**19,473**	**23.7**

Appendix D2: Environmental Justice

Low-Income Census Tracts in the TVA Service Area

Geography	Population 16 Years and Older	Per Capita Income	Poverty %
Census Tract 503, Blount County, Alabama	4,068	18,268	22.6
Census Tract 504, Blount County, Alabama	3,620	19,952	24.1
Census Tract 505, Blount County, Alabama	5,665	18,487	20.9
Census Tract 9557.02, Cherokee County, Alabama	2,987	19,431	25.9
Census Tract 201, Colbert County, Alabama	3,050	18,235	28.2
Census Tract 202, Colbert County, Alabama	1,854	22,417	22.3
Census Tract 203, Colbert County, Alabama	1,289	18,429	46.0
Census Tract 209.01, Colbert County, Alabama	3,553	20,435	21.0
Census Tract 9641, Cullman County, Alabama	4,746	18,032	20.2
Census Tract 9644, Cullman County, Alabama	3,639	22,746	22.6
Census Tract 9648, Cullman County, Alabama	3,667	18,701	28.6
Census Tract 9654.02, Cullman County, Alabama	3,365	19,328	22.9
Census Tract 9657, Cullman County, Alabama	2,175	17,014	23.2
Census Tract 9602, DeKalb County, Alabama	2,652	19,160	20.9
Census Tract 9603, DeKalb County, Alabama	5,896	19,437	20.5
Census Tract 9606, DeKalb County, Alabama	4,857	18,352	20.2
Census Tract 9607, DeKalb County, Alabama	6,529	14,696	23.3
Census Tract 9608, DeKalb County, Alabama	3,959	15,123	27.0
Census Tract 9609, DeKalb County, Alabama	2,973	17,358	28.5
Census Tract 9613, DeKalb County, Alabama	3,827	16,310	28.1
Census Tract 9614, DeKalb County, Alabama	3,262	23,077	25.5
Census Tract 2, Etowah County, Alabama	3,074	14,435	27.2
Census Tract 3, Etowah County, Alabama	1,884	12,755	37.4
Census Tract 6, Etowah County, Alabama	1,498	14,001	32.3
Census Tract 7, Etowah County, Alabama	726	17,139	51.5
Census Tract 8, Etowah County, Alabama	921	13,110	35.6
Census Tract 9, Etowah County, Alabama	2,417	12,737	36.1
Census Tract 10, Etowah County, Alabama	1,176	13,313	32.8
Census Tract 12, Etowah County, Alabama	2,716	23,580	22.2
Census Tract 13, Etowah County, Alabama	1,998	16,223	32.2
Census Tract 16, Etowah County, Alabama	3,150	18,316	22.6
Census Tract 17, Etowah County, Alabama	1,458	17,231	26.1
Census Tract 101, Etowah County, Alabama	1,665	17,103	26.3
Census Tract 104.01, Etowah County, Alabama	2,626	22,803	27.2
Census Tract 104.02, Etowah County, Alabama	4,180	25,310	19.8
Census Tract 108, Etowah County, Alabama	2,297	19,757	20.4
Census Tract 111, Etowah County, Alabama	3,963	15,949	30.4
Census Tract 112, Etowah County, Alabama	1,839	12,795	39.6
Census Tract 9730, Franklin County, Alabama	4,176	14,212	32.9
Census Tract 9732, Franklin County, Alabama	3,140	18,129	30.4
Census Tract 9734, Franklin County, Alabama	2,038	16,806	25.3

Appendix D2: Environmental Justice

Low-Income Census Tracts in the TVA Service Area

Geography	Population 16 Years and Older	Per Capita Income	Poverty %
Census Tract 9737, Franklin County, Alabama	4,757	16,284	22.0
Census Tract 9501, Jackson County, Alabama	4,577	22,127	20.4
Census Tract 9502, Jackson County, Alabama	2,705	19,742	23.4
Census Tract 9503, Jackson County, Alabama	4,533	18,136	23.0
Census Tract 9504, Jackson County, Alabama	1,669	19,083	20.6
Census Tract 9508, Jackson County, Alabama	3,779	20,039	23.5
Census Tract 9511, Jackson County, Alabama	5,542	17,763	25.8
Census Tract 101, Lauderdale County, Alabama	1,783	10,600	32.8
Census Tract 102, Lauderdale County, Alabama	1,636	22,533	35.5
Census Tract 103, Lauderdale County, Alabama	798	12,295	41.8
Census Tract 104, Lauderdale County, Alabama	2,939	22,389	25.2
Census Tract 106, Lauderdale County, Alabama	2,652	17,362	43.3
Census Tract 107, Lauderdale County, Alabama	1,393	9,515	50.9
Census Tract 108, Lauderdale County, Alabama	3,139	16,861	27.8
Census Tract 109, Lauderdale County, Alabama	6,038	24,568	23.5
Census Tract 110, Lauderdale County, Alabama	3,767	18,766	29.6
Census Tract 113, Lauderdale County, Alabama	1,592	19,030	19.9
Census Tract 9794, Lawrence County, Alabama	3,756	19,939	25.3
Census Tract 9796, Lawrence County, Alabama	4,181	22,512	20.0
Census Tract 9799, Lawrence County, Alabama	1,548	20,863	22.3
Census Tract 201.01, Limestone County, Alabama	3,587	20,669	22.5
Census Tract 202.01, Limestone County, Alabama	3,907	17,136	25.2
Census Tract 204.02, Limestone County, Alabama	4,268	22,965	19.8
Census Tract 206, Limestone County, Alabama	3,830	14,575	28.7
Census Tract 207, Limestone County, Alabama	1,815	21,439	30.0
Census Tract 2.01, Madison County, Alabama	716	13,433	46.0
Census Tract 2.02, Madison County, Alabama	3,534	8,175	42.3
Census Tract 3.01, Madison County, Alabama	3,026	17,907	24.1
Census Tract 3.02, Madison County, Alabama	2,666	17,793	22.4
Census Tract 5.02, Madison County, Alabama	1,827	18,904	22.9
Census Tract 6.01, Madison County, Alabama	1,248	23,068	22.4
Census Tract 6.02, Madison County, Alabama	1,806	17,190	27.3
Census Tract 7.01, Madison County, Alabama	2,236	19,933	38.1
Census Tract 7.02, Madison County, Alabama	2,100	21,483	31.4
Census Tract 12, Madison County, Alabama	2,090	8,487	65.2
Census Tract 13.01, Madison County, Alabama	2,733	15,918	37.5
Census Tract 13.02, Madison County, Alabama	1,606	25,343	22.4
Census Tract 14.02, Madison County, Alabama	4,173	27,608	23.9
Census Tract 15, Madison County, Alabama	3,932	15,651	27.8
Census Tract 21, Madison County, Alabama	2,190	10,720	57.3
Census Tract 22, Madison County, Alabama	1,772	19,414	37.4

Appendix D2: Environmental Justice
Low-Income Census Tracts in the TVA Service Area

Geography	Population 16 Years and Older	Per Capita Income	Poverty %
Census Tract 23, Madison County, Alabama	3,792	15,608	45.0
Census Tract 24, Madison County, Alabama	3,233	17,566	29.4
Census Tract 25.01, Madison County, Alabama	2,566	11,135	54.9
Census Tract 25.02, Madison County, Alabama	2,431	14,222	38.7
Census Tract 30, Madison County, Alabama	2,251	16,233	38.9
Census Tract 31, Madison County, Alabama	4,001	27,756	29.2
Census Tract 106.22, Madison County, Alabama	8,958	30,435	28.0
Census Tract 301, Marshall County, Alabama	2,290	20,357	31.1
Census Tract 304.01, Marshall County, Alabama	3,751	23,322	21.5
Census Tract 306, Marshall County, Alabama	5,282	28,951	24.1
Census Tract 307.01, Marshall County, Alabama	2,551	26,753	23.4
Census Tract 308.01, Marshall County, Alabama	3,948	18,504	29.1
Census Tract 308.02, Marshall County, Alabama	5,409	16,726	43.6
Census Tract 309.03, Marshall County, Alabama	4,754	15,252	22.1
Census Tract 309.04, Marshall County, Alabama	4,122	16,581	21.1
Census Tract 310, Marshall County, Alabama	4,308	16,544	24.2
Census Tract 311, Marshall County, Alabama	4,125	14,606	28.8
Census Tract 1, Morgan County, Alabama	3,333	17,342	35.5
Census Tract 6, Morgan County, Alabama	2,275	11,405	56.7
Census Tract 7, Morgan County, Alabama	2,896	13,022	39.3
Census Tract 8, Morgan County, Alabama	2,394	19,935	29.3
Census Tract 9, Morgan County, Alabama	3,843	14,529	36.4
Census Tract 51.09, Morgan County, Alabama	3,228	17,213	27.1
Census Tract 9655.01, Winston County, Alabama	1,960	19,071	20.0
Census Tract 9655.02, Winston County, Alabama	2,145	21,053	25.5
Census Tract 9657, Winston County, Alabama	3,628	18,582	21.3
Census Tract 9658, Winston County, Alabama	3,523	17,853	25.3
Census Tract 307, Catoosa County, Georgia	6,490	21,106	20.1
Census Tract 102, Chattooga County, Georgia	4,696	15,911	23.6
Census Tract 103, Chattooga County, Georgia	2,389	21,665	21.9
Census Tract 104, Chattooga County, Georgia	4,293	17,124	25.1
Census Tract 105, Chattooga County, Georgia	5,279	13,479	21.1
Census Tract 106, Chattooga County, Georgia	1,976	22,422	20.9
Census Tract 403, Dade County, Georgia	3,673	21,294	23.2
Census Tract 504, Fannin County, Georgia	5,612	21,340	23.8
Census Tract 803, Gilmer County, Georgia	4,854	17,416	23.4
Census Tract 804, Gilmer County, Georgia	7,436	21,138	23.9
Census Tract 9703, Gordon County, Georgia	6,905	17,058	31.5
Census Tract 9704, Gordon County, Georgia	4,079	20,247	24.0
Census Tract 9705, Gordon County, Georgia	3,408	19,991	21.6
Census Tract 9706, Gordon County, Georgia	4,588	18,625	27.8

Appendix D2: Environmental Justice

Low-Income Census Tracts in the TVA Service Area

Geography	Population 16 Years and Older	Per Capita Income	Poverty %
Census Tract 101, Murray County, Georgia	2,563	17,060	25.1
Census Tract 102.01, Murray County, Georgia	1,455	18,525	25.1
Census Tract 106, Murray County, Georgia	3,006	16,351	27.1
Census Tract 107, Murray County, Georgia	4,596	16,088	23.3
Census Tract 1.01, Union County, Georgia	2,106	19,788	22.7
Census Tract 201, Walker County, Georgia	5,480	19,994	27.3
Census Tract 202, Walker County, Georgia	2,844	15,471	30.9
Census Tract 203.01, Walker County, Georgia	3,905	17,344	27.1
Census Tract 205.02, Walker County, Georgia	5,288	21,235	21.8
Census Tract 207, Walker County, Georgia	5,698	16,317	23.5
Census Tract 3.01, Whitfield County, Georgia	3,152	17,355	23.5
Census Tract 4, Whitfield County, Georgia	5,820	15,447	31.1
Census Tract 5.02, Whitfield County, Georgia	5,425	13,376	30.8
Census Tract 10, Whitfield County, Georgia	3,102	12,682	24.7
Census Tract 11, Whitfield County, Georgia	3,880	18,074	21.0
Census Tract 12, Whitfield County, Georgia	5,682	14,421	27.2
Census Tract 13, Whitfield County, Georgia	3,074	11,102	37.8
Census Tract 9204, Allen County, Kentucky	3,507	17,121	23.4
Census Tract 9302, Butler County, Kentucky	1,305	15,801	27.3
Census Tract 9303, Butler County, Kentucky	3,693	20,734	35.1
Census Tract 103.01, Calloway County, Kentucky	3,218	4,842	39.0
Census Tract 103.02, Calloway County, Kentucky	5,603	15,633	52.4
Census Tract 104, Calloway County, Kentucky	1,924	15,070	37.6
Census Tract 105, Calloway County, Kentucky	2,627	20,167	26.3
Census Tract 9602, Carlisle County, Kentucky	1,500	22,902	20.8
Census Tract 2001, Christian County, Kentucky	3,242	16,115	30.3
Census Tract 2002, Christian County, Kentucky	3,174	15,702	37.8
Census Tract 2003, Christian County, Kentucky	2,699	12,617	51.7
Census Tract 2004, Christian County, Kentucky	1,933	13,515	37.5
Census Tract 2008, Christian County, Kentucky	2,000	13,167	35.8
Census Tract 2011, Christian County, Kentucky	3,004	18,309	21.7
Census Tract 2013.02, Christian County, Kentucky	5,348	17,016	27.0
Census Tract 9501, Cumberland County, Kentucky	3,146	16,185	23.1
Census Tract 9502, Cumberland County, Kentucky	2,384	21,282	21.1
Census Tract 9202, Edmonson County, Kentucky	3,737	18,714	22.7
Census Tract 9204, Edmonson County, Kentucky	4,828	21,660	20.9
Census Tract 9801, Edmonson County, Kentucky	277	2,588	90.3
Census Tract 9601, Fulton County, Kentucky	2,701	19,168	22.2
Census Tract 9602, Fulton County, Kentucky	2,440	16,692	33.2
Census Tract 201, Graves County, Kentucky	3,097	17,894	26.5
Census Tract 202, Graves County, Kentucky	3,671	17,446	25.6

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Low-Income Census Tracts in the TVA Service Area

Geography	Population 16 Years and Older	Per Capita Income	Poverty %
Census Tract 203, Graves County, Kentucky	4,892	16,489	28.4
Census Tract 9501, Grayson County, Kentucky	2,246	19,208	25.3
Census Tract 9503, Grayson County, Kentucky	3,479	18,813	29.8
Census Tract 9504, Grayson County, Kentucky	5,303	24,523	24.4
Census Tract 9506, Grayson County, Kentucky	3,078	16,760	28.0
Census Tract 9507, Grayson County, Kentucky	1,930	21,403	21.6
Census Tract 401, Livingston County, Kentucky	2,456	20,255	20.1
Census Tract 9603, Logan County, Kentucky	4,725	18,752	21.1
Census Tract 9605, Logan County, Kentucky	3,252	20,239	25.7
Census Tract 9302, Monroe County, Kentucky	1,784	18,563	33.9
Census Tract 9303, Monroe County, Kentucky	1,868	17,817	30.4
Census Tract 9304, Monroe County, Kentucky	3,465	19,692	23.3
Census Tract 9703, Simpson County, Kentucky	3,739	21,526	23.8
Census Tract 9704, Simpson County, Kentucky	4,907	17,257	21.3
Census Tract 9503, Todd County, Kentucky	2,012	18,053	26.6
Census Tract 9504, Todd County, Kentucky	1,082	24,306	21.3
Census Tract 9702, Trigg County, Kentucky	5,282	22,432	20.5
Census Tract 9801, Trigg County, Kentucky	21	2,381	100.0
Census Tract 101, Warren County, Kentucky	2,208	16,893	47.2
Census Tract 102, Warren County, Kentucky	2,917	10,749	51.0
Census Tract 103, Warren County, Kentucky	3,335	12,425	48.1
Census Tract 104, Warren County, Kentucky	5,698	4,773	55.3
Census Tract 105, Warren County, Kentucky	2,353	17,052	37.2
Census Tract 106, Warren County, Kentucky	3,025	29,362	20.0
Census Tract 107.01, Warren County, Kentucky	3,921	25,440	31.1
Census Tract 108.03, Warren County, Kentucky	4,825	21,375	22.4
Census Tract 110.01, Warren County, Kentucky	3,334	14,313	42.6
Census Tract 110.02, Warren County, Kentucky	4,809	17,027	25.2
Census Tract 112, Warren County, Kentucky	3,712	13,161	36.1
Census Tract 113, Warren County, Kentucky	3,287	19,870	20.6
Census Tract 9503, Alcorn County, Mississippi	3,118	20,250	25.6
Census Tract 9505, Alcorn County, Mississippi	5,004	16,211	34.6
Census Tract 9506, Alcorn County, Mississippi	3,340	16,698	22.8
Census Tract 603, Attala County, Mississippi	2,461	15,676	28.9
Census Tract 605, Attala County, Mississippi	2,638	24,820	27.0
Census Tract 606, Attala County, Mississippi	2,823	15,001	41.9
Census Tract 9501, Benton County, Mississippi	4,622	21,707	20.0
Census Tract 9502, Benton County, Mississippi	2,060	17,013	28.5
Census Tract 9502, Calhoun County, Mississippi	1,270	18,252	42.0
Census Tract 9504, Calhoun County, Mississippi	2,605	16,610	28.7
Census Tract 9505, Calhoun County, Mississippi	2,173	13,939	38.8

Appendix D2: Environmental Justice
Low-Income Census Tracts in the TVA Service Area

Geography	Population 16 Years and Older	Per Capita Income	Poverty %
Census Tract 9501, Chickasaw County, Mississippi	3,371	15,797	29.9
Census Tract 9502, Chickasaw County, Mississippi	2,730	19,368	31.4
Census Tract 9503, Chickasaw County, Mississippi	3,344	16,667	28.0
Census Tract 9504, Chickasaw County, Mississippi	4,078	21,700	21.6
Census Tract 9502, Choctaw County, Mississippi	3,025	18,866	28.4
Census Tract 9503, Choctaw County, Mississippi	1,290	17,143	31.8
Census Tract 9501, Clay County, Mississippi	4,408	19,899	22.1
Census Tract 9502, Clay County, Mississippi	1,832	15,853	21.0
Census Tract 9503, Clay County, Mississippi	2,795	15,760	33.8
Census Tract 9504, Clay County, Mississippi	3,654	16,320	34.4
Census Tract 703.25, DeSoto County, Mississippi	2,366	16,900	25.1
Census Tract 704.11, DeSoto County, Mississippi	1,295	18,355	20.3
Census Tract 704.12, DeSoto County, Mississippi	3,189	18,011	19.7
Census Tract 704.22, DeSoto County, Mississippi	1,848	16,761	20.9
Census Tract 706.10, DeSoto County, Mississippi	2,364	17,844	26.7
Census Tract 9501, Itawamba County, Mississippi	3,753	20,258	23.6
Census Tract 9503, Itawamba County, Mississippi	2,820	15,997	23.1
Census Tract 9504, Itawamba County, Mississippi	4,274	20,890	24.8
Census Tract 301, Kemper County, Mississippi	4,449	12,866	44.8
Census Tract 9502.01, Lafayette County, Mississippi	3,022	27,604	29.8
Census Tract 9502.02, Lafayette County, Mississippi	4,597	22,042	35.5
Census Tract 9503.01, Lafayette County, Mississippi	6,351	4,971	71.5
Census Tract 9503.02, Lafayette County, Mississippi	3,333	28,733	26.2
Census Tract 9504.01, Lafayette County, Mississippi	6,054	33,710	22.3
Census Tract 9504.02, Lafayette County, Mississippi	2,907	21,032	25.2
Census Tract 9505.03, Lafayette County, Mississippi	6,115	21,457	35.6
Census Tract 401, Leake County, Mississippi	2,308	19,789	24.6
Census Tract 404, Leake County, Mississippi	5,278	20,609	22.1
Census Tract 406, Leake County, Mississippi	4,309	15,946	37.9
Census Tract 407, Leake County, Mississippi	3,055	14,620	32.0
Census Tract 9501.02, Lee County, Mississippi	3,332	20,023	22.3
Census Tract 9504.01, Lee County, Mississippi	3,176	25,766	26.4
Census Tract 9505, Lee County, Mississippi	4,813	25,759	31.4
Census Tract 9506.02, Lee County, Mississippi	3,299	16,743	26.5
Census Tract 9507, Lee County, Mississippi	2,529	17,468	25.0
Census Tract 9508, Lee County, Mississippi	2,395	19,162	26.4
Census Tract 9509.01, Lee County, Mississippi	2,240	23,797	22.3
Census Tract 9509.02, Lee County, Mississippi	3,584	22,048	27.1
Census Tract 9510.02, Lee County, Mississippi	2,894	14,303	31.2
Census Tract 1.02, Lowndes County, Mississippi	2,042	20,844	23.2
Census Tract 4.01, Lowndes County, Mississippi	5,827	22,167	21.3

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Low-Income Census Tracts in the TVA Service Area

Geography	Population 16 Years and Older	Per Capita Income	Poverty %
Census Tract 4.03, Lowndes County, Mississippi	3,208	18,126	26.6
Census Tract 6, Lowndes County, Mississippi	2,708	12,445	37.6
Census Tract 7, Lowndes County, Mississippi	4,325	14,862	40.0
Census Tract 8, Lowndes County, Mississippi	2,177	14,668	39.2
Census Tract 9, Lowndes County, Mississippi	4,306	21,450	30.0
Census Tract 11, Lowndes County, Mississippi	1,351	16,143	37.7
Census Tract 9504.01, Marshall County, Mississippi	2,000	14,651	45.6
Census Tract 9504, Monroe County, Mississippi	2,459	15,344	34.5
Census Tract 9505.02, Monroe County, Mississippi	3,316	16,531	21.3
Census Tract 9506, Monroe County, Mississippi	2,311	18,435	23.8
Census Tract 9507, Monroe County, Mississippi	1,982	20,838	23.8
Census Tract 9508, Monroe County, Mississippi	2,392	14,532	35.9
Census Tract 104, Neshoba County, Mississippi	2,863	19,183	26.6
Census Tract 105, Neshoba County, Mississippi	2,389	20,912	33.9
Census Tract 106, Neshoba County, Mississippi	3,776	17,640	27.0
Census Tract 107, Neshoba County, Mississippi	3,694	18,455	22.3
Census Tract 9401, Neshoba County, Mississippi	2,881	12,675	27.7
Census Tract 9501, Noxubee County, Mississippi	4,347	16,128	30.4
Census Tract 9502, Noxubee County, Mississippi	2,600	17,716	27.1
Census Tract 9503, Noxubee County, Mississippi	1,715	13,723	45.7
Census Tract 9501, Oktibbeha County, Mississippi	7,339	16,575	37.2
Census Tract 9502, Oktibbeha County, Mississippi	4,958	23,633	28.6
Census Tract 9503, Oktibbeha County, Mississippi	2,633	18,381	36.2
Census Tract 9504, Oktibbeha County, Mississippi	7,469	11,420	43.9
Census Tract 9505, Oktibbeha County, Mississippi	3,734	23,898	30.7
Census Tract 9506.01, Oktibbeha County, Mississippi	4,358	27,222	32.9
Census Tract 9506.02, Oktibbeha County, Mississippi	4,564	21,161	35.4
Census Tract 9507, Oktibbeha County, Mississippi	6,361	23,167	22.1
Census Tract 9501, Panola County, Mississippi	6,064	17,212	22.6
Census Tract 9502, Panola County, Mississippi	2,145	15,373	36.1
Census Tract 9503, Panola County, Mississippi	3,806	26,790	22.1
Census Tract 9504, Panola County, Mississippi	3,973	20,390	19.7
Census Tract 9506, Panola County, Mississippi	5,015	23,000	23.1
Census Tract 9501.02, Pontotoc County, Mississippi	4,349	19,319	19.8
Census Tract 9502, Pontotoc County, Mississippi	4,280	17,997	22.2
Census Tract 9503, Pontotoc County, Mississippi	4,184	21,419	19.7
Census Tract 9502, Prentiss County, Mississippi	4,530	25,083	23.3
Census Tract 9503, Prentiss County, Mississippi	5,083	12,477	34.3
Census Tract 9505, Prentiss County, Mississippi	1,586	15,924	42.1
Census Tract 201, Scott County, Mississippi	4,720	17,811	29.5
Census Tract 202, Scott County, Mississippi	3,525	15,412	31.0

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Low-Income Census Tracts in the TVA Service Area

Geography	Population 16 Years and Older	Per Capita Income	Poverty %
Census Tract 204, Scott County, Mississippi	2,529	13,654	24.4
Census Tract 205, Scott County, Mississippi	3,887	17,074	29.5
Census Tract 206, Scott County, Mississippi	3,009	18,264	28.4
Census Tract 9501, Tallahatchie County, Mississippi	3,019	19,996	22.1
Census Tract 9502, Tallahatchie County, Mississippi	1,675	13,705	31.5
Census Tract 9503, Tallahatchie County, Mississippi	5,655	6,320	28.8
Census Tract 9504, Tallahatchie County, Mississippi	1,734	16,880	34.5
Census Tract 9501, Tate County, Mississippi	4,107	17,995	19.9
Census Tract 9503.01, Tate County, Mississippi	3,123	16,817	24.6
Census Tract 9504, Tate County, Mississippi	4,945	18,290	21.8
Census Tract 9501, Tippah County, Mississippi	3,713	18,579	32.1
Census Tract 9502, Tippah County, Mississippi	4,960	19,352	23.5
Census Tract 9503, Tippah County, Mississippi	2,076	15,530	29.5
Census Tract 9502, Tishomingo County, Mississippi	1,923	17,097	24.3
Census Tract 9504, Tishomingo County, Mississippi	6,200	17,889	19.7
Census Tract 9501, Union County, Mississippi	3,781	17,580	21.7
Census Tract 9502, Union County, Mississippi	3,912	16,996	25.8
Census Tract 9504, Union County, Mississippi	3,383	21,421	22.5
Census Tract 9506, Union County, Mississippi	2,990	19,123	21.1
Census Tract 9503, Webster County, Mississippi	1,359	18,348	47.3
Census Tract 9501, Winston County, Mississippi	2,613	22,282	24.3
Census Tract 9503, Winston County, Mississippi	2,915	15,430	40.5
Census Tract 9504, Winston County, Mississippi	2,817	21,531	38.8
Census Tract 9505, Winston County, Mississippi	3,141	29,644	21.7
Census Tract 9501, Yalobusha County, Mississippi	2,536	19,161	20.8
Census Tract 9502, Yalobusha County, Mississippi	3,130	18,739	24.5
Census Tract 9503, Yalobusha County, Mississippi	4,227	18,630	20.0
Census Tract 9303.02, Avery County, North Carolina	2,435	16,943	23.0
Census Tract 9301, Cherokee County, North Carolina	3,671	16,228	22.1
Census Tract 9303, Cherokee County, North Carolina	1,915	17,051	21.9
Census Tract 9304, Cherokee County, North Carolina	4,964	20,089	21.7
Census Tract 9306.02, Cherokee County, North Carolina	3,598	18,988	20.9
Census Tract 9201, Watauga County, North Carolina	4,036	22,645	21.9
Census Tract 9203, Watauga County, North Carolina	2,129	22,829	20.2
Census Tract 9204, Watauga County, North Carolina	8,217	16,599	58.0
Census Tract 9205, Watauga County, North Carolina	6,928	7,308	58.8
Census Tract 9206.01, Watauga County, North Carolina	5,070	16,631	53.0
Census Tract 9206.02, Watauga County, North Carolina	1,972	28,696	37.8
Census Tract 201, Anderson County, Tennessee	2,548	22,898	29.5
Census Tract 204, Anderson County, Tennessee	3,703	20,270	31.8
Census Tract 205, Anderson County, Tennessee	2,744	17,317	30.0

Appendix D2: Environmental Justice

Low-Income Census Tracts in the TVA Service Area

Geography	Population 16 Years and Older	Per Capita Income	Poverty %
Census Tract 207, Anderson County, Tennessee	1,246	17,398	25.1
Census Tract 208, Anderson County, Tennessee	3,600	16,665	24.6
Census Tract 210, Anderson County, Tennessee	4,732	19,548	34.9
Census Tract 212.02, Anderson County, Tennessee	4,289	24,493	20.6
Census Tract 9504.02, Bedford County, Tennessee	5,187	19,940	24.9
Census Tract 9505, Bedford County, Tennessee	4,673	22,225	20.3
Census Tract 9507, Bedford County, Tennessee	2,066	23,355	20.9
Census Tract 9630, Benton County, Tennessee	2,751	20,658	25.2
Census Tract 9632, Benton County, Tennessee	1,842	16,576	25.4
Census Tract 9633, Benton County, Tennessee	3,111	20,193	25.9
Census Tract 9634, Benton County, Tennessee	3,244	18,921	22.9
Census Tract 9530, Bledsoe County, Tennessee	2,923	20,386	20.0
Census Tract 9531, Bledsoe County, Tennessee	4,765	22,095	23.3
Census Tract 9532, Bledsoe County, Tennessee	3,960	13,689	28.2
Census Tract 101, Blount County, Tennessee	2,295	13,797	38.7
Census Tract 102, Blount County, Tennessee	4,891	23,119	21.1
Census Tract 108, Blount County, Tennessee	2,236	15,554	30.4
Census Tract 103, Bradley County, Tennessee	2,332	15,497	36.6
Census Tract 104, Bradley County, Tennessee	2,410	9,986	51.8
Census Tract 105, Bradley County, Tennessee	3,382	15,592	28.2
Census Tract 107, Bradley County, Tennessee	3,803	10,537	42.8
Census Tract 108, Bradley County, Tennessee	2,321	17,876	40.6
Census Tract 114.02, Bradley County, Tennessee	2,235	21,756	21.3
Census Tract 115, Bradley County, Tennessee	6,887	23,514	19.9
Census Tract 9501, Campbell County, Tennessee	2,531	15,156	31.8
Census Tract 9502, Campbell County, Tennessee	1,974	19,291	33.3
Census Tract 9503, Campbell County, Tennessee	1,424	16,908	30.5
Census Tract 9506, Campbell County, Tennessee	3,489	16,341	22.9
Census Tract 9507, Campbell County, Tennessee	3,929	24,581	31.5
Census Tract 9509, Campbell County, Tennessee	2,347	20,352	24.4
Census Tract 9601, Cannon County, Tennessee	3,240	20,438	21.0
Census Tract 9620, Carroll County, Tennessee	3,304	17,286	23.1
Census Tract 9621, Carroll County, Tennessee	5,444	20,093	20.5
Census Tract 9622.01, Carroll County, Tennessee	2,612	18,520	23.5
Census Tract 703, Carter County, Tennessee	4,795	21,947	30.7
Census Tract 704, Carter County, Tennessee	1,686	16,294	29.3
Census Tract 706, Carter County, Tennessee	2,183	16,481	26.4
Census Tract 709, Carter County, Tennessee	3,080	26,236	25.7
Census Tract 710, Carter County, Tennessee	2,428	18,567	26.0
Census Tract 712, Carter County, Tennessee	3,152	19,346	32.3
Census Tract 713, Carter County, Tennessee	6,042	16,019	27.5

Appendix D2: Environmental Justice

Low-Income Census Tracts in the TVA Service Area

Geography	Population 16 Years and Older	Per Capita Income	Poverty %
Census Tract 714, Carter County, Tennessee	2,625	19,028	24.9
Census Tract 715, Carter County, Tennessee	1,719	15,862	25.3
Census Tract 716, Carter County, Tennessee	1,224	25,814	29.8
Census Tract 717, Carter County, Tennessee	3,172	19,825	24.5
Census Tract 703, Cheatham County, Tennessee	2,748	21,084	24.3
Census Tract 9702, Chester County, Tennessee	4,770	15,193	31.5
Census Tract 9703, Claiborne County, Tennessee	3,648	17,611	29.8
Census Tract 9704, Claiborne County, Tennessee	587	16,167	35.3
Census Tract 9705, Claiborne County, Tennessee	2,275	21,336	22.1
Census Tract 9707, Claiborne County, Tennessee	4,470	18,025	22.7
Census Tract 9708, Claiborne County, Tennessee	3,177	16,987	26.2
Census Tract 9709, Claiborne County, Tennessee	3,702	18,001	27.1
Census Tract 9550, Clay County, Tennessee	4,372	16,413	23.5
Census Tract 9551, Clay County, Tennessee	2,074	16,591	27.7
Census Tract 9201, Cocke County, Tennessee	3,178	17,900	20.3
Census Tract 9202, Cocke County, Tennessee	4,595	15,409	29.9
Census Tract 9203, Cocke County, Tennessee	3,459	20,003	20.4
Census Tract 9204, Cocke County, Tennessee	1,515	19,664	31.3
Census Tract 9205.01, Cocke County, Tennessee	4,613	17,007	35.8
Census Tract 9206, Cocke County, Tennessee	3,584	18,105	31.3
Census Tract 9207, Cocke County, Tennessee	3,520	19,268	22.0
Census Tract 9709, Coffee County, Tennessee	2,889	14,584	35.7
Census Tract 9611, Crockett County, Tennessee	3,155	19,643	22.4
Census Tract 9612, Crockett County, Tennessee	1,454	25,592	19.8
Census Tract 9704, Cumberland County, Tennessee	4,935	15,354	33.7
Census Tract 9705.02, Cumberland County, Tennessee	3,090	16,286	38.2
Census Tract 101.06, Davidson County, Tennessee	2,464	18,282	21.6
Census Tract 103.02, Davidson County, Tennessee	1,484	19,946	32.6
Census Tract 104.02, Davidson County, Tennessee	4,559	12,218	38.4
Census Tract 106.02, Davidson County, Tennessee	2,816	18,339	22.2
Census Tract 107.01, Davidson County, Tennessee	3,242	17,833	23.9
Census Tract 107.02, Davidson County, Tennessee	2,702	15,624	29.0
Census Tract 109.03, Davidson County, Tennessee	3,727	13,789	36.2
Census Tract 109.04, Davidson County, Tennessee	2,198	16,852	33.5
Census Tract 110.01, Davidson County, Tennessee	4,080	15,351	27.3
Census Tract 110.02, Davidson County, Tennessee	2,119	21,112	21.6
Census Tract 113, Davidson County, Tennessee	4,420	18,150	26.6
Census Tract 118, Davidson County, Tennessee	2,081	14,971	42.7
Census Tract 119, Davidson County, Tennessee	1,915	21,932	35.3
Census Tract 126, Davidson County, Tennessee	1,624	14,500	44.1
Census Tract 127.01, Davidson County, Tennessee	4,220	15,436	44.1

Appendix D2: Environmental Justice

Low-Income Census Tracts in the TVA Service Area

Geography	Population 16 Years and Older	Per Capita Income	Poverty %
Census Tract 127.02, Davidson County, Tennessee	2,177	23,196	19.7
Census Tract 128.01, Davidson County, Tennessee	4,193	16,737	36.6
Census Tract 128.02, Davidson County, Tennessee	3,504	15,380	28.0
Census Tract 133, Davidson County, Tennessee	3,376	20,273	23.1
Census Tract 135, Davidson County, Tennessee	1,699	33,102	22.2
Census Tract 136.01, Davidson County, Tennessee	2,478	13,660	46.3
Census Tract 136.02, Davidson County, Tennessee	1,854	6,940	42.9
Census Tract 137, Davidson County, Tennessee	4,462	20,519	38.1
Census Tract 138, Davidson County, Tennessee	1,531	14,676	40.0
Census Tract 139, Davidson County, Tennessee	1,369	11,983	48.9
Census Tract 142, Davidson County, Tennessee	2,046	11,788	50.7
Census Tract 143, Davidson County, Tennessee	1,507	15,376	24.7
Census Tract 144, Davidson County, Tennessee	970	17,584	34.3
Census Tract 148, Davidson County, Tennessee	1,565	6,570	75.0
Census Tract 156.15, Davidson County, Tennessee	3,501	15,505	31.9
Census Tract 156.23, Davidson County, Tennessee	4,040	23,396	21.9
Census Tract 158.02, Davidson County, Tennessee	4,889	18,840	25.1
Census Tract 158.03, Davidson County, Tennessee	1,822	14,309	24.5
Census Tract 159, Davidson County, Tennessee	2,560	12,315	56.7
Census Tract 160, Davidson County, Tennessee	736	18,618	35.5
Census Tract 161, Davidson County, Tennessee	1,734	24,548	25.9
Census Tract 162, Davidson County, Tennessee	2,506	18,689	43.9
Census Tract 163, Davidson County, Tennessee	1,939	22,589	48.2
Census Tract 164, Davidson County, Tennessee	4,101	20,961	27.3
Census Tract 165, Davidson County, Tennessee	4,432	19,008	35.1
Census Tract 166, Davidson County, Tennessee	2,655	47,543	25.8
Census Tract 172, Davidson County, Tennessee	1,302	22,213	25.8
Census Tract 173, Davidson County, Tennessee	2,691	18,196	27.7
Census Tract 174.02, Davidson County, Tennessee	4,800	23,558	29.1
Census Tract 175, Davidson County, Tennessee	2,311	20,076	31.2
Census Tract 181.01, Davidson County, Tennessee	4,331	22,936	25.1
Census Tract 189.01, Davidson County, Tennessee	2,251	27,986	21.3
Census Tract 189.04, Davidson County, Tennessee	2,927	19,240	26.0
Census Tract 190.03, Davidson County, Tennessee	3,382	18,728	32.7
Census Tract 190.04, Davidson County, Tennessee	3,596	14,033	30.0
Census Tract 190.05, Davidson County, Tennessee	2,553	14,850	30.4
Census Tract 190.06, Davidson County, Tennessee	4,063	18,660	23.7
Census Tract 191.05, Davidson County, Tennessee	4,412	23,483	32.1
Census Tract 191.08, Davidson County, Tennessee	2,412	16,243	24.6
Census Tract 191.10, Davidson County, Tennessee	3,234	17,348	20.6
Census Tract 192, Davidson County, Tennessee	2,983	30,397	26.2

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Low-Income Census Tracts in the TVA Service Area

Geography	Population 16 Years and Older	Per Capita Income	Poverty %
Census Tract 193, Davidson County, Tennessee	1,896	7,769	76.3
Census Tract 194, Davidson County, Tennessee	3,662	47,449	27.5
Census Tract 195, Davidson County, Tennessee	5,984	48,494	25.0
Census Tract 9550.01, Decatur County, Tennessee	1,656	21,286	25.5
Census Tract 9550.02, Decatur County, Tennessee	3,683	21,320	23.0
Census Tract 9201.01, DeKalb County, Tennessee	1,910	30,600	26.6
Census Tract 9201.02, DeKalb County, Tennessee	3,929	22,485	24.8
Census Tract 9202, DeKalb County, Tennessee	5,481	27,415	23.6
Census Tract 606.01, Dickson County, Tennessee	3,121	19,270	27.0
Census Tract 606.02, Dickson County, Tennessee	4,898	19,426	28.3
Census Tract 9643, Dyer County, Tennessee	4,340	18,567	25.0
Census Tract 9644, Dyer County, Tennessee	4,827	18,063	28.7
Census Tract 603, Fayette County, Tennessee	2,451	20,389	27.7
Census Tract 605.01, Fayette County, Tennessee	3,348	23,053	29.3
Census Tract 606, Fayette County, Tennessee	3,391	21,976	20.1
Census Tract 9650, Fentress County, Tennessee	2,698	21,350	21.5
Census Tract 9651, Fentress County, Tennessee	3,506	13,339	35.0
Census Tract 9601, Franklin County, Tennessee	2,901	20,122	21.5
Census Tract 9605, Franklin County, Tennessee	3,096	21,675	21.1
Census Tract 9606, Franklin County, Tennessee	3,504	20,628	27.0
Census Tract 9607, Franklin County, Tennessee	3,721	20,403	24.0
Census Tract 9662, Gibson County, Tennessee	3,128	19,027	25.2
Census Tract 9663, Gibson County, Tennessee	2,112	17,293	25.1
Census Tract 9665, Gibson County, Tennessee	4,302	20,370	23.8
Census Tract 9667, Gibson County, Tennessee	4,811	18,975	27.6
Census Tract 9669, Gibson County, Tennessee	2,222	14,276	26.5
Census Tract 9202, Giles County, Tennessee	3,917	16,747	24.0
Census Tract 9208, Giles County, Tennessee	2,435	21,875	21.2
Census Tract 5001, Grainger County, Tennessee	3,161	16,786	29.1
Census Tract 5003, Grainger County, Tennessee	5,289	17,791	23.7
Census Tract 5004.01, Grainger County, Tennessee	2,228	18,972	23.6
Census Tract 901, Greene County, Tennessee	4,939	16,456	41.8
Census Tract 907, Greene County, Tennessee	2,378	17,461	20.0
Census Tract 910, Greene County, Tennessee	5,898	18,684	20.1
Census Tract 913, Greene County, Tennessee	3,912	17,185	21.7
Census Tract 914, Greene County, Tennessee	2,269	22,077	25.5
Census Tract 915, Greene County, Tennessee	2,670	18,413	27.7
Census Tract 9550, Grundy County, Tennessee	2,464	12,310	33.7
Census Tract 9552, Grundy County, Tennessee	3,229	16,432	21.2
Census Tract 9553, Grundy County, Tennessee	3,883	15,867	32.9
Census Tract 1001, Hamblen County, Tennessee	5,195	14,882	32.9

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Low-Income Census Tracts in the TVA Service Area

Geography	Population 16 Years and Older	Per Capita Income	Poverty %
Census Tract 1002, Hamblen County, Tennessee	4,083	18,589	27.1
Census Tract 1003, Hamblen County, Tennessee	2,294	11,553	46.5
Census Tract 1004, Hamblen County, Tennessee	5,186	20,874	32.0
Census Tract 1005, Hamblen County, Tennessee	2,401	24,941	19.7
Census Tract 1007, Hamblen County, Tennessee	4,647	17,800	21.8
Census Tract 1008, Hamblen County, Tennessee	2,692	21,961	32.2
Census Tract 4, Hamilton County, Tennessee	2,914	12,908	22.8
Census Tract 8, Hamilton County, Tennessee	1,480	28,134	24.1
Census Tract 11, Hamilton County, Tennessee	1,504	18,437	38.7
Census Tract 12, Hamilton County, Tennessee	2,685	14,404	45.2
Census Tract 13, Hamilton County, Tennessee	1,294	13,690	48.5
Census Tract 14, Hamilton County, Tennessee	1,490	15,964	31.8
Census Tract 16, Hamilton County, Tennessee	1,821	8,452	71.4
Census Tract 19, Hamilton County, Tennessee	2,783	12,277	54.6
Census Tract 20, Hamilton County, Tennessee	1,140	28,815	26.6
Census Tract 23, Hamilton County, Tennessee	1,062	11,441	45.6
Census Tract 24, Hamilton County, Tennessee	3,850	12,068	47.9
Census Tract 25, Hamilton County, Tennessee	3,018	15,748	45.6
Census Tract 26, Hamilton County, Tennessee	1,727	16,806	39.5
Census Tract 29, Hamilton County, Tennessee	2,146	25,201	23.1
Census Tract 30, Hamilton County, Tennessee	2,098	22,228	19.7
Census Tract 31, Hamilton County, Tennessee	1,708	37,791	27.7
Census Tract 104.33, Hamilton County, Tennessee	3,776	25,371	20.4
Census Tract 104.35, Hamilton County, Tennessee	4,783	27,359	22.7
Census Tract 107, Hamilton County, Tennessee	2,308	25,298	25.4
Census Tract 108, Hamilton County, Tennessee	3,492	24,290	22.5
Census Tract 109.02, Hamilton County, Tennessee	762	27,253	30.6
Census Tract 122, Hamilton County, Tennessee	1,918	10,685	43.4
Census Tract 123, Hamilton County, Tennessee	3,835	16,376	32.8
Census Tract 124, Hamilton County, Tennessee	6,061	14,752	41.9
Census Tract 9606, Hancock County, Tennessee	3,154	16,567	37.0
Census Tract 9502, Hardeman County, Tennessee	5,721	9,852	23.2
Census Tract 9504, Hardeman County, Tennessee	4,277	17,309	31.8
Census Tract 9505, Hardeman County, Tennessee	3,210	17,815	23.0
Census Tract 9506, Hardeman County, Tennessee	2,420	14,193	27.5
Census Tract 9202, Hardin County, Tennessee	3,693	23,562	22.2
Census Tract 9204, Hardin County, Tennessee	3,826	13,549	41.2
Census Tract 502, Hawkins County, Tennessee	3,799	18,570	26.3
Census Tract 503.01, Hawkins County, Tennessee	3,522	22,348	25.2
Census Tract 505.02, Hawkins County, Tennessee	2,608	22,451	28.5
Census Tract 508, Hawkins County, Tennessee	3,942	16,868	30.3

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Low-Income Census Tracts in the TVA Service Area

Geography	Population 16 Years and Older	Per Capita Income	Poverty %
Census Tract 9302, Haywood County, Tennessee	1,351	17,202	29.3
Census Tract 9303.01, Haywood County, Tennessee	3,526	22,090	26.6
Census Tract 9303.02, Haywood County, Tennessee	2,343	15,923	28.8
Census Tract 9752, Henderson County, Tennessee	4,164	22,801	22.8
Census Tract 9754, Henderson County, Tennessee	3,176	17,040	29.9
Census Tract 9755, Henderson County, Tennessee	3,156	16,743	25.9
Census Tract 9690, Henry County, Tennessee	3,873	21,842	22.7
Census Tract 9693, Henry County, Tennessee	2,836	13,948	36.6
Census Tract 9694, Henry County, Tennessee	1,499	17,423	37.6
Census Tract 9698, Henry County, Tennessee	1,674	24,972	20.3
Census Tract 9502, Hickman County, Tennessee	5,209	17,054	33.0
Census Tract 9503.01, Hickman County, Tennessee	2,269	17,343	22.8
Census Tract 1202, Houston County, Tennessee	1,654	19,025	21.8
Census Tract 1203, Houston County, Tennessee	2,297	16,625	28.1
Census Tract 1302, Humphreys County, Tennessee	1,631	19,653	20.5
Census Tract 1303, Humphreys County, Tennessee	4,067	22,662	20.0
Census Tract 9601, Jackson County, Tennessee	1,566	20,220	19.7
Census Tract 9602, Jackson County, Tennessee	2,042	17,151	23.8
Census Tract 9603, Jackson County, Tennessee	4,210	18,328	23.5
Census Tract 9604, Jackson County, Tennessee	1,794	14,718	34.3
Census Tract 9560, Johnson County, Tennessee	833	20,036	22.1
Census Tract 9561, Johnson County, Tennessee	3,837	14,215	23.4
Census Tract 9563, Johnson County, Tennessee	4,726	18,072	31.0
Census Tract 9564, Johnson County, Tennessee	4,066	18,356	28.3
Census Tract 1, Knox County, Tennessee	2,107	42,443	29.4
Census Tract 8, Knox County, Tennessee	3,099	13,805	52.2
Census Tract 9.01, Knox County, Tennessee	1,789	1,917	(no data)
Census Tract 9.02, Knox County, Tennessee	4,063	4,218	63.5
Census Tract 14, Knox County, Tennessee	1,807	7,729	69.9
Census Tract 17, Knox County, Tennessee	1,920	22,024	27.6
Census Tract 19, Knox County, Tennessee	1,297	13,901	46.6
Census Tract 20, Knox County, Tennessee	2,708	14,089	45.0
Census Tract 21, Knox County, Tennessee	2,317	16,164	37.3
Census Tract 22, Knox County, Tennessee	2,838	19,841	24.8
Census Tract 23, Knox County, Tennessee	2,922	22,845	33.7
Census Tract 24, Knox County, Tennessee	3,282	15,615	32.8
Census Tract 26, Knox County, Tennessee	1,922	13,115	50.6
Census Tract 27, Knox County, Tennessee	2,039	14,682	29.1
Census Tract 28, Knox County, Tennessee	3,616	13,667	48.8
Census Tract 29, Knox County, Tennessee	2,896	13,744	49.1
Census Tract 30, Knox County, Tennessee	3,842	21,340	21.9

Appendix D2: Environmental Justice

Low-Income Census Tracts in the TVA Service Area

Geography	Population 16 Years and Older	Per Capita Income	Poverty %
Census Tract 32, Knox County, Tennessee	2,290	16,927	30.3
Census Tract 35, Knox County, Tennessee	4,090	28,471	27.1
Census Tract 37, Knox County, Tennessee	2,152	30,465	24.9
Census Tract 38.01, Knox County, Tennessee	3,834	21,896	29.7
Census Tract 39.02, Knox County, Tennessee	2,414	18,867	24.2
Census Tract 40, Knox County, Tennessee	3,741	21,495	21.1
Census Tract 46.15, Knox County, Tennessee	3,215	24,269	31.5
Census Tract 54.02, Knox County, Tennessee	2,516	22,050	20.9
Census Tract 65.02, Knox County, Tennessee	2,513	18,234	22.3
Census Tract 66, Knox County, Tennessee	3,070	24,669	35.3
Census Tract 67, Knox County, Tennessee	2,814	13,569	37.9
Census Tract 68, Knox County, Tennessee	4,338	12,498	51.6
Census Tract 69, Knox County, Tennessee	7,037	8,427	69.1
Census Tract 70, Knox County, Tennessee	2,027	13,434	51.6
Census Tract 9601, Lake County, Tennessee	4,644	9,031	31.0
Census Tract 9602, Lake County, Tennessee	2,003	22,122	27.4
Census Tract 501, Lauderdale County, Tennessee	3,774	7,747	20.2
Census Tract 502, Lauderdale County, Tennessee	2,765	18,629	25.4
Census Tract 505.04, Lauderdale County, Tennessee	2,311	16,547	34.0
Census Tract 505.05, Lauderdale County, Tennessee	2,573	14,540	45.3
Census Tract 505.06, Lauderdale County, Tennessee	1,948	20,298	20.7
Census Tract 9603, Lawrence County, Tennessee	4,250	13,521	43.3
Census Tract 9605.01, Lawrence County, Tennessee	3,273	14,545	32.9
Census Tract 9702, Lewis County, Tennessee	6,096	19,013	24.4
Census Tract 9753, Lincoln County, Tennessee	4,887	20,426	24.8
Census Tract 9754, Lincoln County, Tennessee	3,392	27,885	20.7
Census Tract 9755, Lincoln County, Tennessee	3,998	19,350	23.9
Census Tract 602.02, Loudon County, Tennessee	5,769	15,763	27.2
Census Tract 607, Loudon County, Tennessee	2,431	21,126	20.0
Census Tract 9702, McMinn County, Tennessee	5,161	13,902	35.7
Census Tract 9703, McMinn County, Tennessee	2,691	16,510	22.9
Census Tract 9705, McMinn County, Tennessee	3,218	18,008	20.7
Census Tract 9706, McMinn County, Tennessee	5,935	18,438	22.2
Census Tract 9301, McNairy County, Tennessee	3,409	15,364	22.7
Census Tract 9302, McNairy County, Tennessee	1,764	16,185	24.6
Census Tract 9303, McNairy County, Tennessee	2,329	16,949	23.4
Census Tract 9304, McNairy County, Tennessee	1,681	22,860	20.7
Census Tract 9305, McNairy County, Tennessee	6,274	17,723	30.2
Census Tract 9701, Macon County, Tennessee	3,788	15,388	29.3
Census Tract 2, Madison County, Tennessee	4,672	20,680	33.3
Census Tract 3, Madison County, Tennessee	3,902	20,787	22.5

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Low-Income Census Tracts in the TVA Service Area

Geography	Population 16 Years and Older	Per Capita Income	Poverty %
Census Tract 4, Madison County, Tennessee	2,701	16,408	33.3
Census Tract 5, Madison County, Tennessee	3,137	12,814	46.7
Census Tract 6, Madison County, Tennessee	1,649	17,779	23.7
Census Tract 7, Madison County, Tennessee	1,936	15,116	32.3
Census Tract 8, Madison County, Tennessee	1,385	8,858	63.8
Census Tract 9, Madison County, Tennessee	1,776	13,214	43.6
Census Tract 10, Madison County, Tennessee	1,620	11,826	41.1
Census Tract 11, Madison County, Tennessee	747	13,383	40.1
Census Tract 14.01, Madison County, Tennessee	1,525	16,546	27.5
Census Tract 16.05, Madison County, Tennessee	2,617	24,113	26.5
Census Tract 501.02, Marion County, Tennessee	4,736	19,969	23.5
Census Tract 503.01, Marion County, Tennessee	4,461	19,577	28.2
Census Tract 9553, Marshall County, Tennessee	3,277	13,519	38.2
Census Tract 105, Maury County, Tennessee	3,443	16,145	36.9
Census Tract 106, Maury County, Tennessee	3,859	17,217	23.4
Census Tract 107, Maury County, Tennessee	3,596	18,372	28.8
Census Tract 108.02, Maury County, Tennessee	5,594	17,806	26.7
Census Tract 110.02, Maury County, Tennessee	5,578	18,650	23.7
Census Tract 9601, Meigs County, Tennessee	2,477	21,047	20.0
Census Tract 9603, Meigs County, Tennessee	3,355	18,750	20.4
Census Tract 9251, Monroe County, Tennessee	6,600	18,385	22.5
Census Tract 9254, Monroe County, Tennessee	6,668	17,635	26.2
Census Tract 9255.01, Monroe County, Tennessee	2,643	17,913	22.8
Census Tract 1001, Montgomery County, Tennessee	1,181	14,711	47.2
Census Tract 1002, Montgomery County, Tennessee	1,321	17,746	19.8
Census Tract 1003, Montgomery County, Tennessee	4,367	19,634	26.5
Census Tract 1004, Montgomery County, Tennessee	2,564	12,595	38.9
Census Tract 1007, Montgomery County, Tennessee	1,051	23,956	27.0
Census Tract 1008, Montgomery County, Tennessee	2,217	11,933	50.7
Census Tract 1009, Montgomery County, Tennessee	1,668	22,831	30.2
Census Tract 1010.01, Montgomery County, Tennessee	3,127	16,377	20.0
Census Tract 1011.01, Montgomery County, Tennessee	1,942	17,587	22.7
Census Tract 1011.02, Montgomery County, Tennessee	5,918	21,861	23.0
Census Tract 1012.01, Montgomery County, Tennessee	1,580	19,792	21.9
Census Tract 1013.04, Montgomery County, Tennessee	3,962	16,602	21.1
Census Tract 1013.07, Montgomery County, Tennessee	1,878	17,041	26.4
Census Tract 1016, Montgomery County, Tennessee	4,442	22,511	21.1
Census Tract 1101, Morgan County, Tennessee	2,156	18,302	28.4
Census Tract 1103, Morgan County, Tennessee	5,394	10,994	22.5
Census Tract 1104, Morgan County, Tennessee	3,813	23,353	23.7
Census Tract 1105, Morgan County, Tennessee	3,987	19,731	25.4

Appendix D2: Environmental Justice

Low-Income Census Tracts in the TVA Service Area

Geography	Population 16 Years and Older	Per Capita Income	Poverty %
Census Tract 9654, Obion County, Tennessee	3,558	21,795	21.8
Census Tract 9655, Obion County, Tennessee	1,859	15,422	29.0
Census Tract 9656, Obion County, Tennessee	2,822	14,586	35.5
Census Tract 9657, Obion County, Tennessee	3,845	24,604	21.1
Census Tract 9659, Obion County, Tennessee	1,007	19,664	20.2
Census Tract 9501, Overton County, Tennessee	1,459	18,083	26.3
Census Tract 9503.02, Overton County, Tennessee	2,393	20,517	24.8
Census Tract 9505, Overton County, Tennessee	4,945	19,945	20.6
Census Tract 9506, Overton County, Tennessee	2,063	18,301	19.8
Census Tract 9301, Perry County, Tennessee	2,489	22,115	33.7
Census Tract 9302, Perry County, Tennessee	3,857	16,330	25.2
Census Tract 9501, Polk County, Tennessee	1,219	21,535	26.4
Census Tract 9502.01, Polk County, Tennessee	1,662	21,969	23.4
Census Tract 9504, Polk County, Tennessee	3,105	21,289	20.1
Census Tract 1, Putnam County, Tennessee	4,207	18,496	27.3
Census Tract 3.02, Putnam County, Tennessee	5,682	14,172	49.7
Census Tract 3.03, Putnam County, Tennessee	1,839	18,196	30.9
Census Tract 5, Putnam County, Tennessee	1,818	24,663	34.5
Census Tract 6, Putnam County, Tennessee	3,189	26,947	21.7
Census Tract 7, Putnam County, Tennessee	2,953	13,863	39.6
Census Tract 8, Putnam County, Tennessee	5,409	8,457	46.7
Census Tract 9750, Rhea County, Tennessee	4,062	21,562	27.0
Census Tract 9753, Rhea County, Tennessee	4,640	16,884	26.1
Census Tract 9754.01, Rhea County, Tennessee	5,762	15,935	29.8
Census Tract 305, Roane County, Tennessee	3,422	14,112	37.8
Census Tract 306, Roane County, Tennessee	3,057	24,625	19.8
Census Tract 308, Roane County, Tennessee	4,966	16,183	25.1
Census Tract 803.01, Robertson County, Tennessee	1,966	19,484	21.6
Census Tract 803.02, Robertson County, Tennessee	2,073	18,573	32.1
Census Tract 804.01, Robertson County, Tennessee	3,801	16,627	29.1
Census Tract 403.05, Rutherford County, Tennessee	1,929	16,467	26.8
Census Tract 404.03, Rutherford County, Tennessee	5,588	19,665	25.2
Census Tract 411.02, Rutherford County, Tennessee	2,283	21,924	28.7
Census Tract 414.01, Rutherford County, Tennessee	3,861	37,325	20.4
Census Tract 414.02, Rutherford County, Tennessee	5,069	19,360	32.4
Census Tract 414.03, Rutherford County, Tennessee	7,404	21,383	33.5
Census Tract 415, Rutherford County, Tennessee	2,713	3,147	62.5
Census Tract 416, Rutherford County, Tennessee	5,359	18,571	29.7
Census Tract 418, Rutherford County, Tennessee	3,420	14,974	31.1
Census Tract 419, Rutherford County, Tennessee	3,270	15,072	35.7
Census Tract 421, Rutherford County, Tennessee	8,041	18,513	32.1

Appendix D2: Environmental Justice

Low-Income Census Tracts in the TVA Service Area

Geography	Population 16 Years and Older	Per Capita Income	Poverty %
Census Tract 9750, Scott County, Tennessee	2,874	16,101	26.7
Census Tract 9751, Scott County, Tennessee	5,477	31,104	27.0
Census Tract 9752, Scott County, Tennessee	5,058	14,363	34.5
Census Tract 9753, Scott County, Tennessee	1,642	16,008	23.1
Census Tract 601.02, Sequatchie County, Tennessee	1,914	19,023	25.7
Census Tract 805, Sevier County, Tennessee	4,128	21,876	22.3
Census Tract 808.01, Sevier County, Tennessee	2,330	14,409	39.7
Census Tract 811.01, Sevier County, Tennessee	1,661	26,753	22.6
Census Tract 2, Shelby County, Tennessee	665	9,578	53.4
Census Tract 3, Shelby County, Tennessee	788	12,041	32.1
Census Tract 4, Shelby County, Tennessee	1,206	9,329	50.6
Census Tract 6, Shelby County, Tennessee	1,710	12,884	37.0
Census Tract 7, Shelby County, Tennessee	3,478	17,284	41.2
Census Tract 8, Shelby County, Tennessee	1,660	8,460	56.7
Census Tract 9, Shelby County, Tennessee	2,107	10,964	47.4
Census Tract 11, Shelby County, Tennessee	2,129	14,498	41.7
Census Tract 12, Shelby County, Tennessee	2,959	17,974	22.5
Census Tract 13, Shelby County, Tennessee	2,619	15,387	54.6
Census Tract 14, Shelby County, Tennessee	1,209	10,770	37.9
Census Tract 15, Shelby County, Tennessee	1,205	15,159	27.1
Census Tract 19, Shelby County, Tennessee	1,115	13,351	23.4
Census Tract 20, Shelby County, Tennessee	1,360	11,839	44.4
Census Tract 21, Shelby County, Tennessee	1,055	24,603	50.1
Census Tract 24, Shelby County, Tennessee	1,716	13,055	46.4
Census Tract 25, Shelby County, Tennessee	2,332	23,981	31.8
Census Tract 27, Shelby County, Tennessee	1,566	18,532	41.7
Census Tract 28, Shelby County, Tennessee	2,431	14,943	45.8
Census Tract 30, Shelby County, Tennessee	2,979	21,796	25.8
Census Tract 32, Shelby County, Tennessee	3,493	26,478	20.9
Census Tract 34, Shelby County, Tennessee	2,170	32,182	26.0
Census Tract 36, Shelby County, Tennessee	1,591	27,938	35.9
Census Tract 37, Shelby County, Tennessee	1,115	14,899	50.3
Census Tract 38, Shelby County, Tennessee	1,081	17,316	43.0
Census Tract 39, Shelby County, Tennessee	1,175	16,031	52.1
Census Tract 45, Shelby County, Tennessee	429	10,070	58.2
Census Tract 46, Shelby County, Tennessee	1,063	16,330	40.8
Census Tract 50, Shelby County, Tennessee	759	8,444	55.2
Census Tract 53, Shelby County, Tennessee	2,450	13,635	33.9
Census Tract 55, Shelby County, Tennessee	1,882	14,634	32.8
Census Tract 56, Shelby County, Tennessee	3,087	16,529	25.4
Census Tract 57, Shelby County, Tennessee	1,925	12,963	30.8

Appendix D2: Environmental Justice

Low-Income Census Tracts in the TVA Service Area

Geography	Population 16 Years and Older	Per Capita Income	Poverty %
Census Tract 58, Shelby County, Tennessee	730	11,123	52.6
Census Tract 59, Shelby County, Tennessee	1,871	10,117	43.9
Census Tract 60, Shelby County, Tennessee	1,650	12,820	36.1
Census Tract 62, Shelby County, Tennessee	1,610	19,290	27.9
Census Tract 64, Shelby County, Tennessee	1,645	19,915	34.4
Census Tract 65, Shelby County, Tennessee	1,940	17,550	45.0
Census Tract 66, Shelby County, Tennessee	1,897	25,243	31.0
Census Tract 67, Shelby County, Tennessee	2,404	10,423	58.5
Census Tract 68, Shelby County, Tennessee	1,769	12,668	44.4
Census Tract 69, Shelby County, Tennessee	2,698	14,203	44.1
Census Tract 70, Shelby County, Tennessee	2,923	14,362	34.4
Census Tract 73, Shelby County, Tennessee	4,798	20,448	38.7
Census Tract 74, Shelby County, Tennessee	2,766	24,165	31.0
Census Tract 75, Shelby County, Tennessee	1,203	11,058	39.8
Census Tract 78.10, Shelby County, Tennessee	1,886	13,054	42.3
Census Tract 78.21, Shelby County, Tennessee	4,099	12,045	52.2
Census Tract 78.22, Shelby County, Tennessee	1,316	12,117	46.9
Census Tract 79, Shelby County, Tennessee	4,421	14,143	30.6
Census Tract 80, Shelby County, Tennessee	4,100	17,663	26.2
Census Tract 81.10, Shelby County, Tennessee	2,045	12,799	41.8
Census Tract 81.20, Shelby County, Tennessee	3,368	18,035	32.2
Census Tract 82, Shelby County, Tennessee	3,638	11,034	52.1
Census Tract 87, Shelby County, Tennessee	3,451	20,879	23.9
Census Tract 88, Shelby County, Tennessee	5,043	10,453	44.0
Census Tract 89, Shelby County, Tennessee	3,121	9,368	50.6
Census Tract 91, Shelby County, Tennessee	1,981	11,816	35.7
Census Tract 97, Shelby County, Tennessee	2,046	18,673	26.1
Census Tract 98, Shelby County, Tennessee	2,719	16,410	28.0
Census Tract 99.01, Shelby County, Tennessee	2,092	14,842	48.9
Census Tract 99.02, Shelby County, Tennessee	1,934	17,446	49.0
Census Tract 100, Shelby County, Tennessee	5,282	13,807	29.4
Census Tract 101.10, Shelby County, Tennessee	5,024	8,233	61.3
Census Tract 101.20, Shelby County, Tennessee	3,301	10,339	52.2
Census Tract 102.10, Shelby County, Tennessee	4,136	13,357	36.3
Census Tract 102.20, Shelby County, Tennessee	5,302	14,985	41.0
Census Tract 103, Shelby County, Tennessee	1,132	9,644	54.6
Census Tract 105, Shelby County, Tennessee	1,336	13,426	34.9
Census Tract 106.10, Shelby County, Tennessee	4,810	12,515	34.4
Census Tract 106.20, Shelby County, Tennessee	2,442	11,829	36.3
Census Tract 106.30, Shelby County, Tennessee	2,568	9,969	55.3
Census Tract 107.10, Shelby County, Tennessee	3,660	17,289	26.0

Appendix D2: Environmental Justice

Low-Income Census Tracts in the TVA Service Area

Geography	Population 16 Years and Older	Per Capita Income	Poverty %
Census Tract 107.20, Shelby County, Tennessee	2,878	15,287	41.7
Census Tract 108.10, Shelby County, Tennessee	4,606	15,594	34.1
Census Tract 108.20, Shelby County, Tennessee	3,390	18,906	22.3
Census Tract 110.10, Shelby County, Tennessee	3,237	16,022	35.1
Census Tract 110.20, Shelby County, Tennessee	981	19,092	27.0
Census Tract 111, Shelby County, Tennessee	1,278	15,362	42.9
Census Tract 112, Shelby County, Tennessee	1,248	11,775	55.0
Census Tract 113, Shelby County, Tennessee	1,172	17,224	47.0
Census Tract 114, Shelby County, Tennessee	4,640	8,968	69.0
Census Tract 115, Shelby County, Tennessee	2,135	10,565	43.7
Census Tract 116, Shelby County, Tennessee	2,014	9,110	46.3
Census Tract 117, Shelby County, Tennessee	1,172	13,000	49.3
Census Tract 118, Shelby County, Tennessee	4,354	17,115	31.9
Census Tract 201.01, Shelby County, Tennessee	3,049	21,207	34.9
Census Tract 203, Shelby County, Tennessee	4,451	23,303	32.1
Census Tract 205.12, Shelby County, Tennessee	3,940	22,064	36.6
Census Tract 205.21, Shelby County, Tennessee	2,658	10,501	45.7
Census Tract 205.23, Shelby County, Tennessee	2,233	11,838	40.8
Census Tract 205.24, Shelby County, Tennessee	3,370	18,193	30.3
Census Tract 205.41, Shelby County, Tennessee	4,446	21,863	20.5
Census Tract 205.42, Shelby County, Tennessee	3,910	14,070	37.6
Census Tract 211.11, Shelby County, Tennessee	2,913	19,624	21.9
Census Tract 212, Shelby County, Tennessee	3,958	4,815	(no data)
Census Tract 216.20, Shelby County, Tennessee	2,666	25,271	30.3
Census Tract 217.10, Shelby County, Tennessee	2,047	17,670	29.0
Census Tract 217.21, Shelby County, Tennessee	3,659	14,230	40.0
Census Tract 217.25, Shelby County, Tennessee	3,586	20,253	20.4
Census Tract 217.26, Shelby County, Tennessee	3,236	15,575	37.3
Census Tract 217.31, Shelby County, Tennessee	1,921	15,462	36.7
Census Tract 217.32, Shelby County, Tennessee	4,314	18,810	29.4
Census Tract 217.41, Shelby County, Tennessee	5,791	16,142	40.4
Census Tract 217.47, Shelby County, Tennessee	2,784	19,781	20.1
Census Tract 217.54, Shelby County, Tennessee	3,135	21,992	20.9
Census Tract 219, Shelby County, Tennessee	3,959	15,136	32.0
Census Tract 220.22, Shelby County, Tennessee	2,234	10,483	51.0
Census Tract 220.23, Shelby County, Tennessee	1,445	24,128	22.9
Census Tract 220.24, Shelby County, Tennessee	2,583	22,828	24.9
Census Tract 221.11, Shelby County, Tennessee	4,102	15,620	29.6
Census Tract 221.12, Shelby County, Tennessee	4,957	14,483	34.0
Census Tract 221.22, Shelby County, Tennessee	3,027	18,814	25.3
Census Tract 221.30, Shelby County, Tennessee	4,585	20,381	28.8

Appendix D2: Environmental Justice
Low-Income Census Tracts in the TVA Service Area

Geography	Population 16 Years and Older	Per Capita Income	Poverty %
Census Tract 222.10, Shelby County, Tennessee	3,622	14,130	36.9
Census Tract 222.20, Shelby County, Tennessee	3,047	17,186	21.7
Census Tract 223.10, Shelby County, Tennessee	4,186	13,953	41.0
Census Tract 223.22, Shelby County, Tennessee	3,241	18,457	25.9
Census Tract 223.30, Shelby County, Tennessee	3,656	14,977	22.3
Census Tract 225, Shelby County, Tennessee	3,766	18,736	25.3
Census Tract 226, Shelby County, Tennessee	3,083	17,074	24.3
Census Tract 227, Shelby County, Tennessee	5,089	13,177	27.3
Census Tract 9801, Shelby County, Tennessee	65	8,348	78.5
Census Tract 9804, Shelby County, Tennessee	494	4,765	(no data)
Census Tract 9751, Smith County, Tennessee	2,306	23,051	24.2
Census Tract 1106, Stewart County, Tennessee	2,338	20,222	21.2
Census Tract 1107, Stewart County, Tennessee	3,948	21,828	20.0
Census Tract 402, Sullivan County, Tennessee	2,266	18,742	29.3
Census Tract 403, Sullivan County, Tennessee	2,265	19,963	21.5
Census Tract 405, Sullivan County, Tennessee	3,584	14,556	37.3
Census Tract 406, Sullivan County, Tennessee	2,459	14,154	42.9
Census Tract 408, Sullivan County, Tennessee	2,720	15,845	26.0
Census Tract 411, Sullivan County, Tennessee	2,056	24,442	20.7
Census Tract 417, Sullivan County, Tennessee	2,704	16,866	22.4
Census Tract 418, Sullivan County, Tennessee	3,781	17,589	24.8
Census Tract 420, Sullivan County, Tennessee	2,889	20,569	19.7
Census Tract 427.01, Sullivan County, Tennessee	3,770	17,435	22.0
Census Tract 428.02, Sullivan County, Tennessee	3,756	16,625	30.1
Census Tract 430, Sullivan County, Tennessee	3,861	17,648	22.5
Census Tract 431, Sullivan County, Tennessee	2,609	19,636	22.2
Census Tract 433.02, Sullivan County, Tennessee	5,058	19,314	22.8
Census Tract 434.01, Sullivan County, Tennessee	4,261	25,239	26.9
Census Tract 201.01, Sumner County, Tennessee	3,045	21,311	22.4
Census Tract 203, Sumner County, Tennessee	3,752	15,423	26.1
Census Tract 207, Sumner County, Tennessee	3,743	18,771	26.9
Census Tract 208, Sumner County, Tennessee	5,378	13,723	22.9
Census Tract 401, Tipton County, Tennessee	4,058	21,881	20.7
Census Tract 406.01, Tipton County, Tennessee	3,981	18,836	21.0
Census Tract 407, Tipton County, Tennessee	3,829	17,052	31.8
Census Tract 802, Unicoi County, Tennessee	5,565	17,424	26.0
Census Tract 804, Unicoi County, Tennessee	2,954	21,394	21.7
Census Tract 401, Union County, Tennessee	5,307	18,383	21.7
Census Tract 402.01, Union County, Tennessee	3,244	17,118	20.3
Census Tract 402.02, Union County, Tennessee	4,623	18,629	29.7
Census Tract 9250, Van Buren County, Tennessee	2,104	21,090	20.0

Appendix D2: Environmental Justice
Low-Income Census Tracts in the TVA Service Area

Geography	Population 16 Years and Older	Per Capita Income	Poverty %
Census Tract 9304, Warren County, Tennessee	4,899	18,342	24.4
Census Tract 9305, Warren County, Tennessee	4,239	15,158	30.0
Census Tract 9306, Warren County, Tennessee	3,143	17,687	26.6
Census Tract 601, Washington County, Tennessee	2,997	18,897	40.7
Census Tract 605.01, Washington County, Tennessee	3,960	22,652	26.6
Census Tract 606, Washington County, Tennessee	6,400	21,873	27.5
Census Tract 607, Washington County, Tennessee	1,945	6,358	(no data)
Census Tract 608, Washington County, Tennessee	2,670	18,472	37.7
Census Tract 609, Washington County, Tennessee	4,701	13,798	45.6
Census Tract 610, Washington County, Tennessee	1,750	14,392	38.5
Census Tract 612, Washington County, Tennessee	2,826	23,339	24.6
Census Tract 620, Washington County, Tennessee	3,111	21,394	24.8
Census Tract 9504, Wayne County, Tennessee	2,504	17,685	24.9
Census Tract 9681.01, Weakley County, Tennessee	2,718	19,832	30.5
Census Tract 9682.02, Weakley County, Tennessee	2,591	3,775	80.4
Census Tract 9682.03, Weakley County, Tennessee	2,465	16,722	36.4
Census Tract 9685, Weakley County, Tennessee	3,390	19,090	19.7
Census Tract 9350, White County, Tennessee	3,390	18,511	20.2
Census Tract 9352, White County, Tennessee	3,077	17,933	21.1
Census Tract 9354, White County, Tennessee	3,162	14,112	22.1
Census Tract 9355, White County, Tennessee	2,763	15,909	28.0
Census Tract 508, Williamson County, Tennessee	5,052	34,235	20.3
Census Tract 305, Wilson County, Tennessee	4,887	17,277	21.5
Census Tract 307, Wilson County, Tennessee	2,422	14,483	38.1
Census Tract 9501, Lee County, Virginia	2,391	15,912	25.1
Census Tract 9502, Lee County, Virginia	3,608	22,046	21.1
Census Tract 9503, Lee County, Virginia	4,588	14,204	32.3
Census Tract 9504, Lee County, Virginia	2,582	14,307	32.2
Census Tract 9505, Lee County, Virginia	4,133	19,563	24.3
Census Tract 9506, Lee County, Virginia	3,487	20,095	23.4
Census Tract 302, Scott County, Virginia	3,508	17,461	21.7
Census Tract 303, Scott County, Virginia	2,813	18,514	21.9
Census Tract 304, Scott County, Virginia	3,041	21,301	25.5
Census Tract 105.02, Washington County, Virginia	3,650	17,269	32.1
Census Tract 9307, Wise County, Virginia	2,821	15,463	20.2
Census Tract 9311, Wise County, Virginia	2,083	15,589	32.8
Census Tract 9312, Wise County, Virginia	5,509	19,394	26.1
Census Tract 9315, Wise County, Virginia	3,838	18,198	25.9
Census Tract 9316, Wise County, Virginia	2,224	17,596	26.3
Census Tract 9317, Wise County, Virginia	1,724	20,592	21.1
Census Tract 202, Bristol city, Virginia	4,079	22,120	27.7

Appendix D2: Environmental Justice

Low-Income Census Tracts in the TVA Service Area

Geography	Population 16 Years and Older	Per Capita Income	Poverty %
Census Tract 203, Bristol city, Virginia	2,153	14,950	40.8
Census Tract 9601, Norton city, Virginia	3,200	19,522	26.5

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Appendix D3: Environmental Justice
Minority Populations in the TVA Service Area

Geography	2016 Population	% Minority Pop.	% White Alone	% Black/African American	% American Indian/Alaska Native	% Asian	% Native Hawaiian/Other Pacific Islander	% Some Other Race Alone	% Two or More Races	% Hispanic/Latino of Any Race
Blount County, Alabama	57,704	4.6	95.4	2	1.2	0.5	0.1	0.9	1.6	8.7
Cherokee County, Alabama	25,897	6.7	93.3	5	1.3	0.4	0	0	1	1.6
Colbert County, Alabama	54,377	20.2	79.8	17	1.3	0.8	0.1	1.4	2.3	2.4
Cullman County, Alabama	81,316	4.1	95.9	1.5	1.2	0.6	0	0.8	1.1	4.2
DeKalb County, Alabama	70,937	12.8	87.2	2	2.7	0.4	0.7	7	2.2	14
Etowah County, Alabama	103,363	18.7	81.3	16.1	1.1	0.9	0.1	0.6	1.5	3.6
Franklin County, Alabama	31,573	10.9	89.1	5	1.3	0.6	0.1	4.4	1.1	16
Jackson County, Alabama	52,608	8.9	91.1	4	3.2	0.6	0.1	1.2	3.2	2.7
Lauderdale County, Alabama	92,641	13	87	10.9	0.9	0.8	0.1	0.4	1.8	2.4
Lawrence County, Alabama	33,433	21.9	78.1	12.2	9.1	0.4	0.2	0.4	5.5	2.1
Limestone County, Alabama	90,257	18.5	81.5	14	1.3	1.8	0.1	1.6	2.5	5.7
Madison County, Alabama	349,973	31.2	68.8	25.5	1.8	3.3	0.3	1.2	2.9	4.7
Marshall County, Alabama	94,534	7.5	92.5	2.8	1.4	0.8	0	2.7	1.8	12.9
Morgan County, Alabama	119,555	18.1	81.9	13.2	1.9	0.9	0	2.3	2.4	7.8
Winston County, Alabama	24,013	3.4	96.6	0.5	2.3	0.3	0	0.2	1.8	2.9
Catoosa County, Georgia	65,645	6.8	93.2	3.4	1	1.9	0	0.8	1.8	2.7
Chattooga County, Georgia	25,046	13.3	86.7	11.1	0.6	0.7	0.1	1.1	0.9	4.6
Dade County, Georgia	16,356	4.8	95.2	1	1.1	1.6	0.6	0.7	1.4	2.1
Fannin County, Georgia	24,017	2.8	97.2	0.3	1.7	0.7	0.1	0.1	1.5	2
Gilmer County, Georgia	28,956	9.6	90.4	1.2	3.2	0.8	0	4.5	1.3	10.9
Gordon County, Georgia	56,079	10.2	89.8	4.9	1.5	1.2	0.2	2.8	1.4	15
Murray County, Georgia	39,358	3.3	96.7	1.2	0.6	0.5	0	1	0.8	14
Towns County, Georgia	10,976	3.5	96.5	1.4	1.5	0.2	0	0.3	1	2.4
Union County, Georgia	22,033	3	97	0.7	1.3	0.8	0	0.3	0.5	2.9
Walker County, Georgia	68,143	7.5	92.5	5.1	0.8	0.7	0	1	1.7	1.9
Whitfield County, Georgia	103,653	11.7	88.3	4.5	1.2	1.7	0.2	4.5	1.7	33.5
Allen County, Kentucky	20,421	3.5	96.5	2	0.3	0.4	0	0.9	0.8	1.9
Butler County, Kentucky	12,828	3.6	96.4	1.3	1	0	0	1.3	0.8	3.4
Calloway County, Kentucky	38,302	8.5	91.5	4.9	0.9	2.3	0.1	0.5	2.7	2.5
Carlisle County, Kentucky	4,954	3.5	96.5	2.4	0.6	0.1	0	0.4	0.9	2.2
Christian County, Kentucky	73,936	28.2	71.8	23.2	1.4	2.2	1	1.2	4.2	7.3
Cumberland County, Kentucky	6,780	5.4	94.6	4.5	0.1	0.8	0	0	1.7	0.2
Edmonson County, Kentucky	12,086	3.7	96.3	2.7	0.9	0.3	0.1	0.3	1.7	1.2
Fulton County, Kentucky	6,323	28.8	71.2	27.4	0.9	0.3	0.1	0.4	2	0.6
Graves County, Kentucky	37,379	9.1	90.9	5.5	1	0.6	0.5	1.7	2.1	5.9
Grayson County, Kentucky	26,092	3.8	96.2	1.7	0.7	0.2	0.1	1.1	0.8	1.2

Appendix D3: Environmental Justice
Minority Populations in the TVA Service Area

Geography	2016 Population	% Minority Pop.	% White Alone	% Black/African American	% American Indian/Alaska Native	% Asian	% Native Hawaiian/Other Pacific Islander	% Some Other Race Alone	% Two or More Races	% Hispanic/Latino of Any Race
Hickman County, Kentucky	4,691	11.8	88.2	9.9	0.4	1.4	0	0.2	1.8	0.9
Livingston County, Kentucky	9,353	2.5	97.5	0.7	1.7	0.1	0	0	1.6	1.5
Logan County, Kentucky	26,757	9.4	90.6	8.2	0.4	0.1	0	0.8	2.2	2.6
Lyon County, Kentucky	8,325	7.8	92.2	6.2	0.8	0.5	0.2	0.4	1.3	1.4
Marshall County, Kentucky	31,213	2	98	1	0.3	0.5	0	0.3	0.9	1.3
Monroe County, Kentucky	10,692	3.9	96.1	3	0.2	0.1	0	0.6	0.6	2.9
Simpson County, Kentucky	17,856	14.3	85.7	11.1	0.9	0.5	0	2	1.5	2.1
Todd County, Kentucky	12,465	13.5	86.5	9	0.8	0.2	0	3.7	1.8	3.9
Trigg County, Kentucky	14,267	9.9	90.1	9.2	0.1	0.7	0	0.2	0.7	1.9
Warren County, Kentucky	121,066	17.9	82.1	10.4	0.8	3.5	0.4	3.3	1.9	5
Alcorn County, Mississippi	37,309	15.3	84.7	12.8	0.6	0.7	0	1.5	2	3.1
Attala County, Mississippi	19,085	45	55	43.7	0.5	0.5	0	0.7	1.4	1.9
Benton County, Mississippi	8,378	38.9	61.1	37	0.5	0	0	1.4	0.2	2.3
Calhoun County, Mississippi	14,724	32.5	67.5	28.5	0.1	0.1	0.6	3.3	1.4	5.5
Chickasaw County, Mississippi	17,357	45.6	54.4	44.1	0.6	0.8	0.3	0.8	1.2	4.2
Choctaw County, Mississippi	8,320	32.2	67.8	31.7	0.3	0.1	0.2	0.1	0.3	0.3
Clay County, Mississippi	20,147	59.5	40.5	58.4	0.4	0.7	0	0.1	0.3	1.3
DeSoto County, Mississippi	170,890	29.3	70.7	25.7	0.6	1.7	0	1.5	1.8	4.7
Itawamba County, Mississippi	23,511	8.6	91.4	7.4	0.2	0.4	0	0.7	0.9	1.4
Kemper County, Mississippi	10,128	64.5	35.5	60.8	3.7	0	0	0	0.5	1.5
Lafayette County, Mississippi	52,193	27.8	72.2	24.4	0.2	2.5	0.2	0.7	1.2	2.4
Leake County, Mississippi	23,011	48.3	51.7	42	6	0.4	0	0.1	0.3	4.3
Lee County, Mississippi	85,281	31.5	68.5	29.2	0.6	1.1	0	1	1.2	2.4
Lowndes County, Mississippi	59,785	46.1	53.9	44.2	0.4	1.1	0.1	0.5	1	1.9
Marshall County, Mississippi	36,196	50.8	49.2	48.4	0.7	0.1	0	1.8	1.1	3.4
Monroe County, Mississippi	36,029	32	68	31.1	0.6	0.2	0	0.1	1.3	1.1
Neshoba County, Mississippi	29,474	39.9	60.1	21.8	17.5	0.8	0	0.3	1.8	1.9
Noxubee County, Mississippi	11,098	69.9	30.1	69.2	0.5	0	0	0.2	0	4
Oktibbeha County, Mississippi	49,424	42	58	37.6	0.5	3.6	0.1	0.8	1.4	1.6
Panola County, Mississippi	34,319	51.5	48.5	51	0.2	0.1	0.1	0.2	1	1.6
Pontotoc County, Mississippi	30,862	19.4	80.6	15.7	0.6	0.4	0	2.9	1.3	6.1
Prentiss County, Mississippi	25,339	16.1	83.9	15	0.2	0.2	0	0.7	1.8	1.3
Scott County, Mississippi	28,268	42	58	37.8	0.8	1.1	0	2.3	0	10.8
Tallahatchie County, Mississippi	14,776	62.3	37.7	46.7	0.6	1.6	0.4	13.3	0.4	15.2
Tate County, Mississippi	28,338	33	67	31.6	0.5	0.3	0.2	0.5	1.6	2.5
Tippah County, Mississippi	22,061	19.2	80.8	17.7	0.2	0.6	0.1	0.9	1.1	4.8

Appendix D3: Environmental Justice
Minority Populations in the TVA Service Area

Geography	2016 Population	% Minority Pop.	% White Alone	% Black/African American	% American Indian/Alaska Native	% Asian	% Native Hawaiian/Other Pacific Islander	% Some Other Race Alone	% Two or More Races	% Hispanic/Latino of Any Race
Tishomingo County, Mississippi	19,503	5.1	94.9	3.2	0.5	0.2	0	1.3	0.9	2.7
Union County, Mississippi	27,989	17.8	82.2	15.6	0.6	0.9	0.1	0.8	1.7	4.4
Webster County, Mississippi	9,922	20.9	79.1	19.9	0.5	0.4	0	0.3	1.1	1.4
Winston County, Mississippi	18,519	48.8	51.2	48	0.5	0	0	0.4	0.1	1.1
Yalobusha County, Mississippi	12,380	41.3	58.7	40	0.6	0.2	0.1	0.4	0.3	1.5
Avery County, North Carolina	17,633	8.1	91.9	4.3	1	0.9	0.1	2	1.4	5
Cherokee County, North Carolina	27,226	6.3	93.7	1.9	3	0.8	0	0.8	2.1	2.9
Clay County, North Carolina	10,730	0.8	99.2	0.4	0	0.1	0	0.2	0.2	3.2
Watauga County, North Carolina	52,745	6	94	1.7	1.4	1.4	0	1.6	2.4	3.4
Anderson County, Tennessee	75,545	8.2	91.8	5	1.1	1.6	0.1	0.6	2.3	2.5
Bedford County, Tennessee	46,331	16.2	83.8	9.8	1.4	0.5	0.3	4.7	2.8	11.5
Benton County, Tennessee	16,173	4.8	95.2	3	1	0.7	0	0.1	0.8	2.2
Bledsoe County, Tennessee	14,073	8.3	91.7	4.5	3.4	0.1	0	0.3	3.8	2.1
Blount County, Tennessee	126,192	5.9	94.1	3.6	1	1.1	0.1	0.3	1.7	3
Bradley County, Tennessee	102,860	8.2	91.8	5.4	0.9	1.2	0	0.8	1.6	5.6
Campbell County, Tennessee	40,008	2.2	97.8	0.7	1.1	0.3	0.1	0.1	1	1.2
Cannon County, Tennessee	13,855	4.8	95.2	1.8	1.2	1.2	0	0.8	1.4	1.9
Carroll County, Tennessee	28,417	13.2	86.8	11.5	1.1	0.4	0	0.4	1.8	2.4
Carter County, Tennessee	56,707	3.4	96.6	1.9	0.8	0.5	0	0.2	1.3	1.6
Cheatham County, Tennessee	39,575	5.1	94.9	2	1	0.8	0.3	1.2	1.6	2.6
Chester County, Tennessee	17,355	13.4	86.6	9.9	0.1	1.3	0.1	2	1.1	2.3
Claiborne County, Tennessee	31,701	3.6	96.4	1.4	1	0.8	0.2	0.4	1.7	1.1
Clay County, Tennessee	7,769	3.2	96.8	1.4	1	0.4	0	0.3	0.3	2.2
Cocke County, Tennessee	35,256	4.8	95.2	2.9	1.2	0.3	0.1	0.3	2.4	2.1
Coffee County, Tennessee	53,808	9.1	90.9	2.9	2.9	1.3	0.1	2.1	3.6	4
Crockett County, Tennessee	14,558	19.7	80.3	14.5	1	0.2	0	4.2	2.4	9.9
Cumberland County, Tennessee	57,895	3	97	0.8	1	0.7	0.1	0.5	1.4	2.7
Davidson County, Tennessee	667,885	37	63	28.8	0.7	4.1	0.2	3.6	2.3	10
Decatur County, Tennessee	11,703	5	95	3.5	0.6	0.6	0.1	0.3	1.9	3.1
DeKalb County, Tennessee	19,159	5.5	94.5	2.3	0.7	0.6	0.1	1.8	1.4	7.2
Dickson County, Tennessee	50,926	7.5	92.5	5.3	0.9	0.7	0.1	0.6	2	3.1
Dyer County, Tennessee	37,970	17.6	82.4	14.9	0.8	0.8	0.2	1	2.3	3.1
Fayette County, Tennessee	39,071	30.5	69.5	28	0.6	0.8	0	1.1	0.9	2.4
Fentress County, Tennessee	17,936	2.1	97.9	0.6	0.4	0.7	0	0.3	1	1.3
Franklin County, Tennessee	41,348	9.8	90.2	4.5	2.5	1	0.1	1.9	3.6	2.9
Gibson County, Tennessee	49,511	21.5	78.5	19.2	0.6	0.4	0.1	1.1	1.8	2.5

Appendix D3: Environmental Justice
Minority Populations in the TVA Service Area

Geography	2016 Population	% Minority Pop.	% White Alone	% Black/African American	% American Indian/Alaska Native	% Asian	% Native Hawaiian/Other Pacific Islander	% Some Other Race Alone	% Two or More Races	% Hispanic/Latino of Any Race
Giles County, Tennessee	29,034	13.8	86.2	11.1	1.1	0.7	0.1	1	2.5	2.1
Grainger County, Tennessee	22,813	2.1	97.9	1.1	0.4	0.6	0	0.1	0.9	2.9
Greene County, Tennessee	68,502	5	95	2.9	0.7	0.6	0	0.9	1.5	2.7
Grundy County, Tennessee	13,494	19.5	80.5	0.8	18.2	0.5	0.2	0.1	18.1	0.2
Hamblen County, Tennessee	63,203	12	88	5.7	0.7	1	0.1	4.8	2.8	11.2
Hamilton County, Tennessee	351,305	24.7	75.3	20.7	0.7	2.4	0.1	1	1.9	5.1
Hancock County, Tennessee	6,609	2	98	0.9	0.9	0.1	0	0.1	0.8	0.7
Hardeman County, Tennessee	25,975	43.9	56.1	42.2	0.5	0.8	0	0.3	1.1	1.6
Hardin County, Tennessee	25,839	5.8	94.2	4.5	0.9	0.1	0.1	0.2	1.5	2.1
Hawkins County, Tennessee	56,567	3.8	96.2	1.8	0.8	0.6	0.1	0.5	1.4	1.3
Haywood County, Tennessee	18,129	54	46	51.1	0.6	0.2	0.5	2.6	1.1	4.2
Henderson County, Tennessee	27,952	10.9	89.1	9.4	0.6	0.2	0.1	0.9	2.1	2.2
Henry County, Tennessee	32,291	10.4	89.6	8.9	0.8	0.4	0	0.2	1.2	2.2
Hickman County, Tennessee	24,251	8.2	91.8	5.4	1.5	0.2	0	1.1	1.9	2.2
Houston County, Tennessee	8,234	5.6	94.4	4.3	1.3	0.3	0	0	1.9	2.1
Humphreys County, Tennessee	18,216	5.4	94.6	3.8	1.2	0.3	0.1	0.5	0.9	2.1
Jackson County, Tennessee	11,526	2.9	97.1	0.7	1.4	0.1	0	0.7	2.2	1.8
Jefferson County, Tennessee	52,851	4.9	95.1	2.9	0.9	0.3	0.1	0.9	1.6	3.4
Johnson County, Tennessee	17,923	6.8	93.2	4.4	1.5	0.3	0	0.9	1.4	1.8
Knox County, Tennessee	448,164	14.4	85.6	10	0.9	2.5	0.2	1.1	2.1	3.8
Lake County, Tennessee	7,643	31.6	68.4	29.8	0.6	0.5	0.1	1	1.4	2.1
Lauderdale County, Tennessee	27,261	38.2	61.8	35.6	1	0.7	0.1	1.2	1.6	2.4
Lawrence County, Tennessee	42,406	4.8	95.2	2.2	1	0.7	0.1	1	1.3	1.9
Lewis County, Tennessee	11,907	5.1	94.9	2.4	0.2	2	0	0.8	1	2.2
Lincoln County, Tennessee	33,582	10.7	89.3	6.2	3.6	0.3	0	1.2	4.2	3.1
Loudon County, Tennessee	50,637	5	95	1.8	0.8	0.9	0.1	1.5	1.4	7.9
Macon County, Tennessee	22,924	2	98	0.5	0.7	0.1	0	0.7	0.9	4.8
Madison County, Tennessee	98,128	40.4	59.6	38.1	0.6	1.3	0	0.5	1.4	3.6
Marion County, Tennessee	28,363	6.5	93.5	2.1	3.5	0.7	0.1	0.3	3.8	1.7
Marshall County, Tennessee	31,335	10	90	7.7	0.9	0.8	0	0.7	1.5	4.8
Maury County, Tennessee	85,767	15.9	84.1	13	0.8	1.1	0	1.2	2.1	5.3
McMinn County, Tennessee	52,606	7.1	92.9	4.5	1.2	0.9	0.1	0.6	2.1	3.6
McNairy County, Tennessee	26,057	8.1	91.9	6.7	0.8	0.3	0	0.3	1.6	1.9
Meigs County, Tennessee	11,804	3.8	96.2	2.7	1.4	0.2	0	0	2.3	1.5
Monroe County, Tennessee	45,482	4.9	95.1	2.6	1.5	0.6	0.2	0.2	1.5	3.9
Montgomery County, Tennessee	189,709	28.4	71.6	21.8	1.4	3.6	0.7	2.1	4.2	9.5

Appendix D3: Environmental Justice

Minority Populations in the TVA Service Area

Geography	2016 Population	% Minority Pop.	% White Alone	% Black/African American	% American Indian/Alaska Native	% Asian	% Native Hawaiian/Other Pacific Islander	% Some Other Race Alone	% Two or More Races	% Hispanic/Latino of Any Race
Moore County, Tennessee	6,314	6.1	93.9	3.5	2.4	0	0	0.1	1	0.3
Morgan County, Tennessee	21,688	5.7	94.3	4.9	0.5	0.1	0.1	0.3	0.6	1.1
Obion County, Tennessee	30,900	14.3	85.7	11.5	0.6	0.4	0	1.8	1.9	3.8
Overton County, Tennessee	22,090	2.3	97.7	1	0.9	0.7	0	0.2	1.2	1.3
Perry County, Tennessee	7,891	5.2	94.8	3.3	1.6	0.2	0	0.2	1.7	2.2
Pickett County, Tennessee	5,096	2.6	97.4	0.9	1.7	0	0	0	1.9	0.6
Polk County, Tennessee	16,697	3.1	96.9	0.4	1.8	0.3	0	0.7	1.9	1.8
Putnam County, Tennessee	74,652	5.6	94.4	2.7	0.8	1.6	0.2	0.5	1.7	5.8
Rhea County, Tennessee	32,461	5.1	94.9	3.1	1.1	0.3	0.1	0.8	1.8	4.4
Roane County, Tennessee	52,983	5.5	94.5	3.3	1.1	0.8	0	0.4	2	1.6
Robertson County, Tennessee	67,905	11.5	88.5	8.2	0.7	0.7	0	2	1.6	6.1
Rutherford County, Tennessee	290,289	20.8	79.2	15.2	1	3.8	0.2	1.1	2.9	7.2
Scott County, Tennessee	22,029	1.8	98.2	0.8	0.8	0.1	0	0.1	0.9	0.7
Sequatchie County, Tennessee	14,710	11.2	88.8	1.4	9.5	0.6	0	0.3	10.1	3.4
Sevier County, Tennessee	94,537	5.4	94.6	1.3	0.9	1.4	0	1.9	1.6	5.4
Shelby County, Tennessee	936,990	60.4	39.6	54.2	0.7	2.9	0.2	3	1.7	6
Smith County, Tennessee	19,176	5	95	3.1	1	0.1	0	0.9	1.2	2.5
Stewart County, Tennessee	13,257	6.5	93.5	2.4	1.7	1.3	0.6	1.4	3.3	2.5
Sullivan County, Tennessee	156,644	5.3	94.7	2.9	0.9	0.9	0.1	0.8	1.9	1.7
Sumner County, Tennessee	172,786	11.3	88.7	7.6	0.7	1.7	0.1	1.2	1.8	4.3
Tipton County, Tennessee	61,558	21.9	78.1	19.4	0.9	1	0.4	0.4	1.7	2.6
Trousdale County, Tennessee	7,970	13.9	86.1	11.8	0.2	2	0	0	0.6	0.4
Unicoi County, Tennessee	17,945	2.5	97.5	1	0.3	0.5	0	0.7	0.6	4.3
Union County, Tennessee	19,081	2	98	0.5	1.2	0.3	0	0.2	1.2	1.5
Van Buren County, Tennessee	5,641	3.4	96.6	0.4	2.1	0.1	0	0.7	2.9	0.9
Warren County, Tennessee	40,099	8.1	91.9	1.7	3	0.9	0.1	2.7	3.8	8.5
Washington County, Tennessee	126,044	8.1	91.9	5.1	0.9	1.7	0.1	0.6	1.8	3.2
Wayne County, Tennessee	16,842	8.3	91.7	6.9	0.5	0.4	0	0.5	0.4	1.9
Weakley County, Tennessee	34,024	11.1	88.9	9.8	0.8	0.2	0	0.5	1.6	2.2
White County, Tennessee	26,373	3.8	96.2	2.9	0.8	0	0	0.1	1.9	2.3
Williamson County, Tennessee	205,645	10.5	89.5	4.8	0.5	4.4	0.1	0.9	1.6	4.6
Wilson County, Tennessee	125,616	11.5	88.5	7.4	0.9	1.9	0.2	1.4	1.5	3.7
Bristol city, Virginia	17,340	10.7	89.3	8	0.5	0.7	0	2	1.8	2
Lee County, Virginia	24,911	6.5	93.5	4.3	0.6	0.7	0	1.3	0.8	1.8
Norton city, Virginia	3,978	12.8	87.2	7.7	0.1	3.3	0	1.7	1.7	2.6
Scott County, Virginia	22,378	1.9	98.1	1.1	0.5	0.3	0	0.1	0.7	1.3

Appendix D3: Environmental Justice
Minority Populations in the TVA Service Area

Geography	2016 Population	% Minority Pop.	% White Alone	% Black/African American	% American Indian/Alaska Native	% Asian	% Native Hawaiian/Other Pacific Islander	% Some Other Race Alone	% Two or More Races	% Hispanic/Latino of Any Race
Washington County, Virginia	54,562	3.7	96.3	1.8	0.6	0.6	0.1	0.8	1.2	1.4
Wise County, Virginia	40,074	7.4	92.6	6	0.5	0.6	0.1	0.4	1.2	1.2

E

Appendix E – Environmental Parameters of the 30 Capacity Expansion Plans

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Appendix E – Environmental Parameters of the 30 Capacity Expansion Plans

Total 2019 – 2038 SO_2 Emissions, tons

	Scenario					
Strategy	1	2	3	4	5	6
A	212,791	173,865	201,770	120,378	83,695	220,429
B	211,490	173,002	207,120	120,972	83,828	218,368
C	205,468	170,291	208,851	122,414	86,254	154,332
D	209,625	169,525	214,745	121,175	83,645	161,583
E	208,831	168,353	210,440	122,084	86,561	160,313

Total 2019 – 2038 NOx Emissions, tons

	Scenario					
Strategy	1	2	3	4	5	6
A	182,944	156,647	197,423	127,796	99,003	189,830
B	182,004	156,281	199,118	126,604	99,113	188,067
C	182,543	154,077	216,288	127,898	100,231	162,428
D	180,028	153,678	199,813	127,246	98,789	158,345
E	179,993	152,765	200,771	127,893	100,491	158,249

Total 2019 – 2038 Mercury Emissions, pounds

	Scenario					
Strategy	1	2	3	4	5	6
A	4,866	3,571	4,688	2,309	1,591	5,195
B	4,818	3,561	4,831	2,308	1,594	5,150
C	4,617	3,482	4,873	2,345	1,611	4,218
D	4,747	3,439	5,100	2,321	1,528	4,582
E	4,739	3,436	4,939	2,326	1,620	4,521

Total 2019 – 2038 CO2 Emission, thousand tons

	Scenario					
Strategy	1	2	3	4	5	6
A	864,604	729,737	1,046,760	615,338	466,348	910,391
B	858,708	729,865	1,043,353	601,694	467,291	897,037
C	846,625	713,598	1,065,086	610,588	463,360	850,544
D	847,283	711,717	1,055,574	607,700	455,048	874,350
E	846,566	706,568	1,052,059	611,374	465,636	871,235

Average Annual CO2 Emission Rate, pounds/MWh

	Scenario					
Strategy	1	2	3	4	5	6
A	543	491	554	426	364	570
B	539	491	553	418	364	562
C	533	480	563	423	361	533
D	534	478	559	421	355	549
E	532	476	558	424	362	546

Average Annual Water Use, billion gallons

	Scenario					
Strategy	1	2	3	4	5	6
A	3,283,787	3,030,727	3,281,329	2,733,646	2,575.906	3,054,300
B	3,273,741	3,029,930	3,307,202	2,732,460	2,577,335	3,042,652
C	3,224,365	3,004,208	3,301,904	2,739,991	2,569,121	2,906,349
D	3,261,849	2,995,082	3,359,382	2,729,968	2,546,023	2,985,662
E	3,254,429	2,992,770	3,328,391	2,737.506	2,567,976	2,969,164

Average Annual Water Consumption, million gallons

	Scenario					
Strategy	1	2	3	4	5	6
A	54,053	51,136	58,823	50,276	45,678	51,895
B	53,958	51,133	58,675	48,706	45,697	51,637
C	53,353	50,708	57,456	48,878	45,582	51,878
D	53,746	50,658	58,999	48,627	45,402	51,363
E	53,719	50,569	58,843	49,087	45,640	51,304

Total 2019 – 2038 Coal Consumption, million tons

	Scenario					
Strategy	1	2	3	4	5	6
A	124.9	100.9	126.9	61.2	54.8	130.2
B	124.1	100.7	129.0	61.1	54.8	129.2
C	120.2	99.7	131.7	60.7	53.5	130.2
D	122.4	99.9	133.1	58.3	51.6	134.2
E	122.3	98.9	130.9	60.4	53.9	133.1

Appendix E - Environmental Parameters of the 30 Capacity Expansion Plans

Total 2019 – 2038 Gas Consumption, billion standard cubic feet

	Scenario					
Strategy	1	2	3	4	5	6
A	5,746	5,219	8,840	5,418	3,783	6,200
B	5,684	5,249	8,809	5,196	3,797	6.034
C	5,736	5,082	8,774	5,347	3,769	6,075
D	5,569	5,094	8,505	5,403	3,784	6,141
E	5,575	5,023	8,607	5,379	3,798	6,180

Total Waste (Coal Combustion Residuals) Production, thousand tons

	Scenario					
Strategy	1	2	3	4	5	6
A	45,373	37,299	45,664	25,432	23,532	47,413
B	45,111	37,214	46,370	25,416	23,524	47,071
C	43,920	36,867	47,251	25,320	23,248	45,996
D	44,582	36,982	47,721	24,694	22,747	47,347
E	44,548	36,614	47,005	25,200	23,336	46,946

Total 2019 – 2038 Ash Production, thousand tons

	Scenario					
Strategy	1	2	3	4	5	6
A	25,749	22,307	25,592	16,629	15,648	26,348
B	25,644	22,264	25,932	16,619	15,647	26,208
C	25,144	22,098	26,366	16,586	15,552	24,935
D	25,445	22,162	26,498	16,315	15,339	25,445
E	25,388	21,970	26,199	16,535	15,591	25,291

Total 2019 – 2038 FGD Material Production, thousand tons

	Scenario					
Strategy	1	2	3	4	5	6
A	19,624	14,992	20,072	8,803	7,884	21,065
B	19,467	14,950	20,438	8,797	7,887	20,862
C	18,776	14,769	20,885	8,734	7,697	21,061
D	19,137	14,820	21,223	8,378	7,408	21,902
E	19,160	14,644	20,806	8,665	7,744	21,654

Appendix E - Environmental Parameters of the 30 Capacity Expansion Plans

Land Use, acres

	Scenario					
Strategy	1	2	3	4	5	6
A	43,365	41.245	59,647	58,400	32,850	51,730
B	33,145	18,980	59,627	58,400	32,850	51,710
C	56,570	54,810	59,679	58,464	47,502	59,711
D	59,034	58,560	60,091	58,560	58,560	59,189
E	38,759	58,464	59,637	58,464	58,464	59,074

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Appendix F – 2019 IRP - Comment Response Report

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Appendix F Responses to Comments

F.1 Introduction

The Draft Integrated Resource Plan (IRP) and Environmental Impact Statement (EIS) were released on February 15, 2019, and the formal notice of their availability was published in the Federal Register on February 22, 2019. This initiated the public comment period which closed on April 8, 2019. IRP Chapter 3 includes a detailed description of the efforts by TVA to engage the public, as well as government agencies, of the availability of the Draft IRP and EIS and encourage them to review and comment on the documents. TVA also held a series of public meetings to describe the project and to accept comments on the Draft IRP and EIS. Details of these meetings are also provided in IRP Chapter 3.

TVA received about 300 comment submissions which included letters, emails, form emails, comment cards at public meetings, petition-style submissions, and submissions through the project website. The comment submissions were signed by about 1,270 people and organizations. These comment submissions were carefully reviewed and synthesized into about 300 individual comment statements. This appendix provides these comment statements and TVA's responses to them. The comments and responses are categorized into six broad topics. Most of these topics are further categorized into more specific issues.

About 1,000 individuals submitted comments as part of organized campaigns. Fifteen of these were participants in one campaign; the organizers of this campaign were not identified. Their comment submission is identified below as Form 1. The remaining individuals participated in a campaign organized by the Tennessee Chapter of The Sierra Club by signing an online form. Each of these sets of identical or nearly identical comments is treated as a single comment submission in this appendix. Within the Sierra Club campaign, 445 of the participants added additional text to their form comments. When the content of this text addressed topics not included in the form comment, it was treated as an individual comment.

The most frequently mentioned topics in the comments included preferences for increased use of renewable energy, reduced use of fossil-fuel generation, and increased energy efficiency efforts. Many commenters also requested that TVA take more aggressive steps to reduce greenhouse gas emissions. A large proportion of the more detailed, technical comments addressed modeling data inputs and assumptions about pricing of a wide range of energy resources, particularly for renewable generation, energy efficiency, and energy storage. Several of the more detailed, technical comments also addressed the metrics, particularly the financial and land use metrics, preparations for large numbers of electric vehicles, and customer adoption of distributed energy resources. Other comment topics included editorial changes to the IRP and EIS documents, the overall planning process, public involvement, and the importance of cost and reliability.

F.2 Responses to Comments

F.2.1 Editorial Comments

F.2.1.1 Draft EIS

1**.** The discussion of hydroelectric generation in Section 2.3.5 should define the timeline to fully complete the Hydro Modernization Program, describe how many of the remaining 69 conventional hydroelectric unit need to be modernized, and explain how these efforts are considered in the alternative strategies and scenarios. (*Commenter: Kendra Abkowitz – Tennessee Department of Environment and Conservation*)

Response: All IRP portfolios reflect investing in and maintaining TVA's existing hydroelectric fleet. Additionally, TVA is in the process of making improvements and uprates to the Raccoon Mountain Pumped Storage Plant which will yield an additional 76 MW of pumped storage capacity; completion of this work is assumed in all cases. TVA has completed 60 hydro unit modernization projects out of 109 conventional hydro units. TVA plans to modernize two to three units per year, and the program is perpetual in nature to maintain capacity and improve efficiency over time. Final EIS Section 2.3.5 and IRP Section 5.2.1.5 have been updated to include this additional information.

2. We recommend that an editorial revision be made to include the word "lead" in the text providing the National Ambient Air Quality Standards criteria pollutants on Page 4-1 of Section '4.2.2 Criteria Air Pollutants', in the first sentence of the first paragraph following the (CO) where "/l," is provided likely referring to "lead" . (*Commenters: Kendra Abkowitz – Tennessee Department of Environment and Conservation, John Shaw*)

Response: Section 4.2.2 of the Final EIS has been revised to correct this error.

3. We recommend that EIS Sections 4.2.2 on Criteria Air Pollutants and 4.3.2 on Greenhouse Gas Emissions explain the primary sources for these emissions in in the region. According to data from the 2014 National Emissions Inventory, on-road vehicles produce more than half (52%) of all NOx emissions in Tennessee (147,638 tons per year) and non-road vehicles produce 9% of all NOx emissions in Tennessee (25,953 tons per year). According to 2016 data from the U.S. Energy Information Administration, transportation comprises 42.4% of Tennessee's CO_2 emissions from fossil fuel consumption and is the largest CO_2 emitter of all end-use sectors in the state. Describing the sources of these emissions would enable the description of the emissions benefits of transportation electrification in its various IRP strategies. (*Commenter: Kendra Abkowitz – Tennessee Department of Environment and Conservation*)

Response: Section 4.2.2 of the Final EIS has been revised to describe the primary regional sources of these emissions.

4. We recommend that EIS Section 5.5.1 - Environmental Impacts of Alternative Strategies and Associated Capacity Expansion Plans: Air Quality address the impact on PM2.5 and PM10 emissions. (*Commenter: Kendra Abkowitz – Tennessee Department of Environment and Conservation*)

Response: Thermal generating facilities emit PM2.5 and PM10 from the combustion of fuel and the operation of evaporative cooling towers. Among fossil-fueled generating facilities, the PM emission rate is higher for coal-fired facilities than for natural gas-fired facilities. Electric utilities, however, produce a small proportion of overall PM emissions, approximately 1.3 percent of statewide PM10 emissions and 3.5 percent of statewide PM2.5 emissions in Tennessee in 2014 (USEPA National Emission Data). More recent 2017 USEPA data (from its trends data set) does not include all sectors of emissions, such as mobile source emissions on roads and emissions from off-road equipment activity. The trends in future PM emissions for each alternative strategy are expected to roughly parallel the trends in CO_2 emissions, as both pollutants are primarily a result of fuel combustion (cooling tower PM is a minor contribution). Because of the very small proportion of regional PM emissions produced by TVA generating facilities, the beneficial impacts of any future reductions in TVA PM emissions are likely to be very small at a regional level.

5. 4.4.1 Groundwater: Ongoing investigations outlined in TDEC Commissioner's Order OGC15 - 0177 (referenced in Draft EIS, page 4-75) and ongoing litigation related to the Gallatin Fossil Plant (referenced in Draft EIS, page 4-25) have resulted in data for select referenced fossil plant site conditions that do not concur with statements included in the Draft EIS. The following are from Draft EIS Section 4.4.1 - Groundwater:

4.4.1.3 Causes of Degraded Groundwater Quality states "Storage of waste in unlined landfills and surface impoundments may result in direct contact between the waste material and groundwater..." Data provided to TDEC under the authority of OGC15-0177 and Agreed Temporary Injunction No. 15-23-IV confirms waste material is in direct contact with groundwater at TVA's fossil plants sites in Tennessee. This is applicable for storage of waste in unlined landfills and surface impoundments.

Response: While TVA agrees that stored CCR material may come in contact with groundwater in some cases, TVA does not believe this statement can yet be made firmly and universally for all storage of waste in unlined landfills and surface impoundments until the ongoing investigations obtain additional data.

4.4.1.4 Groundwater at Facilities Considered for Future Retirement: For Gallatin Fossil Plant, states "Features characteristic of karst development, such as sinkholes, have been observed in specific areas of Gallatin, but there does not appear to be significant groundwater flow conduit." Data provided to TDEC under the authority of the Agreed Temporary Injunction No. 15-23-IV does not lead to this statement being appropriate nor representative of the site's geologic setting nor the documented hydrology. The Non - Registered Site (NRS) at Gallatin does not have an IDL designation. The reference should be referenced as NRS - 83-1324.

Response: The referenced hydrographs and water level data provided to TDEC demonstrate little relationship between water elevation in the ponds and in groundwater monitoring wells, indicating poor hydraulic communication. Therefore, the leakage at Gallatin Fossil Plant is caused by slow seepage from the ponds rather than a strong hydraulic connection such as a pipe-like connection through karst features. The reference to the NRS at Gallatin has been updated in EIS Section 4.4.1.4.

Section 4.4.1.4 states, for Gallatin Fossil Plant, "an [Alternate Source Demonstration] ASD was performed by TVA in 2018 and the source of SSIs for boron and chloride was determined to be the multi-unit Coal Combustion Residuals (CCR) unit". This is relevant to an ASD under authority of the Federal CCR rule. A demonstration in accordance with the State's regulations has not been provided. Given that leachate from the North Rail Loop (NRL) landfill is discharged to the multi-unit CCR unit under a NPDES permit the ASD is conflicted.

Response: Regarding EIS Section 4.4.1.4, the Federal CCR Rule, which has specific requirements apart from state regulations, required that TVA perform an ASD for the NRL. Because the ASD was based on a pre-waste dataset when leachate was not being generated, the conflict of leachate being discharged into the multi-unit CCR unit does not exist, at least for this dataset. TVA acknowledges that the leachate currently discharges to the identified "alternate source", and has rerouted the leachate discharge and eliminate wastewater flows to the Ash Pond Complex. Under the authority of the NRL landfill permit, TDEC has requested that TVA submit either an ASD or an Assessment Groundwater Monitoring Plan under the state monitoring program for the permitted NRL landfill. TVA is working through this process with TDEC and will be submitting the requested documentation for TDEC's review.

Section 4.4.1 does not provide statements regarding groundwater quality for all fossil plant sites. Several of the sites have unlined landfills and surface impoundments with established groundwater monitoring programs. TDEC encourages TVA to provide rationale for this information not being addressed. (*Commenter: Kendra Abkowitz – Tennessee Department of Environment and Conservation*)

Response: Groundwater quality at the Paradise and Bull Run fossil plants was described in environmental assessments that were issued in February 2019 for the retirements of these plants. These EAs are incorporated in the IRP EIS by reference. The IRP EIS describes groundwater at the other currently operating TVA coal-fired plants (Cumberland, Gallatin, Kingston, and Shawnee).

6. 4.7.1 Coal Combustion Solid Wastes: TVA's Draft EIS states that "Two of the six facilities (Bull Run and Kingston) have been converted to dry storage and disposal, while three more facilities (Cumberland, Gallatin, and Shawnee) are projected to complete the conversion by October 2020." TDEC compliments TVA's actions in adopting this operating standard goal. TDEC appreciates TVA's support in preparation of the annual status report documenting progress toward this goal under the authority of Senate Joint Resolution No 784. (*Commenter: Kendra Abkowitz – Tennessee Department of Environment and Conservation*)

Response: Comment noted.

7. 4.7.3.2 Gallatin Fossil Plant: TVA's document states "If closed in place, the CCR pond closure would require decanting, subgrade preparation final cover system installation, and establishment of vegetative cover." TDEC suggests TVA consider adding the processes of dewatering and waste stabilization to this statement for consistency with other CCR surface impoundment closures. (*Commenter: Kendra Abkowitz – Tennessee Department of Environment and Conservation*)

Response: TVA acknowledges and agrees with this comment. Changes have been made in Section 4.7.3.2 of the Final EIS that obviate the need for this correction in the text.

8. EIS Appendix B - Solid and Hazardous Waste: We encourage TVA to verify the forecasted ash production at the Bull Run Fossil Plant and clarify whether this forecast accounts for plant retirement. (*Commenter: Kendra Abkowitz – Tennessee Department of Environment and Conservation*)

Response: EIS Appendix B has been revised per the comment.

9. As Section 4.4 - Water Resources notes, the potential impacts to water resources with exception of cooling water, are generally greater from coal-fired generation than other types of generation due to production of various liquid waste streams. TDEC appreciates the considerations given for intake structures that should minimize adverse effects to aquatic life and wastewater discharges that should minimize adverse effects of heat on aquatic life. TDEC will continue to work with TVA as the strategies move from the planning phase to implementation phase. (*Commenter: Kendra Abkowitz – Tennessee Department of Environment and Conservation*)

Response: Comment noted.

10. TVA must consider and report the full range of effects of the proposed alternatives. The Draft IRP identifies six different future scenarios that represent "a plausible, meaningful future," and are therefore reasonably foreseeable. The Draft IRP presented results for each strategy (e.g., alternative) across each plausible future to create a range of outcomes. An additional outcome of the Draft IRP is an assessment of the environmental effects from applying each strategy in each plausible future. Thus, the IRP produced a range of reasonably foreseeable environmental effects that could result from the adoption of each strategy. Rather than disclosing and analyzing the range of foreseeable environmental effects for each strategy, however, the Draft EIS focuses on the average impact associated with each strategy.

To illustrate this issue, the Strategy B - Promote DER is modeled for each of the six possible futures, and the results of each of those six modeling runs produced different environmental effects. For CO_2 emissions, the results of this modeling are presented in a graph in Draft IRP Appendix I that shows the trends in CO_2 emissions over the planning period for each scenario under Strategy B. The Draft EIS, however, only shows the trend in CO_2 emissions over time as the average of the six scenarios under Strategy B.

Although the Draft EIS vaguely acknowledges that each strategy would have different environmental effects depending on the future, the approach used in the Draft EIS fails to disclose and consider the reasonably foreseeable environmental effects of the alternatives. This problem is amplified by the failure of the Draft IRP and Draft EIS to identify which scenarios are more plausible than others. For example, CO_2 emissions are generally the highest for each strategy under Scenario 1 - Valley Load Growth and lowest under Scenario 5 - Rapid DER adoption.

The averaging of environmental effects across scenarios also leads to the situation where a single event that occurs in a single scenario substantially alters the results. For example, the Draft EIS notes that “Between 2035 and 2038, the strategies show overall increases in CO_2 emissions and emission rates.” However, that increase is “largely due to increased fossil-fueled generation following the retirement of the three Browns Ferry Nuclear Plant units” in Scenario 6 - No Nuclear Extensions. Thus, the averaged results for all strategies show an uptick in CO_2 emissions between 2035 and 2038. That result is misleading, however, because it does not represent the CO_2 emissions trend seen in any of the scenarios aside from the No Nuclear Extensions scenario. For example, the CO_2 emissions for Promote DER (strategy B) trends consistently downward for in all possible future scenarios, except for the No Nuclear Extensions and Valley Load Growth scenarios.

An additional problem with the averaging of the environmental effects is that it appears to lead to lower overall estimated environmental effects. We compiled the projected CO_2 emissions in the year 2039 and compared these with the emissions in the Draft EIS. The Draft EIS consistently presented lower CO_2 emissions that those projected for the Current Outlook scenario in the Draft EIS. Due to data transparency issues, we were unable to similarly compare emissions of conventional pollutants but anticipate the same trend of lower emissions presented in the Draft EIS. (*Commenter: Christina Reichert – Southern Environmental Law Center*)

Response: The charts in Draft EIS Section 5.5 illustrate the environmental effects of the alternative strategies by using the averages of the values for the six scenarios associated with each strategy. For total amounts during the 20-year planning period, the maximum and minimum values of the scenarios associated with each strategy are also illustrated and the particular strategies associated with each maximum and minimum value are identified in the associated text. This approach is used because, as explained in more detail in final IRP Section 6.1.2, each scenario is considered to be equally plausible. The Final EIS contains the new Appendix E which lists the quantities of air emissions, water use and consumption, coal solid waste production, coal and natural gas consumption, and land use for each combination of strategy and scenario.

11. The Draft EIS must supplement the detailed environmental effects presented in the Draft IRP Appendix I because the Draft IRP focuses on the select group of effects used as environmental metrics. Consequently, neither the Draft IRP nor the Draft EIS present scenario-specific information for many other environmental effects “such as air quality impacts from hazardous pollutants or pollutants regulated under the National Ambient Air Quality Standards program, and water quality impacts” that must be considered under NEPA. The full environmental effects from the different strategies in the Draft IRP therefore remain unknown. (*Commenter: Christina Reichert – Southern Environmental Law Center*)

Response: Appendix E of the final EIS contains the strategy- and scenario-specific quantities of SO2, NOx, and mercury emissions, water use, coal and natural gas consumption, and coal ash and FGD residue production.

12. The Draft EIS provides an incomplete programmatic view of potential environmental effects of the alternative strategies evaluated in the Draft IRP. TVA proposes to address more site-specific effects in subsequent reviews tiered from the Final EIS. "Tiering" involves covering broader environmental effects in a more programmatic EIS, followed by detailed site-specific assessments in narrower NEPA analyses that also incorporate by reference the discussions of the programmatic EIS. Although tiering to a programmatic document can sometimes be appropriate, tiering requires adequate analysis of effects. Because the Draft EIS fails to adequately consider indirect effects, TVA cannot tier its site-specific analysis onto this EIS. If TVA remedies the flaws in the Draft EIS, it would need to conduct site-specific analysis at a later date because the Draft EIS fails to adequately address site-specific effects. (*Commenter: Christina Reichert – Southern Environmental Law Center*)

Response: The Draft (and Final) EIS discuss the direct and indirect effects, to the extent they are discernable, of the various energy resource options in Section 5.2 for supply-side energy resource options and in Section 5.3 for energy efficiency and demand response resource options. As stated in the EIS and in the comment statement, TVA will conduct tiered NEPA reviews for future site-specific actions to implement the IRP. These reviews will include analyses of the site-specific effects of those proposed actions, tiering from this IRP EIS only to the extent that the information necessary to conduct any site-specific analysis is already covered in the EIS.

13. The analysis of the effects of TVA GHG emissions in the Draft EIS is inadequate and violates NEPA. TVA claims that because its overall contribution to GHG emissions is relatively "small" as a part of global emissions, the effects of its decision-making on "climate in the TVA region and elsewhere would be small and difficult to quantify." This does not provide the required robust consideration of the impacts of a project's GHG emissions in terms of its relationship to climate change. The impacts of GHG emissions could be better quantified by considering the social cost of carbon. At present, TVA applies a "carbon penalty," with a significantly lower cost than even USEPA estimates in the social cost of carbon, to two scenarios. In recent years, courts has also consistently required federal agencies to consider GHG emissions and costs for the mere sale of fossil fuels, rejecting agency arguments that the connection between the agency decision at issue and the subsequent emissions is too uncertain and attenuated to require NEPA consideration. (*Commenter: Howard Crystal – Center for Biological Diversity*)

Response: TVA has considered a cost of carbon in the Decarbonization scenario. As discussed in IRP Chapter 8, an additional sensitivity analysis conducted after issuance of the draft IRP and EIS included consideration of more stringent carbon penalties. In this sensitivity analysis, coal retirements occur earlier and total CO_2 emissions are lower over the study period. A sensitivity considering the potential for higher operating costs for coal plants was also conducted, indicating some coal retirements in that case. The IRP Recommendation reflects the potential for more than 2 GW of additional coal retirements beyond those already approved by the TVA Board.

The overarching principle in the design of scenarios was to ensure a wide range of possible outcomes. The Decarbonization scenario represents a plausible future in which a CO_2 emission penalty is applied to the utility industry in an effort to curb greenhouse gas emissions. This CO_2 penalty was based on the Minnesota Public Utilities Commission (PUC) Notice of Updated Environmental Externality Values (June 16, 2017). The notice states "the Commission established an estimate of the likely range of costs of future carbon dioxide regulation on electricity generation of $9/ton to $34/ton for CO_2 emitted in 2022 and thereafter." A few other states (Colorado, New York, Illinois) decided to integrate social cost of carbon estimates into utility planning around this same time period. TVA's 2019 IRP scenario development began in November 2017, shortly after this information became available.

Based on this information, TVA used an average of $22/ton of CO_2 derived from the $9/ton to $34/ton range used by the Minnesota PUC, but used 2025 as the starting year based on regulatory development timelines extending from the date of the proposed regulation or legislation to the effective date of the final regulation or the enacted law. Since the scenario was originally developed, the Minnesota PUC published an updated order on January 3, 2018. The updated CO_2 cost values in 2025 are from $10.07 to $46.96/ton (2015$). Due to comments received from the IRP Working Group and the public at large after release of the draft IRP, TVA conducted a sensitivity analysis on the carbon penalty in the Decarbonization scenario by doubling the $22/ton penalty to $44/ton beginning in 2025. This sensitivity aligns to the latest update from the Minnesota PUC, which is largely based on the Federal Social Cost of Carbon of $42/ton in 2020 rising to $60/ton by 2040, which included information from the IPCC. The Valley Load Growth scenario represents a plausible future in which rapid economic growth, technology-driven investments, and a rapid pace of electric vehicle adoption raise electricity use and result in higher energy sales. The CO_2 penalty used in the Valley Load Growth scenario is roughly one-fourth of the Decarbonization scenario and represents a proxy for policy actions that future administrations may undertake as the robust economic situation provides the means to pay for the societal preference for lower emissions.

Alternatively, there are other ways to consider climate change and the potential impacts of GHG emissions. In Section 5.5.2 of the EIS, TVA's analysis incorporates the use of projected GHG emissions associated with the alternative strategies as a proxy for assessing the strategies' potential effects on climate change. The statements on page 5-28 of the Draft EIS noted by the commenter are supported by TVA's analysis. The anticipated reduction of CO_2 emissions resulting from the alternative strategies would be significant, as documented in TVA's quantification of potential GHG emissions. Given the global scope of the impacts of GHG emissions, however, TVA is unable to link these reductions to any particular climate impact in a specific location or region. The EIS includes quantified estimations of greenhouse gas emissions (CO_2 averages and rates) resulting from implementation of each of the alternative strategies, as well as the estimated percent reduction over the 20-year life of the plan. The analysis also discusses how the changing climate would affect TVA's power system and identifies climate change risks relevant to the TVA system. TVA concludes in its analysis that each alternative strategy would result in "continued, significant, long-term reductions in CO_2 emissions from the generation of power marketed by TVA" (EIS Section 5.5.2.2).

14. Draft EIS Section 1.3.3, Power Generation, under Sequoyah Nuclear Plant Units 1 and 2 License Renewal Environmental Impact Statement (2011) states "Evaluated the operation of the two units for an additional 20 years to 2014-2014". The stated timeframe appears to be a typo. (*Commenter: John Shaw*)

Response: EIS Section 1.3.3 has been revised to correct the timeframe.

15. In Section 5.5.4.3, Impacts of Potential Facility Retirements the first sentence in the second paragraph is incomplete. It reads "Any lighting ballasts containing would be removed and properly disposed offsite during preliminary activities after power termination and during the early stages of demolition." (*Commenter: John Shaw*)

Response: Comment noted. EIS Section 5.5.4.3 has been revised to note that this statement refers to lighting ballasts containing mercury.

16. In Section 3.2.3, Potential Retirement of TVA Generating Facilities the key decommissioning activities do not include the removal of hazardous waste (currently stored in localized CCR landfills, gypsum landfills, etc.) to permitted long-term storage sites. Is this not considered a key activity for decommissioning of the fossil plants? (*Commenter: John Shaw*)

Response: The actions analyzed in the IRP EIS include the immediate decommissioning activities that would occur following the retirement of a fossil plant. Decommissioning and decontamination activities listed in EIS Section 3.2.3 do not include the closure of impoundments or ponds, which would be analyzed under a separate environmental review. Coal combustion residuals are managed at TVA facilities in accordance with the CCR Rule, TDEC Commissioner's Order No. OGC15-0177 (for plants in Tennessee except Gallatin) and all other applicable laws and regulations. If TVA chooses to retire the generating facilities identified within the IRP, additional NEPA reviews would be conducted for activities relating to demolition or potential reuse of the site based on considerations applicable at that time.

17. Section 4.2.7 Acid Deposition, second paragraph, last sentence should be revised to state "Emissions from utilities across the eastern US have also decreased significantly...". (*Commenter: John Shaw*)

Response: The text in EIS Section 4.2.7 has been revised as requested.

18. We question why Section 4.4.1.3, Causes of Degraded Groundwater Quality does not identify the failure of a landfill liner as one of the potential cause of degraded groundwater in the Waste Storage category. (*Commenter: John Shaw*)

Response: Text in EIS Section 4.4.1.3 has been revised per the comment.

19. Section 4.4.1.4, Groundwater Quality at Facilities Considered for Future Retirement, under "Kingston Fossil Plant," states "recent sampling activities in September 2018 at the Gypsum Disposal Facility indicated that concentrations for all Appendix I constituents were below the site-specific Groundwater Protection Standards." However, a check of the "2018 Annual Groundwater Monitoring and Corrective Action Report" dated January 31, 2019 indicates otherwise. In this report, Table 6A, Detection Monitoring Statistical Evaluation - Residuum, identifies statistically significant increases (SSI) over background for Boron and Fluoride in Well G-5A. SSI over background for pH is also identified in Wells G-5A and G- 7A. In Table 6B, Detection Monitoring Statistical Evaluation - Bedrock, identifies SSI over background for Boron, Calcium, Chloride, Sulfate, and total dissolved solids for Well G-5B. SSI over background is also identified in Well G-3B for Chloride. This seems to contradict the statement in the Draft EIS. (*Commenter: John Shaw*)

Response: EIS Section 4.4.1.4 uses information from two groundwater monitoring programs at Kingston Fossil Plant; this section has been revised to clarify report references and which data is derived from each program. Recent sampling activities documented in the September 2018 report are a state compliance report that does not contain sufficient data for boron, calcium, chloride, sulfate and TDS to do statistical comparisons. The 2018 Annual Groundwater Monitoring and Corrective Action Report, dated January 31, 2019, was prepared for compliance with the USEPA CCR Rule. The monitoring network established for CCR Rule compliance uses different upgradient wells than are used for the State program referenced in EIS Section 4.4.1.4. Therefore, the results of these reports cannot be statistically compared. Instead, EIS Section 4.4.1.4 has been revised to include additional information from the 2018 Annual Groundwater Monitoring and Corrective Action Report, dated January 31, 2019.

20. Section 4.4.2.4 should quantify the daily condenser cooling water discharge from Kingston Fossil Plant. The plant withdraws 1,107 MGD from the Clinch and Emory Rivers; however only about 21 MGD of discharges are from treated ash pond effluent and wastewater. The discharge point for the other over 1,000 MGD discharged daily is assumed to be Outfall 001, but this is unclear in the text. (*Commenter: John Shaw*)

Response: EIS Section 4.4.2.4 has been revised to clarify that approximately 1,096 MGD of condenser cooling water is discharged through Outfall 2.

21. Section 4.4.3.1, Groundwater Use indicates groundwater use for public water supply is greatest in West Tennessee and Northern Mississippi. Many smaller communities, especially in East Tennessee, have a higher percentage of citizens who rely on groundwater for their water supply because access to public water systems may not be readily available. (*Commenter: John Shaw*)

Response: Comment noted. The Groundwater Use section of the EIS focuses on the quantities of groundwater withdrawn for various uses and does not distinguish the percentage of residents in an area who rely on groundwater as their source of drinking water.

22. Section 4.4.3.2, Surface Water Use identifies five counties accounting for "40 percent of all surface water public supply." Using this methodology minimizes the role of public water supplies in smaller communities. (*Commenter: John Shaw*)

Response: Text in EIS Section 4.4.3.2 has been revised per the comment.

23. Section 4.5.7 Land Use does not describe Prime Farmland and Forest Management at Facilities Identified for Potential Future Retirements. These resources should either be described or the text should state they would not be impacted by plant retirements. (*Commenter: John Shaw*)

Response: EIS Section 4.5.7 has been revised to state that plant retirements would not impact Prime Farmland and Forest Management in the vicinity of a retired facility.

24. Section 4.7.3.3, Kingston Fossil Plant states that per the currently approved TDEC closure plan, the Peninsula Disposal Area is to be left in place (i.e., permanently stored) with an engineered geomembrane, geocomposite drainage layer, protective soil layer, and vegetative cover. Why has removal and consolidation at a permitted storage site been removed from options for the Kingston Fossil Plant when it is still an option for other fossil plants potentially being retired? (*Commenter: John Shaw*)

Response: The Peninsula Disposal Area at Kingston Fossil Plant is permitted under TDEC Division of Solid and Hazardous Waste Management Permit IDL 730000211 as a storage site, and the permitting materials that are currently in effect have identified closure in place as the closure methodology. However, the CCR units at Kingston, including the Peninsula Disposal Area, remain subject to TDEC Commissioner's Order No. OGC15-0177, and the process under that order will result in a determination of the final closure methodology for the CCR units at Kingston. Thus, although closure in place is reflected in the current approved TDEC closure plan, that methodology is subject to revision pending the outcome of the ongoing investigation.

25. Section 4.7 Solid and Hazardous Wastes, Table 4-12 is described in the text as not including special projects such as large-scale renovations, demolitions, decommissioning and boiler cleaning that are considered non-routine. What accounts for the increase of 1.21 tons to 16.06 tons from 2016 to 2017 of hazardous wastes generated from coal plants? This needs to be explained in the text. (*Commenter: John Shaw*)

Response: In 2016, PAF generated 2.24 tons of hazardous waste. In 2017, PAF generated 88.9 tons of hazardous waste. This increase was from hazardous waste generated from a boiler chemical cleaning. Because the increase is attributed to boiler cleaning, which is defined in the text as non-routine, the quantity of hazardous waste generated at coal plants in 2017 has been revised to include only routine hazardous wastes. Special projects such as large scale renovations, demolitions, decommissioning and boiler cleaning are considered non-routine and are not reflected in this table.

26. We suggest that Section 5.2.4.1 Energy Storage Existing Facilities state the electricity generating capacity of the Raccoon Mountain facility: four generating units producing 1,652 MW. (*Commenter: John Shaw*)

Response: The generating capacity of the Raccoon Mountain facility is stated as 1,616 MW (net summer capacity) in EIS Section 2.3.5. The purpose of Section 5.2.4 is to provide a general description of the environmental impacts of energy storage facilities.

27. Please provide an acronym breakdown. (*Commenter: Joe Ozegovich*)

Response: A list of acronyms is provided at the beginning of Volume I.

28. Draft EIS Chapter 5 cites carbon emission rates for each resource except for renewables and biomass. Different units are used for coal, gas, and nuclear carbon emissions. This section should allow direct comparison between carbon emission rates of all energy resources using the same units (e.g., ton CO_2eq/GWh) and citing peer-reviewed references. (*Commenter: Jeanette Berry*)

Response: Emission rates for new supply-side energy resource options incorporated in the capacity expansion plans (portfolios) are listed in Table 5.1 and reported in tons CO_2/GWh for direct emissions (EIS Section 5.2). Life cycle GHG emission rates in Draft EIS Sections 5.2.1 (Fossil-fueled Generation), 5.2.2 (Nuclear Generation), and 5.2.3 (Renewable Generation) are reported in tons CO_2-eq/GWh, with the exception of hydroelectric generation. The sources of these emission rates are cited and are from peer-reviewed journal articles and national laboratory reports, which are typically peer-reviewed. When the original references use units other than tons CO_2-eq/GWh, these units are cited along with rates converted to tons CO_2-eq/GWh. The exception in the Draft EIS was for hydroelectric generation; Section 5.2.3 of the Final EIS has been revised by adding hydroelectric generation life cycle GHG emission rates in tons CO_2-eq/GWh units.

29. Section 5.2.1 states "The life cycle GHG emissions of TVA's nuclear plants have not been determined." The paragraph goes on to cite international reports where the data agree with the IPCC report on life-cycle carbon emissions. The introductory statement undermines the data that follows. It should be modified to reflect the range of carbon emissions based on the two uranium processing methods and reported in the recent international survey of nuclear life cycle studies reported by Warner and Heath 2012. This study reported a median GHG emission rate of 13.2 tons CO_2-eq/GWh (12 grams CO_2-eq/kWh). (*Commenter: Jeanette Berry*)

Response: The statement in EIS Section 5.2.2.1 is factually correct. Because the life cycle GHG emissions of TVA's nuclear plants have not been determined, Section 5.2.2.1 gives the median and interquartile range of life cycle GHG emissions reported by Warner and Heath (2012), as well as a discussion of the difference in life cycle emissions attributable to the uranium processing method based primarily on Fthenakis and Kim (2007). A majority of the nuclear plants included the study by Warner and Heath (2012) utilized uranium enriched by the less carbon intensive centrifuge process. Although Warner and Heath (2012) graphically show life cycle emissions broken down by the emission intensity of the primary source energy mix and enrichment method, they do not present discrete harmonized estimates for the different enrichment methods. The median life cycle GHG emission rate reported by Warner and Heath (2012) is similar to the rate projected by Fthenakis and Kim (2007) for nuclear plants utilizing fuel enriched by the centrifuge process. The only operating enrichment facility in the U.S. utilizes the less carbon intensive centrifuge method, as do most enrichment plants elsewhere. Therefore the emission rates reported by Warner and Heath (2012) are a reasonable approximation of future life cycle GHG emission rates of TVA nuclear plants.

30. Section 5.2.2 on new nuclear resources states that TVA completed an environmental report for a combined license application to the NRC for the construction and operation of a two-unit AP1000 nuclear plant on the Bellefonte site. Because no new nuclear power is added according to Draft IRP Appendix G: Capacity Plan Summary Charts, what is the status of this license application? (*Commenter: Jeanette Berry*)

Response: TVA requested the withdrawal of the Bellefonte license application in March 2016 and the NRC granted the withdrawal in November 2016.

31. Section 4.3.4 states “The policy includes the specific objective of stopping the growth in volume of emissions and reducing the rate of carbon emissions by 2020 by supporting a full slate of reliable, affordable, lower CO_2 energy-supply opportunities and energy efficiency.” It is the mass of emissions (e.g., tons CO_2) rather than the volume that causes environmental impact. Consider replacing the word ‘volume’ with ‘mass.’ (*Commenter: Jeanette Berry*)

Response: EIS Section 4.3.4 has been revised to replace the word volume with mass.

F.2.1.2 Draft IRP

32. TDEC recommends TVA note that Tennessee’s auto-industry has become increasingly committed to manufacturing electric drive components and vehicles for light-, medium-, and heavy-duty vehicle sectors. This should be noted for scenarios and strategies that promote increased investment in and adoption of transportation electrification. Please note the following excerpt from the Drive Electric Tennessee Electric Vehicle Roadmap, released by a consortium of electric vehicle advocates brought together by TVA and its vendor, Navigant:

'Although the Tennessee EV population in 2017 was less than 0.1% of the total light-duty vehicle market, the state is a growing center of R&D innovation in the vehicle electrification and manufacturing space. Tennessee ranks No. 1 in the nation for employment concentration of automobile and vehicle component manufacturing, and of the state’s three major automotive assembly plants, two are committed to producing EVs (the LEAF is assembled at Nissan’s Smyrna plant, and upcoming EV models will be produced at Volkswagen’s Chattanooga plant). Other automotive suppliers produce next-generation EV components for light-, medium-, and heavy-duty vehicles (e.g., DENSO in Maryville). Despite today’s low EV penetration, Tennessee has the automotive foundation to become an EV leader. Furthermore, future EV adoption will support jobs and opportunities in the state’s established automotive manufacturing sector.' (*Commenter: Kendra Abkowitz – Tennessee Department of Environment and Conservation*)

Response: TVA believes electrifying the transportation sector touches many aspects of the TVA mission of energy, environment and economic development. Utilizing electricity for transportation instead of petroleum-based fuels is a more efficient use of energy resources and could increase energy planning forecasts for TVA. Substituting electricity for transportation fuels also stands to greatly decrease emissions and improve local air quality compared to burning fossil fuels in internal combustion engines. Increased demand for electric transportation could increase in-Valley jobs for auto manufacturing, EV electric components and research investment. TVA included variations in pace of EV adoption and potential to impact manufacturing in the Valley across the scenarios. The highest level of EV adoption and manufacturing growth manifests itself in the Valley Load Growth scenario. Information on EV adoption and load growth in the commercial and industrial sectors can be found in IRP Appendix E, Figures E-4 and E-5.

33. We recommend TVA further clarify, define and share assumptions associated with the expansion of solar and the mix of roof top versus ground-mounted solar and utility-scale versus non-utility scale solar that comprises this expansion. Land use expansion due to solar is mentioned in the Draft EIS, but no clear projections were provided on projected generation mix from roof top units versus ground mounted or utility-scale versus non-utility scale solar. Incentivizing one type of solar versus the other could have land use impacts that differ significantly. (*Commenter: David Salyers – Tennessee Department of Environment and Conservation*)

Response: Figures 7-6 and 7-7 in Chapter 7 of the final 2019 IRP provide a breakdown of distributed solar and utility-scale solar capacity. Distributed solar is modeled as rooftop which is assumed to have no land use impact. Additional information related to forecasted capital costs for distributed and utility-scale solar prices can be found in IRP Appendix C, Figure C-7.

34. Electrification of the transportation sector has the potential to significantly impact energy demand and electricity markets in the future. The impacts of electrification will vary considerably depending on depth and breadth of market penetration, electric vehicle costs and electric vehicle infrastructure costs, as well as the timing of adoption, among

other factors. The Draft IRP considers multiple scenarios to understand these impacts, which are referenced in Table E-4. While we appreciate TVA's approach to this analysis, we believe that it would be helpful to include additional information regarding how assumptions for electric vehicle sales projections and subsequent energy demands are reached and then incorporated into scenario design. Specific examples where clarification would be helpful include:

For residential consumers, "energy usage is forecasted for space heating, air conditioning, water heating, and several other uses after accounting for changes in efficiency over time, appliance saturation and replacement rates, growth in average home size, and other factors." However, the U.S. Department of Energy notes that more than 80% of electric vehicle owners charge at home. A typical electric vehicle that uses 30 kWh for every 100 miles will use 4,500 kWh to drive 15,000 miles, which is approximately 43% of the amount of electricity used by the average single-family home within the U.S. over the course of a year. With an anticipated rise in electric vehicle adoption (Figure E-4), it is unclear whether this residential energy usage forecasting takes into account the increased use of electricity from residential charging. We recommend TVA provide additional discussion as to how residential charging is considered in the various scenarios and strategies.

Attributes of the Valley Load Growth scenario in Table 6-2 include "Lower battery prices due to economies of scale drive increased electrification of transportation, magnifying growth." Bloomberg New Energy Finance predicts that electric vehicles will reach price parity with their gasoline counterparts by 2025 and will become cheaper the following year. Based on this expected fall in battery prices, it is unclear why this attribute is confined to only this scenario. A strong federal push to curb greenhouse gas emissions under the Decarbonization scenario could be enhanced by a push to electrify the transportation sector. Similarly, the high penetration of distributed generation, storage, and energy management options under the Rapid DER scenario could complement an increase in transportation electrification, as electric vehicles pair well with and can leverage these DER technologies. We recommend TVA provide additional discussion pertaining to how electric vehicle battery price changes are factored into the various scenarios and consider language that distinguishes between low, medium, high, and exponential transportation electrification growth. We also recommend clarifying whether regional or Tennessee Valley trends, rather than national trends, are used to inform electric vehicle adoption projections.

Figure E-4 only shows light-duty electric vehicle sales projections for the "Current Outlook" and "No Nuclear Extension" scenarios. Please clarify only light-duty EV sales projections are shown, and why they are only for the two scenarios. (*Commenters: Jerry Peyton, David Salyers – Tennessee Department of Environment and Conservation*)

Response: TVA's underlying assumptions around electric vehicles (EV) reflect the broadly held industry assumptions around declining technology costs and increasing power density, but have been customized to reflect consumer preferences in the Valley. A typical charging curve was used in all scenarios, except as part of Strategy D, Promote Efficient Load Shape, as discussed in IRP Appendix C, Section C.1.2. Many of the variations between scenarios are a result of the broader economic environment, rather than the state of the technology.

TVA's Current Outlook scenario included only light duty electric vehicles because the markets for other electric vehicle types have not developed to the point that projections can be made with confidence. The Current Outlook load forecast, including EV projections, was also used in the No Nuclear Extensions scenario. TVA wanted to explore the impacts of broader EV growth, especially in the Valley Load Growth scenario in which rapid EV adoption is a key driver, therefore TVA expanded its projections for EVs in all other scenarios besides the Current Outlook and No Nuclear Extensions to also include medium and heavy duty as well as buses. Learnings from this effort are being incorporated into TVA's load forecasting processes.

35. Electric vehicles have the capability to serve as a distributed energy resource through both electric power generation and storage capabilities. Even without vehicle-to-grid power flows, the ability to flexibly manage charging for electric vehicles while still meeting customer requirements can provide a new kind of distributed resource for the grid. With this in mind, we recommend that TVA provide additional discussion regarding why Beneficial Electrification is incentivized at the "Base" level within the Promote DER strategy design in Figure 6-6.

Similarly, incentives for transportation fuel switching from gasoline/diesel to electric may be a factor in the Promote Resiliency strategy, as the diversification of transportation fuels can strengthen emergency preparedness and resiliency of the transportation sector and can bolster the fleet of electric vehicles that can be used for either electric power generation and/or storage capabilities. We recommend TVA provide additional discussion relating to why Beneficial Electrification is incentivized at the "Base" level within the Promote Resiliency strategy design in Figure 6-6. (*Commenters: Kendra Abkowitz – Tennessee Department of Environment and Conservation, Doug McIntosh, Wolf Naegeli, Gordon Niessen, David Salyers – Tennessee Department of Environment and Conservation*)

Response: At this time it is unclear what impact using electric vehicles as a vehicle-to-grid resource would have on manufacturers' warranties and battery life. Consequently, a vehicle-to-grid resource option was not included in the 2019 IRP but would likely be included in future IRPs. In strategy design, it is important to differentiate promotions across strategies to drive a broader range of results. As electric vehicle charging was deemed most impactful to load shape, Strategy D (Efficient Load Shape) included a time-of-use rate structure (discussed in IRP Appendix C) to incent owners of electric vehicles and distributed batteries to charge these devices at economically efficient times. Elements from a variety of different strategies, such as the time-of-use rate structure, could ultimately be employed in practice to support various objectives.

36. The Draft IRP states that EE programs for residential, commercial, and industrial sectors are included among the resource options and that each was divided into tiers representing distinct price points. We recommend TVA include additional discussion regarding these price points if such information can be shared with the public, and also recommend explaining the difference in book life years for each program type and tier. (*Commenter: David Salyers – Tennessee Department of Environment and Conservation*)

Response: Energy shapes and costs for Energy Efficiency (EE) resource options are informed by TVA's partnership with DNV-GL, an industry leader that provides insight on EE best practices, measure values and modeling, as well as the evaluation, measurement and verification of program results. TVA conducts a Residential Saturation Survey and a Business & Industry Saturation Survey every other year to understand market depth and potential reach of programmatic efforts, which vary from region to region. Also, TVA is an active participant and member with multiple industry trade organizations that specialize in energy programs, including eSource, Association of Energy Services Professionals, and others.

IRP Appendix B contains additional information about the EE programs. Tier 1 EE is primarily education focused on the residential side, while creating avenues for industry collaboration or consulting for commercial and industrial customers. In some cases Tier 1 EE programs include necessary administrative overhead required to start up a program, regardless of the level of participation, such as hiring staff and creating a platform to manage the program. Tiers 2 and 3 represent the increasing costs generally required to expand market depth past a certain level of penetration. For example, the incentive amount for a residential program may need to be increased before additional customers will participate. Book life (typically called life span for programmatic resources) is unique to each program and is influenced by the effective life of the program components in the EE strategy employed such as LED lighting and HVAC systems. Detailed programmatic resource programs and characteristics can be found in IRP Appendix B, Figure B-9.

37. In Section 5.2.1.8, Solar, change the last sentence from "capacityto" to "capacity to". (*Commenter: John Shaw*)

Response: Text in IRP Section 5.2.1.8 has been revised per the comment.

38. Section 5.2.2.1, Nuclear indicates SMRs are to be utilized for replacement of "one of the Browns Ferry nuclear units." However, Section 7.1.2, Expansion Plans, under the resource "Nuclear" states "two SMRs totaling 1200 MW were forced in as part of Strategy C to replace one of the three Browns Ferry units." It would be clearer to state in Section 5.2.2.1 that two SMRs will be utilized to replace one of the Browns Ferry nuclear units. That will bring these two sections into full agreement as to the language utilized. (*Commenter: John Shaw*)

Response: IRP Section 5.2.2.1 has been revised per the comment.

39. Chapter 7: Study Results and Chapter 8: Strategy Assessment and Next Steps – The draft IRP identifies numerous different strategies and the wide assortment of combinations of the available/planned resources that TVA has at its disposal to achieve its objectives. However, it never definitively identifies which strategy or resource combination TVA plans to follow as its future pathway. Certain items are defined as occurring regardless of path forward (i.e., shutdown of reduction of number of coal fossil plants) but most options are left wide open as to final selection. While the public knows what the choices could be, they are uncertain as to what will be chosen for pursuit. (*Commenter: John Shaw*)

Response: As described in IRP Chapter 2, after consideration of stakeholder group input, review of the public comments received on the draft document, and additional analysis, TVA has identified a target power supply mix reflecting elements of all planning strategies evaluated in the IRP. This target, described in Chapter 9 of the final 2019 IRP, expresses the range of resources that best position the Valley for success in a variety of futures while preserving the flexibility to respond to uncertainty.

40. In Section 7.1.7, Thermal Additions it would be clearer to reword the sentence "In Scenario 6, 1200 MW of SMR are promoted..." to read "In Scenario 6, two 600 MW SMR units are promoted..." . This would maintain consistency in information presented.

Similarly, Section 7.1.10, Summaries by Strategy states "Nuclear energy remains the same over time across the cases, with the exception of Scenario 6 Case where the energy from the retired Browns Ferry units is replaced primarily with solar and gas generation". This sentence needs to be revised to include the two 600 MW SMR units being promoted for replacement of one of the Browns Ferry units. (*Commenter: John Shaw*)

Response: IRP Section 7.1.7 and 7.1.10 have been revised per the comment.

41. In Section 8.2, Sensitivity Analysis, the last paragraph discusses the SMR demonstration facility that is currently being planned for construction at the previous Clinch Breeder Reactor site at the Oak Ridge DOE reservation. The Nuclear Regulatory Commission Draft EIS for this facility indicates that this facility will be connected to the TVA grid and be used as a resource for power. There is no indication of this configuration presented or discussed in any of the IRP scenarios presented. This needs to be remedied to account for this resource addition and its planned lifetime of operation. (*Commenter: John Shaw*)

Response: SMR characteristics were based on designs and cost forecasts available when resource options for use in the IRP were finalized. As discussions between TVA, DOE and potential manufacturers continue, potential designs and characteristics will evolve. For modeling purposes, an SMR facility was assumed to have a generating capacity of 600 MW produced by multiple reactors. As explained in Section 7.1.2 of the IRP, Case 6C includes two SMR facilities totaling 1,200 MW with an initial operating license of 40 years that were forced in as part of Strategy C (Promote Resiliency) to replace the MW output of one of three retiring Browns Ferry units. While expansion options in the IRP are not site-specific, the Clinch River site would be a potential location for one or more SMR facilities. A final decision has not been made on TVA's participation in the construction of an SMR, but the potential to pursue construction of an SMR if it becomes cost-effective is considered in the IRP. Refinements in design and implementation, coupled with cost and risk sharing, could improve the SMR's position compared to other resource options.

42. The small modular reactor resource option is described in Draft IRP Section 5.2.2, Appendix Table A.1, and elsewhere as a 600 MW facility. Draft IRP Section 8.2 refers to the joint TVA-Department of Energy SMR demonstration facility at the former Clinch Breeder Reactor construction site. TVA's permit application for this facility, as described in the Nuclear Regulatory Commission Draft EIS, is for two or more SMR units with a maximum capacity of 800 MW. Where will the additional SMR capacity be built that will provide the 1,200 MW of SMR capacity under the Promote Resiliency - Scenario 6 portfolio? (*Commenter: John Shaw*)

Response: The Early Site Permit license application submitted to NRC for the Clinch River site is for an 800-MW facility. As explained in the response to the previous comment, the SMR expansion options in the IRP are not site-specific. Should TVA eventually decide to construct SMRs, TVA will conduct additional evaluations to determine the most feasible site or sites that would support the planned SMR generating capacity.

43. Appendix B, Section B.1.5, Beneficial Electrification (BE) states "Residential and commercial BE programs will have the greatest impact during the day, when the Valley residents are awake and businesses are open." Figure B-6 does not seem to support this statement as commercial and industrial load levels during all hours of the day far exceed residential levels. (*Commenter: John Shaw*)

Response: The statement was intended to characterize each of the shapes individually, normalized to 1.00, and the sentence following this statement addressed the higher overall impact of industrial programs. TVA has revised the text of IRP Appendix B, Section B.1.5 to clarify that "due to energy intensity and round the clock shifts, industrial BE programs tend to have a higher and more consistent impact across all hours and the biggest impact for dollars spent."

44. Appendix B, Section B.2, Model Inputs and Assumptions needs further clarification of the statement "commercial and industrial programs are typically lower cost compared to residential due to larger individual project sizes." This statement seems to be counter-intuitive to most citizens. (*Commenter: John Shaw*)

Response: TVA has clarified this in the final IRP to read "commercial and industrial (C&I) programs are typically lower cost compared to residential programs due to higher C&I energy use that provides a bigger impact for dollars spent."

45. Significant portions of Draft IRP Chapter 5 were copied from the 2015 IRP report and pasted into the new report with inadequate updating. For example, TVA's 2019 IRP included the outdated statement that 'Buffalo Mountain is the largest wind farm in the Southeast...' a phrase copied from the 2015 IRP. At the time in 2015, the statement was true. But in 2017, the 208 MW Amazon East wind farm in eastern North Carolina became the Southeast's largest wind farm. There are numerous other examples of exactly the same language from 2015 being used in the 2019 report. (*Commenter: Simon Mahan – Southern Renewable Energy Association*)

Response: The example cited in the comment, as well as other resource descriptions, have been updated in Chapter 5 of the final IRP.

46. Based on various statement in Draft EIS Section 4.3 - Climate and Greenhouse Gases, TVA's basis for forecasting climate during the planning period is not clear. The various statements include:

Pg. 4-16 - Precipitation and temperature based on least square fit of historic data rather than climate change forecasts.
Sect. 4.3.3 TVA dismisses 4th National Climate Assessment because actual weather conditions have differed from past forecasts.
Sect. 4.3.3 States that the assessment says that the SE precipitation will not vary significantly from natural variability "with the exception of slightly greater winter precipitation".
Sect 4.3.4 TVA adopts a climate adaptation plan - "to operate in a secure, effective and efficient manner in a changing climate."

TVA should clarify whether the climate conditions used in the portfolio modeling are based on historic data or climate forecasts. (*Commenter: Jeanette Berry*)

Response: For load projections, TVA used a 15-year normal to establish climatology for the underlying forecast and core scenarios. TVA has also run a variation in climate sensitivity that reflects the potential for a rise in temperatures and seasonal drought and flooding conditions. The results of this sensitivity are described in Section 8.2.8 of the final IRP.

F.2.1.3 General

47. We commend TVA for its overall development of a comprehensive energy plan and EIS and, specifically, for strategic planning that de-emphasizes conventional coal and pursues lower emission power generation strategies over the 20-year planning period. (*Commenters: Christopher Militscher – U.S. Environmental Protection Agency, John Shaw*)

Response: Comment noted.

48. The plan is evasive, and not user-friendly because the people that will be affected aren't familiar with the jargon in the plan. (*Commenters: Joyce Grimes, Keith and Judy Kibbe*)

Response: Comment noted. TVA has made efforts to improve the readability of the IRP and EIS, including an executive summary at the beginning of Volume I and providing an online fact sheet and interactive report. For this IRP process, we utilized new media to communicate information, including social media, the interactive report, videos and webinars to provide different ways for people to understand the IRP.

49. In the FAQs for the IRP, TVA defines "customers" as "businesses that TVA sells power to, including local power companies and industrial customers. As the nation's largest public power provider, TVA delivers safe, reliable, clean, competitively priced electricity to 154 local power companies and 58 directly served customers." This definition completely misses the point of the "users" of TVA power (serves nearly 10 million people in a seven-state, 80,000 square-mile region) and the resources of the Tennessee Valley, namely the ratepayers (residential and business) and tourists. TVA states it is committed to clean air and a clean water supply for our region, as well as protecting its historical, cultural, and environmental resources. The IRP also states TVA supports environmental stewardship as part of its mission. Anyone who enjoys these resources is a customer. (*Commenter: John Shaw*)

Response: TVA is a wholesale provider of electricity for 154 local power companies and 58 directly-served customers. TVA serves 10 million people in the Valley through those local power companies and directly-served customers. Other components of TVA's mission that benefit a wide range of "customers" are described in Chapter 1 of the IRP.

50. We much appreciate the decrease in the emissions of air pollutants, the intensity of greenhouse gas emissions and generation of coal waste under all strategies. It must be recognized that power generation from coal is not a

viable option for the long-term considering climate change and the environmental insults from coal combustion residuals upon our lands, waters, and air and to the people who work with or live near them. (*Commenter: John Shaw*)

Response: Comment noted.

51. The Executive Summary does not provide enough information on distributed energy resources. In particular, it should define them, describe their cost and how many would be required to make up the difference between [current] capacity and actual [future] requirements. (*Commenter: Jerry Peyton*)

Response: Comment noted. The goal of the Executive Summary is to give an overview of the purpose, scope, process, results, and expectations for the IRP. Distributed Energy Resources are described in greater detail in other areas of the IRP.

52. The conclusion in Draft EIS Section 5.3 that there is no significant difference in water use between the strategies should be highlighted as an environmental benefit in the environmental impacts section of the Executive Summary. (*Commenter: Jeanette Berry*)

Response: The Executive Summary has been revised to note that there is no significant difference in water use between the strategies.

F.2.2 Energy Resource Options

F.2.2.1 Biomass

53. TVA should further evaluate the use of biomass-fueled generation. Biomass is sustainable and readily available in the TVA region and can be used in coal plants or in biomass-only facilities. Besides generating electricity, the use of biomass can produce other salable such as liquid diesel fuels. Such bio-fuels are far more economically efficient than even alcohol and do not compete food and feed supplies. The wood ash from the use of biomass also contains minerals and lime that are directly usable as fertilizers. The now-closed International Paper Plant on Highway 150 in Lawrence County, Alabama is large and ready to handle and process high volume deliveries of biomass, including timber. A large and experienced worker population and services experience with wood processing already exists in the area counties. (*Commenter: Bruce Monzyk*)

Response: As stated in IRP Section 5.2.2.9, two biomass options are included in the IRP evaluation: a new direct combustion biomass facility and a repower option, which is the conversion of existing coal-fired units to biomass-fired units. Due to high capital costs and poor relative heat rates, none of the IRP cases included biomass in the capacity expansion. TVA will continue to consider biomass options in future IRPs.

F.2.2.2 Clean Energy

54. TVA should seek cleaner more sustainable ways to generate, distribute and consume power. (*Commenters: Anonymous 6 , Ranae Anderson, Wendy Behr, Robert Berlin, Ruth Black, Candace Boyd , Frances Burton, Caitlin Canty, Sally Carlson-Bancroft, Esther Cohn, Dorothy Craven, Ann Davis, Jennifer Davis, Lynn Davis, Melanie Davis, Frankie Fachilla, Elizabeth Gentry, Jim Gienapp , Henry Goldberg, Andrew Hamlett, Marita M. Hardesty, Christine Hart, Lauren Herman, Katie Herzig, Chet Hunt, Richard Hutchinson, Andrew Irvine, Nathan Iyer, Kenneth Jobe, Rebecca Johnson, Daniel Joranko, Sherry Kaniper, Ellen Klyce, Leah Larabell, Herman LaVelle , Lindsay Lavelle, Vance Lavelle, Suzana Lightman, Marc Lyon, Celia Mackey, Trish Marshall, Melanie Mayes, Naomi McDougall Graham, Grant Mincy, Margaret Neu, Virginia Nix, Joe Ozegovich, Catherine Pena , DixieLea Petrey, Katherine Ragsdale, Sallie Sabbatini, Mary Self, Judy Shank, Tom Smedley, Vivian Strain, Laura Thurman, Noelle Toumey, Courtney Vick, Heather Waldrup, Steven Waterfield, Daniel Waterman, David Williams, Joan Williams*)

Response: Comment noted. Certain scenarios (i.e., Decarbonization and Rapid DER Adoption) and strategies (i.e., Promote DER and Promote Renewables) considered in the 2019 IRP represent a shift toward "cleaner" power. Ultimately, TVA must be guided by its statutory mandate to sell power at rates as low as feasible, while considering the other parts of TVA's mission including the environment and economic development.

F.2.2.3 Coal

55. Close both Bull Run and Paradise Plants now. (*Commenters: Leo Arnoult, Millie O'Rourke*)

Response: The TVA Board recently approved the retirement of the Bull Run by 2023 and Paradise Fossil Plant by December 2020. An earlier retirement of the Bull Run plant is not feasible due to the time required to conduct necessary transmission system upgrades.

56. Close all coal-fired steam plants before 2050. (*Commenters: Millie O'Rourke, Elizabeth Surface, Tom Surface)*

Response: TVA continuously monitors the fleet for the most economical portfolio to provide power to its customers at the lowest system cost, as well as to support environmental stewardship and spur economic development. The IRP Recommendation includes the potential for more than 2 GW of additional coal retirements beyond those already approved by the TVA board.

57. TVA should retire all coal plants in the next 5 years to protect the water supply for both urban and rural populations and mitigate coal ash pool risks to waterways for all plant, wildlife and residential areas. (*Commenters: Judith Abrams, Catherine Arnoult, Duffy-Marie Arnoult, Emily Burch, Ann Davis, Jennifer Davis, Lynn Davis, Jim Gienapp , Lynn Hubbard , Richard Hutchinson, John Klyce, Ann Kurys, Herman LaVelle , Lindsay Lavelle, Vance Lavelle, Suzana Lightman, Naomi McDougall Graham, Nancy McFadden, Margaret Neu, Catherine Pena , Katherine Ragsdale, Sallie Sabbatini, Mary Self, Paul Slentz, Vivian Strain, Noelle Toumey , Courtney Vick, Jason Waldo, Steven Waterfield, Daniel Waterman*)

Response: See the responses to the two previous comments. For portfolios in which TVA has identified potential coal plant retirements, the action of ceasing operations at the plant have been analyzed, including the reduction in emissions, fuel consumption, waste production, etc. If TVA were to decide to retire a particular coal facility, impacts to water supply and water quality associated with the deconstruction and demolition of that particular facility will be addressed in a future planning process that will include public and agency input. In addition to this analysis, TVA maintains a robust water quality monitoring program at all of its power plants. TVA routinely collects and evaluates information on water quality to assess the causes of and remedies for any adverse impacts of its operations. Some of these monitoring activities are voluntary while others are in conjunction with existing permits or to meet requirements of the CCR rule or other regulatory requirements; each is conducted to protect the people and environment in the area in and around TVA facilities.

58. Coal plants should be closed sooner. *(Commenters: David Bordenkircher, Gail Boyd, Anne Hardin, Daniel Joranko, Sandra Kurtz, Celia Mackey, Pate McCartney, Damon Moglen, Mary Moore, Mindy Mosier, Ken Prahl, Rebecca Russ, Nick Wiggins)*

Response: TVA continuously monitors the fleet for the most economical portfolio to provide power to its customers at the lowest system cost, as well as to support environmental stewardship and spur economic development. The IRP Recommendation also reflects the potential for more than 2 GW of additional coal retirements beyond those already approved by the TVA Board.

59. TVA should not forsake coal fueled power plants as coal is our most plentiful energy source. (*Commenter: Jeff Coppala*)

Response: As stated in Section 5.2.2.2 the 2019 IRP, TVA is considering six coal expansion options, including two integrated gas combined cycle (IGCC) options and four supercritical pulverized coal (SCPC) options. Due to higher relative capital costs, none of the IRP cases included additional coal in the capacity expansion. After the retirement of the Bull Run and Paradise Fossil Plants, TVA will continue to operate four coal plants. The 2019 IRP does include the potential for up to 2 GW of additional coal retirements in certain futures. Future IRPs will consider the evolution of clean-coal technologies.

60. Please review Patent #4,580,505 'Method and Apparatus of Fluidized Beds Involving Heat or Combustion. In the 1970s TVA paid Oak Ridge National Laboratories and University of Tennessee to do experiments in the development of fluidized beds for burning high-sulfur coal, and Patent #4,580,505 was a product of this research. The apparatus involving this patent was first demonstrated in the late 1970s to not only burn stoker sized high-sulfur coal without smoke or odor, but the unit also burned high sulfur coal at temperatures below the ash fusion point. It could fire up and be in full operation in less than 5 minutes. In addition, this unit could also burn 'liquid & gaseous fuels' and biomass alone or simultaneously with the high-sulfur coal at efficiencies, according to the United States Department of Energy, that exceeded Bull Run Steam Plant, touted as the most efficient generating plant, by some fourteen points. In addition, according to DOE at Oak Ridge National Laboratories, this unit appeared suitable for 'Concentrating Nuclear Waste' and thus eliminating the huge stockpiles of storing nuclear waste around the country and the world.

This demonstration unit was withheld from the 1982 Energy Worlds Fair by TVA, UT, & DOE. Further development of this $800 million project was canceled because, according to DOE scientists, it would put power generation in the hands of consumers. I believe TVA should take another look at this technology and build small modular units that could provide multi-fuel capability and load following. (*Commenter: Jim Golden*)

Response: As noted in IRP Section 5.1, TVA established criteria for considering resource options for consideration in the IRP. The resource options include only viable options, including proven technologies that have reasonable prospects of becoming commercially-available during the planning horizon, with the one exception of small modular reactors due to recent work with DOE on an early site permit for a demonstration facility. TVA's Technology Innovation department continues to collaborate with Oak Ridge National Laboratory and other stakeholder partners on a variety of evolving technologies. If these or other technologies have prospects of becoming commercially available, they would be considered in future IRPs.

61. Bull Run should be converted into a co-generation plant. (*Commenter: Stephen Hornbaker*)

Response: The future use of the Bull Run site following the plant retirement is outside of the scope of the IRP. However, the subsequent use of the site will be addressed in a future planning process under NEPA that will include public and agency input.

62. The plan mentions revising existing coal plants to use biomass. How much generating capacity would that actually provide, given that coal has much higher carbon content than biomass, and how will all the extra volume of solid waste be handled? (*Commenter: David Williams*)

Response: As described in IRP Section 5.2.2.9, the 2019 IRP includes the option of converting existing coal-fired units to use biomass fuel. For modeling purposes, this option has a summer net dependable capacity of 124 MW and summer heat rate of 18,000 Btu/kWh. This heat rate is significantly higher than the other available expansion options that generate electricity by the combustion of various fuels, including coal. Due to high capital costs and poor relative heat rates, none of the IRP cases included biomass in the capacity expansion. Biomass combustion waste would be handled in a manner to comply with all applicable laws.

63. Mississippi Lignite Mining Company backs TVA's full utilization of the Red Hills Project, as this decision also supports energy resource diversity and reliability, which are critical elements of portfolio planning. Consumption of lignite, specifically from the Red Hills Power Plant, uniquely supports these critical elements and ensures TVA is well-positioned to respond to variables associated with other fuel sources, such as natural gas price spikes and transportation interruptions, as well as drought conditions affecting hydropower. (*Commenter: Madison Keyes*)

Response: Comment noted.

64. I urge the TVA Board of Directors to recognize the tremendous role coal has played in TVA's past and present, and to increase the role that coal will play in your generation portfolio of the future. Worldwide demand for coal — particularly in developing nations -- is increasing. Removing our nation from the coal generation business also removes our influence, expertise, and innovation from the clean-coal-technology marketplace, and our ability to share that expertise with the rest of the world. (*Commenter: U.S. Senator Rand Paul of Kentucky*)

Response: As stated in IRP Section 5.2.2.2, the 2019 IRP includes six coal expansion options, including two integrated gas combined cycle (IGCC) options and four supercritical pulverized coal (SCPC) options. Due to higher relative capital costs, none of the IRP cases included additional coal in the capacity expansion. After the retirement of the Bull Run and Paradise Fossil Plants, TVA will continue to operate four coal plants. The 2019 IRP does include the potential for additional coal retirements in certain futures. Future IRPs will consider the evolution of clean-coal technologies.

F.2.2.4 Distributed Energy Resources (DER)

65. TVA should consider water heaters equipped with a CTA-2045 interface, as described in documents enclosed with this comment, as a specific low cost way for a utility(s) to engage significant energy use devices as resources and part of a DER portfolio. Both TVA and local power companies have the opportunity to engage consumer home devices in a secure way using CTA-2045 and other communication standards paired with residential equipment which have a built-in interface port which could be built upon this type system. These devices are operated so that the customer experience using the equipment is not impacted and utility performance is reliably engaged for the local power company and other potential aggregators. Open architecture is used so utilities are not 'locked into' a sole service provider. End use device operation provides real time grid edge visibility of resource potentials.
This is the lowest cost load shifting/storage and load management resource. In addition to water heaters, the approach can tie to other loads such as thermostats, electric vehicles service equipment, heating and air-conditioning systems, and pool pumps. A significant scale demonstration of low cost engagement with Distributed Resources, using water heaters as an example is provided. (*Commenter: Sam DeLay*)

Response: The 2019 IRP included residential Water Heater Control Demand Response (DR) and Thermostat Control program options as further explained in IRP Appendix B. Both programs were included in many of the IRP cases, and IRP results will be used to inform future program offerings. The particular type of control and communication interface utilized in such programs is outside the scope of the IRP.

66. What impacts will 'distributed energy' have on the load profile and income stream? Is there potential for industrial load leveling, e.g. nighttime operation, cogeneration? (*Commenter: Gerald Guinn*)

Response: The impacts of distributed energy resources depends on their level of penetration within a portfolio. There is potential for industrial load leveling with distributed storage and CHP.

67. Overall low cost (low PVRR) and beneficial environmental outcomes emanating from Scenario 5 and Strategy B (both focusing of DER advancement) reveal pathways that should shape TVA's ultimate direction and required statutory least cost evaluation. (*Commenter: Ricardo G. Perez*)

Response: Comment noted. Scenarios are alternate plausible futures outside of TVA's control with different economic and regulatory conditions, as well as different potentials for adoption of newer technologies. Following approval of the 2019 IRP, TVA will continuously monitor market trends to determine which scenario attributes are being realized, which in turn will influence actions taken by TVA. If DER is incented, it is important to avoid cost-shifting in the interest of all Valley residents.

68. TVA should promote renewable DER through grants, subsidies or other methods. Promotion of DERs further add resiliency to the overall grid, which will assist in lessening the need for traditional non-renewable sources. Small scale, renewable power generation can be created by landowners through grants provided by TVA or other sources. The IRP can provide guidance for future efforts in securing funding for programs of this type. (*Commenter: Nick Wiggins*)

Response: As explained in IRP Appendix B, Section B.1.1, the IRP incorporates various levels of DER promotion across the different strategies. TVA expects DERs to play an increasing role in the future, in part to support local resiliency. If DER is incented, it is important to avoid cost-shifting in the interest of all Valley residents.

F.2.2.5 Energy Efficiency

69. The 2015 IRP set a 2023 goal for energy efficiency. We recommend that TVA define what alternative(s) would help increase the rate of EE savings to meet the 2023 goal in the 2015 IRP and describe in detail the projections in meeting that goal. Ceasing programs such as the EnergyRight™ incentive program seems counterproductive to fostering energy efficiency. Demand-side management programs and energy efficiency remain the most cost-effective method to reduce overall demand and prevent the need for any additional generating capacity. (*Commenters: Kendra Abkowitz – Tennessee Department of Environment and Conservation, Andrew Hamlett*)

Response: The 2015 IRP established expected ranges of resource additions over time, including for EE. Since the 2015 IRP, consumer average energy use has declined with increasing levels of market driven EE occurring in most sectors. Consequently, TVA sees less need for programmatic EE incentives and instead is emphasizing education and outreach and piloting a program to address low-income sector. The 2023 recommendation in the 2015 IRP was based on expectations for load growth and other conditions evaluated at that time. Since conditions have changed and are pushing the bounds of scenarios considered in the 2015 IRP, it is prudent to update the recommendation for energy efficiency as part of the 2019 IRP. TVA currently offers energy efficiency (EE) programs for homes and businesses through the local power companies. When any programmatic incentive is offered, it is important to avoid cost-shifting in the interest of all Valley residents, especially those with lower incomes. TVA considered various levels of EE programs in the IRP, including the expansion of TVA's Home Uplift initiative aimed at making weatherization improvements in low-income households. TVA has performed additional sensitivity analysis on EE and DR (demand response) market depth (see IRP Section 8.2.3). The IRP Recommendation reflects up to 1,700 MW of additional EE and up to 500 MW of additional DR if the higher market potential can be realized.

70. In addition to the eScore program, we encourage TVA to renew efforts to promote EE in existing homes through the use of prescriptive rebates and incentives. While updated energy codes and appliance standards may increase the efficiency of new homes, additions, and to some extent renovations, they do not improve the efficiency of Tennessee's existing residential buildings. Many of these homeowners lack the means to make improvements such as window replacements, insulation, and building envelope-sealing, which are typically not addressed by homeowners because they are cost prohibitive. While all Tennessee local jurisdictions must adopt a residential energy code that is within seven years of the most recently published energy code, they may opt out of adoption with

a two-thirds majority vote of the local governing body. If opting out, the vote must be completed after each local election cycle. As of June 2018, 86 jurisdictions have opted into the State residential building code (apply the statewide building code to their jurisdiction and utilize the State's building permit system and building inspectors), 80 jurisdictions have opted out (building codes are not recognized nor enforced), and 264 jurisdictions are exempt (building codes are adopted locally, meeting or exceeding the statewide standard; exempt jurisdictions hire their own inspectors and all paperwork is administered locally and audited on a three-year cycle). (*Commenter: Kendra Abkowitz – Tennessee Department of Environment and Conservation*)

Response: Building codes and inspection/enforcement is crucial to improving the quality of housing, including energy efficiency; however, codes and inspections are outside of TVA's purview. With increasing levels of market driven EE occurring in most sectors, TVA is emphasizing education and outreach, supporting quality contractor networks, and augmenting state EE programs. When any programmatic incentive is offered, it is important to avoid cost-shifting in the interest of all Valley residents, especially those with lower incomes. TVA's Home Uplift initiative, currently in pilot phase, seeks to augment the state of Tennessee's Weatherization Assistance Program by working with LPCs and local communities to create a sustainable program aimed at making weatherization improvements in low-income households. TVA is evaluating expanding this pilot program Valley-wide, and the Promote DER and Promote Efficient Load Shape strategies in the 2019 IRP included this expansion. TVA will continue working with LPCs and state and local stakeholders on ways to collectively impact the energy efficiency of housing stock in the Valley over time.

71. TVA should do more to make homes and businesses more energy efficient, thereby reducing the total demand on production. *(Commenters: Wade Austin, Sara Bielaczyc, Mark Bishop, Ruth Black, David Bordenkircher, Jeff Christian, Mary Clarke, Will Connor, Elizabeth Gentry, Pamela Glaser, Sandra Goss, Anne Hardin, Melissa Harris, JJ Johnson, Karen Jordan, Jonathan Levenshus, Maureen May, Melanie Mayes, Craig McManus, Grant Mincy, Wolf Naegeli, Brian Paddock, Ophelia Paine, Wendy Ritchey, Ranan Sokoloff, Elizabeth Surface, Tom Surface, Daniel Waterman, Greg Wathen, Gregory Wellman, Kimberly Wellman)*

Response: TVA currently offers EE programs for homes and businesses through the local power companies in the Valley. TVA has considered various levels of EE programs in the IRP, including the expansion of TVA's Home Uplift initiative aimed at making weatherization improvements in low-income households. TVA has performed additional sensitivity analysis on EE market depth as described in IRP Section 8.2.3. The IRP Recommendation reflects up to 1,700 MW of additional EE if the higher market potential can be realized.

72. TVA acknowledges that it is technically and economically feasible to increase energy efficiency, yet TVA has long lagged most of its peer utilities in the area of EE implementation (see https://aceee.org/topics/energy-efficiency-resource-standard-eers). As a result, TVA is failing to deliver the significant financial benefits from EE available to customers in neighboring jurisdictions. In 2017, TVA captured 0.21% energy efficiency as a percentage of the previous year's total electric sales. By comparison, Georgia Power had more than double the energy savings (0.46%), Duke Energy Carolinas had five times more (1.09%), and Entergy Arkansas delivered six time more efficiency savings than TVA. The Northwest Power and Conservation Council, TVA's counterpart in the Northwest, and Entergy Arkansas have both seen continuously increasing EE savings resulting from their EE programs despite increases in federal standards and state and local codes.

TVA has reduced its EE investments every year since 2014 and the Draft IRP exacerbates this deficiency. TVA claims that EE provides little to no benefit to the IRP portfolios while failing to provide adequate detailed information to support this claim. The failure of TVA's models to capture significant efficiency resources in the portfolios, despite numerous EE programs costing less than $20/MWh, suggests a serious flaw in the modeling practices that require intense scrutiny before any final IRP decisions are made.

Appendix F – Responses to Comments

The proposed reduction in EE efforts is in direct conflict with TVA's stated goal of pursuing a low cost, reliable, risk informed, environmentally responsible and flexible grid. EE is widely accepted as the least cost "new energy" option. Increased EE would facilitate the ability of TVA to diversify its portfolio, reduce cost, increase reliability, reduce risk, increase environmental responsibility, and provide flexibility. It also saves TVA's customers the most money and this money is then available to stimulate other areas of the economy helping TVA achieve its mandate to promote economic development and the general wellbeing of its customers. EE also has the least environmental impact of any other resource. Thus, failure to include ambitious EE efforts in this IRP directly conflicts with all the stated objectives of the IRP. (*Commenters: Scott Banbury, Sandra Kurtz, William Moll, Ian Schiller, Joe and Sarah Schiller, Stephen Smith – Southern Alliance for Clean Energy*)

Response: TVA currently offers EE programs for homes and businesses through the local power companies in the Valley. EE programs are priced according to the incremental cost of energy on the TVA system. That energy value has been declining in recent years as a result of flat to declining demand for electricity in the Valley. TVA is mandated by the TVA Act to conduct least-cost planning, which means that there are no target percentages for resources, but TVA optimizes its power system based on least cost. TVA provided additional information in response to requests by Southern Alliance for Clean Energy (SACE) and Center for Biological Diversity (CBD) that further detailed cost assumptions for the EE options considered in the IRP. A low-income EE program comparison to other Southeast utilities showed that TVA assumptions are in line with other estimates. In the IRP, TVA has considered various levels of energy efficiency programs, particularly the expansion of TVA's Home Uplift initiative for low-income households. TVA has also conducted sensitivity analysis that is detailed in Section 8.2.3 of the final IRP that shows that increased market depth for EE and DR (specifically commercial and industrial) displaces CTs, CCs, and solar on the system as it competes for energy value.

73. TVA should increase energy efficiency targets to 3-5% gain in next 10 years for all TVA service areas. *(Commenters: Judith Abrams, Catherine Arnoult, Duffy-Marie Arnoult, Leo Arnoult, Emily Burch, Ann Davis, Jennifer Davis, Lynn Davis, Jim Gienapp , Lynn Hubbard , Richard Hutchinson, John Klyce, Herman LaVelle , Lindsay Lavelle, Vance Lavelle, Suzana Lightman, Naomi McDougall Graham, Margaret Neu, Catherine Pena , Katherine Ragsdale, Sallie Sabbatini, Mary Self, Vivian Strain, Noelle Toumey , Courtney Vick, Steven Waterfield)*

Response: Under the TVA Act, TVA is mandated to conduct least-cost planning. Therefore, TVA optimizes to least-cost, not to specific targets for particular energy resources.

74. TVA should advocate for a reduction in energy use through a media campaign. (*Commenters: Sandra Goss, Elizabeth Krogman*)

Response: TVA currently offers energy efficiency programs for homes and businesses through the local power companies in the Valley. TVA promotes these programs through various types of media, such as TV, radio and through the TVA website.

75. TVA should help low income people get their houses more energy efficient by providing them with an incentive they would be compelled to take and publicize this more. (*Commenters: JJ Johnson, Lauren Newman, Paul Slentz, Laura Young*)

Response: TVA's Home Uplift initiative, currently in pilot phase, seeks to augment the state of Tennessee's Weatherization Assistance Program by working with LPCs and local communities to create a sustainable program aimed at making weatherization improvements in low-income households. TVA is evaluating expanding this pilot program Valley-wide, and Promote DER and Promote Efficient Load Shape strategies in the 2019 IRP included this expansion. TVA will continue working with LPCs and state and local stakeholders on ways to collectively impact the energy efficiency of housing stock in the Valley over time. See EIS Section 4.9.4 for more information about recent and current TVA programs benefiting low-income populations.

76. TVA will fall further behind Southeast utilities in energy efficiency under this plan. In the 2011 IRP, the TVA Board set goals to achieve 1% annual savings from EE. Its goal was dropped to 0.6% in the 2015 IRP. The draft 2019 IRP further drops the EE goal to zero by the end of the study period. TVA's annual energy savings fell below the regional average and well below the national average in 2017. TVA should return to the goal of being a regional leader in EE.

TVA was once a leader on certain EE programs. TVA pioneered a low-cost, high-impact program for manufactured homes that now serves as a model for other utilities. This important customer sector continues to be overlooked by many other utilities, and TVA is to be commended for developing this program. This program also serves as an example that EE savings are within TVA's reach if the utility is willing to make the investment in a resource that will save customers money and improve livelihoods across the Valley. (*Commenters: Maggie Shober – Southern Alliance for Clean Energy, Stephen Smith – Southern Alliance for Clean Energy*)

Response: TVA currently offers EE programs for homes and businesses through the local power companies in the Valley. TVA has considered various levels of EE programs in the IRP, including the expansion of TVA's Home Uplift initiative aimed at making weatherization improvements in low-income households. TVA has performed additional sensitivity analysis on EE market depth (see IRP Section 8.2.3). The IRP Recommendation reflects up to 1,700 MW of additional EE if the higher market potential can be realized.

77. TVA now treats energy efficiency as a threat to its revenues, and is adding large mandatory fixed fees to customer bills. The Draft 2019 TVA IRP fails to quantify the impact of shifting costs from energy rates to mandatory fixed fees on customer energy use. It is well known that this rate design approach will lead to higher, less energy efficient behaviors. Furthermore, as these billing changes take effect, the economic incentive to invest in EE will be reduced. For example, Knoxville Utility Board's decision to triple fixed fees has effectively wiped out 10 years' worth of efficiency savings effect. (*Commenters: Maggie Shober – Southern Alliance for Clean Energy, Stephen Smith – Southern Alliance for Clean Energy*)

Response: Scenarios evaluated in the IRP included various levels of EE in the respective load forecasts, and EE programs for all sectors were included in the set of available resource options. The preferred Target Power Supply Mix includes the potential for up to 1,700 MW of additional EE by 2038 depending on future costs of implementing EE and the costs of other energy resources. TVA has identified a near-term action to study energy efficiency potential in the Valley as discussed in IRP Section 8.2.3. The IRP does not address rate design. In 2018, TVA implemented a rate change that initiated a wholesale grid access charge, accompanied by a corresponding decrease in the standard service rate so that the overall change was revenue neutral. The impacts of the proposed changes were analyzed by TVA at that time (see www.tva.gov/nepa).

78. I am pleased to see that the IRP includes continuation of the Home Uplift pilot in all tiers of energy efficiency programming. It is important to recognize that there are many ways of supporting low-income energy efficiency that need not always rely on TVA covering all "or the bulk of" costs directly. We have heard from residents who are willing to put "skin in the game," but who don't always have access to the upfront capital necessary to make efficiency investments. We encourage TVA and local LPCs to explore low-income energy efficiency financing options that empower residents of limited financial means to make practical investments in their long-term financial interests. (*Commenter: Madeline Rogero – City of Knoxville*)

Response: Comment noted. While the scope of the IRP does not include identifying new programs, TVA recognizes the importance of programs and will continue to identify opportunities and partnerships that benefit these communities, providing opportunities in these communities to promote economic development. TVA is partnering with LPCs for the current low-income Home Uplift pilot and would work with them on any future programs as well. See EIS Section 4.9.4 for more information about recent and current TVA programs benefiting low-income populations.

79. While the IRP scenarios build in assumptions that the market will continue to drive energy efficiency, it is disappointing to see that, across the IRP strategies, TVA-led energy efficiency programs are not projected to play a significant role in meeting future electricity demand. I encourage TVA to be an energy efficiency leader, both through direct investments that support utility needs as well as through policy and industry leadership that promotes continued market- driven adoption of energy efficiency. This leadership aligns with the goals of the City of Knoxville, and we would be a willing partner to work with you on these efforts.

In particular, the City and a multitude of partners have championed efforts to increase the ability of lower income residents to improve the efficiency of their homes in order to save money, address health stressors, and live more comfortably. TVA has been a critical partner in these efforts, as exemplified through TVA's investment in the Knoxville Extreme Energy Makeover (KEEM) program and Home Uplift in support of KUB's Round It Up program. I cannot underscore enough the importance of TVA's robust engagement in ongoing conversations about how to ensure that those with fewer financial resources are not left out of the transition to an efficient, 21st century energy system.

The reality is that many low-income residents have not received proportional benefits from TVA's EnergyRight Solutions financial incentive programs, even though they have contributed proportionally to the rate-recovery of those programs. Continued investment in programs specifically designed to meet the needs of low-income customers should be considered within the lens of this historical inequity and play an increased role in TVA's future investment in energy efficiency. (*Commenter: Madeline Rogero – City of Knoxville*)

Response: Comment noted. TVA's Home Uplift initiative, currently in pilot phase, seeks to augment the state of Tennessee's Weatherization Assistance Program by working with LPCs and local communities to create a sustainable program aimed at making weatherization improvements in low-income households. TVA is evaluating expanding this pilot program Valley-wide, and several strategies in the 2019 IRP included this expansion. TVA will continue working with LPCs and state and local stakeholders on ways to collectively impact the energy efficiency of housing stock in the Valley over time.

80. TVA downplays the role of energy efficiency resources, particularly for residential customers, in large part by claiming that natural adoption rates of EE eliminate the potential for TVA LPCs to capture additional cost-effective savings though utility efficiency programs. This premise is based on changes in federal standards and local codes (as stated in the Draft IRP sections 7-9 and 7-11). TVA's assertion that its EE potential is eroded by codes and standards does not stand up to scrutiny for the following reasons:

- TVA made this assertion without appearing to examine any empirical evidence on market penetration and saturation rates for the existing housing stock.
- TVA's assertion is easily countered by the real world experiences of regular residential customers in the TVA service area who currently pay high energy bills and lack the efficiency measures typically included in utility efficiency programs, including those offered by TVA in the past. In particular, low-income customers in both urban and rural areas struggle to access these improvements.
- TVA is out of step with many peers. Despite facing the same dynamics regarding efficiency baseline changes and declining solar prices, major utilities in the region and beyond continue to reap substantial savings from utility efficiency programs.

Fundamentally, it appears that TVA's IRP reaches these flawed conclusions because TVA has failed to focus on efficiency needs in existing buildings and equipment, and because TVA has not considered its role in addressing market transformation opportunities.

Federal standards and local codes are not adequate to drive cost-effective investments in retrofit of buildings and cost-effective upgrades of existing equipment. Utility EE programs are essential to help ensure that the benefit to the TVA system is realized when homeowners, businesses, and other customers are making decisions about retrofit or upgrade investments. The benefit to the TVA system can be achieved through rebates, education (customer awareness), or technical assistance services (audits or other decision-making tools). TVA's failure to commit to expanding such programs will reduce overall system benefits and result in higher customer bills. (*Commenter: Stephen Smith – Southern Alliance for Clean Energy*)

Response: Energy shapes and costs for Energy Efficiency (EE) resource options are informed by TVA's partnership with DNV-GL, an industry leader that provides insight on EE best practices, measure values and modeling, as well as the evaluation, measurement and verification of program results. TVA conducts a Residential Saturation Survey and a Business & Industry Saturation Survey every other year to understand market depth and potential reach of programmatic efforts, which vary from region to region. Also, TVA is an active participant and member with multiple industry trade organizations that specialize in energy programs, including eSource, Association of Energy Services Professionals, and others.

With increasing levels of market-driven EE occurring in most sectors, driven by codes and standards and consumer preference, TVA is emphasizing education and outreach. TVA currently offers EE programs for homes and businesses through the local power companies in the Valley. TVA has considered various levels of EE programs in the IRP, including the expansion of TVA's Home Uplift initiative aimed at making weatherization improvements in low-income households. TVA has performed additional sensitivity analysis on EE market depth (see Section 8.2.3). The preferred Target Power Supply Mix includes up to 1,700 MW of additional EE by 2038, if the higher market potential can be realized. One of the near-term actions that TVA is considering is to conduct a market potential study for energy efficiency and demand response.

81. The Northwest Power and Conservation Council, as indicated by a number of references in these comments and our IRP Scoping Comments to TVA, represents the model of the future for treating energy efficiency as a resource in resource planning. NPCC provided workbooks containing the supply curves used to calculate the cost-based measure bundles input into the resource planning model. These bundles were generated using cost and savings parameters of over 4,000 individual EE measures. The range of efficiency programs modeled by TVA fails to adequately encompass the range of available options. Furthermore, the way TVA groups measures and programs together in its modeling lacks appropriate granularity. TVA should expand the number of EE measure options available to the IRP model and use a supply curve based on buckets of installed capacity for each measure. Only if TVA updates this modeling technique and uses correct calculations for EE potential and costs can TVA truly claim to "treat demand and supply resources on a consistent and integrated basis," as required by the TVA Act. (*Commenter: Stephen Smith – Southern Alliance for Clean Energy*)

Response: TVA currently offers EE programs for homes and businesses through the local power companies in the Valley. Energy efficiency programs are priced according to the incremental cost of energy on the TVA system. TVA is mandated by the TVA Act to conduct least-cost planning, which means that there are no target percentages for resources, but TVA optimizes its power system based on least cost. TVA provided additional information in response to requests by Southern Alliance for Clean Energy (SACE) and Center for Biological Diversity (CBD) that further detailed cost assumptions for the EE options considered in the IRP. As part of the information provided, a low-income EE program comparison to other Southeast utilities showed that TVA assumptions are in line with other estimates.

TVA modeled several tiers of aggregated energy efficiency measures for the residential, commercial, and industrial sectors, representing a supply curve with increasing costs at increasing penetrations. These offerings were based on inputs from staff with significant experience benchmarking, designing, operating, and managing programs. This aggregation also reduces the number of possible permutations of measure types in line with the level of granularity for other resource options.

F.2.2.6 Facility Siting

82. TVA should continue to minimize the need to transmit electricity and transport feedstocks through strategically locating generating facilities close to users wherever possible. (*Commenter: Christopher Militscher – U.S. Environmental Protection Agency*)

Response: Comment noted. The 2019 IRP evaluates the resources TVA would use over the next 20 years to meet the energy needs of the TVA region at the lowest cost. It does not address future site-specific actions to implement the plan. In siting a new generating or storage facility, TVA considers numerous factors including the proximity to load centers, proximity to adequate transmission, and the adequacy of the transportation network for delivering fuel to the facility. Locations for future construction of generating facilities would be reviewed on a case-by-case basis, with due consideration given to the impacts to the transmission system and relative location to load centers.

F.2.2.7 Hydroelectric

83. TVA should look to hydroelectric power for a long term source of cheap energy generation. TVA should invest the required maintenance dollars to protect the dam structures and generating equipment. (*Commenters: Jeff Coppala, Lawrence Miller, David Williams*)

Response: All IRP portfolios reflect investing in and maintaining TVA's existing hydroelectric fleet. Additionally, TVA is in the process of making improvements and uprates to the Raccoon Mountain Pumped Storage Plant which will yield an additional 76 MW of pumped storage capacity and completion of this work is assumed in all cases. TVA has completed 60 hydro unit modernization projects out of 109 conventional hydro units. TVA plans to modernize two to three units per year, and the program is perpetual in nature to maintain, but not necessarily add, capacity over time. Final EIS Section 2.3.5 and IRP Section 5.2.1.5 have been updated to include this additional information. As noted in IRP Chapter 5, the 2019 IRP includes three hydro expansion options available for selection. While none of these expansion options were included in the primary cases, TVA identified in subsequent sensitivity analysis the potential for about 200 MW of hydro expansion and has included this expansion in the recommendation.

84. TVA should phase out hydroelectric generation and shift to solar and wind power. (*Commenter: Patrick Rakes*)

Response: TVA's existing hydro fleet provides an important source of low-cost, carbon-free generation to Valley customers as well as multiple other benefits. A variety of hydro, solar and wind expansion options were available for selection in the 2019 IRP, with potential ranges for each included in the recommendation. Both hydro and non-hydro renewable generation provide valuable diversification of the overall resource portfolio.

F.2.2.8 Natural Gas

85. With an increase in natural gas-fired plant investment by TVA under the IRP strategies, TDEC recommends TVA consider calculating the emissions benefits of methane capture and gasification for production of renewable natural gas. Not only could such projects lower emissions from both new and existing natural gas-fired power plants, but the renewable natural gas could also support local compressed or liquid natural gas (CNG/LNG) vehicle fleets and

potentially address food waste. For reference, see the renewable natural gas asset owned by Memphis Light, Gas, and Water. (*Commenter: Kendra Abkowitz – Tennessee Department of Environment and Conservation*)

Response: Comment noted. TVA will continue to evaluate the economics of methane capture as an alternative fuel.

86. Methane leakage from fracking and distribution makes natural gas a worse net GHG polluter than even coal. While methane breaks down in the atmosphere in a decade or two versus CO_2's centuries or millennia, methane has 86 times the impact of CO_2 during that time. All coal generation should be retired as quickly as possible and replaced directly with new solar and wind generation rather than squandering ratepayer's money on new polluting, costly, and fuel-price-vulnerable natural gas plants. (*Commenter: John Todd Waterman*)

Response: Solar expansion is significant in the IRP, ranging from about 6 to 9 GW of nameplate capacity by 2038 under the Current Outlook for electricity demand and up to 14 GW of nameplate capacity in a growth scenario. Sensitivity analysis has identified the potential for up to about 4 GW nameplate of additional wind capacity, if lower wind costs could be realized. The IRP Recommendation also reflects the potential for more than 2 GW of additional coal retirements beyond those already approved by the TVA Board. Natural gas units play an important part in ensuring the reliable integration of intermittent resources such as wind and solar. The IRP recognizes that storage technology is evolving, and the recommendation reflects the potential for up to 5 GW of additional storage which may offset some natural gas generation.

EIS Section 5.2.1.3 describes GHG emissions associated with existing CC and CT plants. This section also identifies fugitive emissions of methane from natural gas extraction as an area of concern. The analysis notes that about 20 to 22 percent of the GHG emissions from CC and CT plants reported by NETL results from the extraction, processing and transport of natural gas, and that these emissions are dominated by methane. This section identifies studies regarding the life cycle carbon footprint of electricity generation from shale gas, including studies that suggest that shale gas results in higher GHG emissions than coal and studies that conclude the opposite.

87. It is my understanding that natural gas and coal are two of the top three sources for TVA's current electricity production. Since use of carbon fuels contributes to the accumulating effects of climate change which are and will continue to negatively impact each of us, I request TVA to be a leader in moving away from the use of both of these fuels. In addition to decommissioning older fossil fuel facilities, I ask that TVA refrain from building additional plants which use carbon fuels.
(*Commenters: Gail Boyd, Andrew Hamlett, Nancy McFadden, Nick Wiggins*)

Response: In 2018, TVA's power supply was 53% carbon-free, and all IRP cases reflect continued reduction in carbon emissions. Solar expansion is significant in the 2019 IRP Recommendation in all cases, which would displace generation from plants using carbon fuels. Under no cases in the 2019 IRP would TVA add new coal units, and the IRP Recommendation reflects the potential for more than 2 GW of additional coal retirements beyond those already approved by the TVA Board. Natural gas units play an important role in ensuring the reliable integration of intermittent resources such as wind and solar. The IRP recognizes that storage technology is evolving, and the recommendation reflects the potential for up to 5 GW of additional storage, which would offset some natural gas generation.

88. TVA should minimize reliance on natural gas for power generation needs. It is more effective to use it for consumers and industry as a heating fuel and may one day power automobiles on a large scale. (*Commenters: Anonymous 5, Jeff Coppala, Nathan Iyer, Celia Mackey, Paul Slentz*)

Response: TVA's forecasts of gas prices and availability account for a wide range of future uses of natural gas. Natural gas-fired generating units play an important role in ensuring the reliable integration of intermittent resources such as wind and solar. The IRP recognizes that storage technology is evolving, and the recommendation reflects the potential for up to 5 GW of additional storage, which would offset some natural gas additions.

89. TVA should restrict all fracking for natural gas. (*Commenters: Amanda Dobra Hope, Charles High*)

Response: TVA purchases natural gas from a variety of suppliers that must comply with all regulations related to fracking.

F.2.2.9 Nuclear Energy

90. TVA should increase the amount of nuclear in its portfolio as a way to produce less carbon pollution from the use of coal and natural gas. (*Commenters: Will Connor, Anjay Friedman, Nathan Iyer, Peter Keese, Keith and Judy Kibbe, Jason Miller*)

Response: TVA's existing nuclear fleet provides an important source of carbon-free baseload power to the system, and TVA continually looks for ways to improve the efficiency of its nuclear fleet. The IRP Recommendation also reflects the potential for more than 2 GW of additional coal retirements beyond those already approved by the TVA Board. Currently, the TVA system needs no additional baseload resources like large-scale nuclear, due in part to the projected increase in economic renewable generation and need for flexible units which can ramp quickly to support renewables integration. Natural gas units play an important role in ensuring the reliable integration of intermittent resources such as wind and solar. The IRP recognizes that storage technology is evolving, and the recommendation reflects the potential for up to 5 GW of additional storage, which would offset some natural gas generation. The IRP considered various new nuclear plants, as described in Section 5.2.2.1 of the IRP. Due to economics and system needs, none of the IRP cases included additional nuclear capacity except for, as explained in Section 7.1.2 of the IRP, Case 6C which includes two SMR facilities totaling 1,200 MW forced in as part of Strategy C (Promote Resiliency) to replace the generation of one of three retired Browns Ferry units. Refinements in design and implementation, coupled with cost and risk sharing, could improve the SMRs' position compared to other resource options.

91. The Draft IRP states that the current energy supply is adequate and does not forecast much future load growth. It also states that the Browns Ferry nuclear units, which may be retired in about 15 years, are being upgraded at a cost of $500 million. Why has TVA already committed to the Browns Ferry upgrades when the Draft IRP indicates they are not necessary? It is important to note that experts in the field of energy economics such as Lazard, Bloomberg Energy, and the National Renewable Energy Laboratory 2018 Energy Baseline report all agree nuclear is the most expensive energy technology option. This action is in direct contravention to all the stated goals of the IRP. (*Commenters: Scott Banbury, Dorothy Craven, Andrew Hamlett, JJ Johnson, Sandra Kurtz, William Moll, Ian Schiller, Joe and Sarah Schiller*)

Response: Currently, the TVA system needs no additional baseload capacity beyond additions previously approved by the TVA Board, which include the uprates at Browns Ferry. Two of the three unit uprates have been completed. These uprates, included in the Base Case, showed a positive return on investment even without an additional license extension.

92. TVA should retire their nuclear plants. The concern over nuclear waste and the cost to build and maintain leave this technology off the table.(*Commenters: Corinne Adrian, Ruth Black, Jeff Coppala, Amanda Dobra Hope, Elizabeth Garber, Andrew Hamlett, Marita M. Hardesty, Melissa Harris, Charles High, Lawrence Miller, Damon Moglen, Fran Myers, Gene Pafford, Ophelia Paine, Ken Prahl, Martha Steele, Rosemary Varner, Jason Waldo*)

Response: TVA's existing nuclear fleet provides an important source of low-cost, carbon-free baseload power to the TVA system. Due to economics and system needs, none of the IRP cases included additional nuclear in the capacity expansion except for, as explained in Section 7.1.2 of the IRP, Case 6C which includes two SMRs totaling 1,200 MW forced in as part of Strategy C (Promote Resiliency) to replace the MW output of one of three Browns Ferry units. TVA complies with all regulations on the management and disposal of nuclear waste as outlined in EIS Section 4.7.2.

93. TVA should expand the use of nuclear power generation with next-generation technology which consumes the waste accumulated from older and current reactors as well as nuclear technology which does not contribute to the inventory of radioactive waste requiring protective storage. (*Commenters: Gail Boyd, Bill Runyan*)

Response: TVA complies with all regulations around the disposal of nuclear waste as outlined in Section 4.7.2 of the EIS. TVA continues to review the potential for recycling commercial nuclear fuel; however a cost-effective means to do so has not yet been found. The IRP generally includes mature and emerging technologies that are commercially viable and available in the U.S. The exception in this IRP is Small Modular Reactors (SMRs), which were included due to TVA's collaboration on the early site permit for this technology at the Clinch River site. Given that there is no commercial nuclear fuel reprocessing plant operating in the U.S., an option including reprocessing of commercial nuclear fuel has not been included in the 2019 IRP, but may considered for inclusion in future IRPs.

94. We are supportive of the Small Modular Reactor program, as these reactors can play important roles in replacing expiring or retiring capacity, and also meeting new energy demands in several scenarios. SMRs offer the inherent advantages of modularity, potentially lower capital investment, siting flexibility, and efficiency while supporting the development of an international marketplace for U.S. technology. In fact, with the announcement today (April 3, 2019) that the U.S. Nuclear Regulatory Commission (NRC) has completed NUREG-2226, the Environmental Impact Statement for an Early Site Permit (ESP) at the Clinch River Site, the City urges TVA to proceed with the SMR initiative, while working closely with Oak Ridge and other affected stakeholders to mitigate potential impacts associated with the project. (*Commenters: Ted Faust, Mark Watson – City of Oak Ridge*)

Response: Comment noted. Due to economics and system needs, none of the IRP cases included additional nuclear in the capacity expansion except for, as explained in IRP Section 7.1.2, Case 6C which includes two SMR facilities totaling 1,200 MW forced in as part of Strategy C (Promote Resiliency) to replace the generation of one of three retired Browns Ferry units. Refinements in design and implementation, coupled with cost and risk sharing, could improve the SMR's position compared to other resource options. TVA continues to work with stakeholders such as DOE regarding potential SMR development.

95. Flibe Energy, Inc. is a small business in Huntsville, AL focused on developing the Liquid Fluoride Thorium Reactor (LFTR, pronounced "lifter"). Based on decades of work at Oak Ridge National Lab, the details behind our modern efforts can be seen in more detail in an EPRI report, downloadable at https://www.epri.com/#/pages/product/3002005460/?lang=en-US. Furthermore, recent awards from the U.S. Department of Energy have opened up new partnerships and opportunities to push our technology development forward.

--https://www.energy.gov/ne/articles/us-department-energy-provides-nearly-20-million-domestic-advanced-nuclear-technology
--https://gain.inl.gov/SiteAssets/2019VoucherAbstracts/19-088_NewsRrelease_GAIN_announcesFY19-2ndRoundVouchers.pdf

A clean and flexible energy source like this should fit neatly into TVA's plans, and we propose incorporating LFTR into the IRP through the following changes:

--Figure 5-1: List of New Assets. Should have the category for Nuclear expanded to include a fourth bullet point that is “Liquid Fluoride Thorium Reactor (LFTR)”.
--Table 5-4: Nuclear Expansion Options. Fourth column with appropriate data filled out for a 600 MWth LFTR.

While we recognize that nuclear development has been difficult, and there are obstacles in our development path, we also know that all new energy technologies are risky. For example, current energy storage options are not capable of meeting TVA’s needs - new technologies will have to be developed. As these energy storage options are included in the IRP, a LFTR should be seriously considered, as it would provide clean, flexible, reliable, and economical energy to the Tennessee Valley. (*Commenter: Kurt Harris*)

Response: TVA continues to evaluate developmental technologies with industry partners. At this time the LTFR design is considered developmental for commercial operation, and the IRP generally includes only mature and emerging technologies that are commercially viable and available in the U.S. The exception in this IRP is Small Modular Reactors (SMRs), which were included due to TVA's collaboration on the early site permit for this technology at the Clinch River site. Due to economics and system needs, none of the IRP cases included additional nuclear in the capacity expansion except for, as explained in IRP Section 7.1.2 of the IRP, Case 6C which includes two SMRs totaling 1,200 MW forced in as part of Strategy C (Promote Resiliency) to replace the MW output of one of three Browns Ferry units.

96. TVA should renege on the Bellefonte sale (giveaway), if possible. To sell a multi-billion dollar asset for $112 million was a steal for Haney. TVA should finish Bellefonte Unit 1. (*Commenter: Stephen Hornbaker*)

Response: Due to economics and system needs, none of the IRP cases included additional nuclear in the capacity expansion except for, as explained in IRP Section 7.1.2, Case 6C, which includes two SMRs facilities totaling 1,200 MW forced in as part of Strategy C (Promote Resiliency) in a No Nuclear Extensions scenario to replace the MW output of one of three retired Browns Ferry units.

97. I strongly urge use of nuclear power and the building or completion of new nuclear plants. I do not think small nuclear plants such as the modular type will prove to be as economical as large nuclear plants. The economies of scale are important. (*Commenter: W.J. Lackey*)

Response: Due to economics and system needs, none of the IRP cases included additional nuclear in the capacity expansion except for, as explained in IRP Section 7.1.2, Case 6C which includes two SMRs facilities totaling 1,200 MW forced in as part of Strategy C (Promote Resiliency) to replace the MW output of one of three retired Browns Ferry units. While traditional large-scale nuclear units have better relative economies of scale, modular nuclear units offer more flexibility and could serve more of a role in promoting local resiliency.

98. What are Small Nuclear Reactors and would they be built at existing nuclear plants? (*Commenters: Anonymous 5, David Williams*)

Response: Small Modular Reactors (SMRs) are a new type of nuclear reactor in which the components are manufactured in a factory and then assembled together onsite. The individual units are smaller in size, allowing for increased flexibility in installation and use. New units could be located at existing nuclear plants or at other sites beneficial to the transmission system or local resiliency. The siting of future generating facilities is outside the scope of the IRP.

99. The IRP states, with the exception of the Brown’s Ferry power uprates, no new nuclear is anticipated with the possible exception of substituting a Small Modular Reactor (SMR) for a Brown’s Ferry unit if it is retired. SMR is an unproven technology with no cost estimate since none have ever been built. Yet TVA included it as a possible option

in its IRP, thus exposing its customers to very significant cost risks. (*Commenters: Scott Banbury, William Moll, Joe and Sarah Schiller*)

Response: SMRs were included as a resource option due to TVA's collaboration on the early site permit for this technology at the Clinch River site. Due to economics and system needs, none of the IRP cases included additional nuclear in the capacity expansion except for, as explained in IRP Section 7.1.2 of the IRP, Case 6C which includes two SMR facilities totaling 1,200 MW forced in as part of Strategy C (Promote Resiliency) to replace the generation of one of three retired Browns Ferry units. Refinements in design and implementation, coupled with cost and risk sharing, could improve the SMR's position compared to other resource options.

100. Nuclear generation options modeled and considered do not incorporate the beneficial adoption of accident tolerant fuel (ATF) for nuclear generation additions to the system capacity and energy forecast. (*Commenter: Ricardo G. Perez*)

Response: TVA continues to evaluate developmental technologies with industry partners, including advancements in nuclear plant design and fuels. Accident Tolerant Fuel is still in developmental stages, and the IRP generally includes only mature and emerging technologies that are commercially viable and available in the U.S. The exception in this IRP is Small Modular Reactors (SMRs), which were included due to TVA's collaboration on the early site permit for this technology at the Clinch River site.

101. The IRP Base Case should assume substantial additional licensing and capital costs to both achieve and maintain an 80-year license via the NRC's Subsequent License Renewal (SLR) process as well as longer routine maintenance and inspection periods in order to test whether the units have substantial marginal value to the system.

TVA assumes in its Base Case and most scenarios that all existing nuclear plants will be relicensed at the end of their current license. TVA's Browns Ferry will reach the end of its current 60-year license in the 2033-2036 timeframe, near the end of TVA's current draft plan. Currently, only two SLR applications have been submitted to the NRC so there is no precedent for TVA to rely on the operation of its nuclear fleet for 80 years.

Furthermore, we do not agree that TVA can assume all licenses will be renewed without significant costs. Most nuclear plants in the U.S. were built between 1970 and 1990 and given a 40-year license by the NRC. Many of those licenses have been extended beyond the original 40 years to include another 20 years, often at significant cost. However, it is unclear whether these plants can and should be operated an additional 20 years (i.e., 80 years), without substantial and perhaps cost-prohibitive capital investment.

In TVA's reply to our request for additional documents, TVA expects, based on preliminary industry estimates, that nuclear relicensing costs for the three-unit Browns Ferry nuclear plant may range from $1 billion to 3 billion. TVA provided no reasonable basis for arbitrarily selecting $2 billion as the modeling assumption.

TVA also stated that work related to Browns Ferry's subsequent relicensing would take place as much as feasible during standard refueling outage schedules for a number of years ahead of relicensing. TVA provided no basis for demonstrating that this assumption can be relied on, and provided no basis for assuming that post-SLR maintenance and operation costs would be similar to present conditions.

Given the scarcity of data provided by TVA, we strongly question what “preliminary industry estimates” relied upon by TVA might represent beyond guesses. TVA should provide a detailed description of the costs associated with the SLR application and compliance process (licensing, engineering, equipment/plant modifications and upgrades, etc.) along with supporting documentation to support such estimates prior to finalizing the IRP. Without such support, it appears that TVA has selected assumptions with the goal of presuming that operating Browns Ferry for 80 years is economic.

Section 3.2.3 of the Draft EIS lists generating facilities that were allowed to retire due to economics in the IRP modeling. No nuclear facilities are included in this section, thus we conclude that TVA did not allow the model to retire Brown's Ferry in order to avoid the additional costs associated with license renewal (i.e., the $2 billion assumption used in this case). For the Final IRP TVA should allow any existing generation to retire to avoid continued costs. This is the only way to a true least-cost planning process that optimizes the entire system's costs. (*Commenter: Stephen Smith – Southern Alliance for Clean Energy*)

Response: TVA's existing nuclear fleet provides an important source of low-cost, carbon-free baseload power to the TVA system. Based on costs related to replacement energy, replacement capacity, transmission system modifications and decommissioning, TVA's analysis indicates that an SLR for the Browns Ferry Plant is economic. For this reason, the retirement of the Browns Ferry Plant is not addressed in the same manner as coal and combustion turbine plants being considered for retirement. The nuclear industry is very early in the process for subsequent license renewals (SLR) for up to 80 years, and TVA will learn a great deal over the next several years that will refine estimates of SLR costs. The costs related to applying for the license itself are a small portion of the $2 billion estimate, while work related to engineering and equipment/plant modifications associated with the extended operation would drive the majority of the costs. Costs would be driven by which systems need to be replaced or upgraded. Modifications occurring as part of the Extended Power Uprates (EPU) should reduce the level of capital investment needed for re-licensure, as some systems have been recently upgraded as part of that effort. For this reason, it was prudent to use a mid-range industry estimate at this time until more refined estimates become available. Similar to industry peers, TVA will investigate initial steps in the SLR process to further inform costs and more detailed evaluations, as well as to allow ample time to address upgrades as much as feasible during standard refueling outages if the Browns Ferry SLR is pursued.

No other units in TVA's nuclear fleet reach the end of their 60-year operating license during the 2019 IRP planning horizon. The Sequoyah units reach the 60-year mark in the early 2040s. An SLR for the Sequoyah units would be evaluated in the next IRP when more will be known about the SLR process and related costs.

F.2.2.10 Renewable Energy

102. TVA should be cautious about renewable energy resources, such as solar power generation, and not be unduly influenced by well-funded environmental groups pushing the renewable platform. They tend to be overly biased toward their particular agenda without taking overall cost into consideration. (*Commenters: Walter Baird, Jeff Coppala, Keith and Judy Kibbe, Elizabeth Surface, Tom Surface*)

Response: Comment noted. All of the portfolios and the Target Power Supply Mix include at least 4 GW of additional, cost effective solar generation.

103. TVA should include more renewables in their long range plans. (*Commenters: Corinne Adrian, Mark Bishop, David Bordenkircher, Butterfly Boucher, Claire Chandler, Adney Cross, Carleen Dowell, Anjay Friedman, Bruce Gaynor , Philip Gubbins, Anne Hardin, Tom Hardin , Dawn Hartley, Nathan Hess, Charles High, Sarah Houston, Laurie Hynson, Rebecca Janssen, Kenneth Jobe, JJ Johnson, Celia Mackey, Madona May, Melanie Mayes, Pate McCartney, Tom McClain, Carol McComiskey, Sadie McElrath, Craig McManus, Jason Miller, Grant Mincy, Sally Monzyk, Mindy Mosier, Thomas Moss, Wolf Naegeli, Rohan Nakra, Jennifer ODonnell, Ben Osterlund , Ophelia Paine, SUSAN PEARCE, Samantha Peters, Amy Phelps, Patrick Rakes, Stefanie Rapp, Michelle Rogers, Sharon Rush, Rebecca Russ, Bonnie Seay, Geoffrey Shrewsbury, Susan B. Solomon, Martha Steele, Elizabeth Surface, Laura Thurman, Steve Vining, Heather Waldrup, Selina Webb, Nick Wiggins*)

Response: Solar expansion is significant in the IRP, ranging from about 6 to 9 GW of nameplate capacity by 2038 under the Current Outlook for electricity demand and up to 14 GW of nameplate capacity in a growth scenario. Sensitivity analysis has identified the potential for up to about 4 GW nameplate of additional wind capacity, if lower wind costs could be realized.

104. TVA should commit to convert to 100% renewable energy supply and generation of all TVA served areas by 2038. (*Commenters: Judith Abrams, Catherine Arnoult, Duffy-Marie Arnoult, Leo Arnoult, Emily Burch, Mary Clarke, Ann Davis, Jennifer Davis, Lynn Davis, Princeton Echols, George Eichbauer, Jim Gienapp , Lynn Hubbard , Richard Hutchinson, Logan Hysen, John Klyce, Herman LaVelle , Lindsay Lavelle, Vance Lavelle, Vivi Lavelle, Suzana Lightman, Jacob Lockwood, Naomi McDougall Graham, Nancy McFadden, Matthew Merritt, Damon Moglen, Margaret Neu, Joe Ozegovich, Catherine Pena , Katherine Ragsdale, Sallie Sabbatini, Mary Self, Paul Slentz, Vivian Strain, Noelle Toumey, Courtney Vick, Steven Waterfield*)

Response: Comment noted. The TVA Act mandates least-cost planning with consideration of environmental stewardship and economic development. Solar expansion is significant in the IRP, ranging from about 6 to 9 GW of nameplate capacity by 2038 under the Current Outlook for electricity demand and up to 14 GW of nameplate capacity in a growth scenario. Sensitivity analysis has identified the potential for up to about 4 GW nameplate of additional wind capacity, if lower wind costs could be realized. A diverse resource portfolio plays an important part in ensuring the reliable integration of intermittent resources such as wind and solar. TVA's diverse power supply was comprised of 53% carbon-free generation in 2018, and the IRP strategies show an average reduction of CO_2 emissions from 2019 to 2038 of 18.9 to 23.4%, as shown in Table 5-4 of the EIS. The IRP recognizes that storage technology is evolving, and the recommendation reflects the potential for up to 5 GW of additional storage, which may offset some generation from carbon emitting sources.

105. TVA should consider burning trash to generate electricity and other forms of reducing the cost of generating electricity. TVA should consider the impact using trash to make electricity would have on our environment. Using trash in place of even a small amount of coal would seem to reduce the cost to produce electricity. (*Commenter: Deborah Danielson*)

Response: Current Green Power Providers (GPP) guidelines exclude municipal solid waste (trash) from eligibility as a biomass resource for environmental reasons. However, GPP guidelines do allow for non-chemically treated or coated waste wood, agricultural crops or waste, animal and other organic waste, energy crops, and landfill gas or wastewater methane. As stated in IRP Chapter 5, two biomass options are included in the IRP evaluation as shown in Table 5-11: a new direct combustion biomass facility and a repower option, which is the conversion of existing coal-fired units to biomass-fired units. Due to high capital costs and poor relative heat rates of biomass fuels, none of the IRP cases contained either of these biomass options. TVA will continue to consider biomass options in future IRPs.

106. Dropping the Green Power Providers program is a big mistake not just for the environment, but also for your reputation—TVA is being seen as less and less solar friendly. (*Commenters: Deborah Hamilton, Doug Kalmer, Celia Mackey, Gordon Niessen, David Williams*)

Response: Comment noted. TVA's Green Power Provider (GPP) program will be discontinued after 2019. TVA is considering related offerings that would begin in 2020. TVA has launched the Flexibility Research Project (FRP) pilot program (described in IRP Section 8.2.5), which works in partnership with local power companies (LPCs) to provide community scale solar options to customers in their service area. Community scale solar provides opportunities for LPC customers to invest in LPC-sponsored community solar facilities as a lower cost alternative to constructing and operating their own rooftop or other solar facilities. The IRP analysis considered distributed generation and storage as resource options, and the results will inform development of future distributed generation offerings by TVA and/or LPCs.

107. From a cost perspective, it may not seem advantageous to expand renewable energy sources now, but the 20-year plan needs to consider the sunk costs that could occur with the introduction of a carbon tax. Increasing costs of fossil fuels and an increase in the demand for renewable energy would cause consumers to get their energy from other states or provide their own energy. (*Commenter: Anjay Friedman*)

Response: One of the six scenarios evaluated in the IRP is Decarbonization, which envisions a future in which there is a CO_2 emission penalty and incentives for non-emitting technologies. TVA also performed a sensitivity analysis to evaluate a doubled carbon penalty of $44/ton of CO_2. The results reflect that a diverse portfolio continues to serve an important role in the reliable integration of intermittent resources such as wind and solar. Solar expansion is significant in the IRP, ranging from about 6 to 9 GW of nameplate capacity by 2038 under the Current Outlook for electricity demand and up to 14 GW of nameplate capacity in a growth scenario. Sensitivity analysis has identified the potential for up to about 4 GW nameplate of additional wind capacity, if lower wind costs could be realized.

TVA's diverse power supply was comprised of 53% carbon-free generation in 2018, and the IRP strategies show an average reduction of CO_2 emissions from 2019 to 2038 of 18.9 to 23.4%, as shown in Table 5-4 of the EIS.

108. Does the plan consider purchasing power from states with a greater solar/wind potential, perhaps investing in that industry elsewhere? (*Commenter: Ken Prahl*)

Response: Yes. Solar expansion is significant in the IRP, ranging from about 6 to 9 GW of nameplate capacity by 2038 under the Current Outlook for electricity demand and up to 14 GW of nameplate capacity in a growth scenario. Most of this solar capacity is expected to be built in the Valley. As described in IRP Section 5.2.1.7, TVA included four wind expansion options in the 2019 IRP. Three of the four options would be sourced out of the Valley, including wind from the Midcontinent Independent System Operator and the Southwest Power Pool regions and wind transported to the Valley over a high voltage direct current transmission line. Wind energy sourced from outside the Valley currently incurs significant additional costs for transmission into the region. Based on economics, none of the wind options were included in the primary 2019 IRP cases. The Target Power Supply Mix (IRP Recommendation) includes the potential for up to about 4 GW nameplate of additional wind capacity, if lower wind costs could be realized.

109. Why is there such little difference in renewables across portfolios? (*Commenter: Claudio Meier*)

Response: In resource planning, it is typical to limit the number of MW additions made in a given year to reflect the practicality of when TVA has knowledge of the resource need, uncertainty about future prices and conditions, and other project management considerations. Solar is approaching cost parity, and the annual solar cap of 500 MW contributed to similar levels of solar additions occurring across a number of cases. Sensitivity analysis doubling the annual solar cap identified the potential for up to 14 GW of nameplate capacity in a growth scenario. Sensitivity analysis also identified the potential for up to about 4 GW nameplate of additional wind capacity, if lower wind costs could be realized. More information about the sensitivity analyses can be found in Section 8.2 of the IRP. The potential increases in solar and wind capacity expansion are included in the IRP Recommendation.

F.2.2.11 Solar Energy

110. TVA should phase out or close coal plants and replace them with more solar and renewable energy. (*Commenters: Anonymous 1 , Corinne Adrian, Leanne Allen, Correna Andrews, Wade Austin, Butterfly Boucher, Nathan Brown, Karen Childres, Will Connor, Natasha Crawley, Donald Dresser, Robert Garrett, Henry Goldberg, John Harkey, Melissa Harris, Nathan Iyer, Jonathan Levenshus, Lawrence Miller, Mary Moore, Lauren Newman,*

Gene Pafford, Ophelia Paine, SUSAN PEARCE, Jerry Peyton, Sherrie Raymond, Wendy Ritchey, Mark Robbins, Michelle Rogers, Sandra Smith, Ranan Sokoloff, Patrick Thompson, Rosemary Varner, John Todd Waterman, Greg Wathen, Selina Webb, Gregory Wellman, Kimberly Wellman, John Williamson)

Response: Comment noted. The IRP Recommendation reflects the potential for more than 2 GW of additional coal retirements beyond those already approved by the TVA Board. Solar expansion is significant in the IRP, ranging from about 6 to 9 GW of nameplate capacity by 2038 under the Current Outlook for electricity demand and up to 14 GW of nameplate capacity in a growth scenario. Sensitivity analysis has identified the potential for up to about 4 GW nameplate of additional wind capacity, if lower wind costs could be realized.

111. Please address how TVA and its energy partners can encourage individual /residential solar investments by homeowners that are economically beneficial to residents and will contribute to a reduction in the pollution generated by energy production. (*Commenters: Anonymous 4 , Deborah Ackema , Corinne Adrian, Denise Alper, Sara Bielaczyc, Gail Boyd, Ann Ercelawn , Elizabeth Garber, Deborah Hamilton, Katie Herzig, Hans-Willi Honegger, Nathan Iyer, Rebecca Janssen, Catherine Koczaja, Dasom Lee, Maureen May, Brian Nothnagle, Ken Prahl, Wendy Ritchey, Jonathan Rossow, Paul Slentz, David Yohn*)

Response: The Green Power Providers program is accepting applicants through the end of 2019. TVA has recently launched the Flexibility Research Project (FRP) pilot program described in IRP Section 8.2.5. This program works in partnership with participating local power companies (LPCs) to provide community scale solar options to customers in their service area. Community scale solar provides opportunities for LPC customers to invest in LPC-sponsored community solar facilities as a lower cost alternative to constructing and operating their own rooftop or other solar facilities. The IRP explored distributed generation and storage as resource options and the results help inform and provide flexibility for development of future distributed offerings by TVA and/or LPCs.

112. TVA should accelerate the deployment and use of solar energy generation, supply and purchase. (*Commenters: Judith Abrams, Craig Anderson, Catherine Arnoult, Duffy-Marie Arnoult, Leo Arnoult, Karen Blanco, Emily Burch, Ann Davis, Jennifer Davis, Lynn Davis, Amanda Dobra Hope, Ann Ercelawn , Jim Gienapp , Lynn Hubbard , Richard Hutchinson, John Klyce, Sandra Kurtz, Herman LaVelle , Lindsay Lavelle, Vance Lavelle, Suzana Lightman, Celia Mackey, Mary Marquart , Trish Marshall, Naomi McDougall Graham, Margaret Neu, Joe Ozegovich, Catherine Pena , Katherine Ragsdale, Sallie Sabbatini, Mary Self, Paul Slentz, Vivian Strain, Noelle Toumey , Rosemary Varner, Courtney Vick, Steven Waterfield, Joan Williams*)

Response: Solar expansion is significant in the IRP, ranging from about 6 to 9 GW of nameplate capacity by 2038 under the Current Outlook for electricity demand and up to 14 GW of nameplate capacity in a growth scenario. Driven by the timing of customer demand, TVA has launched two programs to support accelerated renewable investment: Renewable Investment Agreement (RIA) and the Flexibility Research Project (FRP) pilot. RIA supports utility scale buildouts for large commercial and industrial customers and FRP supports community solar, in partnership with local power companies (LPCs). Community scale solar provides opportunities for LPC customers to invest in LPC-sponsored community solar facilities as a lower cost alternative to constructing and operating their own rooftop or other solar facilities. These programs are described in more detail in IRP Section 8.2.5.

113. Solar generation is not cost-effective or reliable. How does an increase in solar generation meet TVA's mission? (*Commenters: Shawn Edmondson, Ron Rucker*)

Response: Under the TVA Act, TVA is mandated to conduct least-cost planning. Solar prices have decreased appreciably over the past five years. TVA approaches this plan focused on the best way to ensure reliability and meet power demand at the lowest feasible cost. Solar generation is cost effective and, when integrated with the other resources, overall system reliability standards are met.

114. TVA can be an innovator in solar energy and make money in renewables. (*Commenters: Graham Barnard, Anjay Friedman*)

Response: Comment noted.

115. TVA should incorporate solar installation and maintenance training and employment opportunities into TVA IRP targeting economically depressed communities/populations. (*Commenters: Judith Abrams, Catherine Arnoult, Duffy-Marie Arnoult, Leo Arnoult, Emily Burch, Ann Davis, Jennifer Davis, Lynn Davis, Jim Gienapp , Lynn Hubbard , Richard Hutchinson, John Klyce, Herman LaVelle , Lindsay Lavelle, Vance Lavelle, Suzana Lightman, Naomi McDougall Graham, Lawrence Miller, Margaret Neu, Catherine Pena , Katherine Ragsdale, Sallie Sabbatini, Mary Self, Vivian Strain, Noelle Toumey , Courtney Vick, Steven Waterfield*)

Response: Comment noted. While the scope of the IRP does not include identifying new educational or training programs, TVA recognizes the importance of providing opportunities in communities to promote economic development. Section 4.9.4 of the EIS (Volume II) describes TVA programs benefiting minority and low-income communities that are ongoing. While the programs discussed in the EIS focus on improving energy savings and efficiency, TVA will continue in its mission of service and economic development to identify other opportunities such as the development of training programs to serve these communities. The expansion of solar generation under the 2019 IRP is also likely to provide numerous local employment opportunities.

116. TSEA recommends applications, like community solar and microgrids, that offer energy independence at the neighborhood level be included in any future solar offerings from TVA. Essentially, we must have the ability to secure Distributed Energy Resources (DER) collectively that private developers can offer using TVA's Green Power Provider Program. (*Commenter: Jason Carney*)

Response: TVA's Green Power Providers program will be closed to new applicants after 2019. TVA has launched the Flexibility Research Project (FRP) pilot program (see IRP Section 8.2.5), which works in partnership with local power companies (LPCs) to provide community scale solar options to customers in their service area. Community scale solar provides opportunities for LPC customers to invest in LPC-sponsored community solar facilities as a lower cost alternative to constructing and operating their own rooftop or other solar facilities. The IRP explored distributed generation and storage as resource options, and the results will inform development of future distributed offerings by TVA and/or LPCs.

117. I would like to see solar panels installed at the Swan Pond playing fields at KIF. Another great site for a large solar project would be at the old K-25 site at ETTP or on adjacent land which is ready for industrialization. (*Commenter: Martha Deaderick*)

Response: The 2019 IRP evaluates the resources TVA would use over the next 20 years to meet the energy needs of the TVA region at the lowest cost. The location of new generating and storage resources is outside the scope of the IRP. Locations for these facilities will be reviewed on a case-by-case basis, with due consideration given to the impacts to the transmission system and the location relative to load centers.

118. The City applauds TVA for its approach to solar expansion across all portfolios, which allows for continued development of these resources. The agency needs to continue to partner with distributors to integrate such resources into the grid, while minimizing risks posed to our customers at times of highest demand. (*Commenter: Mark Watson – City of Oak Ridge*)

Response: Comment noted. TVA will continue to partner with local power companies (LPCs) to serve the Valley with affordable, reliable and clean energy.

119. TVA should consider selling solar direct to businesses. Businesses would purchase TVA's solar vs a third party because of the virtual elimination of liability insurance. (*Commenter: Michael Meece*)

Response: The IRP does not describe the terms under which end users would purchase solar energy. Driven by the timing of customer demand, TVA has launched two programs to support accelerated renewable investment: Renewable Investment Agreement (RIA) and the Flexibility Research Project (FRP) pilot. RIA supports utility scale buildouts for large commercial and industrial customers and FRP supports community solar in partnership with local power companies (LPCs). These programs are described in more detail in IRP Section 8.2.5. Community scale solar provides opportunities for LPC customers to invest in LPC-sponsored community solar facilities as a lower cost alternative to constructing and operating their own rooftop or other solar facilities. Programs such as these can serve as vehicles for selling solar directly to customers either by TVA or through the LPCs.

120. I could not find specific reference to the percentage of solar by year, or the year by percentage increase in solar. Year by year goals to meet the greatest challenge our world has to be set. Set up Enterprise zones in economically challenged areas for community solar and Multiple Unit Housing. (*Commenter: Joe Ozegovich*)

Response: Tables in IRP Appendix G show solar expansion in 1-year and 5-year intervals. Solar expansion is significant in the IRP, ranging from about 6 to 9 GW of nameplate capacity by 2038 under the Current Outlook for electricity demand and up to 14 GW of nameplate capacity in a growth scenario. . Driven by the timing of customer demand, TVA has launched the Flexibility Research Project (FRP) pilot. FRP supports community solar, in partnership with local power companies (LPCs). Community scale solar provides opportunities for LPC customers, including those in economically challenged areas, to invest in LPC-sponsored community solar facilities as a lower cost alternative to constructing and operating their own rooftop or other solar facilities. While the IRP is not site-specific, siting for future generation needs will be handled on a case-by-case basis and will consider many factors, including environmental justice and economic development opportunities.

121. The IRP indicates, generally speaking, a trade-off between TVA promotion of distributed-scale versus utility-scale solar in terms of meeting projected capacity needs. I strongly encourage TVA to pursue strategies that result in significantly expanded solar capacity at whatever scale (distributed or utility) best meets the needs of TVA and Valley communities. However, it is also important that TVA and LPCs accommodate and do not create or exacerbate barriers to private investment in distributed solar, including barriers that result from ratemaking decisions. (*Commenter: David Briley, City of Nashville*)

Response: Comment noted. Solar expansion is significant in the IRP, ranging from about 6 to 9 GW of nameplate capacity by 2038 under the Current Outlook for electricity demand and up to 14 GW of nameplate capacity in a growth scenario. Solar levels could ultimately be achieved through a combination of utility and distributed scale options. As described in IRP Appendix C.1, each case includes a unique level of distributed solar penetration driven by market conditions in that scenario and promotion, if applicable, in the strategy. The market penetration level of distributed solar is then enforced in the capacity expansion model as a required resource and the remainder of the resource portfolio is optimized in a least cost manner. TVA has launched the Flexibility Research Project (FRP) pilot program which supports community solar, in partnership with local power companies (LPCs). Community scale solar provides opportunities for LPC customers to invest in LPC-sponsored community solar facilities as a lower cost alternative to constructing and operating their own rooftop or other solar facilities.

F.2.2.12 Storage

122. There is an opportunity to reduce life-cycle environmental impacts from utility-scale battery storage facilities through the use of recycled batteries from electric vehicles. Electric vehicle batteries are typically retired from vehicle use when they no longer meet the high standard performance thresholds for that application. These batteries still offer significant storage capacity and can be economically reconditioned and redeployed to store energy for the

stationary grid, such as peak shaving services. The National Renewable Energy Laboratory is exploring this reuse to help increase electric vehicle ownership and reduce the cost/impacts of grid-connected energy storage systems. We encourage TVA to investigate innovative solutions when considering battery storage technologies. (*Commenter: Kendra Abkowitz – Tennessee Department of Environment and Conservation*)

Response: Comment noted. TVA continues to evaluate emerging technologies with industry partners, including advancements in storage technologies and potential reuse options for EV batteries. At this time, the cost to re-purpose vehicle batteries for utility use is uneconomical when compared to new battery systems that are continuing to decline in costs.

123. TVA's IRP should include adequate battery storage for solar and wind power. The IRP should reflect advancements in battery storage research and construction. (*Commenters: Mark Bishop, David Bordenkircher, Elizabeth Garber, Anne Hardin, Melissa Harris, Christine Hart, Sandra Kurtz, Jonathan Levenshus, Melanie Mayes, Fran Myers, Wolf Naegeli, Joe Ozegovich, Ranan Sokoloff, John Todd Waterman, Greg Wathen, Gregory Wellman, Kimberly Wellman, John Williamson).*

Response: One of TVA's goals in the 2019 IRP was to explore the impact of adding storage, both at utility and distributed scales, which could support integration of renewables. The primary cases reflect up to 3 GW of storage additions, and additional sensitivity analysis has been run that increases the potential upper bound to about 5 GW by 2038. The trajectory and timing of additions will be highly dependent on the evolution of storage technologies.

124. TVA should consider using its existing dams as pumped storage because of the longevity and capacity potential. (*Commenters: Stephen Levy, Claudio Meier, Nick Wiggins*)

Response: Comment noted. As noted in Section 5.2.2 of the IRP, the 2019 IRP includes a new pumped-storage hydro unit storage option. Based on economics, this option was not included in any of the IRP cases. Converting existing hydro units for pumping ability would provide additional flexibility but no net increase in capacity.

F.2.2.13 Wind Energy

125. TVA should increase adoption of wind energy assuming its efficiency will continue to increase by 2038. (*Commenters: Carleen Dowell, Joe Ozegovich, Jonathan Rossow, Paul Slentz, Nick Wiggins*)

Response: As noted in IRP Section 5.2.1.7, the 2019 IRP included four wind expansion options: wind from the Midcontinent Independent System Operator , wind from the Southwest Power Pool , wind transported over a high voltage direct current transmission line, and an in-Valley wind option. Wind energy sourced from outside the Valley currently incurs significant additional costs for transmission into the region. Based on economics, none of the wind options were included in the primary 2019 IRP cases. The IRP Recommendation includes the potential for up to about 4 GW nameplate of additional wind capacity by 2038 if wind technology were to become more efficient and prices in-Valley or out of Valley wind energy were to decrease.

126. I am not a supporter of wind farms for several reasons. They devalue the property of nearby homeowners. They are an eyesore in communities that rely on tourism, and harm the tourism economy. Their constant rotation affects the area noise quality. And they are likely to remain an eyesore once they meet their life expectancy. (*Commenter: David Harvey*)

Response: Comment noted.

127. Why was Clean Line wind power totally rejected? (*Commenter: Sandra Kurtz*)

Response: In late 2017, TVA received notice that the schedule for the Clean Line project no longer aligned to the requirements of TVA's interconnection process. TVA subsequently withdrew the project from its interconnection queue and stopped further analysis of the project. Clean Line can submit a new request for TVA to restudy the project. As noted in IRP Chapter 5, the 2019 IRP included four wind expansion options: wind from the Midcontinent Independent System Operator , wind from the Southwest Power Pool , wind transported over a high voltage direct current transmission line, and an in-Valley wind option. Wind energy sourced from outside the Valley currently incurs significant additional costs for transmission into the region. Based on economics, none of the wind options were included in the primary 2019 IRP cases. The IRP Recommendation includes the potential for up to about 4 GW nameplate of additional wind capacity by 2038 if wind technology were to become more efficient and prices in-Valley or out of Valley wind energy were to decrease.

128. Are there other wind turbine technologies that could reduce the price in order to diversify the renewable portfolio? (*Commenter: Sarah Houston*)

Response: The four wind expansion options evaluated in the IRP (see Section 5.2.1.7) are all based on the current horizontal axis, three-blade wind turbine technology, with consideration of future increases in performance and decreases in price. The four wind expansion options differ in the geographic location of the turbines. TVA continues to monitor the evolution of wind turbine technology and will consider different turbine technologies as they become commercially mature and economically viable.

129. Section 5.2.2.7, Wind indicates that "TVA may evaluate the option of building wind facilities in the future..." . This seems to indicate TVA will own these facilities versus buying the power from third-party owned/operated wind farms. Is this correct? (*Commenter: John Shaw*)

Response: Because TVA cannot take direct advantage of tax credits and other investment incentives offered by the federal government to encourage wind power development, it has been more economical to procure wind power resources through PPAs. This situation is changing as the federal incentives are being phased out. TVA will continue to monitor costs and improvements in technology to determine how wind resources might be procured in the future.

130. The Plan should explain that wind was rejected due to low average wind speeds in the Valley, making the cost per harvested kilowatt-hour much higher than solar. (*Commenter: David Williams*)

Response: EIS Section 4.6.1 describes wind speeds in the eastern and cental US and Figure A-2 in the IRP includes a comparison of capacity factors for wind resources in a variety of geographical locations. The In-Valley wind option does have the lowest comparative capacity factor based on the lower wind speeds in the Valley. Wind expansion options are available for sources outside the Tennessee Valley with higher relative capacity factors, but also with higher transmission costs. Based on economics, no new wind was included in the primary cases. The IRP Recommendation includes the potential for up to about 4 GW nameplate of additional wind capacity by 2038 if wind technology were to become more efficient and prices in-Valley or out of Valley wind energy were to decrease. .

131. The capabilities of wind microturbines, which can begin generating power in winds of 2 mph, wasn't considered in the options. These small turbines not only perform well, but are much easier to maintain. Multiple MicroCubes can be combined to create an advanced WindWall on a base that turns to face the most effective direction to catch the wind. (*Commenter: Martha Steele*)

Response: TVA continues to evaluate developmental technologies with industry partners. The IRP generally includes mature and emerging technologies that are commercially viable and available in the U.S. TVA continues to evaluate advancements in technologies, and as new technologies become commercially viable, they will be considered as resource options in the next IRP.

F.2.3 Environmental Impacts

F.2.3.1 Air Quality

132. TVA should retire all coal plants in the next 20 years due to air pollution. TVA's attempt to lighten the backlash on coal ash really didn't work, and TVA's inability to handle the toxic residue will cause serious developmental issues in children. Furthermore, emissions cause asthma and lung-disease. (*Commenters: Christine Hart, Nathan Iyer*)

Response: The IRP Recommendation reflects the potential for more than 2 GW of additional coal retirements beyond those already approved by the TVA Board. Emissions of air pollutants and generation of coal waste decrease under all strategies.

133. Any and all associated environmental considerations (i.e. USEPA's ROD, this TVA-IRP EIS) should endeavor to protect the public health, and improved welfare should include public investments in at-risk infrastructure and at-risk facilities. TVA agency officials should meet the terms of their mission. This includes environmental stewardship with the Oak Ridge Reservation's Federal Facility Agreement partners. This compliance with laws, rules, policies, procedures, and mandated orders should not jeopardize public health and safety; yet, the MRMES/GENII environmental air pollution transport and deposition models have. Any prior or existing recommendation of the HERMES/GENII model by TVA for Tennessee's ridge and valley region is not simply administratively suspect, it is not just a management error, nor is it a clerical error: The current or past decisions to use HERMES/GENII has created a tort harm to the public health, which can be tolled to TVA's derelict acts.

The public has a right to know accurate cumulative human health risks in the environment; yet, TVA's inability to respond directly to this issue of having verified an at-risk computer model that miscalculates cumulative human health-risks substantiates on-going errors and omissions. (*Commenter: C.S. Sanford*)

Response: Comment noted. While TVA did not use air pollution modeling to analyze air quality impacts, emissions of air pollutants, the intensity of greenhouse gas emissions and generation of coal waste decrease under all strategies.

F.2.3.2 Endangered and Threatened Species

134. Appendix A of the draft EIS lists endangered and threatened species reported in the vicinity of TVA generating facilities. TVA should reference this list when planning projects in the vicinity of its generating facilities. We also recommend that the appropriate resource agencies (U.S. Fish and Wildlife Service for federally listed species, Tennessee Wildlife Resources Agency for state-listed animal species in Tennessee, and Tennessee Department of Environment and Conservation for state-listed plant species in Tennessee) be provided the opportunity to comment on the effects of proposed actions on listed species. (*Commenter: Kendra Abkowitz – Tennessee Department of Environment and Conservation*)

Response: Comment noted. When planning site-specific actions to implement the IRP, TVA will conduct an updated review of the status of federally and state-listed threatened and endangered species in the vicinity of the proposed action. TVA will provide opportunities for the U.S. Fish and Wildlife Service and state agencies to comment on the proposed action as appropriate.

135. NEPA requires TVA to examine the impacts of the 2019 IRP on all species, whether listed or not under the Endangered Species Act or other legislation. Any species or critical habitat that might be harmed must have its impacts addressed in the EIS. The Draft EIS does not provide this impact analysis and only provides a brief general

discussion of imperiled species in the TVA service area. The Final EIS must include a comprehensive analysis of unavoidable adverse impacts to all listed or proposed species, as well as their critical habitat, within TVA's sphere of influence. The analysis must address the complete cradle-to-grave impacts of TVA's operations on species and their habitats at every stage of the supply chain. It must include listed species, species proposed for listing, and species petitioned for listing. In addition to the species listed in Draft EIS Appendix A, these species include at least 65 petitioned species affected by the use of coal, 34 petitioned aquatic species affected by dams, 11 species affected by the road infrastructure to operate the TVA system, and 5 petitioned species affected by utility infrastructure, including transmission lines. As part of the analysis, TVA must prepare a programmatic biological assessment and consult and/or confer with the U.S. Fish and Wildlife Service. (*Commenter: Howard Crystal – Center for Biological Diversity*)

Response: The IRP EIS is a programmatic environment analysis that does not itself authorize any site-specific actions, such as the construction and operation of new generating facilities. Consequently, the EIS does not contain site-specific analyses of the potential impacts of each of the IRP alternatives on these resources. Rather, the EIS includes general discussions of aquatic life (Section 4.4.4), vegetation and wildlife (Section 4.5.2), and threatened and endangered species (Section 4.5.3) within the TVA region. These descriptions are followed by a discussion of how impacts to these resources would be addressed during facility siting and review processes when specific proposals to implement the IRP are considered (Section 5.1). Threatened and endangered species were highlighted in the discussion given the additional mandate TVA has to consider effects to these species.

TVA will conduct the appropriate detailed impact analyses when it proposes actions to implement the IRP. While site- and implementing action-specific impact analyses are not possible at this time, the EIS quantifies the land area requirements for implementing the alternative strategies. The land area requirements associated with power generation facilities provide an indicator of the potential for impact to many biological resources. TVA will consider mitigation of any impacts through siting and facility design processes at the time additional environmental reviews are conducted for site-specific actions implementing the IRP.

136. TVA should consider the cumulative impacts of DER resources on listed species. (*Commenter: Joyce Stanley – Department of Interior*)

Response: The IRP EIS is a programmatic environment analysis that does not itself authorize any site-specific actions, such as the construction and operation of new generating facilities. Consequently, the EIS does not contain site-specific analyses of the potential impacts of each of the IRP alternatives on these resources. Cumulative impacts of site-specific actions will be addressed in future reviews of actions to implement the IRP.

137. TVA should review and incorporate guidelines for best management practices to ensure that projects are installed and managed in ways that reduce their environmental impacts and effects to listed species, migratory birds, and bald and golden eagles, if any [e.g., best practices identified by the Department in its "Land-Based Wind Energy Guidelines" (2012) if considering development of wind energy projects]. (*Commenter: Joyce Stanley – Department of Interior*)

Response: Section 5.2.3.4 of the EIS states that TVA anticipates the developers of wind farms will follow USFWS Land-Based Wind Energy Guidelines on future wind farms. The IRP is not site-specific, and future siting for specific resource builds of any kind would be handled on a case-by-case basis. TVA will coordinate with appropriate resource agencies (U.S. Fish and Wildlife Service for federally listed species, state agencies for state-listed species) while assessing the site-specific impacts of those future actions on listed species, migratory birds, bald and golden eagles, and their habitats.

138. TVA should reduce the footprint of proposed energy projects to minimize impacts on wildlife habitat, listed species, and migratory birds by researching the newest innovations (e.g., installing wind turbines with “wind lenses,” installing solar panels on rooftops, wind turbine collision-avoidance technology to reduce impacts to listed bats and migratory birds, utilizing approaches such as bladeless wind energy collectors, enclosing blades in cones or drums, raising the turbine’s “cut-in speed,” etc.). (*Commenter: Joyce Stanley – Department of Interior*)

Response: TVA considered both small- and large-scale commercial rooftop solar resources as well as utility-scale solar for new capacity to serve future load. As discussed in Section 5.1 of the EIS, when planning new generating facilities, TVA uses several criteria to screen potential sites. Through this systematic process, TVA attempts to minimize the potential environmental impacts of the construction and operation of new generating facilities, including minimizing impacts to wildlife habitat. The IRP is not site-specific, and future technologies for new generating and storage facilities of any kind will be handled on a case-by-case basis. Section 5.2.3.4 of the EIS states that TVA anticipates the developers of wind farms will follow USFWS Land-Based Wind Energy Guidelines on future wind farms. TVA will coordinate with appropriate resource agencies to provide comments on the effects of specific actions on listed species.

139. All new and proposed energy projects should include requirements to monitor and measure impacts to listed species and their habitats, when applicable; information generated by monitoring can be used to inform and improve future energy development projects. (*Commenter: Joyce Stanley – Department of Interior*)

Response: The IRP is not site-specific, and future siting for new generating and storage facilities of any kind will be handled on a case-by-case basis. TVA will coordinate with appropriate resource agencies (U.S. Fish and Wildlife Service for federally listed species, state agencies for state listed species) during the assessment of impacts of those future site-specific actions on listed species and their habitats.

F.2.3.3 Greenhouse Gas Emissions and Climate Change

140. I do not think TVA adequately used the contents of the 2018 National Climate Assessment nor the recent IPCC report. The risks associated with climate change have not been adequately incorporated in TVA's plan. (*Commenters: Christine Hart, Nathan Iyer, Kenneth Jobe, JJ Johnson, Celia Mackey, Melanie Mayes, Nancy McFadden, Craig McManus, Thomas Moss, Wolf Naegeli, Lauren Newman, Ian Schiller, Paul Slentz*)

Response: In EIS Section 4.3, TVA provides a description of the current climate and recent climate trends of the TVA region, with a description of projected changes in climate expected this century based on the Fourth National Climate Assessment and related sources. In the EIS, TVA acknowledges that identifying trends in regional climate parameters is a complex topic. In EIS Section 5.5.2, TVA addresses predicted impacts of climate change to the Southeast U.S., discusses how the changing climate would affect TVA’s power system and identifies climate change risks relevant to the TVA system.

The amount of predicted climate change in the Valley is relatively low based on USEPA and other reports, and this expectation is reflected in the Current Outlook scenario. TVA and stakeholders were interested in evaluating the potential impact of a more severe variation in climate. TVA conducted a sensitivity on variation in climate using stochastic analysis to determine the potential impacts of persistent extreme weather patterns. The results of this analysis are described in IRP Section 8.2.8. This analysis shows that the TVA power system becomes summer peaking and summers are drier, causing thermal derates at nuclear and coal facilities. Derated nuclear and coal capacity is initially replaced with CTs until 2,100 MW nameplate of solar is added by 2038. Overall hydro generation is higher due to warm and wet winters, but hydro capacity remains the same.

141. Court rulings have established that the impact of greenhouse gas emissions on climate change is the kind of impact analysis that NEPA requires. Although the Draft EIS includes qualitative analysis of climate impacts both on

TVA's system and resulting from TVA's system, that analysis is inadequate. Tennessee is already experiencing disproportionate damage from climate-related events and climate change is affecting the TVA electric system. As TVA acknowledges in the Draft EIS, "elevated water temperatures can reduce thermal generation by causing forced deratings, additional use of cooling towers (which reduces net generation), and/or nuclear plant shutdown." However, the EIS fails to acknowledge that in 2012, TVA experienced those exact limitations at Gallatin and Cumberland Fossil Plants through a combination of warmer surface water temperatures and reduced stream flows from the U.S. Army Corps of Engineers. It is vital that TVA consider the effects that climate change will have on its ability to provide power to the Valley.

In addition to considering the effects of climate change on TVA's system, the draft EIS must also consider the climate change effects resulting from increased CO_2 emissions. The Draft EIS fails to adequately discuss the "significance" of the effects of the alternative strategies on climate change because it only quantifies the volume of CO_2 emissions without also monetizing the climate damage that results from those emissions. Although the Draft EIS provides a general, qualitative discussion of climate, that discussion fails to discuss the actual incremental effects of climate. Instead, TVA should use the social cost of carbon to disclose and analyze the actual incremental effects of the CO_2 emissions resulting from the strategies. (*Commenters: JJ Johnson, Ken Prahl, Christina Reichert – Southern Environmental Law Center*)

Response: The draft EIS considers CO_2 and global warming impacts, and portfolios have been evaluated against metrics to determine the environmental impact. The EIS addresses the effects of power production on the environment, including climate change, the effects of climate change on the Valley, and air emissions and water use in TVA's power operations. TVA's diverse power supply was comprised of 53% carbon-free generation in 2018, and the IRP strategies show an average reduction of CO_2 emissions from 2019 to 2038 of 18.9 to 23.4%, as shown in Table 5-4 of the EIS. TVA's diverse power supply was comprised of 53% carbon-free generation in 2018, and the IRP strategies show an average reduction of CO_2 emissions from 2019 to 2038 of 18.9 to 23.4%, as shown in Table 5-4 of the EIS.

Due to comments received from the IRP Working Group and the public at large after release of the draft IRP, TVA conducted a sensitivity analysis on the carbon penalty in the Decarbonization scenario by doubling the $22/ton penalty to $44/ton beginning in 2025. This analysis aligns to the latest update from the Minnesota Public Utility Commission, which is largely based on the Federal Social Cost of Carbon of $42/ton in 2020 rising to $60/ton by 2040, which included information from the IPCC.

In EIS Section 5.5.2, TVA addresses predicted impacts of climate change to the Southeast US, discusses how the changing climate would affect TVA's power system and identifies climate change risks relevant to the TVA system. This section also uses an analysis of projected GHG emissions associated with the alternative strategies as a proxy for assessing the strategies' potential effects on climate change. The anticipated reduction of CO_2 emissions resulting from the alternative strategies would be significant, as documented in TVA's quantification of potential GHG emissions. Given the global scope of the impacts of GHG emissions, however, TVA is unable to link these reductions to any particular climate impact in a specific location or region. The EIS includes quantified estimations of greenhouse gas emissions (CO_2 averages and rates) resulting from implementation of each of the alternative strategies and the preferred Target Power Supply Mix, as well as the estimated percent reduction over the 20-year life of the plan. TVA concludes in its analysis that each alternative strategy and the Target Power Supply Mix would result in "continued, significant, long-term reductions in CO_2 emissions from the generation of power marketed by TVA" (EIS Section 5.5.2.2).

Please see response to Comment 13 for additional information on the IRP Decarbonization scenario and Double-Decarbonization sensitivity, as well as to Comment 140 for additional information on the variation in climate sensitivity. TVA notes that thermal derates are higher in some years (such as in 2012) than in others, and stochastic analysis performed to derive expected case results include variation in unit output driven by a number of factors including thermal derates. The thermal derates of the Cumberland and Gallatin Fossil Plants along the Cumberland River in 2012 were higher than normal and TVA installed supplemental temporary cooling capacity at the Cumberland plant. While 2012 was unusually warm and dry, the need for derates and other measures at the Cumberland and Gallatin plants was due in large part to the long-term drawdown of Lake Cumberland while the Wolf Creek Dam was being repaired. This greatly reduced water flows in the Cumberland River.

142. TVA should attempt to mitigate future damages to at-risk infrastructure due to climate change: This includes ash-pile washouts due to 500-year rainfall events, stagnant mercury-tainted air pollution plumes, water pollution leachate, settled toxic mud re-suspension and transport, non-point source (NPS) water pollution, etc. (*Commenter: C.S. Sanford*)

Response: The EIS considers CO_2 and global warming impacts, and portfolios have been evaluated against metrics to determine the environmental impacts. The EIS addresses the effects of power production on the environment, including climate change, the effects of climate change on the Valley, and air emissions and water use in TVA's power operations. EIS Section 5.5.2.2 includes a discussion of potential measures to increase the climate resiliency of the TVA power system.

F.2.3.4 Historic Properties

143. We acknowledge that the IRP EIS is programmatic and concur with TVA's approach to consult under Sections 106 and 110 of the National Historic Preservation Act on individual projects proposed in the future to implement the IRP. (*Commenters: Hal Bell, Samantha Henderson, Patrick McIntyre, Lee Nalley – Kentucky State Clearinghouse*)

Response: Comment noted. TVA will follow NHPA Section 106 and 110 and State Historic Preservation Office procedures when planning proposed actions to implement the IRP.

144. Please restrict all desecration of cultural lands or monuments. (*Commenter: Amanda Dobra Hope*)

Response: As a federal agency, TVA is responsible for identifying, managing, and protecting cultural resources that are found on its property or affected by its actions. These cultural resources may include historic buildings, structures, sites or objects, archaeological resources, Native American burials, funerary objects, sacred items, and other historic resources. Laws, executive orders, and associated regulations are in place that obligate TVA to protect these important sites and resources. These include the National Historic Preservation Act (NHPA), the Native American Graves Protection and Repatriation Act (NAGPRA), and the Archaeological Resource Protection Act (ARPA).Prior to taking any action that would implement the IRP, TVA will determine whether the action has potential to adversely impact cultural resources, consistent with Section 106 of the NHPA. TVA will also resolve any potential adverse effects before taking action.

F.2.3.5 Land Use

145. The Draft IRP and EIS state that all of the strategies would require a large land area, for the construction of new generating facilities, and that most of this land area would be occupied by solar facilities. Unlike other types of generating facilities, solar facilities result in a low level of impacts to the land they occupy and the sites can be readily returned to their original condition or use. This distinction is supported by TVA's programmatic Environmental Assessment on solar photovoltaic projects and should be clearly stated in the Final IRP. Solar projects can also be developed on brownfield sites, landfills, and marginal land creating positive land use attributes. (*Commenters: Gil Hough, Gordon Niessen, Madeline Rogero – City of Knoxville, Kenny Wiggins, David Williams*)

Response: The low level of impacts to the land occupied by solar facilities, relative to other types of generating facilities, and the potential to readily return the solar facility site to its previous condition or use are stated in the draft and final EIS. The EIS also describes the potential for developing solar facilities on previously disturbed and marginal lands. However, based on recent and projected solar facility development trends, such lands are expected to comprise a very small proportion of the land occupied by future solar facilities in the TVA region. Section 8.1.2 of the final IRP has been revised to note the relatively low level of land use impacts resulting from solar facilities.

146. The resource portfolios require between 18,300 and 58,400 acres of land for new solar portfolios. Although this is 0.03 - 0.10 percent of the TVA service area, it is a large area in absolute terms. The specific types of land uses that are being considered for solar facilities should be described in more detail. We recommend that, wherever possible, solar facilities should be limited to those on existing building or new structures that would not require additional land, and not developed on greenfield sites. While there may also be contaminated sites that could potentially house solar facilities, the extent to which such sites would be used is unclear. (*Commenter: Lindsay Gardner – Tennessee Wildlife Federation*)

Response: All of the solar capacity expansion in the portfolios associated with each strategy, other than solar generation installed as a customer-owned distributed energy resource, is utility-scale, single-axis tracking PV solar. Based on recent and projected solar development trends, almost all of this solar capacity will be developed on greenfield sites. The majority of the customer-owned solar installed in the TVA region to date has been on buildings, with smaller amounts on previously disturbed and greenfield sites. A large proportion of disturbed, brownfield sites in the TVA region that are potentially available for solar development are not large enough to host multi-megawatt utility-scale solar facilities. The cost of developing solar facilities on brownfield sites can also be high if there are restrictions on penetrating the surface of the site.

147. TVA should revise plan to increase rooftop utilization of solar (vs. open land use) to reduce adverse wildlife habitat impact. (*Commenters: Judith Abrams, Catherine Arnoult, Duffy-Marie Arnoult, Leo Arnoult, Emily Burch, Ann Davis, Jennifer Davis, Lynn Davis, Jim Gienapp , Lynn Hubbard , Richard Hutchinson, John Klyce, Herman LaVelle , Lindsay Lavelle, Vance Lavelle, Suzana Lightman, Naomi McDougall Graham, Margaret Neu, Gordon Niessen, Catherine Pena , Katherine Ragsdale, Sallie Sabbatini, Mary Self, Tom Smedley, Vivian Strain, Noelle Toumey , Courtney Vick, Steven Waterfield, Joan Williams*)

Response: TVA acknowledges that the impacts of rooftop solar facilities on wildlife habitat and several other resources are lower than those of ground-mounted solar facilities, particularly the ground-mounted facilities at greenfield sites. The solar resources considered in the planning process included both small- and large-scale commercial solar, residential solar, and utility-scale solar for new capacity to serve future load. Based on current solar development trends, most of the small scale commercial and residential solar and a significant proportion of large scale commercial solar would likely be constructed on rooftops. All of the new solar capacity selected in the portfolios is utility-scale solar. The portfolios also contain varying amounts of customer-owned distributed energy resources, which would likely include rooftop commercial and residential solar. As discussed in EIS Section 5.1, TVA will conduct a comprehensive review of the potential environmental impacts of any solar facilities it proposes and implement measures to reduce and mitigate adverse impacts.

148. The Draft IRP includes a land use metric that appears to overstate the potential land impacts from the construction of utility-scale solar and wind. The land use metric is the expected number of acres needed for new generation under each strategy. However, there are different types of land use, and each use is valuable in different ways. The Draft IRP should at least explain what type of land use is being affected by each portfolio. Best practices for utility scale renewable energy include land use considerations to ensure siting is sustainable, cost effective, and pollinator friendly.

For example, contaminated land may actually benefit from being used to house utility-scale solar and wind. The U.S. Environmental Protection Agency's RE-Powering America's Land Initiative specifically analyzed the potential for reusing abandoned industrial sites for wind farms and utility-scale solar. According to the results of this study, building utility-scale renewable generation on contaminated land has several potential advantages:

- Lowers development costs and shortens development timeframes;
- Leverages existing infrastructure;
- Protects open space;
- Improves economics with reduced land costs and tax incentives specific to degraded lands; and
- Reduces project cycle times through streamlined permitting and zoning.

As part of this project, the USEPA assessed brownfields across the country and identified those that can house utility-scale renewables. There are abundant contaminated sites across the Tennessee Valley that could hold utility-scale solar or wind installations with minimal land use costs. For example, Nashville Electric Service sited a 2 MW solar farm on a closed landfill site in Nashville.

The Draft EIS acknowledges that new utility-scale solar resources could be sited on brownfields, but does not explain what proportion of the "land used" in each portfolio consists of brownfields. Because of this lack of data transparency, we cannot determine whether the land use metric distinguishes between the "land use effects" for contaminant land versus greenfields or cropland. To the extent the Draft IRP and Draft EIS fail to distinguish between the categories of land use affected by utility-scale solar or wind, the land use metric would inaccurately inflate the potential negative effects of utility-scale solar and wind. (*Commenters: Jason Carney, Christina Reichert – Southern Environmental Law Center*)

Response: TVA acknowledges that the intensity of impacts to the land occupied by solar facilities is relatively low compared to other types of generating and storage facilities. TVA also acknowledges benefits of solar development on brownfield sites. As noted in the response to Comment 146 [Gardner: The resource portfolios require between 18,300 and 58,400 acres...] many brownfield sites are not suitable for the utility-scale, single-axis tracking solar facilities incorporated into the capacity expansion plans. The land use metric reflects the land area expected to be occupied by the new generating and storage facilities comprising the capacity expansion plans associated with each alternative strategy and the Target Power Supply Mix (IRP Recommendation). It does not distinguish the type of land expected to be occupied by the generating and storage facilities. As described in Section 5.5.5 of the EIS, the land occupied by the utility-scale, single-axis tracking solar facilities included in each capacity expansion plan is expected to be relatively flat land mostly in agricultural use. The capacity expansion plans presented in the draft IRP do not include any new wind generation. The IRP Recommendation for the power supply mix includes the potential for future wind capacity expansion. This wind generation, whether in the TVA region or outside the TVA region, is likely to be in rural areas with the individual wind turbines located some distance from buildings. Therefore, any wind capacity expansion is likely to be located on agricultural or other relatively undisturbed sites. TVA assumes this wind generation would occupy between 0.8 and 1 acre/MW of nameplate capacity (see EIS Section 5.2.3.4). This land requirement is conservatively based on the area occupied by the wind turbines and associated infrastructure and does not include the area between individual turbines which can be devoted to other uses.

149. TVA should carefully consider the overall cost and impact of each of the resource options (e.g., land-use impact: about 1/4 acre is needed per MW of nuclear power generated vs. 8 acres per MW of solar. That's a significant negative environmental / aesthetic impact of solar.) (*Commenter: Kenny Wiggins*)

Response: Costs and impacts of each resource option are considered and discussed in the IRP and EIS. In particular, Section 5.5.5 of the EIS discusses land requirements for solar generation. While solar facilities require more land area oer unit of generation than other resource options, solar facilities have a low level of impact to the land and the potential to readily return the solar facility site to its previous condition or use.

150. Following the retirement of the Bull Run Fossil Plant in 2023, its buildings and structures should be disassembled and completely removed. TVA should remove all abandoned structures, remove the coal ash to the degree possible, and clear the land for reuse. (*Commenters: Ted Faust, Mark Watson – City of Oak Ridge*)

Response: The future use of the Bull Run site following the retirement of the plant is outside of the scope of the IRP. However, the subsequent use of the site will be addressed in a future planning process under NEPA that will include public and agency input.

151. Large scale use of solar energy requires too large of a footprint. Adverse environmental impacts as a result include vegetation clearing and grading, increased rainfall runoff, and increased probability of impacts from extreme weather conditions. (*Commenter: Ron Rucker*)

Response: Section 5.5.5 of the EIS discusses land requirements for solar generation. Over 90 percent of the land area occupied by utility-scale solar facilities constructed in the TVA service area to date was previously in agricultural use. The low level of impacts to the land occupied by solar facilities, relative to other types of generating facilities, and the potential to readily return the solar facility site to its previous condition or use are stated in the EIS. The EIS also describes the potential for developing solar facilities on previously disturbed and marginal lands. Solar facilities are required to be built to code (e.g., American Society of Civil Engineers' Minimum Design Loads for Buildings and Other Structures), and they can be built to survive hurricane force winds, such as in South Florida.

152. The land use metric fails to consider some of the positive aspects of the Red Hills Project. The 2019 IRP EIS should recognize that surface mining impacts are temporal and can be mitigated once the project is complete if appropriate measures are taken. MLMC has taken those measures. Since surface mining activities began at the Red Hills Mine in 1998, MLMC has been implementing mining and nationally award-winning reclamation techniques that have been proven to protect and even enhance the affected environment. (*Commenter: Madison Keyes*)

Response: The land use metric only includes the land area occupied by generation and storage facilities included in the various capacity expansion portfolios. It does not include the land area necessary to extract and transport fuels to new generation facilities or to existing generating facilities, such as the Red Hills Project. Life cycle impacts are not quantified because of the lack of published information applicable to the full suite of TVA's current and proposed future energy resources.

153. TVA should assess the potential impacts of large-scale facilities (solar, biomass, etc.) on space used (i.e., loss, fragmentation and displacement of species habitat), and site energy projects to avoid lands with known high-resource values and minimize conflicts with wildlife habitat, particularly threatened, endangered and sensitive species habitats, and habitat elements that support biodiversity (e.g., using landscape assessment tools to avoid placing wind turbines near bat roosting areas or major migratory bird pathways). (*Commenter: Joyce Stanley – Department of Interior*)

Response: The IRP and associated EIS do not address future site-specific actions to implement the plan. Such actions will be comprehensively reviewed as described in EIS Section 5.1.

154. TVA should site energy projects on disturbed sites, such as abandoned mines, landfills and agricultural fields, when possible, reducing overall environmental impacts and potential effects to listed species and their habitats. (*Commenters: Janine Howard – Virginia Department of Environmental Quality, Joyce Stanley – Department of Interior*)

Response: Comment noted. TVA uses a comprehensive site-screening process when planning new energy projects and the minimization of impacts to listed species and other environmental resources is a major component of this process.

155. TVA should consider the introduction of invasive plant species from disturbance of proposed energy project sites and potential impacts. (*Commenter: Joyce Stanley – Department of Interior*)

Response: The potential introduction of invasive plants is one of many environmental impacts that TVA will consider during the review of future, site-specific actions to implement the IRP.

156. Due to the decline in pollinators, DCR also recommends the planting of native pollinator plants in the buffer areas of the planned facilities, which bloom throughout the growing season as well as the development of an invasive species management plan for these projects. (*Commenter: Janine Howard – Virginia Department of Environmental Quality*)

Response: Comment noted. While outside the scope of the IRP, TVA notes that such measures will be considered during the planning of future facilities.

F.2.3.6 Life Cycle Impacts

157. Section 5.2 of the Draft EIS describes the environmental impacts of the various supply-side resource options. It quantifies the direct emissions of air pollutants and greenhouse gases per unit of electricity generated. Section 5.5 quantifies the direct emissions under each of the alternative strategies and portfolios during the 20-year planning period. Section 5.2 also describes the life-cycle emissions of greenhouse gases from the resource options. The EIS does not, however, describe the direct and indirect changes in emissions (both "well-to-wheels" emissions from fuel switching as well as the elimination of tailpipe emissions), and the associated beneficial environmental impacts, associated with potential incentives for the electrification of transportation through beneficial electrification programs. (*Commenter: Kendra Abkowitz – Tennessee Department of Environment and Conservation*)

Response: Because of the lack of published information applicable to the full suite of TVA's current and proposed future energy resources, life cycle impacts of the alternative strategies are not quantified. Several studies have shown that widespread adoption of electric vehicles dependent on electric utilities with relatively low CO_2 emission rates, such as the TVA system has a present and will have in the future, results in an overall reduction in emissions of CO_2 and other air pollutants.

158. The Environmental Impact Analysis should consider the life cycle impacts and externalities of the various potential fuel sources. Natural Gas would need to include the impacts of fracking. Coal would need to include the lower life expectancy of coal miners and the impacts of fly ash spills. Both should recognize the future costs of higher heat-related mortality and financial impacts of increased severity of weather from climate change. Without at least estimating these costs, it is impossible to fairly weigh the options for energy generation. (*Commenters: Deborah Hamilton, Sarah Houston, Sandra Upchurch, Michael Walton*)

Response: EIS Section 5.2 includes information about life cycle GHG emissions from many supply-side resources. Because of the lack of published information applicable to the full suite of TVA's current and proposed future energy resources, life cycle impacts of the alternative strategies are not quantified.

F.2.3.7 Parks, Managed Areas and Ecologically Significant Sites

159. Section 4.5.6 of the DEIS describes several parks, managed areas and ecologically significant sites in the vicinity of generating plants that are candidates for partial or full retirement. Examples include the Cumberland Fossil Plant, Gallatin Fossil Plant, the Old Hickory State Wildlife Management Area, the Kingston Fossil Plant, the

Shawnee Fossil Plant, and the Colbert Combustion Turbine Plant. It is unclear if and how these areas would be impacted by plant retirements. Full closure of the areas would result in the loss of important boat ramps and hunting, fishing, and wildlife viewing access. Any land use changes and redevelopment associated with plant retirements should be carefully assessed on an individual basis with public review and comment. (*Commenter: Lindsay Gardner – Tennessee Wildlife Federation*)

Response: Section 5.5.5 of the final EIS has been revised to discuss potential effects to parks, managed areas, and ecologically significant sites in the vicinity of plants considered for retirement. Redevelopment of retired plant sites is outside the scope of the IRP, and will be assessed on a site-specific basis with public and agency input.

160. 4.5.6.2 - Parks and Managed Areas at Facilities Identified for Potential Future Retirements: TDEC recommends TVA define the meaning of “vicinity” in relation to parks, managed areas, and ecologically significant sites near or on the 8 generating plants considered for full or partial retirement. (*Commenter: Kendra Abkowitz – Tennessee Department of Environment and Conservation*)

Response: EIS Section 4.5.6.2 has been revised to better define the meaning of “vicinity” in relation to parks, managed areas, and ecologically significant sites near or on the 8 generating plants considered for full or partial retirement.

161. TVA should consider using its underutilized properties and/or easements for projects like parks, conservation areas, and/or trails as part of the maintaining this area's great natural resources of water, shoreline, forest and open space. TVA should include the public and property owners in the discussions on how to address these potential projects. (*Commenters: Ted Faust, Pamela Glaser, Melanie Mayes*)

Response: Future use of TVA property and easements for parks, conservation areas, and/or trails is outside of the scope of the IRP. Site-specific land uses and property transfers are reviewed by TVA on a case-by-case basis, and will include the input of nearby property owners and the public.

F.2.3.8 Socioeconomics

162. Section 5.5.6.1 - Impacts of Potential Facility Retirements: TDEC recommends TVA provide additional information on how reductions of tax equivalent payments for each state, due to facility retirements, will impact state revenues. If reductions of tax equivalent payments due to facility retirements are already included in the IRP and EIS, then TDEC suggests that TVA clarify this in the final versions. (*Commenter: Kendra Abkowitz – Tennessee Department of Environment and Conservation*)

Response: Section 4.8.3 of the EIS provides an overview of tax equivalent payments for each state in the TVA PSA. As noted in Section 5.5.6 of the EIS, before implementing a specific resource option, TVA will conduct a review of its potential socioeconomic impacts. This review will include local government revenues including TVA tax equivalent payments.

163. I would be willing to pay more each month to help pay for systemic changes that would help TVA clean up our atmosphere, promote healthier lifestyles, and preserve our wilderness areas. (*Commenters: Wade Austin, Sadie McElrath*)

Response: Comment noted. Under the TVA Act, TVA is mandated to conduct least-cost planning with consideration of environmental stewardship and economic development aspects of our mission.

164. TVA should find ways to employ those who have made their livelihood from mining and burning coal in the growing solar and wind industries. (*Commenter: Donald Dresser*)

Appendix F – Responses to Comments

Response: When future plant retirement decisions are made, TVA would help place some interested employees in available positions across the TVA power service area. Because the IRP is programmatic and does not address the future siting of generating facilities, site-specific analyses of employment changes are not possible at this time. TVA's analysis found that Strategies B, C, D, and E would all result in small increases in employment. Most of these increases are attributable to Scenario 5: Rapid DER Adoption.

165. From the Energy Information Administration (EIA) we know that there are 15.4 Million people in the South that experience unaffordable utility bills and reduce or forgo food and medicine, leave their home at unhealthy temperatures, receive disconnect notices, are unable to heat their home, or are unable to cool their home as a result. It would be helpful if the IRP included the specific statistics for these items within TVA's service territory to demonstrate the full 'cost to serve.' (*Commenter: Michael Walton – green|spaces*)

Response: Comment noted. At this time, data suggested above is not readily available for the entire TVA PSA. Section 4.8 and 4.9 of the EIS include socioeconomic, low-income and minority population information for the TVA Power Service Area. See response to Comment 170.

166. TVA should partner with non-profit organizations to promote renewable energy education in schools and communities of color since there is a disproportionate rate of adoption and understanding in these communities. (*Commenter: Jason Carney – Tennessee Solar Energy Association*)

Response: Comment noted. TVA continues to focus on its energy efficiency programs and partner with non-profit organizations throughout the Valley. For example, TVA is sponsoring a Minority Contractor Workforce Development pilot to recruit new energy program workers.

167. The subject EIS acknowledges the “potential for local socioeconomic impacts associated with plant retirements,' but does not offer substantive detail about the recently announced closure of the Bull Run Fossil Plant. The loss of 100 high paying jobs and the associated impacts on the environment, transportation industry, tourism (through impact on the fisheries), and the multiplied effects to our City and to Anderson County are consequential. (*Commenter: Mark Watson – City of Oak Ridge*)

Response: Socioeconomic impacts associated with the Bull Run Fossil Plant were addressed in the Potential Retirement of Bull Run Fossil Plant Final Environmental Assessment and Finding of No Significant Impact (see www.tva.gov/nepa).

168. All strategies do not have comparable impacts on state and local economies. Because the economic development piece of TVA’s mission directly impacts the prosperity and livelihood of real people and real communities on a daily basis, closer consideration of each strategy’s economic impact is warranted beyond consideration of the Valley as a single unit. MLMC concedes that a full economic impact analysis at the local or county-wide level would be a daunting task and likely beyond the scope of this IRP and EIS process. However, at a minimum, TVA should evaluate how each strategy impacts the economy of the energy resource’s associated state and how each PPA source’s utilization by TVA (or lack thereof) impacts that energy resource’s state economy. (*Commenter: Dave Liffrig – Mississippi Lignite Mining Company*)

Response: Because the IRP is programmatic and does not address the future siting of generating facilities or specific PPAs, site-specific analyses of socioeconomic changes are not possible at this time. When specific actions to implement the IRP are proposed, TVA will evaluate the socioeconomic impacts at various geographic scales.

169. It is really hard to believe that more DER and renewables won't create much more employment opportunities than a few large plants. (*Commenter: Claudio Meier*)

Response: The Percent Difference in Employment economic metric, described in EIS Section 5.5.6 and IRP Section 6.4.2, 7.2, and Appendix J, compares the potential economy-wide employment changes that result from each of the alternative strategies. Changes are described in the context of the entire TVA service area. TVA's analysis found that Strategies B, C, D, and E would all result in small increases in employment. Most of these increases are attributable to Scenario 5: Rapid DER Adoption.

170. Closing coal plants impact more than the TVA employees who find themselves looking for a new job. They impact entire communities - from coal mines who supply the plants to the trucks who bring in the coal every day, from school districts whose budgets rely on the tax receipts to the local businesses where TVA employees and suppliers invest their resources. Shutting down reliable sources of energy production such as coal-fired units, destroying an entire industry, undercuts both TVA's statutory mission and its stated commitment to economic development. (*Commenter: U.S. Senator Rand Paul of Kentucky*)

Response: The 2019 IRP Recommendation calls for the continuation of a diverse generation portfolio, relying heavily on carbon-free sources of hydro, nuclear, and solar, along with continued use of coal, natural gas, and energy efficiency. While coal will continue to be part of TVA's generating mix for years to come, TVA must continue to optimize the generating portfolio in response to changing demand, prices of fuel and renewable generation, and environmental regulations. EIS Section 5.5.6.1 briefly describes potential changes in employment resulting from the retirement of TVA coal plants and select CT units. If TVA formally proposes the retirement of a generating facility, TVA will conduct a thorough analysis of the socioeconomic impacts and help transition TVA employees and the surrounding communities.

F.2.3.9 Solid and Hazardous Waste

171. EIS Section 4.2.5, Mercury, describes the significant reduction of mercury emissions between 2000 and 2017. These emission reductions are credited to retirement of coal-fired units and installation of flue gas desulphurization and selective catalytic reduction systems. Since gypsum from flue gas desulphurization is being placed in dry landfills locally at the still operating fossil plants, does this not increase the risk of surface and ground water contamination from mercury contained in this gypsum? (*Commenter: John Shaw*)

Response: Flue gas desulphurization (FGD) residue produced during operation of air emission reduction systems is placed into lined landfills at 2 of the 4 facilities (Gallatin and Kingston) that are the subject of this IRP. At the remaining two facilities (Cumberland and Shawnee), lined landfills are actively being constructed that will receive the FGD residue upon commencement of operation. Further, TVA conducts periodic groundwater monitoring at each facility to evaluate the potential for leaching of contaminants from landfills to groundwater and surface water.

172. All solid and hazardous wastes produced by TVA Kentucky facilities by operations or demolition should be disposed of in accordance with the appropriate Kentucky Statutes and Regulations and approval by the Kentucky Division of Waste Management. All solid waste generated by this project must be disposed of at a permitted facility. If asbestos, lead paint and/or other contaminants are encountered during this project contact the Division of Waste Management for proper disposal and closure. (*Commenter: Lee Nalley – Kentucky State Clearinghouse*)

Response: As discussed in Final EIS Section 4.7, TVA complies with all solid and hazardous waste management regulations. TVA will continue to follow solid and hazardous waste disposal and closure requirements, and will coordinate with appropriate federal and state agencies for future projects.

F.2.3.10 Water Resources

173. Several TVA facilities, primarily combined cycle plants, use ground water for industrial purposes. TDEC suggests that the use of reclaimed wastewater be considered for Tennessee facilities rather than high quality ground water. TVA must consider potential impacts of their water withdrawals (ground water or surface water) on public

water systems. Under the Tennessee Safe Drinking Water Act and associated rules (Rule 0400-45-01-.34), there is a provision requiring entities contemplating water withdrawals to consider the impact on existing public water supply sources (surface water or ground water). TVA needs to bear this in mind when building new plants or upgrading others that would add additional water withdrawal and potentially impact water systems. Combined cycle combustion turbine plants should be given a priority over the simple cycle plants. The gas-fired simple cycle combustion turbine plants use "once through cooling" water. The gas-fired combined cycle combustion turbine plants recycle at least some of the cooling water and are much more efficient in their use of water for cooling. TDEC encourages TVA to include these considerations in the Final EIS. (*Commenter: Kendra Abkowitz – Tennessee Department of Environment and Conservation*)

Response: The IRP EIS is a programmatic environment analysis and the impacts of subsequent site- or project-specific actions proposed to implement the IRP will be the subject of additional environmental review during the planning of those actions. TVA will analyze the impacts to all water resources as part of that analysis and will minimize impacts to water resources to the extent practicable.

174. Ground-water monitoring for retired facilities needs to be maintained where any CCRs are left in place. As described in EIS Section 4.4.1.4, several facilities have shown elevated levels of a number of inorganic constituents/metals (arsenic, lithium, beryllium, cadmium and nickel, boron barium cobalt, zinc, vanadium). Adequate and effective waste storage for CCRs continues to be a concern. TDEC encourages TVA to include these considerations in the Final EIS. (*Commenter: Kendra Abkowitz – Tennessee Department of Environment and Conservation*)

Response: Groundwater monitoring of the impoundments left in place will be undertaken with periodic sampling of wells established within the groundwater monitoring network as required by the CCR Rule. In conjunction with this plan, TVA will also continue to work with the states to obtain samples and evaluate groundwater quality associated with all CCR management facilities. Final EIS Section 5.5.3.1 has been revised to clarify that groundwater monitoring programs will continue following potential retirement of these facilities.

175. TVA should not use aquifers for cooling water and contaminate them with coal ash. (*Commenter: Chad Riggs*)

Response: Comment noted. TVA notes that it is currently working under the direction of TDEC to investigate contamination that was discovered in shallow monitoring wells in the vicinity of the Allen Fossil Plant near Memphis. TVA is not using the five production wells in the Memphis Aquifer during the course of the investigation. A response action plan is under development and interim actions are being taken.

176. TVA should update the Environmental Impact assessment and mitigation plans in the TVA IRP utilizing current statistics on water quality and potential risks to incorporate the scientific findings from March 2019 reports. (*Commenters: Judith Abrams, Catherine Arnoult, Duffy-Marie Arnoult, Leo Arnoult, Emily Burch, Ann Davis, Jennifer Davis, Lynn Davis, Jim Gienapp, Lynn Hubbard , Richard Hutchinson, John Klyce, Herman LaVelle, Lindsay Lavelle, Vance Lavelle, Suzana Lightman, Naomi McDougall Graham, Margaret Neu, Catherine Pena , Katherine Ragsdale, Sallie Sabbatini, Mary Self, Vivian Strain, Noelle Toumey, Courtney Vick, Steven Waterfield*)

Response: TVA has updated Section 4.4 of the final EIS with information from the groundwater monitoring reports released on March 1, 2019. These reports were released after issuance of the draft EIS.

177. I am very concerned about the state you are leaving your shut down plants in and the pollution and toxic waste that has been left behind. What are TVA's future plans to better contain coal ash containment ponds and areas? The environmental damage from a breach present major health hazards to surrounding communities and wildlife. What will happen to these containment areas when coal plants are retired? Please consider going above and beyond what

current regulations of the state or federal government require in your clean up and containment plans. (*Commenters: Anonymous 5, Ruth Black, Ted Faust, Deborah Hamilton, Mindy Mosier, Brenda Stilson*)

Response: Comment noted. When a retirement decision is made, long-term management of coal ash containment ponds would be evaluated by TVA. The public would have an opportunity to comment during this evaluation. Additional information about coal ash containment can be found at TVA's website.

178. I think it will be very important in the future to tend the waterways so that these big rains run off efficiently. Maybe in some areas we could use large drainage ditches like in California. Also, we need to keep and preserve as much natural habitat as possible, especially wetlands. (*Commenter: Sharon Rush*)

Response: Comment noted.

179. TVA should consider effects from facility construction and operation (e.g., water discharges, leachate from coal combustion residuals landfills) on aquatic resources during project siting and design, and choose alternative that would minimize impacts (*Commenter: Joyce Stanley – Department of Interior*)

Response: Comment noted. The impacts to water resources is one of many environmental impacts that TVA will consider during the review of future, site-specific actions to implement the IRP.

180. TVA needs to protect our groundwater and its workers from coal ash and invest in renewable energy. (*Commenter: Catherine Arnoult*)

Response: Environmental stewardship is one of the key aspects of TVA's mission and environmental responsibility is one of the goals of this IRP process. Solar expansion is significant in the IRP, ranging from about 6 to 9 GW of nameplate capacity by 2038 under the Current Outlook for electricity demand and up to 14 GW of nameplate capacity in a growth scenario. TVA is also committed to the safety and health of everyone who works on TVA sites, including coal ash sites. TVA and its contractors are required to comply with Occupational Safety and Health regulations and follow a Site Specific Safety & Health Plan.

F.2.4 General Comments

F.2.4.1 Opposition

181. I'm personally and professionally opposed to this. Our energy bills are already some of the highest in the country. (*Commenter: Natasha Buttrey*)

Response: Comment noted. Under the TVA Act, TVA is mandated to conduct least-cost planning. The IRP will assist TVA in maintaining lower rates, to the benefit of TVA energy consumers.

F.2.4.2 Planning Process

182. The Tennessee Department of Environment and Conservation appreciates the opportunity to provide comments on the Draft 2019 IRP and EIS. TDEC is the environmental and natural resource regulatory agency in Tennessee with delegated responsibility from the U.S. Environmental Protection Agency (USEPA) to regulate sources of air pollution; solid and hazardous waste; radiological health issues; underground storage tanks; and water resources. TDEC's comments are made in the context of proposed alternatives that would have environmental and other impacts within Tennessee. TDEC's comments do not address any environmental and other impacts of the proposed alternatives within other states. Further, it is TDEC's expectation that TVA will consult with the Department to consider site-specific environmental and other impacts associated with future actions within Tennessee when particular generation strategies and options are selected for implementation. Please note that these comments are not indicative of approval or disapproval of the proposed action or its alternatives, nor should

they be interpreted as an indication of future permitting decisions by TDEC. (*Commenter: Kendra Abkowitz – Tennessee Department of Environment and Conservation*)

Response: Comment noted. TVA will consult with the Department to consider site-specific environmental and other impacts associated with future actions within Tennessee when particular generation strategies and options are selected for implementation.

183. TDEC believes that increasing the use of clean(er) fuels like natural gas and renewables (solar, wind and hydro), provides the best alternatives for future sustained improvements in Tennessee's air quality. TDEC recognizes and appreciates the changes TVA has made in the overall generating network and especially those that have resulted in the dramatic improvements in SO2 and NOx emissions across the region. TVA is to be commended for modernizing and upgrading a number of the emissions control systems on their generating plants and for playing a key role in meeting the air quality attainment strategies that have resulted in the current air quality successes we now enjoy across Tennessee. TDEC recognizes that TVA's future planning assumptions and likely outcomes are not fixed but rather fluid in nature and include many variables. The future, however, does hold the promise of continued cooperative growth and economic expansion with the vision of cleaner energy resources and the ability to meet the upcoming energy demands of Tennessee while preserving the good air quality from which we are now are benefitting. (*Commenter: David Salyers – Tennessee Department of Environment and Conservation*)

Response: Comment noted.

184. TDEC recommends TVA continue to follow the planned retirement of the aging facilities that TVA has already identified. TDEC also recommends that TVA continue to evaluate the roles renewables may have in augmenting existing and future energy needs and to the extent practical, allow these clean resources to help support the generating networks across the region. TDEC also recognizes that the two nuclear facilities in Tennessee may not be able to be relicensed in the future and would encourage the evaluation of the SMR research and demonstration of concept programs as possible future alternatives to conventional nuclear power in Tennessee. (*Commenter: David Salyers – Tennessee Department of Environment and Conservation*)

Response: Comment noted. The IRP Recommendation reflects the potential for more than 2 GW of additional coal retirements beyond those already approved by the TVA Board. Renewables are also an important part of the IRP. Solar expansion is significant in the IRP, ranging from about 6 to 9 GW of nameplate capacity by 2038 under the Current Outlook for electricity demand and up to 14 GW of nameplate capacity in a growth scenario. Additionally, SMRs have greater flexibility than larger scale nuclear. As the work around the technology continues to evolve, TVA will continue to evaluate how it might be used. SMRs are one of the technologies that were not included in any portfolios based on economics. Sensitivity analysis has been run to inform cost levels necessary to improve the SMR's position compared to other resource options, and key findings from the analysis are included in IRP Chapter 8.

185. TVA should be commended for the significant amount of work it has completed as part of the IRP process, and particularly for its innovative approach to measuring and modeling DER and sensitivities within the IRP. We appreciates the outreach that TVA has provided during the IRP development process and comment period and hope this engagement with stakeholders will continue as it works to finalize the IRP and implement generation strategies. (*Commenters: Mark Watson – City of Oak Ridge, David Salyers – Tennessee Department of Environment and Conservation*)

Response: Comment noted.

186. The analytical results in the Draft IRP highlight the foundational role that natural gas will play in moving the Valley forward towards diverse energy and economic objectives and for recognizing the role that natural gas generation will play in supporting the Valley's evolving needs. This is apparent in the scenarios in which TVA employed a fuel and technologically neutral approach which allowed a more robust accounting of the attributes of natural gas generation. The Draft IRP results also show the role of natural gas generation in increasing resiliency and providing flexibility with increased generation from intermittent renewable energy resources. Attributes of natural gas that contribute to resiliency include supply redundancy, the use of compressor units that run on natural gas and help with system management, a network of physical gas storage infrastructure, and the underground location of most natural gas pipelines. (*Commenter: Todd Snitchler – American Petroleum Institute*)

Response: Comment noted.

187. The Tennessee Valley Industrial Committee, an association of 35 of TVA's direct served customers, appreciates the opportunity to participate in the IRP process through participation in the IRP Working Group and on the TVA Regional Energy Resource Council. TVIC commends TVA for the thoroughness of the IRP process, including the inclusiveness of the composition of the IRP Working Group; TVA's openness and transparency during the process; the unmatched process of involving stakeholders; the value of a balanced resource portfolio and continuing focus on energy at the lowest feasible cost, environmental stewardship, and economic development; and the emphasis on least cost planning (while maintaining reliability) that enabled straightforward, unbiased decision-making. TVIC wants to see TVA supply low cost, reliable electricity to Valley consumers now and in the future, and the IRP process is a valuable step towards making that a reality. (*Commenter: Rob Hoskins – Tennessee Valley Industrial Committee*)

Response: Comment noted.

188. The Tennessee Valley Industrial Committee recommends that, because of the rapidly changing electricity environment, TVA ultimately adopts a planning strategy that is flexible with respect to resource decisions - stepping away from resources if costs prove too high, or the lack of load renders them unnecessary, or mobbing rapidly into new resource investments if the cost and feasibility of those resources merit a shift. For this same reason, TVA should also be flexible as to when it commences its next IRP. Rapid industry changes suggest more frequent IRPs. (*Commenter: Rob Hoskins – Tennessee Valley Industrial Committee*)

Response: Comment noted.

189. TVPPA would like to express its sincere appreciation for the process through which TVA developed the 2019 IRP. Our board of directors and leadership team believe the process was both comprehensive and innovative. In particular, we are pleased TVA invited the participation of Huntsville Utilities President & CEO Wes Kelley, Memphis LG&W Senior Vice President, CFO & CAO Dana Jeanes and North East Mississippi USEPA General Manager & CEO Keith Hayward. TVPPA believes customer participation and stakeholder input are vitally important not only to the process, but to the success of the final product. I am confident TVA staff directly involved in the process will attest to the valuable perspective these senior executives, as representatives of TVA's 154 wholesale power customers, brought to the creation of this IRP.
(*Commenter: Douglas Peters - TVPPA*)

Response: Comment noted.

F.2.5 Integrated Resource Planning

F.2.5.1 Cost of Implementing a Strategy

190. It is essential for TVA to turn to a proactive planning process which seeks to actually reflect the cost that climate change imposes on valley residents. TVA should incorporate the US federal government's estimate of the social cost of carbon, as used in various regulatory applications, into every energy planning model to adequately reflect the actual cost society bears from carbon-intensive energy sources. Without this essential cost reflected, the 'model' will continue to select high-social-cost technologies with low short-term costs. (*Commenter: Ian Faucher*)

Response: Due to comments received from the IRP Working Group and the public at large after release of the draft IRP, TVA conducted a sensitivity analysis on the carbon penalty in the Decarbonization scenario by doubling the $22/ton penalty to $44/ton beginning in 2025. This sensitivity aligns to the latest update from the Minnesota PUC, which is largely based on the Federal Social Cost of Carbon of $42/ton in 2020 rising to $60/ton by 2040, which included information from the IPCC.

As discussed in IRP Chapter 8, the additional sensitivity analysis conducted after issuance of the draft IRP and EIS included consideration of a more stringent carbon penalty. The results of this sensitivity analysis show that coal retirements occur earlier and total CO_2 emissions are lower over the study period. A sensitivity considering the potential for higher operating costs for coal plants was also conducted, indicating some coal retirements in that case. The IRP Recommendation reflects the potential for more than 2 GW of additional coal retirements beyond those already approved by the TVA Board.

Please see response to Comment 13 for more information regarding the design of the Decarbonization scenario and related sensitivities.

191. My suggestion to TVA for the 20 year plan is to completely eliminate the debt to the federal government, keep the power rates at its current level, and stop TVA bonuses and apply those hundreds of millions of dollars toward the debt. (*Commenter: Ken Ogle*)

Response: The TVA long range financial plan provides continued focus on simultaneously reducing operational costs, investing in the efficiency of the generation and transmission system, and working to lower debt. TVA funds virtually all operations through electricity sales and power system bond financing. TVA makes no profit and receives no tax money. In 2014, TVA made its final scheduled repayment on Congress' original $1 billion investment in the TVA power system, but TVA continues to make annual payments on the government's remaining equity investment in TVA. TVA works to recruit top talent in order to meet its mission fully, and will continue to work to make the Valley a great place to live, work and play.

F.2.5.2 Data Inputs and Assumptions

192. The Draft IRP fails to treat DER on a consistent and integrated basis. One of this ways in which this occurs is through mischaracterization of participant costs associated with DER in the new total resource cost metric. TVA states that total resource cost is meant to represent PVRR plus net of costs/savings from an individual's participation in DER programs. PVRR is a separate metric, so in essence, total resource cost reflects TVA's assessment of the strategies' potential costs to third parties. Based on the limited information available in the Draft IRP, the total resource cost metric appears to mischaracterize or inaccurately represent participant costs associated with DERs.

As a preliminary matter, TVA does not explain whether or how participant costs factor into to its determination of "lowest system cost." Participant costs are non-utility, secondary costs to ratepayers who voluntarily participate in electricity generation by paying for, installing, and using DERs. Any purported participant costs should be weighed alongside other costs to third parties, such as costs resulting from the health effects tied to living near coal- and gas-fired power plants.

Due to a lack of data transparency, we are unable to recreate the calculations for total resource costs. However, an examination of the logic behind PVRR and total resource cost suggests that the framework the Draft IRP uses to conduct its analysis inaccurately assesses the participant costs associated with DER.

Promote DER has PVRR values lower than all other strategies, and breaks even with the Base Case. According to the Draft IRP, Promote DER has the highest total resource cost (which is PVRR plus “participant costs”). The logical conclusion is that the Draft IRP projects high participant costs for Promote DER (and other strategies that include higher amounts of DER). But that finding is contradicted by many studies and real world programs.

For energy efficiency, in particular, the National Laboratories of the Department of Energy have identified cost-effective opportunities to save over 35% of residential electricity use in Tennessee through energy efficiency in under five years, with similar savings levels of 15-30% for other sectors. In their recently issued IRP, Georgia Power shows similar dynamics for customers and utility-sponsored efficiency programs, with levelized costs of efficiency hovering around $0.02/kWh for most of the next twenty years, compared to retail rates at least 500% greater. Given that efficiency investments are cost-effective for customers, with payback periods shorter than the planning horizon for the Draft IRP, it is highly unlikely that there would be a net increase in participant costs for efficiency programs.

For distributed solar, even without federal tax credits, there would still be a net-positive financial return for an investment in DER given the cost reductions anticipated by Lazard. The same is true based on the costs estimated in recent IRP filings in the Southeast. In Georgia, for example, installed cost estimates for residential and commercial distributed solar in 2018 registered at $2.50-2.98/watt and $1.85/watt, respectively (pre-tax credits). Within the Tennessee Valley, consumer behavior also supports the net benefits of installing distributed solar. For example, BlueCross BlueShield recently announced that it plans to install 4.3 MW worth of solar panels to power its corporate headquarters because solar generation would be cheaper than purchased electricity. The company anticipates that it will save $23 million in energy costs over the projected useful life of the solar equipment (twenty-five years).

The same conclusion can be drawn for demand response. As part of a study by the Department of Energy’s Smart Grid Investment Grant Program, the Sacramento Municipal Utility District found that under almost all scenarios it ran, alternative rate and customer system offers and recruitment (*Commenter: Christina Reichert – Southern Environmental Law Center*)

Response: Some customers will adopt DER without promotion from TVA, representing market-driven DER. Costs and benefits associated with market-driven DER are not included in Total Resource Cost (TRC). TRC seeks to provide a full picture of resource costs associated with TVA promoting DER adoption above the market-driven level through a strategy, whether those costs would be incurred by TVA or by the DER participant.

Additional information related to solar adoption assumptions can be found in IRP Appendix C and at the IRP Supporting Documents link at tva.com/irp. Additional information on demand response programs modeled in the IRP can be found in IRP Appendix B. TVA has run sensitivity analysis on expanded DR market depth indicating a potential for up to 500 MW by 2038; the results of this analysis are described in IRP Section 8.2.3.

193. A second problem with the treatment of DER is that the Draft IRP includes DER costs that were not reviewed by any third-party consultant. TVA hired a third party consultant ”Navigant Consulting, Inc.” to compare TVA’s planning parameters with other industry sources and ensure the modeled assumptions were representative of the respective generating technologies. From the list in Navigant’s summary letter, it appears that Navigant did not

review the vast majority of DER modeled in the draft IRP. These include residential distributed solar, residential battery storage, residential energy efficiency, commercial energy efficiency, industrial energy efficiency, and residential demand response. For the parameters not independently reviewed, TVA does not provide sufficient information to evaluate the basis and accuracy of its cost estimates. Given the data transparency issues in the Draft IRP, the lack of third party review of TVA's cost estimates for DER is all the more concerning. Navigant reviewed parameters for only small and large commercial distributed solar. That review is still opaque because the review published in the Draft IRP discusses Navigant's review of "all of the solar PV parameter values," and does not disclose the analysis for each category of solar generation nor information for each parameter. (*Commenter: Christina Reichert – Southern Environmental Law Center – Southern Environmental Law Center*)

Response: TVA's cost assumptions for distributed solar were informed by cost estimates provided by Navigant and escalation forecasts informed by Department of Energy Sunshot targets. Cost assumptions for distributed storage systems were based on Tesla Powerwall 2 values and projections that are publicly available. Details on assumptions are included in Chapter 5 and Appendix A of the IRP, as well as additional detailed data made available under the IRP Supporting Documents link on the TVA IRP website.

Energy shapes and costs for EE resource options are informed by TVA's partnership with DNV-GL, an industry leader that provides insight on EE best practices, measure values and modeling, as well as the evaluation, measurement and verification of program results. TVA conducts a Residential Saturation Survey and a Business & Industry Saturation Survey every other year to understand market depth and potential reach of programmatic efforts, which vary from region to region. Also, TVA is an active participant and member with multiple industry trade organizations that specialize in energy programs, including eSource and the Association of Energy Services Professionals.

194. A third problem with the treatment of DER is the failure to acknowledge the untapped resource of energy efficiency. Rather than treating EE on par with supply-side resources, the draft IRP includes assumptions that severely restrict its implementation. Effectively implementing EE avoids costs associated with producing energy, reduce costs for complying with environmental regulations, lower wholesale energy costs through reduced demand, and reduce major risks for costly projects like buying and building power plants. Despite these benefits, the Draft IRP consistently hamstrings EE in its model by the following:

i. The "historical" participation rates used in the draft IRP fail to take advantage of the actual potential of EE in the Valley. Overall, the structure and incentive levels envisioned for program delivery through the Draft IRP are not clear. Due to the lack of transparency regarding the Draft IRP's methodology for modeling EE, it is difficult to parse out why the Draft IRP is missing the abundant EE potential in TVA territory.

The Draft IRP uses "historical data" to estimate and project the participation rates for EE programs. Using TVA's own historical data does not accurately characterize the current and future availability of energy efficiency. TVA has "reduced" 8 energy incentives and instead implements the eScore system, which was never implemented or promoted as a resource. In commercial and industrial sectors, TVA includes "some standard rebates" but focuses on "customized solutions" such as Strategic Energy Management, which is a platform for industrial and commercial customers to talk about efficiency options but does not incentivize adopting those options. In the 2015 IRP, TVA identified "blocks" of available EE measures that went beyond their existing programs. It is not clear why TVA did not do so here.

Rather than using participation rates in residential educational programs and the commercial and industrial forum programs convened by TVA, the draft IRP should look to the full range of existing EE programs that effectively deliver EE at least cost. Duke Energy Carolinas, for example, more effectively implements a suite of programs that exceed 1% of sales. These programs include incentives to residential and nonresidential customers for installing energy efficient appliances and devices to drive reductions in energy usage, such as the following:

- Residential EE Programs:
- Energy Assessments
- Energy Efficient Appliances and Devices
- Energy Efficiency Education
- Income-Qualified Energy Efficiency and Weatherization Assistance
- Multi-Family Energy Efficiency
- My Home Energy Report
- Smart $aver Energy Efficiency
- Non-Residential EE Programs:
- Non-Residential Smart $aver Prescriptive
- Non-Residential Smart $aver Custom
- Non-Residential Smart $aver Custom Assessment
- Non-Residential Smart $aver Performance Incentive
- Small Business Energy Saver

Of course, it is not only the breadth and diversity of program offerings that drives participation rates. It is also the utility's commitment to implementing the programs. As noted above, TVA has not historically sought to implement its EE programs with the necessary commitment.

ii. The Draft IRP overstates U.S. Department of Energy codes and standards as a constraint on EE as a resource. TVA claims that it has curtailed its EE efforts because of increasing effective codes and standards from the U.S. Department of Energy. As a preliminary matter, this claim is made without reference and does not reflect historical reality: efficient technologies have consistently advanced and are expected to do so, as noted by TVA's own consultant Navigant. Further, to the extent TVA assumes that the Department of Energy's upstream efficiency standards will continue to be strengthened over the course of the planning period, that claim is undermined by Department's recent moves to roll back existing codes (*Commenter: Christina Reichert – Southern Environmental Law Center*)

Response: As described in IRP Appendix B, TVA's eScore platform provides educational resources and connections to approved contractors to support EE installations. TVA also provides for home efficiency evaluations, providing residential customers with detailed reports including efficiency scores, pictures of problem areas, and recommendations. Additionally, TVA's commercial and industrial EE programs include standard rebates but focus more on customized solutions. TVA continually evaluates opportunities to improve EE programs, leveraging insights from industry leader DNV-GL, related trade associations specializing in EE, and market and saturation surveys. The 2019 IRP also includes a Low Income EE program (TVA's Home Uplift initiative) that is currently in pilot phase and is incoporated in all resource portfolios. This program seeks to augment the state of Tennessee's Weatherization Assistance Program by working with LPCs and local communities to create a sustainable program aimed at making weatherization improvements in low-income households. TVA is evaluating expanding this pilot program Valley-wide, so several strategies in the 2019 IRP (Promote DER and Promote Efficient Load Shape) included this expansion. The IRP Recommendation includes working with LPCs to expand programs for low-income residents, as described in IRP Section 9.4. Regarding the impact of DOE codes and standards, IRP Appendix B includes additional detail on historical and projected impact of DOE codes and standards over time. TVA utilizes DOE electricity use intensity data by source in developing load forecasts.

195. The Draft IRP overestimates the costs associated with supply-side renewable resources, underestimates their value, and impedes their deployment in the model. Absent these flaws, strategies promoting utility-scale solar, utility-scale wind, and utility-scale renewables+storage would prove at least as competitive as the Base Case.

One example of this is with the new integration cost and flexibility benefit, which serve only to raise the cost of intermittent resources, like solar and wind. They are intended to incorporate the costs of integrating intermittent resources onto the grid and the benefits from resources that can quickly ramp up when intermittent resources are unavailable. The Draft IRP characterizes integration cost as driven by the need for system resources to absorb sub-hourly fluctuations by intermittent resources. TVA describes the integration cost components as the operating and maintenance costs for resources that step in to generate electricity when solar or wind becomes unavailable. TVA assigns integration costs to new solar and wind. On the other hand, TVA assigns new aeroderivative CTs and utility battery storage flexibility benefits. The flexibility benefit is purported to be a sub-hourly benefit that accounts for highly flexible resources' ability to more efficiently absorb sub-hourly fluctuations in intermittent resources.

After releasing the Draft IRP, TVA performed a sensitivity analysis that removed all integration costs and flexibility benefits and then reran the model to determine their effect of the Draft IRP's results. The sensitivity analysis shows that this metric has a "minor" effect on capacity decisions. When removed from the Base Case, the difference is roughly 100 MW less added CT capacity.

More importantly, when comparing the results of the Base Case and the sensitivity analysis, the major difference appears to be cost. In the sensitivity analysis, PVRR and total resource costs are $100 million cheaper when the flexibility benefit and integration cost are removed.

Even while employing TVA's flawed flexibility metric, the draft IRP shows that the Promote DER strategy has substantially similar flexibility to the Base Case. This result, taken in conjunction with the results of the sensitivity analysis, shows the metric's uselessness. Because the flexibility benefit and integration cost appear to only increase costs and have a negligible effect on resource decisions, it should be removed. (*Commenter: Christina Reichert – Southern Environmental Law Center*)

Response: Applying an integration cost when evaluating intermittent resource additions is a common industry practice. IRP Appendix D contains a link to an industry study of this practice. Sensitivity analysis results show that modeled integration costs and flexibility benefits currently have minor effects on long-term expansion plans. However, they represent real sub-hourly costs that would be incurred with increases in intermittent resources or benefits that would be realized with increases in more flexible resources. Also, it is important to understand integration costs and flexibility benefits in specific asset evaluations.

TVA employed a new metric in the 2019 IRP, Flexible Resource Coverage Ratio, as a first step to lend insight to flexibility needs and capabilities of various resource portfolios. While the TVA system needs flexibility to cover the largest projected 3-hour ramp with some room to spare, TVA will continue toevaluate a sufficient level of coverage to allow for unit outages and other factors.

196. The restrictions on the availability of utility-scale solar are unsupported. These restrictions limit its availability until 2023 and set an unreasonable 500 MW/year cap and an unknown cumulative cap on the ability of the model to select utility-scale solar.

First, without explanation or support, the draft IRP assumes that utility-scale solar units would not be available until 2023, regardless of size or technology type. However, other Southeastern utilities have recently proposed to add utility-scale within that timeframe. For example, Duke Energy Florida similarly has proposed to build three utility-scale solar projects, each beginning service prior to 2020. The NREL 2018 Annual Technology Baseline and the

EIA, in its 2019 Annual Energy Outlook indicate utility-scale solar development can be in 1 to 2 years. Although that timeline may be slightly extended for TVA because it would need to comply with NEPA requirements, that process would not take three years more than similarly situated utilities.

After the issuance of the Draft IRP, TVA ran a sensitivity analysis to evaluate the impact of accelerating utility-scale solar construction. The analysis reflects recent Facebook and Google solar signings of approximately 700 MW that would come online by 2021 and assumes 500 MW per year accelerated solar additions thereafter until economic solar additions pick up in the mid-2020s. The sensitivity analysis demonstrates that accelerating utility-scale solar construction makes economic solar additions occur sooner in the twenty-year planning period and results in approximately 800 MW of additional utility-scale solar by 2038. The results also show that renewable generation would slightly displace natural gas generation and result in a greater reduction in CO_2 emissions.

Second, the Draft IRP includes an unreasonably low annual cap on solar additions. After the Draft IRP was issued, TVA ran a sensitivity analysis that doubled the annual solar cap to 1,000 MW and removed the cumulative cap. The sensitivity analysis results show (1) accelerated solar installation due to favorable pricing in the mid- to late-2020s and (2) the installation of approximately 750 MW of solar above that installed under the Base Case. When the solar cap is doubled, the model shows similar results and lower carbon emissions as renewable energy displaced natural gas generation. (*Commenters: Gil Hough –Tennessee Solar Energy Association, Simon Mahan – Southern Renewable Energy Association, Christina Reichert – Southern Environmental Law Center, Stephen Smith – Southern Alliance for Clean Energy*)

Response: Comment noted. Solar expansion is significant in the IRP, ranging from about 6 to 9 GW of nameplate capacity by 2038 under the Current Outlook for electricity demand. In resource planning, it is typical to limit the number of MW additions in a given year to reflect the practicality of when TVA has knowledge of the resource need and other project management considerations. As solar is an economic option, additions were "maxing out" in some cases. In response to related stakeholder input, additional sensitivities have been run with increased annual caps for solar additions. As a result of these analyses, the IRP Recommendation includes the potential for up to 14 GW of solar additions by 2038 in a growth or promotion case.

Driven by the timing of customer demand, TVA has launched two programs to support accelerated renewable investment: Renewable Investment Agreement (RIA) and the Flexibility Research Project (FRP) pilot. RIA supports utility scale buildouts for large commercial and industrial customers, and FRP supports community solar, in partnership with local power companies (LPCs). Community scale solar provides opportunities for LPC customers to invest in LPC-sponsored community solar facilities as a lower cost alternative to constructing and operating their own rooftop or other solar facilities. Related to RIA, TVA recently announced projects totaling 675 MW for Facebook and Google with online dates by 2021 and recently issued an RFP to contract for additional solar to meet customer demand with a targeted online date by 2022. By the time the IRP is published in June of 2019, it was prudent to assume that the next round of renewable additions could dependably be online by 2023, even though some portion may come online sooner.

197. Another problem with the treatment of supply-side renewable energy in the Draft IRP is the inflation of estimated utility-scale storage capital costs. The draft IRP estimates ranges from $1,850 -2,800/kW. In November 2018, Lazard projected that commercial and industrial battery applications would cost $1,263-1,849/kW, lower than the lowest level shown in the Draft IRP. Bloomberg New Energy Finance similarly showed in March 2019 that since the first half of 2018, lithium-ion battery energy storage prices have dropped further to $187/MWh.

Lazard expects all chemical battery types to see double-digit cost reduction from 2018 level in the next four years. For example, lithium-ion batteries are projected to cost 28% less in 2022 than in 2018; flow batteries would cost about 40% less by the same time. In comparison, for lithium-ion batteries, the Draft IRP assumes that costs will drop by 3% per year, and by slightly over 15% in the next five years. These technologies could become cost competitive in the next ten to twenty years.

Lazard's results are even more conservative than the recent analysis by BNEF, which showed that the cost for lithium-ion batteries have fallen by 76% since 2012. BNEF found that batteries co-located with renewables like solar are already starting to compete "in many markets and without subsidy" and are starting to compete with natural gas peaker plants. Therefore, TVA's model should capture the cost reduction momentum shown in studies from industry leaders, and allow battery projects to be cost-effectively built within its planning horizon. (*Commenters: Simon Mahan – Southern Renewable Energy Association – Southern Renewable Energy Association, Christina Reichert – Southern Environmental Law Center*)

Response: Battery storage technology is rapidly evolving and therefore its costs will be frequently monitored as the 2019 IRP is implemented. IRP cost estimates for utility-scale battery storage were informed by recent RFI responses and Navigant Consulting's third-party review. Benchmarking requires calibration to differences in MW size, hours of duration, balance of system, and cost structure. Related to structure, augmentation and warranty that ensure output over the lifespan can be included in capital costs or in annual O&M. In TVA's assumptions, these costs were included in capital costs. Clarification on these differences has been included in the discussion of battery storage cost trajectories included in Appendix C of the IRP. When accounting for differences in structure, AC/DC conversions, and inflation, TVA's battery storage cost assumptions align closely to Lazard's cost estimates. TVA's IRP assumes a downward trajectory in costs, similar to IEEE's mid-range case.

198. TVA seems to be modelling costs for solar energy that do not align with widely available estimates from leading organizations and government agencies. This biases the draft IRP models against more favorable conclusions in regard to solar energy. (*Commenter: Jason Carney*)

Response: Solar cost estimates were informed by responses to a recent RFP for installations in the Valley and reflect expectations that costs will continue to decline for the next decade. Figure C-7 in IRP Appendix C provides a graphical representation of solar costs used in the 2019 IRP, expressed in nominal $/kW (DC). IRP solar cost assumptions are declining in real terms. When benchmarking, it is important to calibrate to a common basis for comparison. These and other resource costs were evaluated and informed by Navigant Consulting's third-party review.

199. TVA seems to have modeled the costs of solar and the costs of battery storage separately without recognizing the significant synergies achieved when they are combined. By doing so, TVA disadvantaged the cost of DER and solar in its IRP modelling. (*Commenter: Jason Carney*)

Response: One of TVA's goals in the 2019 IRP was to explore the impact of adding storage, both at utility and distributed scales, which could support integration of renewables. TVA assumed that some portion of distributed solar generation would be paired with distributed storage. In strategies that incented utility-scale storage, battery storage was added in a 10% or 25% match to utility-scale solar expansion, but not assumed to be solely tied to solar operationally which could limit its benefits. Results for strategies C, D, and E demonstrate that incenting storage does increase levels of expansion solar. However, based on forecasted costs for battery storage, these incentives do raise overall system costs. TVA will continue to monitor rapidly evolving storage technologies for improving economics.

200. We commend TVA for using a third party to benchmark supply-side resource assumptions, including capital costs, but it appears that TVA disregarded Navigant's recommendations in favor of assumptions that would drive TVA's desired outcome. As indicated in figures in our comment letters, TVA used high estimates for solar, wind, and storage (outside the range of industry sources) but low estimates for natural gas and nuclear resources (within the

first quartile of or below the range of industry sources). The very high cost estimate for wind, 177% of the highest industry source, eliminates the selection of wind in the portfolios. The forecast overnight costs of distributed solar is also much higher than NREL forecasts.

The assumed capital cost for Small Modular Reactors (SMR) is unrealistically low. The assumed cost in the Draft 2019 IRP is half the assumed cost of this resource in TVA's 2015 IRP despite the fact that no SMRs have been built nor have any designs been certified yet by the NRC. Recent experiences with new nuclear power construction projects did not demonstrate cost reductions, rather project cost estimates skyrocketed, which led to the cancellation or suspension of all but one new nuclear power projects in the country. The only remaining new nuclear power project under construction is Southern Company's Plant Vogtle in Georgia. The two Toshiba-Westinghouse AP1000 design reactors at Plant Vogtle have been under construction since 2009 and have more than doubled in cost from original estimates of $14 billion and are more than five years delayed, if they are ever even completed.

Why is TVA willing to be aggressive with these unsubstantiated costs of an unproven technology and at the same time be overly conservative on the costs of proven technologies like wind and solar? As a planning assumption, these fantasy costs are reckless and potentially dangerous to ratepayers - it lays the groundwork for TVA to develop an SMR, which will inevitably saddle ratepayers with the exorbitant costs as budgets and schedules are busted. Construction of new nuclear is such a big risk that outgoing TVA CEO Bill Johnson explained when speaking in Memphis on November 6, 2018: "My point is simple," Johnson said. "Nuclear construction is the riskiest activity you can engage in in the power business. Take it from me."

Despite attempts by TVA to skew the IRP results, some conclusions sneak through the stacked assumptions. The models do not pick SMRs in any cases, even those where SMRs are incentivized. One case builds SMRs because TVA forced it into the model despite the economics. On the other hand, the results show that solar is too attractive to suppress completely. In the Draft 2019 IRP TVA imposes arbitrary annual caps on utility-scale solar additions. However, a little farther south Florida Power & Light, which is a comparable utility to TVA in terms of sales and customers, is projecting to add an average of 750 MW of solar per year in the next 10 years with additions growing to over 1 GW in a year in the later 2020s. In 22 of the 30 IRP cases the resource planning models built up these caps, indicating that the plans are missing out on additional cost-effective solar. Unfortunately, energy efficiency and wind resources did not fare so well under TVA's unrealistic assumptions. (*Commenters: Jason Carney, Simon Mahan – Southern Renewable Energy Association, Maggie Shober – Southern Alliance for Clean Energy, Stephen Smith – Southern Alliance for Clean Energy*)

Response: Cost estimates for natural gas resources reflect TVA experience with recent gas builds, including two CC plants in the last few years. Cost estimates for SMRs were informed by TVA's collaboration with DOE on an early site permit and were based on the latest estimates available when IRP resource costs were developed. No SMRs were included based on economics, and an SMR appears only in Case 6C where an SMR was forced in to promote resiliency in that scenario and strategy combination. Refinements in design and implementation, coupled with cost and risk sharing, could improve the SMR's position compared to other resource options. Utility-scale solar and wind cost estimates were informed by a recent RFP for renewable generation in or deliverable to the Valley. Battery storage costs were informed by a recent RFI, with augmentation and warranty expenses that ensure output over the asset life reflected in capital costs. All generating and storage resource costs and operating characteristics were reviewed by Navigant, as the Navigant letter describes in Appendix A of the IRP.

Regarding solar costs, TVA's long-term trajectories are relatively aligned to industry sources, including the 2018 NREL ATB forecast which lists costs in 2016 year dollars as $/kW (DC). The best reference for solar price forecasts used in the 2019 IRP is found in Appendix C, Figure C-7, which represents cost forecasts in nominal dollars. A conversion of the nominal utility scale overnight capital cost forecasts that TVA used to 2016 year dollars results in

TVA's overnight capital costs falling below the ATB projections. TVA does use a slightly higher assumption for fixed O&M, resulting in long-term trajectories being relatively aligned.

Solar expansion is significant in the IRP, ranging from about 6 to 9 GW of nameplate capacity by 2038 under the Current Outlook for electricity demand and up to 14 GW of nameplate capacity in a growth scenario. TVA used a 500 MW annual cap on solar buildouts to reflect practical integration of solar onto the TVA system. Resource limits are common in resource planning, and the IRP includes annual caps on gas additions as well.

Regarding wind costs, TVA's long-term trajectories are within NREL ATB's mid-case range, roughly in the bottom third of that range. TVA has run a sensitivity analysis using the lower end of NREL ATB's mid-case range, which shows the potential for up to about 4 GW nameplate of wind capacity additions by 2038 included in the recommendation.

Regarding comparisons to Florida Power & Light (FPL), FPL is similar to TVA in size but experiences higher levels of solar irradiance and milder winters. These differences drive higher solar capacity factors in the FPL region and impact direct comparisons.

201. TVA confirms in the IRP that they would be contracting with private companies through Power Purchase Agreements for their renewable resources. Therefore, it is confusing why TVA includes solar estimated cost as part of the overnight capital cost. Rather, it is both logical and consistent to include energy as the levelized cost of electricity (LCOE) or as energy prices over 20 or 30 years, given the asset and technology lifespan and warranties for these systems. It is understood the capital cost is used as an input to calculate carrying costs, partially akin to an LCOE; however, the advantaged capital structures and tax benefits realized by projects our members develop, which in turn are passed through as savings to TVA, would likely result in lower prices than otherwise implied by TVA's modeling process. (*Commenter: Gil Hough –Tennessee Solar Energy Association*)

Response: TVA used recent RFP responses to inform current solar pricing on a $/MWh basis for the IRP. These offers reflect the ability of solar developers to capture tax incentives. Solar was included in IRP Appendix Table A.1 to show all resources stated on a consistent overnight capital cost basis in 2017 dollars and prices. The best reference for solar price forecasts used in the 2019 IRP is found in Appendix C, Figure C-7, which represents forecasts in nominal dollars and declining in real terms for the next decade. Solar PPAs were modeled in the IRP with levelized cost streams with consideration of capacity factor, energy price, and 20-year contract length for consideration in the IRP. The IRP Recommendation for solar expansion does not preclude TVA building solar if economic to do so.

202. TVA had Navigant evaluate its data input regarding wind energy and solar energy. In Draft IRP Appendix A - Generating Resource Cost and Performance Estimates, Navigant stated that "43 percent of the values showed numerical differences of greater than 10 percent, characterized here as "material ." While the inputs that deviated are not spelled out, our industry members suggest that TVA is assuming an unrealistically high cost for renewables.

The National Renewable Energy Lab (NREL) publishes the Annual Technology Baseline (ATB) as a resource for "realistic and timely set of input assumptions (e.g., technology cost, fuel costs), and a diverse set of potential futures (standard scenarios) to inform electric sector analysis in the United States." NREL's ATB is one of the most comprehensive resources for various energy resource inputs and is used by regional transmission organizations including the Midcontinent Independent System Operator and PJM. NREL's ATB data should be used for model inputs and future forecasts.

NREL's ATB evaluates single-axis tracking systems, with the best performing projects achieving an estimated 27% capacity factor (NREL ATB projects located in Daggett, CA). As a proxy for fixed-tilt solar projects, we recommend that a 20% capacity factor be used (NREL ATB projects located in Kansas City, MO). NREL's ATB converts solar DC power to AC power output for capacity factor purposes while keeping several financial metrics in $/kW-DC units.

To provide a better range of pricing and performance, we recommend that the "Mid" overnight costs for Kansas City and Daggett utility-scale solar projects from NREL's ATB should be compared to PVWatts for those cities, and then scale to the PVWatts for TVA's territory, along with 20% and 27% capacity factors, respectively, beginning in 2019. In addition, these academic publications and reports are dated as soon as they are published and do not traditionally reflect the most-current marketplace and industry costs for delivering these resources to TVA. (*Commenter: Gil Hough –Tennessee Solar Energy Association*)

Response: Solar cost estimates were informed by responses to a recent RFP for installations in the Valley and reflect expectations that costs will continue to decline for the next decade. Figure C-7 in IRP Appendix C provides a graphical representation of solar costs used in the 2019 IRP, expressed in nominal $/kW (DC). IRP solar cost projections are declining in real terms and generally align with NREL ATB estimates when adjusted for the capacity factors that can be realized in the Valley (which are lower than California) and for inflation (nominal vs. real).

As explained in IRP Appendix A, TVA used historical information provided by Clean Power Research and capacity factors from recently-signed TVA Valley solar PPAs to inform annual capacity factor assumptions of 20 percent for fixed-axis and 23 percent for single-axis tracking on an AC basis. Calculating this from a DC basis would yield 17 percent and 20 percent which is similar to the ATB's capacity factors for Kansas City.

Solar expansion is significant in the IRP Recommendation, ranging from about 6 to 9 GW of nameplate capacity by 2038 under the Current Outlook for electricity demand and up to 14 GW of nameplate capacity in a growth scenario.

Wind cost estimates were also informed by responses to a recent RFP for installations in or deliverable to the Valley. Additional sensitivity analysis has identified the potential for up to about 4 GW nameplate of additional wind capacity, if lower wind costs could be realized.

203. According to guidance from the IRS, solar power projects that qualify for the 30% investment tax credit in 2019, 26% ITC in 2020, or the 22% ITC in 2021 each have until the end of the year 2023 to become operational. A 10% ITC is available for projects that commence construction during or after 2022, and for projects that become operational in or after 2024. At the same time, the federal ITC is slated to decline, and the NREL ATB shows that solar power installed costs are anticipated to decrease, almost in the same proportion as the ITC phaseout through 2023.

Applying the ITC phase-out to the NREL ATB 2018 overnight capital costs results in overnight costs of approximately $700/kWDC for projects that begin construction between now and 2021, and are operational by the end of 2023. By 2024, when the bulk of the ITC has expired, solar pricing is anticipated to decline an equivalent amount; thus the overall levelized cost of energy of utility-scale solar projects are expected to remain relatively flat from 2019-2030. For utility-scale solar projects with 20% capacity factors, and taking the ITC into account for near-term projects, overall LCOE is anticipated to remain in the mid-$30s/MWh range for the next decade. For projects with 27% capacity factors, LCOE values in the $20s/MWh are anticipated by the industry.

It is our industry members' opinion that utility-scale projects in the TVA region can currently be delivered with an LCOE in the low to mid-$30/MWh range thanks to the ITC value and for the decade ahead with the forecasted future cost-declines following the ITC step-down to 10%. Also, the Georgia Power 2019 IRP has stated that the company's average solar power purchase agreement has reached $36/MWh, which is in line with the NREL ATB values. (*Commenters: Gil Hough –Tennessee Solar Energy Association, Simon Mahan – Southern Renewable Energy Association*)

Response: Solar cost estimates were informed by responses to a recent RFP for installations in the Valley and reflect expectations that costs will continue to decline for the next decade. Figure C-7 in Appendix C provides a graphical representation of solar costs used in the 2019 IRP, expressed in nominal $/kW (DC). IRP solar cost projections are declining in real terms and generally align with NREL ATB estimates when adjusted for capacity factors that can be realized in the Valley and for inflation (nominal vs. real). Solar expansion is significant in the IRP Recommendation, ranging from about 6 to 9 GW of nameplate capacity by 2038 under the Current Outlook for electricity demand and up to 14 GW of nameplate capacity in a growth scenario.

204. The IRP must properly value the benefits of distributed solar resources. Distributed solar resources can provide wholesale ancillary services in the same fashion as utility-scale assets and can also offer ancillary services on the local or distribution level with supportive policies and standards in place. Local voltage support is critical to operating the distribution system within system constraints, and distribution system operators rely on a distributed set of the voltage regulating equipment to provide that support. Distributed solar resources can augment and sometimes replace this equipment, providing real and reactive power support as identified by the distribution operator.

On an aggregated basis, utility-scale and distributed solar resources complement each other and provide significant reliability and transmission/distribution benefits to both the local and regional grid. While solar output may vary at individual locations due to localized cloud coverage, accurately assessing the sum of solar resources installed across a geographic area often reduces and mitigates the impact of variable output managed by the grid operator. In a recent study regarding the integration of wind and solar in the PJM territory, General Electric International, Inc. (GE) found that PJM's sizeable geographic footprint significantly reduced the magnitude of variability-related challenges as compared to smaller balancing areas. GE noted that an individual solar PV plant's variability is reduced substantially when solar plants are aggregated and located in a geographically diverse manner throughout the PJM territory. (*Commenter: Gil Hough –Tennessee Solar Energy Association*)

Response: TVA acknowledges that solar resources, both utility and distributed scale, have the potential to provide grid services. This potential is limited by the capacity factor of solar resources. TVA will continue to work with the LPCs and TVPPA on the potential for distributed solar to contribute grid services across the Valley.

205. Although TVA's modeling does evaluate potential solar, wind, and storage resources, TVA assumes prices for such resources that are significantly higher than industry standard assessments. As a result, TVA's modeling tends to underselect clean energy resources, while artificially and incorrectly over-favoring fossil resources.

TVA used several different solar, wind, storage supply options for their capacity expansion plan modeling. TVA calculated total overnight capital costs for each of these supply options; these costs are listed in 2017 dollars/kW in Draft IRP Table A-1.

In order to assess the reasonableness of these costs, we gathered capital cost projections from six other utility IRPs, as well as from independent government and industry reports on actual costs, and converted those values to 2017 dollars per kW for consistency. The non-utility reports were the November 2018 Lazard Levelized Cost reports, the US Energy Information Administration 2019 Annual Energy Outlook (EIA AEO), and the National Renewable Energy Laboratory 2018 Annual Technology Baseline (NREL ATB). The NREL ATB data are available only for 2016, 2030 and 2050; we interpolate to 2020 (the earliest that TVA could add much supply). The NIPSCo estimates are from actual utility-scale solar, wind and storage bids for 2023 projects from a recent RFP, supplemented by a survey of utilities and independent experts; Wabash Valley Power Association used EIA's 2016 estimates; CLECO used the 2018 ATB; Dominion and PacifiCorp do not provide any source for their cost estimates.

The results of our review, presented in a figure and tables in our comment letters, show some of TVA's cost assumptions appear to overestimate the cost of renewable and energy storage technologies:

- The capital cost for utility solar resources used in the TVA IRP is 35% to 45% higher than the prices bid in NIPSCo's RFP and estimated by Lazard.
- TVA's estimate for wind is 35% higher than NIPSCo and Lazard, and even further above the estimate by PacifiCorp, which has considerable experience building wind plants.
- TVA's battery cost is about twice as high as those of other sources.

While TVA's estimates for the distributed solar options are close to the other available estimates, any analysis of the value of distributed energy resources, especially with solar, should credit those resources with the value of reduced loading on the T&D system, the value to the host customers of back-up power supply when the utility T&D system experiences an outage, and the local and state property and sales tax benefits of in-region solar. TVA does not appear to have monetized those values in the analysis undergirding the Draft IRP.

This overpricing of clean energy resources is quite consequential for TVA's modeling. The Draft IRP projects adding 3,700 to 8,800 MW of new solar capacity and zero wind capacity between 2023 and 2038 based in the 30 combinations of scenarios and strategies provided in the IRP.

We compared TVA's projected solar additions to those in ten recent IRPs, mostly from the South and Midwest. The proposed additions have been normalized by annualizing them over the planning period in the particular IRP and dividing by the utility's current peak load to control. The resulting annual rate of solar additions is shown in Figure 2 of the Sierra Club comment letter. For ease of calculation, the minimum total MW solar addition value was used for those utilities that projected a range of solar additions (such as TVA). Relative to other utilities, TVA's rate of proposed annual solar additions contemplated by the Draft IRP is below average. Those additions are additionally backloaded, so benefits occur more slowly and TVA winds up continuing to run obsolete generation longer than necessary.

TVA likewise overprices energy efficiency in its modeling, and, as with generation resources, this has the tendency to depress selection of EE resources in its Draft IRP modeling. Figure 3 displays the range of costs (in 2017 dollars) for residential EE programs featured in the Draft IRP and for other utilities. For residential programs, there is a significantly greater range of costs per MWh saved assumed by TVA when compared to other utilities. These higher costs significantly impact TVA's modeling results. The amount of EE expansion contemplated in the Draft IRP across scenarios ranges from 20 to 85 MW between 2020 and 2038. Like the solar additions analysis, Sierra Club reviewed the amount of EE expansion projected by other utilities in their latest IRPs to calculate the level of annual EE expansion (MW) relative to the MW peak load for each utility. Notably, the analysis did not include many of the leading jurisdictions in EE development, but instead was a comparable group of Midwest and southern utilities. Figure 4 displays these values for the various utilities. At 0.0001 MW of EE expansion per MW of peak load, TVA has one of the smallest expansion projections for its size compared to the other utilities surveyed. (*Commenters: Zachary Fabish – Sierra Club – Sierra Club, Simon Mahan – Southern Renewable Energy Association*)

Response: Solar cost estimates were informed by responses to a recent RFP for installations in the Valley and reflect expectations that costs will continue to decline for the next decade. Figure C-7 in IRP Appendix C provides a graphical representation of solar costs used in the 2019 IRP, expressed in nominal $/kW (DC). IRP solar cost projections are declining in real terms and generally align with NREL ATB estimates when adjusted for capacity factors that can be realized in the Valley and for inflation (nominal vs. real). Solar expansion is significant in the IRP, ranging from about 6 to 9 GW of nameplate capacity by 2038 under the Current Outlook for electricity demand and up to 14 GW of nameplate capacity in a growth scenario.

Wind cost estimates were informed by responses to a recent RFP for installations in or deliverable to the Valley. Additional sensitivity analysis on wind costs has been run based on lower mid-range NREL ATB costs, identifying the potential for up to about 4 GW nameplate of wind capacity by 2038.

IRP cost estimates for utility-scale battery storage were informed by recent RFI responses and Navigant Consulting's third-party review. Benchmarking requires calibration to differences in MW size, hours of duration, balance of system, and cost structure. Related to structure, augmentation and warranty that ensure output over the lifespan can be included in capital costs or in annual O&M. In TVA's assumptions, these costs were included in capital costs. Clarification on these differences has been included in the discussion of battery storage cost trajectories in Appendix C of the IRP. When accounting for differences in structure, AC/DC conversions, and inflation (nominal vs. real), TVA's battery storage cost assumptions generally align to Lazard's cost estimates. TVA's IRP assumes a downward trajectory in costs, similar to IEEE's mid-range case. Battery storage technology is rapidly evolving, so costs will be frequently monitored for changing economics.

Distributed solar installations are modeled assuming the elimination of transmission losses. Going forward, TVA will continue to work with the LPCs and TVPPA to better understand and be able to incorporate locational benefits of distributed resources on the system.

Energy shapes for EE program tiers are informed by TVA's partnership with DNV GL, which provides insight on best practices, measure values, modeling, and ultimately the evaluation of program results. Also, TVA conducts a Residential Saturation Survey and a Business & Industry Saturation Survey every other year to understand market depth and potential reach of programmatic efforts and participates in EE-focused trade organizations. With increasing levels of market driven EE, TVA is emphasizing education and outreach. TVA currently offers EE programs for homes and businesses through the local power companies in the Valley. TVA has considered various levels of EE programs in the IRP, including the expansion of TVA's Home Uplift initiative aimed at making weatherization improvements in low-income households. TVA has performed additional sensitivity analysis on EE market depth. The IRP Recommendation reflects up to 1,700 MW of additional EE if the higher market potential can be realized.

206. The winter reserve margin will be 25% compared to 17% summer. If this language remains in the IRP it will punish Valley residents who heat their homes and water with electricity. As it exists today, TVA's wholesale rate structure penalizes any LPC that has a load profile dominated by residential all electric homes. This is derived from TVA's non-coincident monthly peak demand charge and the newly instituted Grid Access Charge. The reserve margin language in the IRP will be used as a justification to increase the demand charge during the winter months by assigning a cost to the required capacity.

TVA's reserve margins aren't dictated by any given month since TVA cannot create capacity on a monthly basis. TVA's wholesale rate should collect capital costs based on its top 200 hours of demand. This should be a coincident demand charge/Grid Access Charge. As an electric utility TVA should reward all electric homes not punish them. (*Commenter: Michael Watson*)

Response: As noted in IRP Appendix D, the reserve margin is a planning target used to account for various risks associated with serving electrical load, including extreme weather, load forecast error, and plant outages (planned and unplanned) to continue providing a high level of reliability to TVA customers. Recognizing that the TVA system is dual-peaking in both summer and winter, the 2018 Reserve Margin Study determined that winter peak load variability due to weather is more unpredictable and that additional reserve margin is required to ensure reliability in winter (see Figure D-1 in IRP Appendix D). TVA's targets of 17% for summer and 25% in winter also align with neighboring peer utilities. For example, Georgia Power's 2019 IRP lists long-term targets at 16.25% for summer and 26% for winter.

207. According to Draft IRP Section A.4.4, TVA continues to rely on solar data provided by Clean Power Research in 2014 and wind generation data "based on simulation of TVA's existing wind contracts." Since the 2014 data were created there has been significant technological development in terms of solar panel output, inverter selection, and

other relevant technology. Since TVA contracted for power, wind turbines have trended towards larger generation capacity, with taller towers and longer blades. TVA has updated its cost data for all technologies, and its performance data for gas technologies. However, neither the solar nor wind performance data reflect current technology.

If TVA has updated its analysis of Net Dependable Capacity (NDC) for solar and wind since the 2015 IRP, these analyses have not been provided for public review. The information provided in the Draft IRP and data received from TVA in response to a request under NEPA and FOIA was not sufficient to provide informed evaluation of the methodology used to calculate NDC for these resources. (*Commenter: Stephen Smith – Southern Alliance for Clean Energy*)

Response: Solar data provided by Clean Power Research for the 2015 IRP included 15 years of consistent, validated, time-series irradiance measurements. Although technological advancements have lowered the cost per kWh, the energy patterns themselves should remain consistent. Additionally, TVA incorporated capacity factors and hourly generation patterns from TVA solar PPAs that came online in recent years to further inform assumptions in the 2019 IRP.

As noted in IRP Appendix A, TVA uses a combination of data from 3TIER, a third-party company specializing in renewable energy assessment and forecasting, and data from TVA wind PPAs to develop the planning assumptions around wind shape and capacity factor for use in the IRP. A “typical week” hourly shape for each month was developed by 3TIER for each wind option. Unit characteristics for wind expansion options were informed by Navigant Consulting and recent renewable RFP responses.

208. Another way in which the Draft 2019 IRP fails to update its assumptions about solar and wind power is that it fails to consider the potential to utilize these resources as dispatchable. A number of recent solar and wind projects have been deployed as dispatchable resources, and studies show that solar and wind can provide many of these flexible benefits.

In particular, “dispatchable” or “fully flexible” solar options that can provide necessary system flexibility or support capacity services. This is described in a report that reviewed Duke Energy’s proposed solar integration charge: “Modern solar plants can control their output faster and more accurately than conventional generators. If they are equipped with automatic generation control (AGC) they can provide that response to the system operator during contingencies. Solar plants normally operate at their full available output, and have no reserve capacity to offer, because they have zero marginal production cost and are therefore more economic than fuel burning generators. If, however, a solar generator is curtailed for some reason it will have available generation capacity that could be called upon to support power system reliability.”

The financial and operational advantages of AGC on solar plants has been demonstrated in recent studies. An NREL report published March 2017 found that solar and wind equipped with sophisticated “grid friendly” controls can contribute to grid stability and reliability. A study for Minnesota Pathways published in November 2018 found that additional solar capacity coupled with curtailment is less expensive than seasonal storage. An E3 report published October 2018 looked at operating solar in four modes: “Must-Take,” “Curtailable,” “Downward Dispatch,” and “Full Flexibility.” The report uses the conditions of Tampa Electric’s actual system to show that much of the inflexibility attributed to solar in traditional modeling is because it is modeled in the “Must-Take” mode only. The E3 report found continuing value for solar power on the Tampa Electric system at the highest level tested (28% penetration) using the “full flexibility” mode.

For wind generation this phenomenon is sometimes called "over-subscription." TVA should include the following new resources in its IRP modeling, with relevant updates to costs, NDC, and capacity factor: curtailable solar, downward dispatch solar, full flexibility solar, and oversubscription wind. The inclusion of these resources along with reasonable cost assumptions and the elimination of arbitrary caps on resources will allow the model to do a true least-cost analysis. (*Commenter: Stephen Smith – Southern Alliance for Clean Energy*)

Response: As noted in IRP Chapter 5, because TVA cannot take direct advantage of the current investment incentives offered to promote solar and wind power development, it is more financially advantageous to acquire these resources through PPAs. In most instances these contracts require that TVA pay for the full output of the facility, regardless of curtailments. TVA acknowledges that solar resources have the potential to provide ancillary services, but the potential is limited by hours solar generation is typically available and its capacity factor. At this point in the process, it is not feasible for TVA to incorporate different operational modes for solar in the IRP analysis. TVA will continue to evaluate alternative ways to structure solar power purchase agreements and to consider variation in solar operation of potential TVA solar builds in the future.

209. The start years for in-valley wind and battery storage should be updated to 2022 and 2020, respectively. The EIA assumes wind projects have a 3 year lead-time and utility battery storage projects have a 1 year lead-time.

Conversely, the start year for certain other generation technologies should be pushed back beyond 2023. This may not affect the IRP significantly, because these resources are not chosen by the model unless they are forced in manually by TVA staff. Nuclear projects of any kind have longer lead-times and would not be available in 2023. The EIA assumes nuclear projects have a 6 year lead-time, which seems rather unsupportable given recent issues with nuclear project development. (*Commenter: Stephen Smith – Southern Alliance for Clean Energy*)

Response: Comment noted. TVA has reviewed and believes it prudent to retain the 2023 start year for wind as generally indicative, given the TVA Board is scheduled to decide on the IRP in August of 2019. This assumption does not preclude contracting for a wind PPA were it to be economic for the system and available to come online a year sooner. Given current higher costs for battery storage, additions in the near-term are not expected. Similar to wind, the assumption does not preclude battery storage from coming online sooner if economic options arise. No nuclear expansion options were included in the IRP, beyond the SMR forced in as part of Case 6C to promote resiliency in that scenario and strategy combination. Navigant reviewed all generating and storage resource cost and operating characteristic assumptions, including construction timelines. While minor changes in dates would not affect the IRP significantly, TVA will give consideration for more variation in near-term timelines in the next IRP.

210. TVA modeled energy efficiency measures by calculating a levelized cost of energy (LCOE) for each model-selectable tier, with LCOE levels increasing for higher tiers. We understand through communications with TVA that it discounted both the costs (irrelevant since all are in the first year) and the energy saved at a discount factor of 8%.

TVA's LCOE calculation is not performed in an industry-standard manner. To defend its calculations TVA provided a screenshot of a presentation given by the DOE Office of Indian Energy in 2015 to calculate the LCOE of wind power. That same presentation goes on to recommend two DOE-developed models for calculating LCOE. Neither of those models discount energy as a part of the LCOE calculations.

To confirm that TVA misunderstood the DOE presentation, SACE reached out to the Office of Indian Energy to inquire about this LCOE formula. We were answered by a senior analyst at NREL, who explained that there are two categories for methodologies for calculating LCOE: a recovery-based model and a cash-flow approach. The analyst clarified that "Most discounted cash flow models I've seen tend to not discount the energy denominator." We believe the cash flow model is the most relevant here because it is used to calculate the NPV of an investment whereas a recovery-based model replaces cash analyses with a simplifying formula.

The National Standard Practice Manual for Assessing Cost-Effectiveness of Energy Efficiency Resources (known as the NSPM) includes a section on discount rates and a table showing common discount rates by utility type. The NSPM recommends a low-risk discount factor for EE because it is a low-risk investment. The NSPM table provided in our comment letter shows a low-risk discount rate of -1% to 3%, much lower than the 8% used by TVA for all resources. Higher discount rates put resources with higher upfront costs (i.e., EE and renewables) at a disadvantage to resources with ongoing lifetime costs (i.e., gas, coal, nuclear).

TVA should not discount the energy savings when calculating the LCOE of EE options in its IRP modeling, but if it continues to use this inappropriate methodology, it should use a more appropriate discount rate of 3% or less. EE costs are just one way TVA is manipulating IRP assumptions to remove any obligation for EE from the utility. It is irresponsible and goes against TVA's mandate under the TVA Act to prioritize residents of the Tennessee Valley and perform system planning to optimize the lowest possible system cost. (*Commenter: Stephen Smith – Southern Alliance for Clean Energy*)

Response: LCOE calculations are provided both in the IRP and in response to requests for the purposes of comparing resources of differing generation shapes and capacities. Calculating LCOE by taking the present value of both cash flows and energy yields a cash flow when multiplied by yearly energy that is equivalent to paying for the program up front. The 2019 IRP uses a tiered approach for programmatic DER such as EE. Each program tier is assigned an overnight capital cost (administrative costs, program costs, and incentives), as well as a corresponding impact shape and program life. Overnight capital costs for all resources are recovered over the program life span with a method similar to a payment function using TVA's corporate discount rate, thus putting resource evaluations on equal footing and would be equivalent to using LCOE.

211. Wind energy developers can qualify projects for specific production tax credit vintages by commencing construction in a year and bringing such projects online within four calendar years. For example, a wind energy project that commences construction by the end of 2016 has until the end of 2020 to begin operation, and still qualify for the full PTC. Projects that begin construction in 2017 have until the end of 2021 to become operational, 2018 projects by 2022, and 2019 projects by 2023. Renewable energy project developers frequently safe harbor qualified clean energy equipment, in anticipation of a future contract and reflect cost reductions in the proposals.

The PTC is awarded on a generation basis, at a rate of $24/MWh for the first ten years of a project's operation. Because the PTC is a tax credit and it frequently exceeds a project developer's total tax base, developers will frequently monetize the PTC with tax equity. Tax equity erodes the full dollar value of the PTC. According to the Lawrence Berkeley National Lab (LBNL), for a developer with tax appetite, the 100% PTC value is reduced to $19.8/MWh. According to LBNL, developers should expect a $15-$19/MWh reduction in overall cost of energy from the PTC. To achieve an equivalent PTC cost reduction, we recommend that wind energy resources' overnight capital costs be reduced by roughly $600/kW for resources that become operational in 2020 (reflecting 100% of the PTC value), $500/kW for wind resources operational in 2021 (80% of PTC value), and $400/kW for wind resources operational in 2022 (60% of PTC value). Due to the high cost of tax equity for project financing, it is estimated that the 40% PTC (for projects that commence construction in 2019) is essentially value-less and not anticipated to be attractive to many wind developers. (*Commenter: Simon Mahan – Southern Renewable Energy Association*)

Response: As noted in the footnotes for Table A.1 in IRP Appendix A, the projection for wind capital costs assumes that tax credits expire/decrease per current federal law. Following the expiration of current tax credits, wind capital costs increase at less than the rate of inflation to account for improvements in technology.

212. Levelized Cost of Energy (LCOE) values are important metrics for easily comparing energy resources and benchmarking assumed data assumptions against real-world PPAs. LCOEs are frequently reported in IRPs as dollars-per-megawatt hour figures, or $/MWh. TVA did not provide any LCOE metrics for its existing or new

generation technology cost assumptions. TVA asserts in its 2019 IRP that: “Because dispatch costs and expected output vary widely across all of the IRP scenarios, LCOE is not a useful metric to benchmark resource costs. A better comparison, and the standard for resource planning, is to compare $/kW installed capital costs. These are the actual inputs in to the capacity expansion model and the costs benchmarked by TVA’s independent third-party contractor.” However, in its 2015 IRP, TVA stated that, “Levelized Cost of Energy (LCOE) is a common metric to allow comparisons of total resource costs reflective of capital costs, asset lives and expected fuel costs.” Assuredly TVA created LCOEs for its generation technology assumptions; however, we suspect TVA is intentionally withholding this information because TVA’s LCOEs are wildly out of touch with current market offerings.

Meanwhile, in the 2019 IRP, TVA does provide a $/MWh value for its system average cost economic data, essentially a system LCOE. TVA’s 2019 IRP explains: “In addition to computation of the total plan cost (PVRR) over the full 20-year study period, a system average cost metric was calculated. This metric provides an alternative view of the revenue requirements for the study period expressed per MWh. It is not intended as a forecast of wholesale or retail rates over the study period. Rather, it was developed to gauge the potential rate impact associated with a given portfolio and provides an indication of relative rate pressure across the strategies being studied. Reviewing this metric in combination with PVRR and the financial risk measures provides a clearer picture of the cost/risk balance for each resource plan.” TVA is simultaneously arguing that an LCOE for individual generation technologies is useless, but an aggregated system-wide averaged LCOE somehow “provides a clearer picture.” TVA should publish its generation technology LCOE data. (*Commenter: Simon Mahan – Southern Renewable Energy Association*)

Response: LCOE can provide a meaningful comparison for generating resources operating at similar capacity factors and for DER programs with defined shapes that are not dispatchable like traditional generating assets. However, across a long-term planning horizon such as the 20 years evaluated in the IRP, the expected generation from certain units varies based on electricity demand, anticipated fuel and other variable costs, and how a resource is dispatched. LCOE is highly dependent on generation levels and can provide results that are not meaningful in comparison. The capacity optimization model minimizes the present value of revenue requirements (PVRR) rather than the LCOE of particular resources. System Average Cost accounts for annual fixed and variable costs resulting from the economic dispatch of a system optimized for the lowest PVRR in each case. LCOE is a metric resulting from that optimization, rather than an input.

F.2.5.3 IRP Working Group

213. TVA should eliminate the use of non-disclosure agreements with IRP Working Group members. The requirement that IRP Working Group members sign a non-disclosure agreement in order to view and discuss “confidential information” is inconsistent with TVA’s mission as a public power entity. It also did not provide any meaningful protection to TVA as, while TVA claimed the agreement protected information that “could reasonably be expected to have an adverse effect on TVA operations, assets or individuals,” the vast majority of this information, according to TVA, was released with the draft IRP. This information could not have been reasonably expected to harm TVA in one month and not the next. (*Commenter: Daniel Tait – Energy Alabama*)

Response: TVA uses non-disclosure agreements to allow confidential materials to be shared with IRP Working Group members so that those members can provide informed feedback during the IRP development process, while at the same time maintaining the confidentiality of sensitive information. As the commenter indicates, a vast majority of this information has been made broadly available to the public in the IRP/EIS after completion of deliberations with the Working Group members.

214. The IRP Working Group should be given more power. While we were pleased to participate as an IRP Working Group member, the group holds little to no power and is unable to affect the ultimate outcome of the IRP or influence

the decisions of the TVA Board of Directors. When a group as diverse as the IRP Working Group agrees on an action unanimously or with a clear majority, its views should be respected.

On multiple occasions, TVA staff overruled the recommendations of the IRP Working Group. Most noticeable was the TVA's insistence on including the new Land Use environmental metric. TVA chose to ignore the IRP Working Group objections to this metric and its methodology. Because this metric disproportionately affected solar expansion due to the metric's flawed methodology, a reasonable observer can conclude TVA ignored the IRP Working Group in order to disadvantage solar energy.

For future IRPs, TVA should increase the voting weight of the IRP Working Group to 60% and allow the IRP Working Group to independently present its recommendations to the TVA Board of Directors. (*Commenter: Daniel Tait – Energy Alabama*)

Response: TVA engaged external stakeholders in several ways during the development of the 2019 IRP: webinars, public meetings, materials posted online, videos, public comment periods, and structured groups to provide study and input along the way of developing the IRP. The IRP Working Group is established to help shape the inputs and considerations of the study with individual perspectives. Through the course of 14 meetings, IRP Working Group members provided input individually and through small group discussions. In most instances, the 20 members provided varying viewpoints on discussion questions. While in many cases, several members agreed, the group was not requested, and did not provide, any consensus input. Regarding the land use metric, TVA changed the approach of the metric, and added clarifying context in the IRP narrative, based on the IRP Working Group and Regional Energy Resource Council input. Evaluating land use as one of the comparative measures among portfolios is aligned with TVA's mission of environmental stewardship.

215. Before publication of the draft IRP, TVA staff should brief the IRP Working Group on all material changes between the most recent completed IRP and the IRP under development. The IRP Working Group consists of individuals and organizations with varying levels of background in energy. TVA has a responsibility to explain the intricacies of electricity planning and operations so that all members, and the public, have an opportunity to provide meaningful input. TVA did provide context for some changes when discussing the modeling inputs, but did not fully explain the differences in results between IRPs. For example, the 2019 IRP uses a seasonal reserve margin that was not used in the 2015 IRP. Although we disagree with its use, TVA did explain to the IRP Working Group why it was adopting it. TVA did not, however, adequately explain how the seasonal reserve margin has changed the outcome of the 2019 draft IRP relative to the 2015 IRP. TVA should have shown the IRP Working Group draft IRP results based on 2015 reserve margin assumptions so that the IRP Working Group could debase the merits of the new seasonal reserve margin. Total resource costs and "blocks" for energy efficiency programs are also new additions in 2019 compared to the 2015 IRP and neither was adequately explained to the IRP Working Group. (*Commenter: Daniel Tait – Energy Alabama*)

Response: TVA has made available a broad range of information, both publicly and through the IRP WG sessions. Information about the 2015 IRP is available on TVA's public website. During meetings, IRP Working Group members were encouraged to ask questions, request additional information, and seek clarifications. TVA staff were on hand to respond immediately or soon after requests were made. TVA will continue to work to refine and enhance its stakeholder engagement process and will consider this feedback as we prepare for the next IRP process. The study TVA performed to update planning reserve margins for use in annual planning and in the 2019 IRP is discussed in IRP Appendix D.2. Appendix D in the final IRP includes peer benchmarking on reserve margins, including those utilities that have recently established seasonal reserve margins.

216. Section 3.2, IRP Working Group defines the 2019 IRP Working Group as "consisting of 20 external stakeholders representing 20 organizations". Of the 12 members who represent interest groups, two represent

“community and sustainability interests.” However, there is no identification of who these members are or what community or sustainability interest were represented. Due to the size of TVA’s coverage (10 million people in a seven-state, 80,000-square-mile region), it would be expected that considerably more communities would be included for representation. At a minimum, one member from each community that contains a TVA resource (coal fossil plant, nuclear reactor, hydro dam, etc.) should be included in this group. (*Commenter: John Shaw*)

Response: TVA identifies sectors to serve on the IRP WG to provide representative perspectives from a broad set of stakeholder interests. IRP Working Group member’s names and affiliations are not identified until the final IRP is published to maintain a pre-decisional and deliberative dialogue and prevent external influences on the IRP Working Group.

217. Section 6.1.2, Construction of Scenarios indicates that the IRP Working Group presented individual rankings of the scenarios. It would be interesting to see the IRP Working Group rankings to compare against the five unique scenarios that TVA summarizes in Table 6-2. (*Commenter: John Shaw*)

Response: The IRP Working Group ranked a larger set of potential scenarios than the 6 that were ultimately included (see IRP Working Group Meeting 4 materials posted on TVA IRP website). Their rankings were weighted equally with the TVA rankings. In general, there was agreement between the top scenarios. In other instances, where there were differences in the rankings, scenarios were combined to incorporate various parts of individual scenarios.

F.2.5.4 Planning Process

218. We request that TVA consider other benefits, beyond reductions in air emissions reductions (including greenhouse gases) and water consumption and the use of domestic resources, associated with power industry advances that can be expected over the next 20 years. (*Commenter: Christopher Militscher – U.S. Environmental Protection Agency*)

Response: The 2019 IRP and EIS consider a wide range of metrics, including new discussion around environmental justice, land use, and life cycle analysis. TVA will continue to monitor technology advancements and modeling techniques for use in future IRPs.

219. During the comment period on the drafts, the Southern Alliance for Clean Energy submitted a request under the Freedom of Information Act for information used in the modeling process and referenced in the draft IRP. Per NEPA regulations, this 'incorporated material' should have been 'reasonably available for inspection by potentially interested persons within the time allowed for comment,” and any “[m]aterial based on proprietary data which is itself not available for review and comment shall not be incorporated by reference.” This information was not made available until April 3, close to the end of the comment period. The information that was released at that time was incomplete and lacked the Reserve Margin Study, Intermittent Resources Study, and Flexibility Study. The late release of the information, as well as the lack of some information, prevented more informed public comments. TVA should have proactively released this information to provide for more meaningful public input. (*Commenters: Maggie Shober – Southern Alliance for Clean Energy, Stephen Smith – Southern Alliance for Clean Energy, Daniel Tait – Energy Alabama*)

Response: Information that TVA relied on in its draft EIS and IRP analyses was made available in the draft IRP and draft EIS that were posted for public review on February 15, 2019. TVA received a FOIA request from SACE on March 26, 2019, and from the Center for Biological Diversity (CBD) on March 28, 2019. On April 3, 2019, TVA responded to these FOIA requests, providing further explanations and clarifications on the information provided in the draft IRP and draft EIS. When the information requested was already in the document, the TVA response identified that information with citations.

220. TVA should refrain from making program changes during the development of an IRP. Since the publication of the Notice of Intent for the 2019 IRP, TVA has continued to reduce its energy efficiency and renewable energy programs by introducing the new Grid Access Charge and eliminating the Green Power Providers program without a replacement. These actions belie the stated purpose of the 2019 IRP, flexibility. They also make TVA appear, at worst, hostile to energy efficiency and renewable energy, and at best, hostile to customer savings and ownership of generation assets. TVA also recently decided to close the Bull Run and Paradise coal-fired power plants. These have resulted in changes to the Base Case after the issuance of the Draft IRP. However, TVA did not similarly update the Base Case when it changed the energy efficiency and renewable energy programs. Consequently, many of the portfolios show energy efficiency and renewable energy additions that will no longer occur. (*Commenter: Daniel Tait – Energy Alabama*)

Response: The IRP process takes 18 months and that during that time, TVA continues to make business decisions that are in the best interest of the Valley. Until the 2019 IRP is approved by the Board, TVA operates under the 2015 IRP. TVA continuously monitors the fleet for the most economical portfolio to provide power to its customers at the lowest system cost. TVA has launched two programs to support accelerated renewable investment: Renewable Investment Agreement (RIA) and the Flexibility Research Project (FRP) pilot. RIA supports utility scale buildouts for large commercial and industrial customers and FRP supports community solar, in partnership with Local Power Companies.

In February 2019, the TVA Board made the decision to retire Paradise Unit 3 in 2020 and Bull Run by 2023. This decision was made at this time because it was in the best interest of the Valley as a whole. Waiting until the IRP was complete would have added undue cost to TVA's operations and ultimately, customers in the Valley.

221. The public's ability to review and comment on the Draft IRP has been limited by a lack of data transparency. Following the development of the 2015 IRP, SELC recommended that TVA provide more transparency, particularly for results of sensitivity analysis, during the IRP development process to enable full stakeholder engagement. Unfortunately, the 2019 IRP process continues to suffer from a troubling lack of data transparency that hinders the public's ability to provide meaningful input on the Draft IRP. For example, TVA does not disclose the specifics of the third party review of its cost and performance estimates for supply-side resources. TVA provides even less detail regarding the cost and performance estimates for demand-side resources such as energy efficiency. Similarly, TVA does not disclose specific information regarding participant cost assumptions in the new Total Resource Cost metric, or disclose sufficient detail to evaluate the economic case for its new seasonal reserve margin.

In addition to the data transparency issues noted above and additional issues identified elsewhere in our comments, the Draft IRP again fails to include the results of sensitivity analyses, despite identifying which sensitivity analyses TVA plans to run. During the comment period, we were able to obtain the results of an updated Base Case analysis and a handful of sensitivity analyses, not directly from TVA, but through networks of interested citizen groups. TVA's unwillingness to provide this information to the public in a timely and straightforward way significantly hinders our and the public's ability to comment on the draft IRP.

Without seeing the results of those analyses and having a complete understanding of the data and assumptions used in the draft IRP, we are unable to fully and meaningfully engage in the public notice process on the draft IRP and the associated draft EIS. (*Commenter: Christina Reichert – Southern Environmental Law Center*)

Response: TVA has conducted extensive outreach through this IRP process to inform and involve stakeholders, in an effort to ensure the public is aware of and can participate in this important planning effort. These outreach efforts exceed the requirements for public involvement under NEPA as well. The IRP has included public scoping meetings and webinars, the creation of and consultation with the IRP Working Group (which consists of a cross-section of public stakeholders), regular input from the Regional Energy Resource Council (another stakeholder body), and public meetings to gather input on the draft documents. On numerous other occasions, TVA provided information and updates to other stakeholders across the Valley.

TVA has made available a broad range of information, both publicly on the TVA webpage and through the IRP Working Group sessions. For this IRP process, TVA utilized new media to communicate information, including social media, an interactive website, videos and webinars. This process has been significantly more transparent than of any regional peer utility. TVA will continue to refine and enhance its stakeholder engagement process.

222. The draft IRP proposes to switch to a dual seasonable peak because of "weather-driven variability around summer and winter peak load" using thirty-seven years of data. The draft IRP overstates the desirability of natural gas generation through an inflated winter reserve margin analysis and an erroneous presentation of load and temperature data. Our concerns over the winter reserve margin include the following:

1) Both the North American Electric Reliability Corporation (NERC) and the SERC Reliability Corporation (SERC) project a reserve margin requirement for TVA of 13.15-15%, far below the 25% winter reserve proposed in the Draft IRP. The SERC projection of 13.15-14.41% was determined for the region by its Resource Adequacy Working Group through an independent probabilistic planning reserve margin study and was found sufficient to maintain reliability with a zero or near-zero risk to resource adequacy. A SERC analysis also projected that TVA's current system will have 0 loss-of-load hours, loss-of-load-events, loss-of-load frequency, and unexpected unserved energy through 2022. None of these projections consider TVA's ability to access power from neighboring utilities with excess capacity.

2) The Draft IRP states that the switch to seasonal peaks instead of one driven primarily by the system annual peak is "weather-driven variability around summer and winter peak load." Using thirty-seven years of data, the draft IRP states that TVA's winter peak loads represent a higher level of variation than the summer loads, which they correlate with seasonal peak demands. However, the winter peak appears to be based on extreme winter weather events in the distant past, rather than current weather patterns and the trend of winter temperatures in recent decades. This weather-based argument suffers from two major issues: (1) weather data from many decades past is not suitable for deriving inferences about future capacity needs; and (2) the existence of variation from average winter temperatures does necessarily require a higher reserve margin. A review of winter temperatures between 1980 and 2018 at Nashville, Memphis, and Knoxville "the largest load centers" shows steadily rising temperatures and the coldest winter temperatures occurring over two decades ago. Recent trends also show less extreme winter temperature variation.

3) TVA retained AstrapÃ© to evaluate their reserve margin as has been done by several neighboring utilities recently. Experts have critiqued some of AstrapÃ©'s assumptions, and many of those assumptions appear to have been used in the Draft IRP (for example, the $15,000/MWh value of lost load or severely limiting the contribution of demand response). Although TVA did not provide the public with its full reserve margin study when it published the Draft IRP, the assumptions in other similar studies by AstrapÃ© have, for example, (1) overstated the degree to which load is correlated with temperature changes at extremes; (2) understated the potential for DER to contribute to meeting demand at any time but especially during peak; and (3) understated the capability of interregional transfers from neighboring utilities.

In addition to physical reliability, TVA's reserve margin determination also hinges on economic valuations. It is therefore important for the public to understand how the economic evaluation was performed and whether adequate and accurate data were chosen to perform the analysis. Presenting a detailed description of the methodology behind the economic evaluation of reserve margins "including the factors and mathematical equations used in the calculation" would improve the data transparency of the draft IRP and allow for meaningful public engagement on this critical assumption including in TVA’s modeling. (*Commenter: Christina Reichert – Southern Environmental Law Center*)

Response: As noted in IRP Appendix D, the reserve margin is a planning target used to account for various risks associated with serving electrical load, including extreme weather, load forecast error, and plant outages (planned and unplanned) to continue providing a high level of reliability to TVA customers. Recognizing that the TVA system is dual-peaking in both summer and winter, the 2018 Reserve Margin Study determined that winter peak load variability due to weather is more unpredictable and that additional reserve margin is required to ensure reliability in winter (see IRP Figure D-1). TVA's targets of 17% for summer and 25% in winter also align with neighboring peer utilities. For example, Georgia Power's 2019 IRP lists long-term targets at 16.25% for summer and 26% for winter.

Reserve margins referenced by NERC and SERC are based on the summer profile. As TVA was predominantly a summer-peaking system in the recent past, TVA previously targeted a 15 percent annual (summer-based) reserve margin that resulted by default in winter reserve margins of about 28 percent with higher output from thermal units in winter. Now that the system has become winter-peaking by a few hundred megawatts and solar is expected to play an increasing role at both utility and distributed scale and will not contribute to early morning winter peaks, it is prudent to focus now on reserve margins needed to ensure reliability across both peak seasons.

TVA, along with other utilities, continue to analyze weather patterns and the pros and cons of using longer or shorter historical periods to inform future planning. Weather is by far the largest factor in determining short-term load variability, especially during periods of extreme cold as additional electrical heating appliances are utilized. The polar vortex of 2014 resulted in one of the top 10 highest winter peaks above weather-normal and had a higher percent difference above normal than any of the past 37 summer peaks, as shown in IRP Figure D-1. It is therefore necessary to plan for higher reserves in winter, as extreme weather is one of the major risks that the Reserve Margin covers. Based on questions received from stakeholder groups and in public comments, TVA performed a sensitivity analysis modeling warmer temperatures on average and more frequent drought and flooding. The results of this analysis are included in Chapter 8 of the final IRP document.

The Reserve Margin study considered TVA's ability to purchase from its neighbors, informed by a distribution of firm market purchases made in recent years which ranged from about 2,500 to 6,000 MW. The ability to purchase power from neighboring regions reduces reserve margin requirements by about 2 percent. The study also considered use of contracted demand response. Finally, additional language has been added to the economic evaluation portion of the reserve margin discussion.

223. IRP processes should be transparent and involve stakeholders throughout the process. A successful IRP minimizes total system costs without limiting customer choice, leading to the lowest possible customer bills, rather than focusing on rates or spending choices by private customers. It should evaluate the entire life cycle cost of all resources, both supply and demand and existing and potential. A successful IRP should be overseen by an engaged oversight body. The Draft IRP reflects a 20th century business model without regard to the quality of life in the valley, through centralized TVA management of the region's electricity resources. As a result, TVA appears poised to further reduce its investment in helping customers manage their energy bills and burdens, slow-walk or halt renewable additions, and continue to invest in old, expensive, inflexible resources. We call on TVA to rebuild this IRP in a transparent and objective manner, and if its staff will not, we call on the TVA Board of Directors to reject the IRP in its current form. (*Commenters: Stephen Smith – Southern Alliance for Clean Energy, Sandra Upchurch, Rosemary Varner*)

Response: TVA has conducted extensive outreach through this IRP process to inform and involve stakeholders, in an effort to ensure the public is aware of and can participate in this important planning effort. These outreach efforts satisfy the requirements for public involvement under NEPA as well. The IRP outreach has included public scoping meetings and webinars, the creation of and consultation with the IRP Working Group (which consists of a cross-section of public stakeholders), regular input from the Regional Energy Resource Council (another stakeholder body), and public meetings to gather input on the draft documents. On numerous other occasions, TVA provided information and updates to other stakeholders across the valley.

TVA has made available a broad range of information, both publicly on the TVA webpage and through the IRP Working Group sessions. For this IRP process, TVA utilized new media to communicate information, including social media, an interactive website, videos, and webinars. This process has been significantly more transparent than of any regional peer utility. TVA will continue to refine and enhance its stakeholder engagement process.

224. The Draft IRP artificially maintains the operation of uneconomical coal-fired power plants. The model prevents most coal units from being retired until 2025. That assumption forces certain resources to remain online instead of allowing economics to inform planning decisions and directly violates least-cost planning by requiring customers to pay for existing resources regardless of the ability of other resources to meet the same energy needs more cost-effectively. If it were true that no other resource could meet the energy needs of customers at lower costs, this violation could be called a modeling error with little real-world impact were the other modeling concerns addressed.

However, that is not the case. Recently published cost evaluations (the March 2019 Vibrant Clean Energy study) show that today the vast majority if not all of TVA's operating coal fleet's generation could be more cost-effectively met by renewables located within 35 miles of the existing plants, and within five years, renewables would be more than 25% more cost-effective. It is troubling that TVA might choose to keep more expensive plants online without full consideration of lower-cost alternatives. This concern touches on every aspect of TVA's charge; without being addressed, each strategy considered in the IRP is higher-cost, more environmentally damaging, and less supportive of economic development. Given that the IRP did not even consider solar with storage configurations, an argument over capacity value cannot counter this concern.

The Vibrant Clean Energy study showed that many existing coal-fired units in the Valley could be replaced today by local renewables "at an all-in cost lower than the existing coal plant's ongoing marginal costs." . We recognize that replacing coal plants with new wind and solar is more complex in practice. For example, local utility-scale wind and solar alone may not replace the annual energy of a retired coal plant. However, the addition of utility-scale battery storage would make solar and wind energy dispatchable. And DER investment would offer incremental generation and could increase flexibility in light of relatively flat load projections. Moreover, the study noted that in the Southeast, "almost all coal plants are substantially at risk to replacement by local solar in 2025" so "it is hard to imagine Southeastern utilities not relying heavily on solar and complementary load shifting resources to replace the coal and save customers money." Least-cost planning should allow coal retirements when those retirements are economical. The Draft IRP should remove this restriction, and allow the model to retire uneconomical coal-fired power plants. (*Commenter: Christina Reichert – Southern Environmental Law Center*)

Response: TVA continuously monitors the fleet for the most economical portfolio to provide power to its customers at the lowest system cost. In February 2019, the TVA Board made the decision to retire Paradise Unit 3 in 2020 and Bull Run by 2023. As noted in Chapter 5, the 2019 IRP allows for the uncontrolled Shawnee units to be retired as early as 2020 and all other units as early as 2025. The year 2025 represents the first year that the TVA transmission system could be modified to enable the retirement of the remaining coal fired units other than Shawnee and maintain reliability and grid stability. The IRP Recommendation also reflects the potential for more than 2 GW of additional coal retirements beyond those already approved by the TVA Board.

225. The Draft IRP fails to comprehensively account for costs from emissions of air pollutants. In certain scenarios, the Draft IRP includes a cost per ton of CO_2 ranging from $5 to $45. The social cost incurred from TVA's generation is otherwise unaccounted for in the draft IRP. The draft EIS considers some of the environmental effects from

emissions of conventional pollutants, but that analysis is not a substitute for including the impacts of harm from conventional pollution in the IRP itself.

Because it fails to consider those harms, the Draft IRP understates the costs of generating units that create economic damage to the residents of the Valley. Using the AP2 model and data from the U.S. Environmental Protection Agency's Air Markets Program Data, those damages can be calculated for recent historical emissions. These damages from SO2 and NOx range from approximately $1.6 billion in 2016 to $650 million in 2018. Cumulatively, the damage exceeded $3 billion over the last three years. By ignoring that damage, the Draft IRP implicitly subsidizes generation of electricity from fossil fuels.

As a result, the Draft IRP's methodology does not provide objective advice about optimal planning strategies for the economic development or environmental well-being of the Valley. The Draft IRP should integrate damages from conventional pollutants as a metric to be considered in an updated IRP. (*Commenter: Christina Reichert – Southern Environmental Law Center*)

Response: As part of the IRP analysis, environmental metrics are created for each portfolio. These environmental metrics are considered in evaluating tradeoffs in strategy performance, and are then analyzed in detail as a part of the EIS. The emissions of conventional air pollutants are quantified in Section 5.5.1 of the final EIS, and any damage costs associated with these pollutants would be proportional to these emissions.

226. The Draft IRP fails to consider effective demand response programs, instead relying on outdated programs that lead to underuse of DR. TVA has operated DR programs for years, and those projected by the Draft IRP closely resemble those historical programs. However, the opportunity and means of incentivizing customers to modify their power demand has dramatically shifted in recent years through technological and rate design innovations. The Draft IRP should consider these innovations because they may be more financially and technically effective than traditional DR programs incorporated in the Draft IRP.

Recent programming, as reported to the U.S. Energy Information Administration, had potential peak savings of 2,291 MW, with TVA using 1,033 MW of that in 2017. Overall, that potential represents about 3% of the proposed summer peak. The FERC and Global Energy Partners have both concluded that achievable peak demand savings for TVA exceed 10%. Reviews of over 100 studies have concluded that price signals with enabling technology have the ability to function as automated DR programming and provide median demand savings ranging from 12% to 33%, depending on program design. (*Commenter: Christina Reichert – Southern Environmental Law Center*)

Response: As described in IRP Appendix B, TVA's current offerings of Demand Response are varied and include the Interruptible Power Program (IP), Peak Power Partners, Voltage Optimization, and Instantaneous Response. These programs offer a variety of terms with the ability to provide for economic load reduction, reliability load reduction, or both and contributed about 1,550 MW of dispatchable capacity in 2018. The 2019 IRP assumes these existing programs continue and also includes residential Water Heater Control and Thermostat Control DR program options as further explained in Appendix B. Both programs were included in many of the IRP cases, and IRP results will be used to inform future program offerings. Following the draft IRP, TVA ran a sensitivity analysis of the potential for expanded EE and DR market depth, which increased the upper bound of DR potential additions to 500 MW in the IRP Recommendation.

227. The Draft IRP fails to allow the model to select distributed battery storage. Instead of treating utility-scale and distributed battery storage on a consistent basis, the Draft IRP models the former as a selectable resource while treating the latter as a resource that is not selectable and is tied to distributed solar capacity. That modeling assumption rigidly limits the potential of adoption of distributed storage by allowing end-users to achieve only three decreed levels of market penetration. The Draft IRP incorporates this assumption because "the technology is rapidly

evolving and there was a desire to understand its impacts in combination with distributed solar." However, that type of analysis would have been better suited to a sensitivity analysis run separate from the core Draft IRP results. Therefore, to treat distributed and utility-scale solar on a consistent basis, the Draft IRP should allow distributed battery storage to be selected by the model. The input data for selectable distributed battery storage should also include consideration of the various grid services it can provide, including the capability to operate as a 'virtual power plant' combining the storage of thousands of individual residential batteries. Other utilities are starting to exploit these capabilities. (*Commenters: Christina Reichert – Southern Environmental Law Center, Ian Schiller, Joe and Sarah Schiller*)

Response: When TVA ran initial testing cases allowing independent selection of utility and battery storage options, no amounts were selected based on economics. One of TVA's objectives in this IRP was to evaluate potential impacts of battery storage on other resource selections. Ultimately, TVA elected to match storage with solar at both utility and distributed scales to enable exploring the potential impact of this rapidly evolving technology on the balance of the portfolio. TVA acknowledges that storage at all scales has the potential to provide a variety of grid services depending on its usage application. TVA will continue working with LPCs and TVPPA to explore options related to distributed storage and various grid services.

228. The Draft IRP fails to consider utility-scale solar+storage and wind+storage as resource options. However, TVA's 2019 request for proposals stated for renewable energy resources stated that "TVA is interested in procuring up to 200 MW of new stand-alone renewable energy resources or renewable energy + battery energy storage systems (BESS)." In its November 2018 analysis, Lazard projects that the combination of solar+storage would cost less than TVA's Draft IRP assumption for storage alone. Given that storage attached to solar can claim many of the same federal tax incentives as solar, this oversight also means that the total contribution of both technologies has been unnecessarily restricted by modeling choices. Moreover, the combination of renewables and storage allows intermittent renewables to compete freely with dispatchable resources like CTs. (*Commenters: Jeanette Berry, Christina Reichert – Southern Environmental Law Center, Joe and Sarah Schiller*)

Response: One of TVA's goals in the 2019 IRP was to explore the impact of adding storage, both at utility and distributed scales, which could support integration of renewables. TVA assumed that some portion of distributed solar generation would be paired with distributed storage. In strategies that incented utility scale storage, battery storage was added in a 10% or 25% match to utility scale solar expansion, but not assumed to be solely tied to solar operationally which could limit its benefits. Results for strategies C, D, and E demonstrate that incenting storage does increase levels of expansion solar. However, based on forecasted costs for battery storage, these incentives do raise overall system costs. TVA has updated IRP results to reflect the Board's decision to retire the Paradise Unit 3 and Bull Run fossil plants, resulting in an IRP Recommendation that reflects the potential for up to about 5 GW of total storage additions (previously 3 GW in the draft report) that may offset some natural gas additions. More information on the recommended Target Power Supply Mix can be found in Section 9.4 of the Final IRP. TVA will continue to monitor rapidly evolving storage technologies for improving economics.

229. The updated Base Case analysis highlights the flaws of the Draft IRP. One week prior to the end of the comment period of the Draft IRP, TVA gave working group members the results from an updated Base Case analysis. The updated Base Case includes retirements of Paradise Unit 3 and Bull Run Fossil Plant as reductions in baseline firm supply.

Under the Current Outlook, the analysis replaces Bull Run and Paradise with a combination of utility-scale solar and CTs in every strategy except for the strategy that incentivizes utility-scale storage at a high degree (Strategy D - Efficient Load Shape). However, the analysis includes the same faulty assumptions -- discussed in our other comments -- that appear to significantly hamper deployment of utility-scale storage in the Draft IRP. The analysis includes an unnecessary 25% winter reserve that incentivizes buildout of CTs in the Draft IRP. It includes inflated capital costs for utility-scale storage which affect economical use of storage in the Draft IRP. And the analysis, like the Draft IRP, fails to make utility-scale renewables+storage selectable resources. Those flawed assumptions made it impossible for utility-scale renewables+storage to compete with CTs.

In addition to incorporating the faulty assumptions that undermine the conclusions of the Draft IRP, the updated Base Case analysis produces an interesting result, which does not appear to be explained. The analysis suggests that nearly 4 GW less capacity is necessary in 2038 than what was modeled under the Draft IRP. The Draft IRP models 37,902 MW capacity in 2038 for Base Case strategy under the Current Outlook scenario. Compare that to the updated Base Case analysis under the Current Outlook scenario with 34,162 MW capacity in 2038), almost 4 GW less capacity overall. Due to data transparency problems, we are unable to analyze this result, and ask TVA to explain this curious result. (*Commenter: Christina Reichert – Southern Environmental Law Center*)

Response: TVA provided the Working Group with the updated Base Case on February 28, 2019, which was two weeks after the Board decision to retire Bull Run and Paradise 3. The public comment period closed on April 8, 2019.

Solar and storage was a selectable resource but was not selected based on the high cost of storage relative to other options. TVA has provided information in the IRP as well as in response to FOIA requests detailing cost assumptions for storage and how they are in line with industry assumptions and forecasts. The draft Base Case summer capacity was about 39,600 MW, and the updated Base Case summer capacity was about 40,000 MW. The small increase in summer capacity of about 400 MW is due to the replacement of Bull Run and Paradise 3 with additional solar and CT capacity. Solar capacity is selected primarily for its energy value, adding to the summer capacity but not to the winter capacity.

230. If the flaws in the Draft IRP that we describe elsewhere in our comments flaws were corrected, the IRP would unambiguously demonstrate that strategies promoting DER and supply-side renewables are competitive with the Base Case. Even under the flawed analysis of the draft IRP, Strategy B - Promote DER is the least-cost option. If the draft IRP properly analyzed DER by treating them on a consistent and integrated basis, that conclusion would be all the more apparent.

Similarly, Strategy E - Promote Renewables would likely prove competitive with the Base Case under a corrected analysis. Under the flawed analysis, Strategy E has slightly higher PVRR than the Base Case, but that distinction is minor because it accounts for less than 0.3% of TVA's budget over the twenty-year planning period. Moreover, as discussed in our comments, the flaws in the Draft IRP overstate the costs of renewables while simultaneously understating their benefits and limiting their ability to be added to the grid. If those errors were corrected in the Draft IRP, Promote Renewables would likely also prove competitive with the Base Case.

TVA should remedy the flaws discussed in our comments and reissue the draft IRP. Regardless of whether TVA in fact reissues the Draft IRP, it should select a strategy that promotes DERs and renewables over the twenty-year planning period. (*Commenter: Christina Reichert – Southern Environmental Law Center*)

Response: Comment noted. Solar expansion is significant in the IRP, ranging from about 6 to 9 GW of nameplate capacity by 2038 under the Current Outlook for electricity demand and up to 14 GW of nameplate capacity in a growth scenario. Sensitivity analysis has identified the potential for up to about 4 GW nameplate of additional wind capacity, if lower wind costs could be realized. The IRP Recommendation reflects aspects of all the strategies and significant potential to add renewables, which could be achieved with a combination of utility and distributed resources. TVA will continue to partner with LPCs and customers to identify potential DER opportunities.

231. TVA Should Objectively Evaluate Options without Preferential Treatment. The analysis in the Draft 2019 IRP appears to drive the results away from renewables and energy efficiency in preference to building new natural gas generation and even new nuclear generation by forcing it in one case despite it being uneconomic.
One example of this is that EE is not treated as an equal resource. The Draft 2019 IRP represents an abrupt reversal of the prior two IRPs by proposing zero to minimal EE in any of the cases analyzed. The 2015 IRP projected less EE than the 2011 IRP, suggesting constraints and unrealistic assumptions were put into the models for EE, and these have only been made more unrealistic for this IRP. TVA chose before setting out on this IRP process to halt investment in EE, and tailored the assumptions and methodology toward an outcome with little to no EE. That goal was achieved in the results of the Draft 2019 IRP where EE levels are so low they are essentially meaningless.

If an IRP model is choosing supply-side resources at all, there are cost-effective demand-side options that should also be a part of that resource portfolio. TVA assumes some EE is available at a cost lower than its forecast power prices. Half of the measures (besides low-income) are cheaper than the lowest prices in TVA’s Power Price Forecast, so why do the results include so little EE? Unfortunately we do not have enough information to know definitively, but we suspect that TVA has put annual or overall constraints on the model and thus limited the amount of EE it can choose even if it is the most economic resource.

Utilities across the nation, including TVA’s counterpart in the northwest, the Bonneville Power Authority (BPA), and regional utilities to the east and west, Entergy Arkansas and Duke Energy Carolinas, are all investing in EE and seeing reductions in system costs and customer utility bills. The Electric Power Research Institute estimates that by 2035, the economic opportunity for EE savings could reach 20,676 GWh in Tennsesse and 18,106 GWh in Alabama. In Tennessee alone customers have the potential to save over $300 million over the next 30 years just by replacing electric furnaces when they wear out with high-efficiency heat pumps. This one measure has an average payback period of less than 3 years in Tennessee and is applicable for 16% of homes state-wide. But that cost-effective EE will not be captured without action by TVA.

The Northwest Power and Conservation Council, which performs resource planning for the region that includes BPA, estimates that EE investments reduced customer bills by one third in 2014. By leaving these savings on the table, TVA will be charging customers more to generate the electricity they could have paid less to save. (*Commenter: Maggie Shober – Southern Alliance for Clean Energy*)

Response: The 2019 IRP recommends up to 14,000 MWs of new solar by 2038 and only recommends new nuclear if the economics improve through cost efficiencies or cost sharing. Energy shapes and costs for EE resource options are informed by TVA's partnership with DNV GL, an industry leader that provides insight on EE best practices, measure values and modeling, as well as the evaluation, measurement and verification of program results. TVA conducts a Residential Saturation Survey and a Business & Industry Saturation Survey every other year to understand market depth and potential reach of programmatic efforts, which vary from region to region. Also, TVA is an active participant and member with multiple industry trade organizations that specialize in energy programs, including eSource and Association of Energy Services Professionals.

232. During the comment period the Center for Biological Diversity sent TVA a detailed request for information used during the IRP development, including details on the criteria used and assumptions made to assign incentive levels for each strategy and the specific values of the “base,” “moderate,” and “high” incentive levels for each pairing of strategy and scenario. TVA’s April 3, 2019 response did not provide the requested information on the specific values of the incentive levels or on the process by which those values were determined. Incentives, including the current below market rate TVA pays for solar electricity generated under the Green Power Providers program (Draft EIS at 2-10), could be important in increasing the adoption of solar distributed generation. Given this lack of information, the

Center is unable to provide more detailed comments on the role of incentives in TVA's analysis. (*Commenter: Howard Crystal – Center for Biological Diversity*)

Response: In its April 3, 2019, response, TVA provided an explanation for the specific values of the approach for determining base, moderate and high incentive levels. Specific values for marginal energy cost by scenario were also provided in the file entitled "Solar Adoption assumptions for FOIA" posted on the TVA IRP website in the IRP Supporting Documents folder.

233. The Draft IRP assumes that retirement of fossil generating resources will only occur at the expiration of current contracts or otherwise based on economic considerations alone. The statement that "uncertainty around future environmental standards for CO_2" is a "key consideration" for coal retirements strongly suggests that TVA would only accelerate those retirements if federal regulations made them more costly. In an April 5, 2019 letter to the Center, TVA stated it was considering a sensitivity analysis that doubles the CO_2 penalty in the Decarbonization scenario to $44/ton beginning in 2025, indicating that the CO_2 penalty assumed in the Decarbonization scenario was $22/ton in 2025. Both these values ignore the additional costs of continued fossil fuel power production quantified by the social cost of carbon. Basing the decision-making on economic considerations alone also contradicts the purpose of NEPA to consider public health, environmental, socioeconomic, wildlife, and other impacts. (*Commenter: Howard Crystal – Center for Biological Diversity*)

Response: Due to comments received from the IRP Working Group and the public at large after release of the draft IRP, TVA conducted a sensitivity on the carbon penalty in the Decarbonization scenario by doubling the $22/ton penalty to $44/ton beginning in 2025. This sensitivity roughly aligns to the Federal Social Cost of Carbon of $42/ton in 2020 rising to $60/ton by 2040, which included information from the IPCC.

As discussed in IRP Section 8.2, additional sensitivity analysis conducted by TVA after publication of the draft IRP/EIS considered the potential for more stringent carbon penalties by doubling the decarbonization scenario. In this sensitivity analysis, coal retirements occur earlier and total CO_2 emissions are lower over the study period. A sensitivity considering the potential for higher operating costs for coal plants was also conducted, indicating some coal retirements in that case. The IRP Recommendation reflects the potential for more than 2 GW of additional coal retirements beyond those already approved by the TVA Board.

234. Due to certain tax benefits that will phase out early in the planning period, TVA should 'front-load' solar generation beginning in the year 2020, rather than limiting solar expansion until 2023 and later. (*Commenter: Gil Hough –Tennessee Solar Energy Association*)

Response: Comment noted. Solar expansion is significant in the IRP, ranging from about 6 to 9 GW of nameplate capacity by 2038 under the Current Outlook for electricity demand and up to 14 GW of nameplate capacity in a growth scenario.

Driven by the timing of customer demand, TVA has launched two programs to support accelerated renewable investment: Renewable Investment Agreement (RIA) and the Flexibility Research Project (FRP) pilot. RIA supports utility scale buildouts for large commercial and industrial customers, and FRP supports community solar, in partnership with Local Power Companies. Related to RIA, TVA recently announced projects totaling 675 MW for Facebook and Google with online dates by 2021 and recently issued an RFP to contract for additional solar to meet customer demand with a targeted online date by 2022. By the time the IRP is published in August 2019, it was prudent to assume that the next round of renewable additions could dependably be online by 2023, even though some portion may come online sooner.

235. TVPPA looks forward to partnering with TVA on the development of its next IRP. TVPPA believes TVA's next IRP should include not only the impacts of distributed energy resources (DERs) on its load forecasts, but also identification of DERs as discrete, controllable assets that can be used to manage the daily load curve.

To that end, TVPPA is already making plans to develop the first-ever Tennessee Valley Distribution IRP, which will identify those DERs, model their ability to be used in TVA's control center, and, in essence, capture retail customer input into TVA's IRP process in unprecedented ways. With recent IRPs focused on Balanced Portfolio, Energy Efficiency & Renewables, and most recently Flexibility, TVPPA would specifically like to propose that the next TVA IRP focus on the benefits of creating a fully transactive generation, transmission and distribution system within the Tennessee Valley.

We believe DERs can and will be long-term assets to TVA's system. TVPPA and Seven States Power Corporation are prepared to provide valuable insight into how DERs can be viewed not only in terms of load projection, but also in terms of aggregated assets TVA can call on to serve load at a much lower cost than traditional generation or the open market. (*Commenter: Douglas Peters - TVPPA*)

Response: Comment noted. TVA endeavors to understand the benefits of DERs to the distribution system and the transmission system.

236. As TVA acknowledges, its coal-fired power plants lack environmental controls necessary to comply with federal Clean Water Act requirements such as the Effluent Limitation Guidelines, 80 Fed. Reg. 67,838 (Nov. 3, 2015), 40 C.F.R. part 423 (the "ELGs"), requiring elimination of certain waste streams and setting limits on discharges of mercury, arsenic, and selenium for others. TVA estimates that it would need to spend $466 million by the end of 2023 to upgrade its coal fleet with such controls. It would be prudent to examine whether or not spending such a colossal sum was, at the very least, in the best long-term interests of TVA's customers in order to keep an aging coal fleet in operation, or whether it would be a better outcome to retire some or all of the plants before the end of 2023.

However, while TVA has rightly determined (outside of the IRP process) that it is in the best interest of the TVA system to retire, rather than retrofit, the Paradise and Bull Run coal-fired units, TVA's resource modeling was precluded from considering such retirement of the Cumberland, Gallatin, and Kingston plants, as well as two of the units at Shawnee. See Draft IRP at 5-7. Collectively, this amounts to roughly 5 gigawatts of coal-fired capacity, or well over 60% of TVA's coal fleet capacity. As a result, TVA forces the model to ignore the issue of whether or not market purchases or solar or other renewable energy would be better for ratepayers over the next four-and-a-half years and beyond than would expending huge sums to keep all of these coal plants operating. A serious question on that point is before TVA, and TVA's Draft IRP and underlying modeling fails to evaluate the impact of such pre-2025 capital costs for environmental compliance.

Particularly given that the ELG-compliance decision to retrofit or retire coal units is one of the largest and most immediate resource allocation questions TVA has before it, it is imperative that TVA conduct modeling to determine whether or not expending hundreds of millions of dollars to install ELG controls at Cumberland, Gallatin, Kingston, and Shawnee rather than retiring some or all of those units in favor of market purchases or investments in clean energy is in the best interest of ratepayers. The Sierra Club is confident that it is not. (*Commenter: Zachary Fabish – Sierra Club*)

Response: TVA continuously monitors its generating fleet for the most economical portfolio to provide power to its customers at the lowest system cost. In February 2019, the TVA Board made the decision to retire Paradise Unit 3 in 2020 and Bull Run by 2023. As noted in IRP Chapter 5, the 2019 IRP allows for the uncontrolled Shawnee units to be retired as early as 2020 and all other units as early as 2025. The year 2025 represents the first year that the TVA transmission system could be modified to enable the retirement of the remaining coal-fired units other than Shawnee and maintain grid stability. Since the publication of the draft IRP, TVA performed a sensitivity analysis detailed in IRP Chapter 8 that included higher ongoing operating costs for existing coal units that could in part result from higher compliance costs, including ELG compliance. The IRP Recommendation reflects the potential for more than 2 GW of additional coal retirements beyond those already approved by the TVA Board.

237. Throughout its modeling for the Draft IRP, TVA assumed that solar resources have no capacity value since TVA expects to experience peak demand in the winter after sunset. However, if TVA purchased some excess winter capacity from adjacent control areas with summer peaks, the summer solar output could prove to be as valuable as any other capacity.

To investigate this possibility, Sierra Club used information from the FERC Form 714 database to determine whether each interconnected control area is summer or winter peaking, and if summer peaking, how much lower its winter load compared to its summer load. That difference in load represents capacity for purchase by winter-peaking systems, such as TVA. Since most thermal generators have higher capacity in the winter than in the summer, due to lower temperature cooling water and denser air, the winter capacity surplus may be even larger than the summer-winter load differential would suggest.

This research identified several areas adjacent to TVA that forecast continued summer peaks. Although the transfer capacities from each of these control areas to TVA was not available, Sierra Club identified the interconnections between the adjacent areas and TVA. Table 2 of our comment letter summarizes the number of interconnections and winter surplus for each of the adjacent control areas. These four systems, Louisville Gas & Electric/Kentucky Utilities, MISO, PJM, and Southern Company, have about 45,000 MW of winter surplus capacity. Not all of that capacity would be deliverable to TVA, due to transmission constraints within and between control areas. Even a small portion of this capacity should suffice to meet TVA's excess winter peak. A combination of solar to provide low-cost energy and summer capacity, and purchases to provide winter capacity, should allow TVA to safely retire additional fossil generation, saving the costs of operating, maintaining and upgrading those units.

Figure 5 of our comment letter illustrates these interconnections. Our analysis does not include the four 161-kV lines from Electric Energy, Inc., a wholesale subsidiary of Ameren and a part of MISO. It also excludes the Associated Electric Cooperative, Inc. and the Duke utilities, which are winter-peaking. (*Commenter: Zachary Fabish – Sierra Club*)

Response: In determining planning reserve margins, TVA considers import and export capabilities and constraints for firm purchased power from neighboring regions (approximately 20 zones modeled), as stated in IRP Appendix D.1. Appendix D in the final IRP includes peer benchmarking on reserve margins. TVA continues to monitor market options to meet capacity needs.

238. TVA states in the Draft EIS that "TVA's Adaptation Plan (TVA 2016g) specifies that each TVA major planning process shall identify any significant climate change risks." However, neither the Draft IRP nor the Draft EIS indicate that TVA modeled and impacts of climate change on its existing generation fleet. TVA relies heavily on generation from hydro and water-cooled nuclear and fossil power plants, two technologies likely to be impacted by climate change.

Increases in water temperature present the need to curtail water-cooled generation resources. SACE commented on this matter in the process for TVA's 2015 IRP. In its response, TVA acknowledged this issue, noting that it had already derated individual plants and installed additional cooling at others. Since this is an ongoing issue and not a one-time phenomenon, TVA should include the costs of expanding water cooling capability in the operations and maintenance costs of existing water-cooled generation or deduct the derated capacity from the Net Summer Dependable Capacity from water-cooled generation.

It is concerning that this was still not addressed in the Draft 2019 IRP despite TVA's response from our comments in 2015 acknowledging the issue. This is just one climate change related risk. TVA should evaluate the potential impacts of climate change on its existing and future generation resources as a part of this planning process. (*Commenter: Stephen Smith – Southern Alliance for Clean Energy*)

Response: TVA conducted a sensitivity on variation in climate using stochastic analysis to determine the potential impacts of persistent extreme weather patterns. The results of this analysis are described in IRP Section 8.2.8. This analysis shows that the system becomes summer peaking and summers are drier, causing thermal derates at nuclear and coal facilities. Derated nuclear and coal capacity is initially replaced with CTs until 2,100 MW nameplate of solar is added by 2038. Hydro generation is higher from warm and wet winters, but capacity remains the same.

239. The modeling of energy storage does not appear to align with the latest Federal Energy Regulatory Commission guidance. FERC Order Number 841, issued in February 2018, stated "In a November 2016 Notice of Proposed Rulemaking (NOPR), the Commission noted that market rules designed for traditional generation resources can create barriers to entry for emerging technologies such as electric storage resources. Today's final rule helps remove these barriers by requiring each regional grid operator to revise its tariff to establish a participation model for electric storage resources that consist of market rules that properly recognize the physical and operational characteristics of electric storage resources." FERC noted in its rule that artificial "restriction on competition can reduce the efficiency of the RTO/ISO markets, potentially leading an RTO/ISO to dispatch more expensive resources to meet its system needs." Even though RTO/ISO tariff implementation is due by December 2019, utilities should strive to follow the spirit of FERC Order Number 841 in developing multiple modelling capabilities, sensitivities and analyses around energy storage issues. In keeping with the principles of FERC Order Number 841, it is recommended that multiple energy storage configurations be evaluated (e.g., 2MW/2MWh, 2MW/4MWh, 2MW/8MWh, etc.), using sub-hourly dispatch, with multiple revenue streams (e.g., capacity credit, energy, frequency/voltage control, etc.), as stand-alone projects as well as coupled with generation resources (such as renewable energy resources).

Models that use sub-hourly intervals can better quantify the value of both capacity and flexibility benefits provided by advanced energy storage. By comparing flexibility benefits to the cost of storage "thereby using a "net cost" analysis of capacity investment options" planners can more accurately compare advanced energy storage with traditional capacity resources. Analysis of models that look at system flexibility needs and risk management will be more likely to reduce costs to ratepayers, including through use of storage. In addition to providing an LCOE regarding energy storage options, it is also recommended that values also be provided in $/kW-mo or $/kW-yr terms. (*Commenter: Simon Mahan – Southern Renewable Energy Association*)

Response: In the 2019 IRP, TVA modeled a 25 MW / 100 MWh utility battery energy storage system configuration, along with other storage options. In addition to modeling hourly capacity and energy benefits for storage, TVA modeling also inlcuded a sub-hourly flexibility benefit for battery storage in modeling to reflect additional value, which is described in IRP Appendix D.4. TVA continues to evaluate additional storage benefits related to ancillary services. Ancillary services provided vary by application, and future project-specific analyses will include benefits related to that specific project.

240. TVA relies on an insufficient capacity-centric planning framework. This process essentially attempts to resolve one problem: how to deliver power during each annual peak. TVA explained it's "capacity first" process by stating that: "The development of resource portfolios was a two-step process. First, an optimized portfolio, or capacity plan, was generated, followed by a detailed financial analysis. This process was repeated for each strategy/scenario combination and for additional sensitivity runs."

TVA is undervaluing low-cost energy resources (like wind energy and solar energy) and the ability of those resources to reduce overall system costs by displacing higher cost generation. To underscore this point, TVA stated that it "...uses an energy production profile to dispatch wind energy rather than price." TVA uses this same approach for hydro and solar resources. Synapse Energy Economics has noted the deficiency of capacity expansion models, stating: "In addition, some capacity expansion models are unable to endogenously retire EGUs, and require these decisions to be made outside of the model construct. While making decisions outside the model reduces computational requirements, it may introduce user error or bias. For example, a modeler may not review economic retirements, and thus fail to capture a cost-effective compliance mechanism."

According to Moody's Investors Service, "Some coal plants still perform economically, but competitiveness could come under pressure as market conditions evolve...Most municipal- or G&T-owned coal plants in the US are old and have high production costs. According to the report, 72.3% of these plants, or about 65.0 gigawatts, have operating costs exceeding $30 per megawatt hour, which Moody's views as the threshold above which coal plants are vulnerable to be displaced by cheaper generation options. Newer units that came online after 2000 use more efficient technology and run at lower heat rates and operating costs, enabling many of them to be competitive with the market and achieve higher capacity factors. Others are located adjacent to coal mines, allowing them to eliminate transportation costs from their overall fuel expenses. Nonetheless, each plant's competitiveness will ultimately depend on external factors including the price of natural gas and renewable energy in the vicinity, regional transmission organization reserve margins and the extent of political support for various fuels." As Moody's points out, broader energy market forces will render higher cost energy resources (such as existing steam turbine generation) obsolete and likely to be out-competed by lower cost energy resources such as renewable resources.

Much of TVA's modeling and methodologies are unchanged from the 2015 IRP. TVA's over-reliance on capacity-focused modeling underestimates renewable energy benefits while retaining older, less efficient generation. Taken to the extreme, a capacity-only planning process could lead to unusual model results that recommend significant power generation development or legacy generation retention that are rarely used, at the expense of low-cost energy options. This outcome appears to have occurred, given that low-cost wind energy generation has been devalued in TVA's IRP process. Capacity-focused planning does not initially address economic costs; alternatively, an energy-based financial dispatch model would efficiently dispatch necessary resources. TVA should evaluate energy planning options, not just capacity. (*Commenter: Simon Mahan – Southern Renewable Energy Association*)

Response: IRP Section 6.3 describes the resource portfolio modeling as a two-step process, the development of an optimized capacity expansion plan followed by a financial analysis. The optimized capacity expansion plan not only optimizes capacity against the reserve margin requirements and the balance of supply and demand, but also optimizes for least cost considering energy requirements, generation and transmission operating limits, fuel and purchase limits, environmental costs, retirement options, and adoption of distributed generation. The second step of financial analysis uses a full production cost model with forecasted financial results and stochastics to optimize 20 years of hourly chronological dispatch of the TVA system and develop generation, costs, emissions, and financial statements for each portfolio. The full analysis is much more than a capacity-only process, but rather a full capacity, energy, production cost, financial, and risk-informed process.

As discussed in Chapter 8, the additional sensitivity analyses conducted by TVA prior to finalizing the IRP included consideration of more stringent carbon penalties as well as higher future capital and operating costs for coal units. In this sensitivity analysis, coal retirements occur earlier in the planning period while coal capacity at the end of the planning period is unchanged.

241. Nuclear capacity is not increased in any scenario / strategy combination, although Strategy C under the No Nuclear Extensions scenario would adopt small modular reactors to replace Browns Ferry nuclear units. During the

public hearing, the TVA representative explained that Small Modular Reactors are not actually included in the model because SMRs are considered 'under development.' TVA should consider expanding carbon free capacity by building Pressurized Water Reactors and Advanced Pressurized Water Reactors in addition to SMRs. Under a scenario with aggressive cost incentives for carbon-free electricity sources, such as under H.R. 763, this nuclear electricity production should become cost competitive within the modeled time frame. (*Commenter: Jeanette Berry*)

Response: Comment noted. SMRs were included as a selectable option but were not included in any portfolio due to their cost relative to other resource options. Conventional reactors, such as Pressurized Water Reactor (PWR) and Advanced Pressurized Water Reactor (APWR) were also included as selectable options as described in IRP Section 5.2.2.1.

242. According to Draft EIS Section 5.5.2.2, "TVA has specific targets related to GHG emissions (TVA 2017f). These include a 31 percent reduction in Scope 1 and Scope 2 GHG emissions by 2025 and a 21 percent reduction in Scope 3 GHG emissions by 2025. Scope 1 GHG emissions are direct emissions from applicable sources owned or controlled by TVA, including vehicles. Scope 2 GHG emissions are indirect emissions from the generation of power used by TVA. Scope 3 GHG emissions are from sources not owned or controlled by TVA but related to TVA activities and include, among other things, business travel, employee commuting and contracted waste disposal. . ." These emission reduction objectives were established before the 2018 IPCC report demonstrated the need for rapid decarbonization, with aggressive action within 12 years. Using the IPCC report as a guide, TVA should plan for at least a 50% reduction in CO_2 by 2030 compared with 2010. The IRP should also include a comparison between TVA's planned emission reductions by scenario and the IPCC international goals. (*Commenter: Jeanette Berry*)

Response: Comment noted. The projected percent CO_2 reduction between 2010 and 2030 under the Reference Case (Base Case strategy evaluated in the Current Outlook) is approximately 56 percent. The 2010 emissions data can be found on Figure 4-13 in the final EIS and the 2030 emissions data can be found on Figure 5-7 in the final EIS.

F.2.5.5 Public Involvement

243. Section 1.2.3.4, Public Outreach and Engagement states "TVA developed an outreach strategy to foster broader engagement from different demographic groups..." However, the Draft 2019 IRP public comment period started February 15, 2019 and closes April 8, 2019 (45 days). During that time there were only seven public meetings scheduled, along with one public webinar, to provide the public over the whole of TVA's coverage area (10 million people in a seven-state, 80,000-square-mile region) access to TVA staff in an effort to answer to their questions. The provided review period and public meetings are not reasonable to properly allow for "broader engagement" of the public, as TVA states is desirable. For Roane County citizens specifically, there were only single meetings held in Knoxville and in Chattanooga. Very few people in the area probably ever heard of these meetings due to the limited local newspaper notifications (Knoxville News Sentinel and Chattanooga Times Free Press only). Even if interested, Roane County citizens would have had to travel 50+ miles on a work day to either meeting, which were held in the early afternoon, in order to participate.

Since Roane County has already endured considerable effects as a result of the ash spill at the Kingston Fossil Plant (the largest in the nation), greater consideration should have been given to provide more localized meetings for public comment. This is especially true since Roane County will be impacted greatly regardless of which path forward TVA chooses from the IRP. TVA's planned decisions will impact Roane County in areas such as water resources, air quality, coal combustion residual landfills, a nearby nuclear plant, a planned small modular reactor demonstration facility, nearby hydroelectric facilities, and invasive species (aquatic plants and fish). In addition, Roane County will also have to address the socioeconomic effects from the planned 2038 shutdown of the Kingston

Fossil Plant. Fact is, TVA would be hard pressed to find an area with higher future impacts from their operational decisions and plans than Roane County, as outlined in this IRP. (*Commenter: John Shaw*)

Response: Although TVA has an 80,000 square mile service territory, it strived to provide adequate opportunities for interested people to attend either an in-person meeting or an online meeting. During the public comment period for the 2019 IRP, TVA conducted a webinar that provided the same presentation as in-person meetings. An online interactive report was also available throughout the public comment period and remains online with information about the final recommendation. The IRP results indicate the potential for more than 2 GW of additional coal retirements beyond those recently approved by the Board. Specific asset retirement decisions will require more detailed evaluation and require TVA Board approval.

244. Draft IRP Section 3.2.3, Potential Retirement of TVA Generating Facilities states all of the portfolios include the potential retirement of all coal units, including Kingston Fossil Plant, by 2038. What notification has been provided to local governments that will be impacted by this decision? (*Commenter: John Shaw*)

Response: The IRP results indicate the potential for more than 2 GW of additional coal retirements beyond those recently approved by the Board, however future retirement decisions will require further evaluation of the specific facility and require TVA Board approval. TVA has made extensive efforts during the Integrated Resource Planning process to inform stakeholders, including local, state and federal officials, of this effort. Through this outreach, TVA has been clear that the IRP is based upon a "scenario" planning approach that provides an understanding of how future decisions would play out in future scenarios. The retirement of TVA's coal plants was reviewed as one potential future decision, as was the retirement of other types of TVA facilities. Should TVA decide to retire facilities in the future, all affected stakeholders would be notified during the decision-making process. Future environmental reviews under NEPA will be provided for public comment.

245. I sincerely hope that future TVA public meetings will allow the public to speak. At the Huntsville meeting, people weren't prepared for writing out short questions. We were only allowed a short period of time to write out questions, and then all of the questions were not addressed with the group. Only questions that seemed to 'meet approval' were addressed, and some of those questions were rephrased. We were told that there wasn't time to address all of the questions, but yet there was time for us to speak to the TVA representatives one on one. (*Commenters: Mindy Mosier, Martha Steele*)

Response: TVA does strive to provide adequate and different opportunities for interested people to ask questions. A time limit was placed on the Q&A session to allow time for all meeting attendees to review the meeting materials, talk one-on-one with TVA representatives, and make written comments. When a similar question was posed by multiple people, the meeting facilitator consolidated a question to allow the panelists to address several facets of the same topic in their answer. This also allowed time for a greater variety of questions to be answered by the panel. In addition to the question and answer session, TVA representatives were available for discussion and comments and questions were also accepted via email, through mail, and online. TVA will continue to refine and enhance its stakeholder engagement process.

246. At the Nashville public meeting, there was a lot missing from what appeared to me to be a very 'wonky', 'process-driven', 'pedestrian' presentation. There was no 'aspirational' aspect to it at all. The use of 'scenarios' was not very meaningful. The closing of a few coal plants was not explained, but I would surmise they are being closed because they are older and no longer economically viable and not due to a long-term green energy strategy. The '5 strategy' approach was very pedestrian and wonky. (*Commenter: Marc Lyon*)

Response: TVA will continue to refine and enhance its stakeholder engagement process.

F.2.5.6 Purchased Power

247. TVA should not procure power or develop purchase agreements from power companies that market green power. (*Commenter: Jeff Coppala*)

Response: TVA's IRP process is intended to evaluate TVA's current energy portfolio and alternative future portfolios on a "lowest system cost" basis to meet future electrical energy needs of the TVA region, while taking into account TVA's mission of energy, environmental stewardship and economic development. As documented by TVA in its IRP study, in many cases renewable energy options represent the lowest system cost basis.

248. We applaud TVA for its most recent RFP (announced April 1, 2019) for utility scale renewable and renewable + storage capacity and energy. While we recognize that TVA has the ability to contract more renewable assets in this procurement opportunity, the 200 MW capacity limit in the RFP does appear arbitrary. (*Commenter: Gil Hough – Tennessee Solar Energy Association*)

Response: Comment noted.

F.2.5.7 Resource Plan Implementation

249. In evaluating any resource acquisition, TVA should be mindful that the models used to assess future system needs and available resources make excellent theoretical decisions. In the real world, however, planners will not have perfect knowledge of future conditions and costs, and TVA will need to be nimble in adapting to a changing marketplace. In addition, different types of resources have varying degrees of risk associated with integration into the existing system. This implementation risk must also be part of the resource evaluation. (*Commenters: Rob Hoskins – Tennessee Valley Industrial Committee, Cortney Piper – Tennessee Advanced Energy Business Council*)

Response: Comment noted.

250. Implementation Plans. How rapidly can these changes be made and how does that impact the plan? Do you have actual results that have been made by a power supplier to use as a best practice? What is your estimate of the final distribution of power to be produced by: Nuclear, Natural Gas, Coal, Hydro, Wind, Solar, DER? What is the total capital expenditure anticipated to accomplish the transition? What portion of the improvements be paid for by the customers? (*Commenter: Jerry Peyton*)

Response: The IRP is a long-range strategic plan for the next 20 years. Each IRP is periodically updated to reflect the most recent assumptions but also lessons learned and best practices from other utilities. The recommended ranges of resource additions over the next 20 years serve as a guide to TVA. Details about percentages of capacity and generation as well as total cost can be found in IRP Chapters 7 and 9 and the IRP appendices.

251. As the IRP is being implemented, TVA must maintain and increase awareness of advanced energy trends and economic opportunities. Specific examples of these trends and opportunities include:
- Corporate America's demand for advance energy technologies during site selection.
- Consideration of the state of Tennessee's goal to become the top electric vehicle producer in America.
- Preparing for the upcoming hydrogen economy, including fueling gas turbines with hydrogen as well as hydrogen-powered transportation. (*Commenter: Cortney Piper – Tennessee Advanced Energy Business Council*)

Response: Comment noted. TVA actively monitors trends and advancements that may influence future energy needs. These considerations are critical to the development of TVA IRPs.

252. The North Carolina State Clearinghouse has reviewed the Draft IRP and EIS and has the following comments. 1) 37 hazardous waste sites occur within one mile of the project area. Site files should be reviewed to ensure appropriate precautions are incorporated into construction activities. 2) During plan implementation, every feasible

effort should be made to minimize waste generation, recycle materials and use recycled products and materials where suitable. Any wastes generated that cannot be beneficially reused or recycled must also be disposed of at an approved solid waste management facility. We recommend that any contractors be required to provide proof of proper disposal for all waste generated as part of the project. 3) We recommend removal of any abandoned or out-of-use storage tanks. Petroleum tanks must be installed and maintained in accordance with applicable local, state, and federal regulations. Petroleum spills must be contained and the area of impact must be properly restored. Petroleum spills of significant quantity must be reported to the state. Any soils excavated that show evidence of petroleum contamination must be reported immediately to the local Fire Marshall and the state notified. Petroleum contaminated soils must be handled in accordance with all applicable regulations. 4) Construction activities may require a NPDES Construction Stormwater permit. Open burning and demolition or removal of structures containing asbestos material must comply with state regulations. 5) Consultation with the Eastern Band of the Cherokee Indian Tribe is required. The State Department of Transportation, Division of Emergency Management, and Natural Heritage Program have no comments. (*Commenter: Crystal Best – North Carolina Department of Administration*)

Response: The IRP is not site-specific, and future siting for specific resource builds of any kind would be handled on a case-by-case basis. TVA will coordinate with your agency during future reviews of site-specific activities.

253. The Virginia Department of Environmental Quality has coordinated the review of the Draft IRP and EIS with state departments, local governments, and local planning districts. Following are comments on the proposal. 1) In general, stream and wetland impacts should be avoided to the maximum extent practicable. To minimize unavoidable impacts, we recommend the following practices [listed in the comment letter]. For any future facility that will have a point source discharge, coordinate with the DEQ Southwest Regional Office to obtain the appropriate VPDES permits. 2) The use of riprap to reduce increased bank erosion resulting from modernized hydroelectric facilities must comply with Virginia erosion and sediment control and stormwater management acts and may require a General Permit for stormwater discharges from construction activities. 3) Minimize fugitive dust during construction activities in accordance with applicable state regulations. Open burning must meet applicable state regulations and may require a permit. Use precautions to restrict the emissions of volatile organic compounds and oxides of nitrogen during construction. 4) Review databases to determine if any waste sites are close to specific project sites. Follow applicable requirements related to waste management, asbestos-containing material and lead-based paint, petroleum release sites, and fuel storage tanks.5) Coordinate with the Virginia natural heritage programs and Department of Game and Inland Fisheries for updated natural heritage and threatened and endangered species information and impact determination. 6) Coordinate with the Division of Conservation and Recreation to minimize impacts to recreation resources. 7) Any construction within Department of Transportation right-of-ways must comply with applicable regulations and have a Land Use Permit. 8) Follow the listed pollution prevention recommendations. (*Commenter: Janine Howard – Virginia Department of Environmental Quality*)

Response: The IRP is not site-specific, and future siting for specific resource builds of any kind would be handled on a case-by-case basis. TVA will coordinate with your agency during future reviews of site-specific activities.

F.2.5.8 Scenarios

254. We recommend that TVA clarify if any of the scenarios contemplate accelerated vehicle electrification and the associated electricity demand that would result. The Draft EIS does not describe the contemplated grid or demand impact of transportation electrification. The IRP uncertainties of “Electricity Demand” and general “Electrification” listed in Draft EIS Section 3.1 should address the possibility of increased electric vehicle adoption in the region. The Draft IRP appendices mention electric vehicle and battery charging (C.1.2) and, specifically, “E.2 - Varying Uncertainties to Stress Scenario Bounds” states that, “in the Valley Load Growth scenario, a very high penetration rate of electric vehicles was used to reach ‘very high’ outcomes for Electricity Demand and Electrification.” The consideration for these uncertainties changed depending on the scenarios examined. TVA might consider defining

these uncertainties and describing where such beneficial electrification strategies fit within the planning process, particularly with regard to the balance between increased electric demand from electric vehicle adoption and the health and environmental benefits of lower overall transportation emissions through vehicle electrification. (*Commenters: Kendra Abkowitz – Tennessee Department of Environment and Conservation, Hans-Willi Honegger*)

Response: Information about vehicle electrification in each scenario can be found in IRP Appendix E – Scenario Design. Appendix C – Distributed Generation also includes information related to the time-of-use rate structure employed as a part of Strategy D, Promote Efficient Load Shape.

255. TVA should incorporate an exponential climate change rate in your planning models. (*Commenters: Mark Bishop, Claudio Meier*)

Response: In EIS Section 4.3, TVA provides a description of the current climate and recent climate trends of the TVA region, with a description of projected changes in climate expected this century based on the Fourth National Climate Assessment and related sources. In the EIS, TVA acknowledges that identifying trends in regional climate parameters is a complex problem. In EIS Section 5.5.2, TVA addresses predicted impacts of climate change to the Southeast US, discusses how the changing climate would affect TVA's power system and identifies climate change risks relevant to the TVA system.

The amount of predicted climate change in the Valley is relatively low based on USEPA and other reports, and this expectation is reflected in the Current Outlook scenario. TVA and stakeholders were interested in evaluating the potential impact of a more severe variation in climate. TVA conducted a sensitivity on variation in climate using stochastic analysis to determine the potential impacts of persistent extreme weather patterns. The results of this analysis are described in IRP Section 8.2.8. This analysis shows that the system becomes summer peaking and summers are drier, causing thermal derates at nuclear and coal facilities. Derated nuclear and coal capacity is initially replaced with CTs until 2,100 MW nameplate of solar is added by 2038. Hydro generation is higher from warm and wet winters, but capacity remains the same.

256. Under "Uncertainties", in Scenario 4 Decarbonization, of the "IRP draft capacity expansion plans", incentives for non-emitting technologies are mentioned, i.e., a general expansion of solar power production. However, it does not detail what technologies will be used. (*Commenter: Hans-Willi Honegger*)

Response: Scenarios are futures that are outside of TVA's control. In a Decarbonization scenario, TVA envisions that there could be incentives for non-emitting technologies. This could be technologies that are known today (e.g., hydro, solar, wind) or technologies that will be developed in the future.

257. TVA modeled several scenarios which it describes as future policy environments over which it has no control. However TVA failed to include the one scenario transcending all the others climate change. Climate change is not a scenario that TVA has any discretion to consider or not. It is imposed by nature and is a real constraint whether TVA chooses to acknowledge it or not (see the 2018 Fourth National Climate Assessment and the 2018 IPCC Special Report on Global Warming of 1.5 C). The other dimension of the IRP is the various strategies it will pursue in each of these scenarios. Given that climate change cannot be ignored, the strategies TVA modeled can be reduced to two: Base Case or Decarbonization consistent with the requirements to avoid irreparable climate change impacts. Failure to do so exposes TVA customers to unacceptable cost, reliability, and environmental risks.

The insignificant cost differences among the strategies TVA did model in the various scenarios demonstrates there is no financial constraint preventing TVA from implementing a more aggressive strategy of renewable deployment and retirement of fossil fuel generating assets that would address the climate change scenario in a manner compatible with all of its other stated objectives. (*Commenters: Scott Banbury, William Moll, Joe and Sarah Schiller*)

Response: The IRP Recommendation considered the potential for a decarbonized future and results, on average, showed carbon reduction of 70% across all portfolios from a 2005 baseline. The amount of predicted climate change in the Valley is relatively low based on USEPA and other reports, and this expectation is reflected in the Current Outlook scenario. TVA and stakeholders were interested in evaluating the potential impact of a more severe variation in climate. TVA conducted a sensitivity on variation in climate using stochastic analysis to determine the potential impacts of persistent extreme weather patterns. The results of this analysis are described in IRP Section 8.2.8. This analysis shows that the system becomes summer peaking and summers are drier, causing thermal derates at nuclear and coal facilities. Derated nuclear and coal capacity is initially replaced with CTs until 2,100 MW nameplate of solar is added by 2038. Hydro generation is higher from warm and wet winters, but capacity remains the same.

Additionally, TVA ran a sensitivity including consideration of more stringent carbon penalties by doubling the decarbonization scenario from $22/ton of CO_2 to $44/ton beginning in 2025. Results indicate coal retirements occur earlier in the planning period and the available coal generating capacity at the end of the planning period remains unchanged. The base Decarbonization Case shows a carbon reduction of 78%, while this Double Decarbonization sensitivity increased this carbon reduction further to 80% from a 2005 baseline.

258. My biggest quip with the base IRP is a seeming adherence to the social discount rate. I can applaud many strategies proposed, such as the promotion of distributed energy sources, resiliency, efficiency, and renewable energy. But the social discount rate, projecting energy needs in just a couple of decades as opposed to the whole of the 21st century and beyond, limits what can be accomplished. (*Commenter: Grant Mincy*)

Response: Comment noted.

259. The IRP does not explicitly discuss the impact of minimum load resulting from the scenarios studied. Management of minimum load and resulting stress (operational and economic) it poses for base load and intermediate load units, in particular large inflexible aging coal units like PAF3 and CUF 1&2. (*Commenter: Ricardo G. Perez*)

Response: IRP scenarios have different rates of peak and energy growth, resulting in different load shapes. These load shapes were fed into the capacity optimization model to determine optimal resource mixes to meet the load shapes, considering peaks and minimums and options to add and retire resources. Rapid DER Adoption has the greatest load swings and lowest minimums across the scenarios. The IRP considers minimum load to be an important aspect in generation planning and has developed the Flexibility Turn Down Factor metric to specifically measure this for all portfolios. This metric, described in IRP Chapter 6, table 6-9, is the ability of the system to serve low load periods as measured by the percent of must-run and non-dispatchable generation to system demand. Chapter 8.1.3 shows the resulting metric for all the portfolios.

260. Scenario 1: Current Outlook appears to indicate that no immediate changes are planned. What is the reserve capacity available to meet increased demand? What are the variables that would signal a requirement for increased production? What would be the first move that would be made to increase output? What time period does this option cover? (*Commenter: Jerry Peyton*)

Response: The Current Outlook indicates no new capacity is needed until the mid-2020s. Increased demand above the Current Outlook would prompt consideration of additional capacity options. Consistent with the IRP serving as a compass to provide general direction only, specific resource additions would require additional analysis before a final decision is made. TVA continues to monitor when and how future capacity needs are addressed.

261. TVA should amend the Decarbonization Scenario to study a path towards achieving net zero emissions by the 2040-2050 timeframe. This goal is based on reports from the scientific community and policy proposals and has already been adopted by several large electric utilities such as Xcel Energy and Southern Company. These reports also deem the electricity sector to be one of the easier to decarbonize, so the sector is expected to decarbonize faster than the overall economy. This expectation exists not only among the scientific community, but also among investor groups. Earlier in 2019, a group of investors and pension funds sent a letter to the top 20 largest publicly traded electric generators in the United States asking for detailed plans to achieve carbon-free electricity by 2050 at the latest.

Under the Base Case Strategy, the Decarbonization Scenario still has 30-31 MMTons of CO_2 and 5% and 19% of energy from coal and gas, respectively, in 2038. This generally appears to assume that coal will be replaced with gas, but SACE would note that this is a process that is already under way in the U.S. electric power market, and therefore does not represent a significant decarbonization effort. Decarbonization requires technology shifts that cannot be represented by replacing coal with gas. TVA should revise its Decarbonization Scenario to require net zero emissions by a specified year in the 2040-2050 timeframe. Even if that year is outside of the IRP framework, TVA would need to be on a trajectory toward net zero emissions in 2038, to meet goals in the 2040-2050 range. (*Commenter: Stephen Smith – Southern Alliance for Clean Energy*)

Response: As described in IRP Appendix E - Scenario Design, TVA worked with the IRP Working Group to develop the Decarbonization scenario. Due to comments received from the IRP Working Group and the public at large, TVA conducted a sensitivity on the carbon penalty in the Decarbonization scenario by doubling the $22/ton of CO_2 to $44/ton beginning in 2025. This level of penalty is in line with current legislative proposals. The results of this sensitivity show an acceleration of coal retirements but no change in the amount of coal capacity retired (more than 2 GW) over the study period. Additionally, this more stringent carbon pentalty sensitivity reduced CO_2 emissions an additional 5% compared to the base Decarbonization scenario.

262. In its discussion of the Decarbonization Scenario, TVA assumes that decarbonization policies will reduce economic growth. SACE requested documentation TVA used to come up with this assumption in our document request under NEPA and FOIA. TVA's response stated the following.
"The Decarbonization scenario represents a plausible future in which a CO_2 emission penalty is applied to the utility industry in an effort to curb greenhouse gas emissions. A CO_2 penalty would very likely result in an increase in natural gas units, and consequently demand for natural gas, as higher CO_2 emitting plants such as those fired by coal become uneconomic. Demand and price for natural gas would rise, leading to an increase in electricity prices. Based on information from the US Bureau of Economic Analysis, US Bureau of Labor Statistics, and US Energy Information Agency, there is an inverse correlation between the real price of electricity and labor productivity. Please see related posted information for a comparison of U.S. Labor Productivity vs. Price of Electricity."

TVA's response claims there is an inverse correlation between the real price of electricity and labor productivity. However, this claim is incomplete and misleading. Changes in labor productivity per hour do not have a significant impact on overall labor productivity or economic output per worker as shown in the January 2019 University of Tennessee Knoxville (UTK) "An Economic Report to the Governor of the State of Tennessee. The trends and small gains in labor productivity per hour on the national scale cited by TVA have likely had a negligible impact on how the labor force make contributions to the regional economy in the Tennessee Valley. UTK notes several explanations of the overall low productivity in the state: "There is still no consensus on why productivity has become so sluggish. One explanation is diminished marginal gains from the computer revolution. The service sector generally suffers from relatively weak gains in productivity, and its rise has been another one of the factors contributing to slower overall productivity growth."

Moreover, U.S. GDP continues to grow with declining energy usage. This indicates that the industries contributing to GDP growth do not require significant energy to produce economic output. Therefore, it is unlikely that long-term trends in electricity prices, within a reasonable range, will have a discernible impact on economic output.

The relationship between energy use and economic output is illustrated by looking at energy demand, gross domestic product (GDP), and energy intensity indexed to 2000 levels. “The movement of economic activity away from energy-intensive heavy industries toward less energy-intensive service sectors” was noted by the International Energy Agency as a primary reason for this trend in its most recent market series report on energy efficiency. This strongly mirrors UTK’s observations about reliance on service sectors for economic growth.

TVA’s Decarbonization scenario claims that curbing greenhouse gas (GHG) emissions will make the US less competitive globally. However, as evidenced above, countries have dramatically increased GDP growth during the past two decades, and have done so with less energy-intensive economies. Unchecked GHG emissions disincentivizes energy efficiency, which then promotes energy to be used in a way that makes minimal contributions to the economy. Ultimately, the GHG policies in the Decarbonization scenario would have a negligible impact on US global competitiveness. TVA should remove this assumption from the Decarbonization scenario before finalizing the IRP.

The TVA staff should also consider whether additional costs for new fossil plants of any kind, including gas, will be likely to have higher overnight costs driven by stricter permitting regulations. (*Commenter: Stephen Smith – Southern Alliance for Clean Energy*)

Response: The chart TVA provided depicts the relationship between the real price of electricity and productivity (output per worker hour) over the 1995 – 2018 period (the past 23 years), with all data converted to an annual basis.

The University of Tennessee (UTK) graph depicts real GDP output per worker for the respective total Tennessee and U.S. economies and their manufacturing sectors on a quarterly basis over the past 10 years. This period includes the 2008 – 2009 Great Recession period (2008-Q1 – 2009-Q2 inclusive) and the subsequent economic expansion.

Note that the period from 2006 – 2018 is the very period in which higher real U.S. electricity prices correspond to low U.S. productivity growth. If we look back at data in the back half of the 1990s through mid-2000s (i.e., 1995 – 2005), we observe lower average real electricity prices and higher productivity growth. Specifically, productivity over this period averaged 2.8% per year, while the average real price of electricity averaged 9.1 cents per kWh. Looking at the 2008 – 2018 period that is shown within the chart from UTK, U.S. productivity growth averaged 1.3% against a real electric price of 10.0 cents per kWh. The latter period coincided with the Obama administration’s stricter regulatory regime toward fossil energy resources (along with a multitude of other regulations impacting numerous industries) which positively impacted the price of electricity.

Since TVA’s initial response, first quarter data for 2019 has been released. The reported real price of electricity has fallen to 9.4 cents per kWh while the reported productivity figure is 3.6%. This suggests that the underlying relationship we posit has not fundamentally changed (Note: the only exceptions are post-recession productivity does tend to temporarily spikes in output per worker given the near-term impact of layoffs; this phenomenon cannot be maintained, however).

TVA disagrees with the claim that “Changes in labor productivity per hour do not have a significant impact on overall labor productivity or economic output per worker.” In fact, the rate of change in output per worker hour is highly correlated with output per worker (or per job). According to the Bureau of Labor Statistics data showing the relationship back to 1972 (both series calculated as percent change from previous quarter at an annual rate), the correlation between the respective growth rates for these two series over the 1972 – 2019 period is 92.2%. The correlation over the 2008 – 2019 period is 92.1%.

The UTK report contains charts comparing the European Union (EU), the United States, China, and India over the 2000 – 2017 period for GDP growth, primary energy demand, and imputed energy intensity. Since China and India were developing nations over a significant portion of this period and the EU and the U.S. are developed OECD economies, it is more reasonable to compare the latter two. In particular, the EU has had a carbon trading program in effect since January 1st of 2005.

Over the past 19 years, the U.S. economy has grown 14% faster on a cumulative basis or 0.73% per year on average than the EU. While economic growth within the two regions began to diverge in 2003, the spread began to widen in late 2004 as the EU's carbon policy was about to be implemented. It is well understood that electricity (and petroleum) prices are more expensive in the EU than the U.S. (real costs are higher). A carbon tax would not just impact electricity costs, it would impact all energy usage in electricity, transportation, and manufacturing. Granted, the EU's carbon tax and higher real energy costs are not the only differences between the two economies. However, they are a substantive one. Any policy which makes a primary input (such as energy) relatively more expensive will, ceteris paribus, result in lower real growth in economic output at the margin. TVA is assuming that GDP growth in the Decarbonization Case will be 0.22% per year lower than in the Reference Case scenario. This is roughly 30% of the average difference in growth between the EU and the U.S. during the 21st century. Placed in that context, it is a very reasonable assumption.

Furthermore, TVA's energy forecast implicitly acknowledges the relationship between energy use and GDP growth. Indeed, energy use is virtually flat over the first decade of the forecast horizon while regional GDP grows by 1.8% per year.

The notion that the U.S. economy is more driven by a non-energy intensive service sector as opposed to an energy-intensive manufacturing sector is also not necessarily supported. Employment growth has clearly been higher in the service sector than in the manufacturing sector (which is an element that UTK is highlighting), which has clearly lost jobs since roughly 1979, while the service sector has grown. However, to honestly assess this we need to look at the comparative GDP data, not just employment data. Looking at the relative shares of real U.S. GDP by type, broken out for domestic Goods and Services consumption since 2002 (this as far back as the BEA data goes), Total Services consumption comprises 44% of U.S. GDP, versus 45% back in 2002. Goods consumption makes up 31% of U.S. GDP, versus 27% back in 2002. Together they comprise 74% of U.S. GDP in 2018 (versus 72% back in 2002).

The remaining share of GDP is made up of Domestic Private Investment and Government spending. Note that the Goods consumption share has actually risen slightly relative to total Services consumption. In addition, it should be noted that utility expenditures fall under Services.

263. TVA states it modeled the decarbonization scenario based on "Federal regulations that curb carbon emissions." The Energy Innovation and Carbon Dividend Act, H.R. 763, has gained significant support in the 116th Congress two months ago. TVA should model the decarbonization scenario by assuming that the emission reduction targets specified in this legislation are met by electricity generation with renewables, storage, nuclear and other carbon-free sources. This modeling can be done using two methods:

1. Using the emissions reduction approach in H.R. 763 Section 9903 which sets emissions reductions targets of 5 percent/year for the years 2025 to 2034 and 2.5 percent/year for the years 2035 to 2050, both against a 2016 reference year.

2. Using the carbon fee approach in H.R. 763 Section 9902. (*Commenter: Jeanette Berry*)

Response: The Decarbonization scenario is not based on any specific regulation but a proxy for future regulation of legislation. TVA does not think it is prudent to model a specific legislative proposal that is likely to change. Instead, TVA envisioned a representative regulatory proxy in the Decarbonization scenario and also conducted a sensitivity that doubled that carbon penalty to approximately $44/ton of CO_2 in 2025, as described in IRP Section 8.2. Across all portfolios, results indicate a carbon reduction of 70%, on average, from a 2005 baseline by 2038. Individually, the base Decarbonization Case shows a carbon reduction of 78%, while the Double Decarbonization sensitivity increased this carbon reduction further to 80% from a 2005 baseline.

F.2.5.9 Sensitivity Testing

264. The potential generation from solar under Strategy E: Promote Renewables, as shown in Draft EIS Figure 3-4, is surprisingly small in comparison to other generating sources. At 63%, carbon-free generation is significant under the Promote Renewables scenario, yet it is only 2% higher than the Base Case of 61%. We recommend analyzing sensitivities with higher penetrations of utility-scale and distributed solar. Increasingly, residents and businesses alike are seeking 100% renewable or carbon-free forms of electricity and future scenarios with significantly higher penetration of renewables should be considered in the Final EIS and IRP. (*Commenters: Kendra Abkowitz – Tennessee Department of Environment and Conservation, Jason Carney*)

Response: Solar expansion is significant in the IRP, ranging from about 6 to 9 GW of nameplate capacity by 2038 under the Current Outlook for electricity demand and up to 14 GW of nameplate capacity in a growth scenario. Driven by the timing of customer demand, TVA has launched two programs to support accelerated renewable investment: Renewable Investment Agreement (RIA) and the Flexibility Research Project (FRP) pilot. RIA supports utility scale buildouts for large commercial and industrial customers and FRP supports community solar, in partnership with local power companies (LPCs). Community scale solar provides opportunities for LPC customers to invest in LPC-sponsored community solar facilities as a lower cost alternative to constructing and operating their own rooftop or other solar facilities.

265. Draft IRP Section 8.2 states that TVA plans sensitivity analysis to evaluate SMR technology. This analysis should evaluate the importance of using SMRs to follow load and the resulting environmental benefits through reduced CO_2 emissions. At present, according to a TVA representative at a public meeting and IRP Appendix D, nuclear is only modeled as a baseload asset. Because SMRs have the potential to follow load, TVA should be a leader in their development for complementing intermittent renewable energy. (*Commenter: Jeanette Berry*)

Response: Comment noted. Due to economics and system needs, none of the IRP cases included additional nuclear in the capacity expansion except for, as explained in Section 7.1.2 of the IRP, Case 6C which includes two SMRs facilities totaling 1,200 MW forced in as part of Strategy C (Promote Resiliency) to replace the MW output of one of three retiring Browns Ferry units. After the draft IRP was published, TVA performed a sensitivity analysis that is detailed in IRP Chapter 8 to understand how much SMR costs may need to improve to become economic. Refinements in design and implementation, coupled with cost and risk sharing, could improve the SMR's position compared to other resource options.

F.2.5.10 Strategies

266. We applaud TVA's increase in home energy retrofits for low income populations and encourage continued growth and investment in this area under all IRP strategies. (*Commenters: Kendra Abkowitz – Tennessee Department of Environment and Conservation, Martha Deaderick*)

Response: Comment noted. Under the 2019 IRP Recommendation, TVA will work with our local power company partners to expand programs for low-income residents and refine program designs and delivery mechanisms with the goal of lowering total cost.

267. In a scenario that includes accelerated vehicle electrification, it is unclear whether and how the corresponding action alternatives (Strategy B, C, D, and E) would mitigate and/or address the potential environmental impacts tied to spikes in electricity demand from vehicle charging. With the number of electric vehicles in the TVA service area increasing and the emphasis being placed on electric vehicle manufacturing in Tennessee, TVA should clarify whether it analyzed the impacts of allowing customers to use two way meters to use electric vehicle batteries as a distributed storage resource. This option may help TVA reach the goals of Strategies B (Promote DER), C (Promote resiliency), and D (Promote Efficient Load Shape). We encourage TVA to provide additional clarification regarding this in the Final EIS. (*Commenter: Kendra Abkowitz – Tennessee Department of Environment and Conservation*)

Response: At this time it is unclear how using EV batteries as a storage resource would impact manufacturers' warranties and EV battery life, so TVA did not include EV batteries as a distributed storage resource in this IRP. Strategy D (Promote Efficient Load Shape) included a time-of-use rate structure to incent EV and battery charging at off-peak times.

268. Particularly under Strategy C - Promote Resiliency and regarding distributed solar, storage and microgrids, TDEC recommends TVA consider the benefit of allowing customer-sited solar to be utilized as a back-up power source for microgrids in the event of emergencies and grid outages. Under past solar programs, including Green Power Providers, the terms of the purchase agreement with TVA prevented customers from being able to utilize power from their solar arrays during grid outages due to concerns over backfeeding. However, with the rise of microgrids, so too has risen the use of Automatic Transfer Switches (ATS) to island a facility from the grid. The ATS allows facilities to continue operating while preventing backfeeding power into distribution lines. Further, advances in battery storage and black start-capable inverters have grown to make microgrids feasible solutions to complement conventional backup generation for critical facilities. Given the number of State facilities throughout Tennessee, many of which may be called upon to serve as shelters or staging areas during catastrophic emergencies, TDEC recommends strong consideration be given to incentive programs that encourage islanding and microgrid projects utilizing solar, as these projects foster greater resiliency of facilities within the State. (*Commenter: Kendra Abkowitz – Tennessee Department of Environment and Conservation*)

Response: Specific program design is outside the scope of the IRP. However, TVA continues to monitor the capabilities of Automatic Transfer Switches, battery storage and inverters and engage in related conversations with local power companies.

269. How is TVA addressing climate change? With scientists telling us that climate change is happening at an alarming rate, please include a clear and impactful response to climate change. (*Commenters: Anonymous 1 , Anonymous 2 , Anonymous 3 , Claire Chandler, Ann Davis, Jennifer Davis, Lynn Davis, Ann Ercelawn , Jim Gienapp , Henry Goldberg, Deborah Hamilton, John Harkey, Dawn Hartley, Katie Herzig, Richard Hutchinson, Daniel Joranko, Rob Kaniper, Herman LaVelle , Lindsay Lavelle, Eric Lewis, Suzana Lightman, Celia Mackey, Madona May, Tom McClain, Carol McComiskey, Naomi McDougall Graham, Jack McFadden, Kent Minault, Damon Moglen, Margaret Neu, Millie O'Rourke, Catherine Pena , Katherine Ragsdale, Sallie Sabbatini, Mary Self, Rosemary Varner, Courtney Vick, Steven Waterfield, Daniel Waterman, John Todd Waterman, Greg Wathen*)

Response: Between 2005 and 2017, TVA reduced carbon emissions by 47 percent. In the future, the IRP Recommendation considers the potential for a decarbonized future and results, on average, showed carbon reduction of 70 percent across all portfolios from a 2005 baseline. In Table 5-4 of the EIS, TVA provides the potential CO_2 emissions resulting from each alternative strategy, including the IRP Recommendation, from current conditions through 2038. The EIS considers CO_2 and global warming impacts, and portfolios have been evaluated against metrics to determine the environmental impact. The EIS addresses the effects of power production on the environment, including climate change, the effects of climate change on the Valley, and air emissions and water use in TVA's power operations.

Due to comments received from the IRP Working Group and the public at large, TVA conducted a sensitivity on the carbon penalty in the Decarbonization scenario by doubling the $22/ton of CO_2 to $44/ton beginning in 2025. The base Decarbonization Case shows a carbon intensity reduction of 78%, while the Double Decarbonization sensitivity increased this carbon reduction further to 80% from a 2005 baseline.

270. TVA should shift focus from generation to grid management. Grid resilience should be a key goal, and the implications of pursuing grid resilience include both increased distributed generation and increased renewables. With the increased usage or solar energy along with the coming growth in electric cars, 'smart' appliances and industrial energy management systems, TVA should be able to communicate with these various sources of power and energy control so that the grid can operate more efficiently. (*Commenters: Mark Bishop, Nathan Brown, Celia Mackey, Steve Vining*)

Response: Comment noted. TVA owns and operates the bulk transmission system but local power companies in the Valley own and operate the distribution system that serves end-use customers. Local power companies install smart grid at their discretion, independent of TVA. For reasons noted in the comment, TVA included strategies to Promote Resiliency and Promote Efficient Load Shape.

271. The Draft IRP confirms that Strategy B - Promote DER would perform as well, and in many ways better, than Strategy A - Base Case. In the Base Case no specific resource types are promoted beyond continuation of existing programs as currently forecasted. All of the other strategies promote different combinations of resource types. Each strategy is evaluated with fourteen scorecard metrics that seek to "reflect desired goals and priorities in areas related to cost, risk, environmental stewardship, operational flexibility, and Valley economics."

The new (for 2019) total resource cost metric is the only metric by which the Base Case performs better by more than a negligible margin over Promote DER. However, as discussed elsewhere in our comments, that metric is not directly relevant to determining the "lowest system cost," and, in any event, does not accurately reflect the economics of DER for participants. After correcting this and other errors, the Promote DER strategy and other non-Base Case strategies explored in the draft IRP would likely be even more competitive than currently projected. (*Commenter: Christina Reichert – Southern Environmental Law Center*)

Response: Where DER is added as a part of a portfolio, TVA is depending on that resource to serve load and maintain reliability. TVA's traditional cost metrics capture the cost of the incentive from TVA to the customer but not the remaining cost of the distributed resource. Given promotion in a strategy, DER is added as a least-cost option from a TVA perspective, and costs borne by TVA are captured in PVRR. Total Resource Cost is a supplemental metric that sheds light on the total cost of the portfolio, reflecting cost of distributed resources in a consistent manner to how costs are treated for supply-side resources.

272. Each energy resource option should stand on its own and not require incentives in order to make it viable. (*Commenters: Jeff Coppala, W.J. Lackey, Kenny Wiggins*)

Response: Comment noted.

273. TVA should take a hard look at partnering with local distributors such as NES to deploy a charging station at most, if not all, service stations so that electric car drivers could pull in and charge their cars as conveniently as they

can today with gasoline engines. One TVA representative told me that there is $11B worth of gasoline sold annually in the TVA service area, so it would seem to me to a good opportunity to sell more electricity and offset some of the losses in revenue due to energy efficiency and distributed power generation networks by doing this. (*Commenters: Elizabeth Garber, Steve Vining*)

Response: Comment noted. While such proposals are outside the scope of the IRP, TVA continues to seek opportunities for partnerships to promote economic development in the Valley. TVA believes electrifying the transportation sector touches many aspects of the TVA mission of energy, environment stewardship, and economic development.

274. Strategies B through E should be implemented by TVA. (*Commenter: Martha Deaderick*)

Response: Comment noted.

275. Many of the scenarios offer benefits and in terms of making decisions that create change, and given the crucial status of our state's need to seriously adopt ways that lead to a more sustainable future, I would support both B and C. (*Commenter: Pamela Glaser*)

Response: Comment noted.

276. TVA should not make choices based on greenhouse gas emissions. (*Commenter: W.J. Lackey*)

Response: Comment noted. Greenhouse gas emissions and their effect on the environment are among the many factors that TVA is considering in making decisions on the 2019 IRP.

277. One of the strategies TVA includes in the IRP is “Promote Renewables.” TVA was widely criticized in its 2015 IRP for exaggerating the cost of renewables in its modelling and, as noted in other comments on the 2019 Draft IRP, seems to continue that practice of consistently exaggerating the costs of renewables while understating the costs of fossil and nuclear. In addition, TVA projects the availability date of renewable resources as no sooner than 2023 while are modelling these resources using 2018 costs. In reality these renewable resources could be implemented within a year or two and their costs in 2023 will be much lower than today. For these reasons and others, it is not accurate for TVA to claim it has a “Promote Renewables” strategy in this IRP.

The most ambitious strategy adds only 4,000 to 10,000 MW of new solar nameplate capacity by 2038. This is at most 500 MW of solar capacity expansion per year, and possibly less than 200 MW. In addition, the IRP projects no new wind or hydro additions and very modest amounts of new storage capacity (battery, pumped storage, etc.). Failure to commit to additional wind resources, currently the least expensive power resource available, and one still declining significantly in price, is as mystifying as it is appalling. TVA acknowledges that additions of new hydro, pumped hydro and chemical storage, and demand response are technically and economically feasible but concludes additions of these resources, with the exception of some modest battery additions) are not likely. Again, this is unacceptable given that TVA should feel obligated to add every bit of low carbon resource possible in the light of currently accepted climate science projections.

TVA cannot claim to have modelled a strategy that “Promotes Renewables” that leaves most renewables out of the strategy. This is another example of where TVA’s draft IRP seems to be in direct conflict with its statutory requirements and stated objectives. It is leaving the lowest cost generating resource wind entirely out of the IRP, underutilizing solar, the next least cost option, and several other renewable options that would facilitate the ability of TVA to diversify its portfolio, reduce cost, increase reliability, reduce risk, increase environmental responsibility, and provide flexibility. We urge TVA to reevaluate the IRP by modelling much more ambitious renewable goals using more accurate industry accepted cost estimates so that it truly does consider a “Promotes Renewables” strategy.

This is mandated by current climate science and achieves TVA's mandate to promote economic development and the general wellbeing of its customers at the least cost. Thus, TVA should model a strategy that sets hard benchmarks for percentage increases of renewable energy installed to replace fossil fuels. This would define a boundary on the modeling process to prevent it from producing the absurd result of low cost electricity in a broken global climate system. (*Commenters: Scott Banbury, William Moll, Ian Schiller, Joe and Sarah Schiller*)

Response: Solar cost estimates were informed by responses to a recent RFP for installations in the Valley and reflect expectations that costs will continue to decline for the next decade. Figure C-7 in IRP Appendix C provides a graphical representation of solar costs used in the 2019 IRP, expressed in nominal $/kW (DC). IRP solar cost projections are declining in real terms and generally align with NREL ATB estimates when adjusted for capacity factors that can be realized in the Valley and for inflation (nominal vs. real). Solar expansion is significant in the IRP, ranging from about 6 to 9 GW of nameplate capacity by 2038 under the Current Outlook for electricity demand and up to 14 GW of nameplate capacity in a growth scenario.

Distributed solar installations are modeled assuming the elimination of transmission losses. Going forward, TVA will continue to work with the LPCs and TVPPA to better understand and be able to incorporate locational benefits of distributed resources on the system.

Wind cost estimates were informed by responses to a recent RFP for installations in or deliverable to the Valley. Additional sensitivity analysis has identified the potential for up to about 4 GW nameplate of additional wind capacity, if lower wind costs could be realized.

IRP cost estimates for utility-scale battery storage were informed by recent RFI responses and Navigant Consulting's third-party review. Benchmarking requires calibration to differences in MW size, hours of duration, balance of system, and cost structure. Related to structure, augmentation and warranty that ensure output over the lifespan can be included in capital costs or in annual O&M. In TVA's assumptions, these costs were included in capital costs. Clarification on these differences has been included in the discussion of battery storage cost trajectories in Appendix C of the IRP. When accounting for differences in structure, AC/DC conversions, and inflation (nominal vs. real), TVA's battery storage cost assumptions generally align to Lazard's cost estimates. TVA's IRP assumes a downward trajectory in costs, similar to IEEE's mid-range case. Battery storage technology is rapidly evolving, so costs will be frequently monitored for changing economics.

278. Given the urgent need to reduce carbon emissions, TVA should model a strategy that sets a schedule of benchmarks for fossil fuel plant retirement. This should be considered another dimension of a boundary condition within which modeled strategies must be contained. Modeling strategies driven only by least cost leads to absurd results such as low cost electricity but a broken global climate system.

The Draft IRP projects significant quantities of coal and natural gas electricity generation in all strategies at the end of the 20 year planning horizon. Accelerated coal retirement was anticipated in some strategies, but not at a rate that current climate science mandates! This is entirely inconsistent with the overwhelming consensus of US and international climate scientists who have communicated in unequivocal terms the urgent need to rapidly decarbonize our economies. If TVA were to increase its energy efficiency and renewable ambitions as called for in our other comments it could greatly accelerate the retirement of all coal generation and achieve a coal-free grid well before 2038. Other utilities such as NIPSCO have recently recognized the potential cost savings from accelerating the closure of their coal facilities.

Given that natural gas and nuclear are currently the two largest power generation resources in TVA's generation portfolio, and will remain so over the planning period, TVA states that a diversified power portfolio is one of its IRP objectives. The continued reliance on natural gas and nuclear does not increase the diversity of the portfolios. TVA must retire natural gas generation, not add more, if it is to make room for more renewable generation and meet the other objectives of the IRP. The IRP found virtually no cost difference in strategies that increased renewables so there are no economic constraints to retiring fossil generation by replacing it with renewables. Adding additional gas generation will lock TVA into a higher carbon emissions future for the anticipated service life of the assets. (*Commenters: Scott Banbury, William Moll, Ian Schiller, Joe and Sarah Schiller*)

Response: TVA is mandated by the TVA Act to conduct least-cost planning. TVA continually evaluates its assets relative to other generating options. In the IRP, in addition to cost, TVA also evaluates portfolios based on risk, environmental impacts, operational flexibility, and Valley economics. Solar expansion is significant in the IRP, ranging from about 6 to 9 GW of nameplate capacity by 2038 under the Current Outlook for electricity demand and up to 14 GW of nameplate capacity in a growth scenario. This addition is enabled by the addition of natural gas and storage to meet winter reserve requirements. The IRP also explores the potential for up to about 5 GW of storage, which may displace the need for some gas generation.

279. Under all of the strategies and scenarios, the Draft IRP anticipates the continuing to operate most of its currently utilized coal units through the end of the 20 year planning period. In addition, the percentage of the energy mix contributed by coal in 2039 is only 2 or 3 percentage points lower than the percentage in 2019. As a result, the Draft IRP anticipates the continued projection of large quantities of coal ash. With the size of the TVA coal fleet anticipated to operate over a 20 year period, TVA would continue to be one of the nation's largest coal ash producers.

As you know, the coal ash spill at the Kingston coal plant was one of the largest environmental disasters in our nation's history. The spill itself cause massive amounts of damage to the environment and to nearby residents, and the resulting cost of cleanup has exceeded $1 billion and continues to increase. This disaster and its financial and ecological outcomes impose a special responsibility upon TVA to be national leaders with respect to the environmental impacts of coal ash. One strategy for implementing this responsibility would be a strategy to minimize and eventually eliminate coal ash generation at TVA power stations. The 20 year planning period in the Draft IRP would be an ideal timespan to incrementally but deliberately implement this draw down, but unfortunately a large amount of coal generation is still anticipated to be in the TVA generating mix 20 years from now.

Although TVA attempted to evaluate generation strategies that would provide a range of potential future generation portfolios, all strategies--including the Base Case as well as the strategies that would Promote DER and Promote Renewables-- produce millions of new tons of coal ash every year that will have to be managed and disposed of properly. Under the Current Outlook scenario, the Base Case strategy is estimated to produce 2.269 billion tons of coal ash over 20 years, whereas the Promote Renewables strategy is estimated to produce 2.227 billion tons over this same time period. The reduction of 42 million tons has positive environmental benefit. However, the tight alignment in coal ash production across all strategies under each scenario suggests that TVA did not evaluate sufficiently strong strategies to reduce coal use (and thus reduce coal ash production). Sierra Club suggests that TVA evaluate sensitivities that expand the lower range of coal use options under evaluation for the IRP, as part of a strategy to reduce coal ash production. (*Commenters: Scott Banbury, William Moll*)

Response: TVA continually evaluates its assets relative to other generating options. In the IRP, in addition to cost, TVA also evaluates portfolios based on risk, environmental stewardship, operational flexibility, and Valley economics. The IRP Recommendation also reflects the potential for more than 2 GW of additional coal retirements beyond those already approved by the TVA Board. This upper bound is informed by the Decarbonization scenario and two sensitivities: Double Decarbonization and Increased Cost of Coal. The Double Decarbonization sensitivity doubles the carbon penalty from the Decarbonization scenario. The Increased Cost of Coal sensitivity increases the long-term operating cost of the existing coal units (capital and O&M). Both sensitivities result in earlier retirement of 2 GW of coal capacity while the available coal capacity at the end of the planning period remains unchanged.

280. While it is commendable that, under all the proposed strategies, TVA will have reduced its CO_2 emissions by more than 60% since 2005, the projected level of reduction is insufficient to avoid the impacts described in the 2018 IPCC special report and the Fourth National Climate Assessment. In order to limit the future temperature increase to 1.5°C, for example, the global share of renewable generation of electricity must reach 60% by 2030 and 77% by 2050. The Draft IRP projects approximately 5% wind and solar by 2038 and continued reliance on a large proportion of fossil generation.

NEPA regulations require the consideration of reasonable alternatives, even if they are not within the jurisdiction of the lead agency. TVA must therefore consider additional alternatives that accelerate GHG emission reductions, including a “path to zero emissions” alternative. There is no reason TVA should not plan for replacing fossil generation with carbon-free generation and reduce its historically large GHG footprint at a far faster rate than currently proposed. (*Commenter: Howard Crystal – Center for Biological Diversity*)

Response: The IRP process evaluates TVA’s current energy resource portfolio and alternative future portfolios of energy resource options on a “lowest system cost” basis to meet the future electrical needs of the TVA region while taking into account TVA’s mission of energy, environmental stewardship and economic development. TVA did not consider an alternative that would result in an entirely carbon free power generation mix because such an alternative would not meet the “lowest system cost” mandate. Please see the response to Comment 13 for additional information about the Decarbonization scenario and sensitivity analyses.

281. We recommend that TVA adopt a combination of Strategy B: Promote DER and Strategy C: Promote Resiliency. We believe these two strategies both provide a customer-focused approach at least cost with maximum flexibility to the system for the lowest cost and risk with the maximum amount of environmental and economic benefit for the people of the Tennessee Valley. The purpose of the IRP is to determine how TVA can continue to provide low-cost, reliable electricity, support environmental stewardship, and spur economic development in the Valley over the next 20 years and we believe there is no better way to accomplish this than for TVA to embrace solar, battery storage, and other renewable and advanced energy technologies through these two strategies. (*Commenter: Gil Hough –Tennessee Solar Energy Association*)

Response: Comment noted. The IRP Recommendation recognizes the positive aspects of all strategies, including Strategies B and C.

282. The TVA Act mandates that TVA projects “shall be considered primarily as for the benefit for the people of the section as a whole and particularly the domestic and rural customers to whom the power can be economically made available, and accordingly that sale to and use by industry shall be a secondary purpose...” Therefore, according to the TVA Act, domestic and rural customers should be given preference for projects; this is best done through TVA support of distributed energy resources to residential and rural customers that also assist local power companies in their customer solutions approach to bring DER technologies “closer to the customer.” (*Commenter: Gil Hough – Tennessee Solar Energy Association*)

Response: Comment noted. Through the integrated resource planning process, TVA is considering the appropriate energy mix for the benefit of all residents of the Valley.

283. The IRP should accurately quantify the risk associated with CO_2 emissions resulting from potential future regulation as well as from the impacts of climate change. Strategies with higher future CO_2 emissions (notably Strategy A: Base Case) are extremely risky due to potential federal regulation brought by legislation, legal action or emergency declaration by the President of the United States and the damage from extreme weather events. Only strategies with lower future CO_2 emissions should be considered due to the reduced risk to both TVA and Valley residents. The clear best strategy to improve resiliency and system flexibility is a combination of increased coal retirements and increased use of solar and storage. According to the Draft IRP, TVA can retire 3,000 MW of coal and replace it with solar with no upward pressure on rates, improved environmental performance, and increased system flexibility and grid resiliency. (*Commenter: Gil Hough –Tennessee Solar Energy Association*)

Response: TVA is mandated by the TVA Act to conduct least-cost planning. TVA continually evaluates its assets relative to other generating options. In the IRP, in addition to cost, TVA also evaluates portfolios based on risk, environmental stewardship, operational flexibility, and Valley economics. The IRP Recommendation also reflects the potential for more than 2 GW of additional coal retirements beyond those already approved by the TVA Board. This upper bound is informed by the Decarbonization scenario and two sensitivities: Double Decarbonization and Increased Cost of Coal. The Double Decarbonization sensitivity doubles the carbon penalty from the Decarbonization scenario. The Increased Cost of Coal sensitivity increases the long-term operating cost of the existing coal units (capital and O&M). Both sensitivities accelerate the retirement of more than 2 GW of coal but do not increase the magnitude of coal retirements over the 20-year study window.

284. Strategy E seems to say that TVA is only promoting renewables or primarily promoting renewables due to consumer demand and not because this is a TVA priority or goal. Why would this be a strategy only because consumers want it? As a huge supplier of energy, TVA should lead consumers with good ideas, not only react to good consumer ideas. (*Commenter: Susan Moresi*)

Response: Under the Base Case strategy, utility-scale solar is added based on economics. Strategy E – Promote Renewables evaluates the impact of promoting solar to higher amounts beyond economic solar to respond to customer demand.

285. Implementing a smart grid that allows the utility company to manipulate major appliances and HVAC systems in customer facilities could be a potential inconvenience to customers. (*Commenter: David Williams*)

Response: Residential demand response (DR) was an attractive resource in the IRP with up to about 300 MWs of opt-in residential water heater and HVAC programs added. TVA owns and operates the bulk transmission system, while local power companies in the Valley own and operate the distribution system that serves end-use customers. Local power companies install smart grid at their discretion to achieve a variety of benefits, including minimizing downtime. TVA in partnership with LPCs will continue to evaluate the market potential of residential DR programs, considering customer needs and expectations.

286. TVA's IRP modeling suffered from flaws and biases that tend to undercount the benefits of clean energy and to instead overly favor fossil generation, the results nonetheless provide a strong signal that TVA should pursue a renewables-focused approach. First, the retirements of the Bull Run and Paradise coal units - as approved by the TVA Board on February 14, 2019 - are consistent not only with TVA's environmental stewardship obligations but with protecting ratepayers. Although the studies supporting these retirements occurred largely exogenous to the IRP process, TVA should nonetheless undertake similar economic analyses of its other coal units, particularly so as to, as discussed elsewhere in our comments, ensure that TVA makes properly informed retrofit-or-retire decisions for units who have yet to install controls to bring them into compliance with the federal Effluent Limitation Guidelines for Steam Electric Power Generating stations.

As a federal corporation and under the environmental protection mandates of the TVA Act, TVA is in a place of heightened responsibility when it comes to compliance with federal statutes. Even with the phase out of the Bull Run and Paradise plants, TVA will continue to operate a large and polluting fleet of coal-fired power stations. In fact, the Draft IRP modeling suggests only a modest reduction in the amount of energy generated from coal at the end of the 20 year planning period compared to levels today. Carrying such a large fleet of coal generation into the next two decades brings along the risk that lawmakers or regulators will require additional reductions in the discharge of pollutants into waterways" to (finally) meet the expressed intent of the Congress in the Title I Declaration of Goals and Policy of the Clean Water Act" and that risk is nearly exclusively created by continued use of the TVA coal-fired power plants. None of the other generating types evaluated by TVA, and certainly not solar or other renewable sources, carrying with them the risk of TVA having to spend significant capital and raise electric rates in order to achieve compliance with stronger enforcement of current Clean Water Act regulations or promulgation of future ones.

Second, the modeling results show that TVA does not need and should not acquire additional coal-fired generating units or additional nuclear units. Instead, the modeling shows that more flexible and scalable resources, such as solar generation, are needed to better serve TVA's customers and achieve TVA's economic and environmental goals. While the modeling suggests that TVA could look at solar and gas combustion turbine resources as being in competition with each other to address future energy needs, this is likely only because TVA has over-priced clean energy resources, as discussed elsewhere in our comments (or placed unrealistic throttles on total solar acquisitions, as illustrated in part by post-Draft IRP sensitivity analyses TVA has performed). Sierra Club is confident that updated modeling analyses with adjustments to solar and storage pricing would recommend that TVA acquire significantly more renewables in place of generation from both new gas and existing fossil generation. Nonetheless the results of TVA's modeling as performed provide clear signposts showing that if real-world solar prices are less than what TVA's modeling assumed (as is overwhelmingly likely the case), TVA should acquire those resources in order to best serve its customers. Indeed, every single strategy across the multiple scenarios examined results in additional renewables in TVA's system.

Third, and most importantly, TVA's modeling indicates that there is almost no variance in the present value revenue requirement (PVRR) among the different strategies TVA examined, and even less variance in the impact on Valley economics among the strategies. As the Scorecard Metric Comparisons in the Draft IRP show, the range in PVRR values across the strategies for each scenario generally vary by only as much as 1%; employment and per capita income metrics likewise show little variation (and only tiny overall impacts). As a result, the main difference between the different strategies TVA examined is in environmental impacts, with strategies focusing on renewables resulting in emissions of tens of millions of tons of carbon dioxide less than TVA's Base Case strategy. This presents TVA with a clear direction, given its three-part mission of providing affordable electricity, fostering economic development, and achieving environmental stewardship: all strategies fulfill TVA's cost and economics obligations, and therefore TVA should differentiate among the strategies primarily based on environmental impact. (*Commenter: Zachary Fabish – Sierra Club*)

Response: TVA is mandated by the TVA Act to conduct least-cost planning. TVA continually evaluates its assets relative to other generating options. In the IRP, in addition to cost, TVA also evaluates portfolios based on risk, environmental impacts, operational flexibility, and Valley economics. The IRP Recommendation also reflects the potential for more than 2 GW of additional coal retirements beyond those already approved by the TVA Board. This upper bound is informed by the Decarbonization scenario and two sensitivities: Double Decarbonization and Increased Cost of Coal. The Double Decarbonization sensitivity doubles the carbon penalty from the Decarbonization scenario. The Increased Cost of Coal sensitivity increases the long-term operating cost of the existing coal units (capital and O&M). Both sensitivities accelerate the retirement of more than 2 GW of coal but do not increase the magnitude of coal retirements over the 20-year study window.

287. MLMC supports TVA's goal of flexibility and believes the 2019 draft IRP successfully accomplishes this goal. Specifically, MLMC supports TVA's commitment to acquire coal from the Red Hills Power Project at a relatively constant rate of about 4.5 million tons/year. (*Commenter: Dave Liffrig – Mississippi Lignite Mining Company*)

Response: Comment noted.

288. Why is the mission (and strategies) focused on affordable = low price versus low-cost energy (considering all costs) + externalities? (*Commenter: Claudio Meier*)

Response: TVA is mandated by the TVA Act to conduct least-cost planning. TVA continually evaluates its assets relative to other generating options. In the IRP, in addition to cost, TVA also evaluates portfolios based on risk, environmental stewardship, operational flexibility, and Valley economics. TVA has not found a consensus source for externality values. The Double Decarbonization sensitivity envisions a high carbon penalty starting at $44/ton of CO_2 in 2025 which could be a proxy for externalities associated with CO_2 emissions.

289. The results from TVA's Draft 2019 IRP are nearly uniform for each scenario across the different strategies, suggesting the assumptions made in each strategy are not different enough to have a material impact on results. The Draft 2019 IRP fails to explore strategies that represent meaningful differences for stakeholders or the Board to use when recommending a strategy to inform TVA's future planning purposes.

As just one example, TVA's high incentives for distributed solar leads to that resource being 10% of total capacity in 2038 under the Current Outlook scenario. In its 2019 Annual Energy Outlook, EIA forecast that distributed solar will make up 6% of total capacity nationwide under current policy and economic conditions. TVA's highest level of incentives for this technology results in only marginally better penetration than EIA's modest projection under current conditions.

Across scenarios, it is notable that the lowest PVRR cases are for Scenarios 2 (Economic Downturn) and 5 (Rapid DER Adoption) for all strategies. The scenarios with the least overall CO_2 emissions are Decarbonization and Rapid DER Adoption scenarios. For neither metric does the strategy matter much. However, the Rapid DER Adoption scenario has even lower emissions than the Decarbonization scenario and falls in the lowest cases for PVRR. Considering that TVA has a mission to support environmental stewardship and economic development, pursuing policies consistent with these two scenarios would be consistent with its mission.

It is evident that DER adoption can benefit the Valley through reduced costs, reduced emissions, and more customer options. TVA should implement a strategy of DER integration that also includes the energy efficiency resources left out by its egregious modeling methodologies in this IRP. (*Commenter: Stephen Smith – Southern Alliance for Clean Energy*)

Response: Scenarios are different views of the future that are outside of TVA's control so TVA cannot pick a scenario but rather implement strategies that perform well across various scenarios. The scenario in effect at any given time has much more impact on the resulting portfolio than the strategy TVA implements. It is important to note that average national forecasts distort the underlying differences in regional regulatory policy and market dynamics. The Southeast and, more specifically, the TVA service area, has low retail electricity prices compared to the national average and does not have state renewable portfolio standards (with the exception of North Carolina). The TVA service area has less solar irradiance that many areas of the country (more cloud cover). Lower rates, less solar irradiance, and no renewables targets, rooftop solar mandates, or incentives all lead to longer payback periods and thus less and slower adoption than other areas of the country like California and Arizona. TVA has included aspects of all strategies, including Promote DER strategy, in the IRP Recommendation. The EIA distributed solar photovoltaic forecast includes industrial solar as part of the distributed solar. In the TVA modeling, the majority of industrial solar was considered as "customer driven" and thus part of the "utility solar" rather than distributed solar (see 2019 Annual Energy Outlook, Electric Market Sector, Renewable Energy Generating Capacity and Generation).

290. The IRP analysis shows that renewable energy, distributed energy resources, battery storage, beneficial electrification, and energy efficiency can all play a role in meeting the potential capacity needs of the Tennessee Valley in ways that are cost-effective, less impactful on our environment, and respectful of utility grid constraints. Strategies that maximize the use of these resources, which can be scaled to meet the needs of the market without resulting in ratepayers being locked in to long-term investments in fossil fuel generation, should be prioritized. (*Commenter: Madeline Rogero – City of Knoxville*)

Response: Comment noted.

291. The confirmed closing of two additional coal-fired power plants, in particular the Bull Run Fossil Plant, will help the City of Knoxville make progress toward our emission reduction goals and have meaningful, positive impacts on local air quality and environmental health. TVA should prioritize strategies that achieve continued reduction in reliance on coal-fired generation. (*Commenter: Madeline Rogero – City of Knoxville*)

Response: Comment noted.

292. While it is encouraging to see continued reductions in carbon intensity through 2038 across all alternatives, it is clear from the IRP that TVA anticipates that fossil fuel resources will continue to provide a significant portion (37% - 39%) of Valley electricity for the next two decades. Constituents in Knoxville are challenging the City to significantly decrease carbon emissions and expand the use of zero-carbon clean energy. Many businesses across the Valley are committing to clean energy goals. TVA, working with local power companies (LPCs), should create and deploy opportunities for their customers (including cities like Knoxville) to expand and accelerate the use of zero-carbon energy sources in order to further reduce the portion of our electricity provided by fossil fuels. Such opportunities could take the form of green tariff programs or similar products that allow customers to directly invest in clean energy in ways that align with the needs of the regional and local utility grid.
(*Commenter: Madeline Rogero – City of Knoxville*)

Response: TVA has launched two programs to support accelerated renewable investment: Renewable Investment Agreement (RIA) and the Flexibility Research Project (FRP) pilot. RIA supports utility scale buildouts for large commercial and industrial customers and FRP supports community solar, in partnership with Local Power Companies. These programs are described in more detail in IRP Section 8.2.5. The IRP explored distributed generation and storage as resource options and the results help inform and provide flexibility for development of future distributed offerings by TVA and/or LPCs.

F.2.5.11 Strategy Evaluation Metrics

293. A successful IRP seeks to minimize total system costs without limiting customer choice, thus leading to the lowest possible customer costs. TVA is misguiding readers by including the Total Resource Cost in TVA's 2019 IRP metrics. This is a frankly patronizing analysis: customers may have very good reasons to invest in technologies such as building insulation, energy efficiency appliances, self-generation, or storage. These customer-driven investments help TVA reduce costs, and TVA should incentivize them appropriately. But TVA fails to include the customers' non-energy benefits - such as health, comfort, resilience, or values-based investing. Indeed, how would TVA comprehensively value such varied personal benefits? But by presuming to call this a "total resource cost" metric, TVA has adopted a patronizing attitude that these benefits are not part of the "total." It is not up to TVA whether customers should invest in such technologies beyond TVA's definition of economic rationality.

Customers who participate in EE programs will typically experience reduced bills as a result of investments in EE that substantially exceed the costs borne at the utility system level. Accordingly, TVA should restore its focus on a lowest system cost metric. The TVA Act is clear that TVA's resource planning process must aim for the lowest system cost. The act specifies that "the term 'system cost' means all direct and quantifiable net costs for an energy resource over its available life, including the cost of production, transportation, utilization, waste management, environmental compliance, and, in the case of imported energy resources, maintaining access to foreign sources of supply." Even given the skewed and opaque assumptions TVA used develop the potential supply portfolios under each Scenario and Strategy Case one thing is clear: investing in DERs and large-scale solar is the best option for the Valley. The cases with the lowest PVRR are those in the Economic Downturn Scenario and Rapid DER Adoption Scenario. (*Commenters: Maggie Shober – Southern Alliance for Clean Energy, Stephen Smith – Southern Alliance for Clean Energy*)

Response: The 2019 IRP aims to identify a portfolio that will meet the energy needs of the Valley at the lowest feasible cost. TVA remains focused on traditional cost metrics of present value of revenue requirements (PVRR) and the system average cost. However, with higher levels of distributed energy resources in a resource plan as dependable capacity and energy, it is prudent to consider the magnitude of cost that would be required to provide that resource. The Total Resource Cost metric highlights the additional cost net of energy benefits (over and above the TVA incentive within a given strategy) that would be borne by the Valley. TVA supports customer choice but seeks to avoid cost shifting between participants and non-participants.

294. A far better way to assess the differential land use of solar versus fossil-fired thermal generation would be to regard the tax base implications of different strategies. In the Draft IRP, TVA uses two different metrics as part of its evaluation of economics impacts to the TVA service territory of the different strategies modeled: the percentage difference in real per capita income, and the percentage change in employment. However, these metrics hinge quite closely on the same sort of data that informs the present value of revenue requirement, or PVRR, and as a result, neither offer much additional light in evaluating different strategies and outcomes, nor vary very much from strategy to strategy. Indeed, most of the percentage differences in real per capita income and percentage changes in employment cluster very close to the value "0.00%," deviating in general no further than to 0.01% or, less commonly, -0.01% on either side.

Instead, TVA should look at impacts to local tax bases. Construction of solar farms in rural areas can add significantly to the tax base for the poorer parts of TVA's service territory, providing injections of resources into local governments for use in schools, local infrastructure, and local police, fire, and other emergency services. All of that is likely to contribute to economic development in underserved communities, something entirely consistent with TVA's mission. As is, by focusing on Valley-wide aggregate employment impacts, TVA is unable to assess whether (as is likely) strategies that result in the construction of solar farms and/or distributed generation resources will help struggling areas even if more broad economic impacts across the region are less clear.

Studies examining the impact of wind energy generation in rural areas indicate the value of such a metric. As researchers at the Oklahoma State University Department of Agricultural Economics found, "wind energy systems can provide a significant increase to the tax base of a county, particularly rural counties . . . . each wind turbine provides the ad valorem tax base of hundreds of acres of unimproved land." That additional tax revenue is of critical importance in rural areas:

"This source of funding could provide significant benefits to school districts, particularly in a number of rural districts facing declining asset values or decreased revenues from mineral severance taxes. Further, given the nature of the long-term power purchase contracts under which wind generated electricity is sold and the relatively long life of wind energy assets, wind energy facilities can provide relatively stable sources of school revenue for significant periods of time."

These effects would play out similarly in rural areas of TVA's service territory where solar installations or other renewable generation facilities would be likely to be placed. There are locations, for example, like former industrial sites or abandoned commercial property (e.g., brownfields) where redevelopment with photovoltaic solar panels would enhance the property value, eliminate blight, allow for reestablishment of ground covering with local vegetation, and result in higher local and state property tax revenues that could be used to support public parks budgets. In addition, solar development in rural areas can result in new sources of income to ranchers and farmers, in the form of royalty payments from solar developers. This additional income has the benefit of being drought-proof and insulated from changes in national and international commodity prices.

Capturing the impact of such enhances to rural economies is critical to TVA's ability to accurately evaluate the economic development benefits that flow from a renewables-focused strategy. (*Commenter: Zachary Fabish – Sierra Club*)

Response: TVA is similar to other utilities in using the percentage difference in per capita income and the percentage change in employment. TVA's impact on these two metrics is small on the grand scale of the Valley economy. However, TVA will continue to test new metrics to capture additional or emerging economic benefits in future IRPs. Most of the renewable generating facilities from which TVA purchases power and that are currently under development in the Valley are in rural areas, and this facility siting trend is expected to continue in the future. TVA agrees that such facilities can result in important benefits to the local rural economies.

295. TVA's Draft IRP employs multiple different metrics to help TVA and the public evaluate the effect of the different strategies examined on TVA's environmental stewardship goals. Some of these metrics, such as emissions of greenhouse gases, are extremely valuable. Similarly, coal ash from coal-fired power stations must be managed properly regardless of the locations of its creation and disposal. As such, metrics such as quantities of greenhouse gas emitted or coal ash generated are useful ways of comparing the results of different strategies.

However, the "Land Use" metric, simply in terms of raw acres, is a poor metric for evaluating the IRP modeling results, as not all land is the same, and neither is all use. Relatedly, the metric fails to consider benefits that may flow from prudent use of land. Likewise, a focus on bare acres of land used by various strategies modeled tends to disfavor energy generation that may "use" significant land, but uses it only mildly.

First, whereas other aspects of the environmental metrics TVA employs in the Draft IRP are rooted in more-or-less fungible impacts, it is misleading at best and severely distorting at worst to focus a metric on acres of land used without reference to which acres are used, and how they are used. Quite obviously there is a huge difference between the use of an acre of brownfield, an acre of agricultural land, and an acre of virgin wilderness. Different parcels of land have different characteristics that are critical to evaluating the environmental harm that might flow from using them: the degree of prior development or degradation, the type and quality of ecosystem services provided by the land, and the historical, cultural, aesthetic, or ecological value of the land, to name but a few.

Further, the type of use of a parcel is a critical component of determining the impacts of that use on the parcel. An acre used for a solar farm is impacted far less than an acre used to store coal ash (or nuclear waste, for that matter). A solar farm need not be permanently emplaced on land, and does not involve the issues of soil contamination, groundwater seepage, or surface pollutant runoff that coal-related uses would entail; nor does installation of a solar farm require anywhere near the degree of land disturbance that constructing a coal ash impoundment would involve.

There is a great deal of information indicating that solar installations can have a very positive environmental impact on the land they are emplaced on. This can take the form of making agricultural land more economically viable (and therefore less susceptible to development pressures) as well as well-designed solar projects that can provide important land benefits. Studies at the National Renewable Energy Laboratory, North Carolina State University, and others show the potential benefits include revegetation of degraded land, reduced erosion, and, particularly when revegetated with native grasses and forbs, improved habitat for wildlife and pollinators. As shown in some of these studies, the land can also be returned to agricultural use after removal of the solar facility.

TVA's proposed metric elides all of these issues, despite the issues being acknowledged in the Draft EIS. In the Draft EIS, TVA notes that "building-mounted PV facilities would not require additional land and would have few other impacts," that tracking-system solar "can be built on brownfield, [or] cropland" with minimal impacts. Draft EIS at 5-14. TVA further observes that "[a]n increasing proportion of PV facilities have been and are expected to be constructed on cropland, where the amount of grading required to prepare the site is low relative to other land types." Id. Later, TVA states that:

"Despite the large land requirements of utility-scale solar facilities, which typically displace agricultural operations including grazing, or, to a much smaller extent forest, the impacts of solar facilities on the land are low relative to other types of generating facilities. The construction of solar facilities typically does not require extensive excavation and solar facilities have little associated permanent or semi-permanent infrastructure that hinders restoration of the site after the facility is dismantled."

Plainly, the "land use" metric does little else besides suggest that solar-favoring strategies use more land than solar-disfavoring strategies, without indicating whether or not that difference in quantity of acres used has any bearing on the quality of use, and attendant environmental harm or benefit. It is a misleading metric, and TVA should ignore it in evaluating the results of this IRP, and should not bother with employing it in future IRPs. (*Commenters: Zachary Fabish – Sierra Club, Joe and Sarah Schiller*)

Response: Metrics assist TVA in evaluating tradeoffs of resource portfolios. There is no weighting of metrics or quantitative scoring of portfolios. The land use metric is used to highlight the impact that resource decisions could have on land in the Valley. The IRP is a long-term resource plan for the Valley. Additionally, any specific projects during the implementation of the IRP will consider opportunities to use brownfield sites.

296. The IRP analysis of Total Resource Cost indicates that some strategies require additional investment from participants net of energy savings, driven by distributed energy resources such as energy efficiency and distributed generation. However, it is critical to recognize that there are a multitude of non-energy benefits that participants receive by participating in such programs. TVA should seek to include the value of non-energy benefits in its cost analyses in order to more accurately capture the true value of these programs to the Valley.

Especially in the case of low-income energy efficiency programs, including TVA's Home Uplift pilot, additional participant costs are borne not by the low-income families served but by supportive community partners, including the City of Knoxville, that provide leveraged funds for TVA's investment. These additional community investments are more than justified by a multitude of non-energy benefits such as improved health, improved quality and affordability of local housing stock, and financial stability. The aggregate value of these benefits accrues not just to participating families but also to the communities in which they live. (*Commenter: Madeline Rogero – City of Knoxville*)

Response: Non-energy benefits are difficult to quantify in a long-term Valley-wide energy resource plan. When specific projects are being considered, a full site-specific or project-specific economic analysis would be conducted and could consider additional community investments from partner organizations. The Total Resource Cost metric does not specify who would pay the additional investment but just highlights that there are additional costs to be borne by the Valley whether that is organizations, LPCs, communities, or individuals.

F.2.6 Other

F.2.6.1 Comments Out Of Scope

297. TVA should be left alone. It is a mistake to close it down. (*Commenter: Rhonda Brown*)

Response: Comment noted. The IRP does not propose closing TVA down.

298. Executive pay, and board pay should be closely examined. The assumption that greater pay means better management should be more closely examined. (*Commenters: William Harper, Sarah Houston, Millie O'Rourke, Diana Page*)

Response: Comment noted.

299. The amount of pesticides that you spray should be criminal. These substances are directly linked to lymphatic cancers, specifically childhood. The fact that you spray our land, soak our land actually, with these chemicals makes me so upset as it does many others. I ask that you please quit spraying toxic, cancer causing chemical on our land. This is not unfounded, this is proven information. (*Commenters: Leah Larabell, Sharon Rush*)

Response: Comment noted. For more information about TVA's use of pesticides and other vegetation management practices please see TVA's Transmission System Vegetation Management Program website at and the draft Transmission System Vegetation Management Programmatic EIS.

300. TVA needs to be encouraging the cooperatives in Tennessee to move forward with providing broadband Internet access, not standing in the way. (*Commenter: Jason Waldo*)

Response: Comment noted. While outside the scope of the IRP, TVA notes that it is currently in the process of expanding its fiber capacity. In addition to improving the reliability and resiliency of TVA's transmission system, this expansion is expected to assist with economic development opportunities in the valley. TVA will continue to partner with states, local power companies, and other service providers to provide these opportunities.

301. TVA should continue to guard the power generation network from saboteurs from either inside and outside the country. (*Commenter: Jeff Coppala*)

Response: Comment noted. Protecting the health and safety of the public and TVA employees, as well as maintaining the security of TVA's facilities, continues to be a top priority. TVA has a comprehensive cybersecurity program aligned to industry best practices that operates to predict, protect, detect and respond to threats. In addition to having multi-layered threat analysis capabilities, TVA performs continuous monitoring, penetration testing and vulnerability assessments.

302. Climate change denial is a popular public opinion. (*Commenter: Celia Mackey*)

Response: Comment noted.

303. Alabama has passed a law against Agenda 21 and Alabama became the first state to adopt a tough law protecting private property and due process by prohibiting any government involvement with or traceable to 'Agenda 21,'The Alabama Senate Bill (SB) 477 legislation, known unofficially as the "Due Process for Property Rights" Act. The law, aimed at protecting private property rights, specifically prevents all state agencies and local governments in

Alabama from participating in the global scheme in any way. TVA is pushing a rate structure where users are charged a different rate depending on the hour of the day and 'Green Premium' charges. Consider this to be the served Notice the TVA Board of Directors and will expect a reasonable reply within 30 days of their reception of this notice. (*Commenter: Donald Boxley*)

Response: Comment noted. The scope of TVA's IRP does not address potential changes to the rate structure.

F.3 Index of Commenters

Following is a list of the commenters, their affiliations, and the identification number(s) of the comment statements to which they contributed. In a few cases, handwritten names were difficult to read and the names listed below are TVA's best interpretations. This index is divided into two sections. The first section lists those who submitted individual comments. Form-style comments are identified by the name of the form (as listed above in Chapter 1 of Appendix F). The second section lists the signers of each of the form-style comments.

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F.3.2 Form Commenters

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Abrams, Judith, New York, NY; Arnoult, Catherine, Memphis, TN; Arnoult, Leo, Memphis, TN; Burch, Emily, Clayton, MO; Davis, Ann, Memphis, TN; Davis, Jennifer, Jackson, WY; Davis, Lynn, McMinnville, TN; Hubbard, Lynn, Seattle, WA; LaVelle, Herman, Memphis, TN; Lavelle, Lindsay, Memphis, TN; Lavelle, Vance, Memphis, TN; Lightman, Suzana, Memphis, TN; Neu, Margaret, New York, NY; Ragsdale, Katherine, Nashville, TN; Waterfield, Steven, Seattle, WA

F.3.2.2 Tennessee Chapter of The Sierra Club Campaign Online Form

Abel, Sandra, Walland, TN
Ackley, Sandy, Tullahoma, TN
Acosta, Heather, Kingsport, TN
Adams, Karis, Lexington, TN
Addis, Barbara, Knoxville, TN
Ahmed, Tarik, Knoxville, TN
Akselrad, Kathleen, Hilham, TN
Aldridge, Saundra, Huntsville, AL
Alegre, Joe, Chattanooga, TN
Alexander, Dana, Arlington, TN
Alexiades, V., Knoxville, TN
Allen, Joseph, Nashville, TN
Allison, Dianne, Huntsville, AL
Amos, Ashley, Sweetwater, TN
Ananka, Maryia, Chattanooga, TN
Andersen, Susan, Hermitage, TN
Anderson, Betty, Bowling Green, KY
Anderson, Sherry, Clinton, TN
Anthony, Kate, Ringgold, GA
Armes, Hal, Sardis, MS
Armour, Ellen, Nashville, TN
Armstrong, Kathy, Hermitage, TN
Arnett, Brian, Starkville, MS
Arnett, James, Nashville, TN
Atha, Patty, , AL
Atkins Jr., John H., Morristown, TN
Atkinson, Eileen, Clarkrange, TN
Austin, Debra, Jefferson City, TN
B., Christine, Gastonia, NC
Baccheschi, Belle, Greeneville, TN
Bagwell, Amy, Germantown, TN
Baisden, Ronald, Johnson City, TN
Baker, Angie, Brentwood, TN
Baker, Kellie, Franklin, TN
Baker, Kristina, Southaven, MS
Bakewell, Deborah, Brentwood, TN
Bales, Elliott, Hixson, TN
Balog, Amy, Pikeville, TN
Banbury, Scott, Memphis, TN
Barber, Ann, Knoxville, TN
Barham, Kristy, Dyersburg, TN
Barnes, Paula, Memphis, TN
Barnes, Rachael, Bristol, TN
Barritt, Jim, Shelbyville, TN
Baxter, Michaela, Cookeville, TN

Beaver, Amanda, Chattanooga, TN
Beavers, Nancy, Woodlawn, TN
Beck, Charles, Chattanooga, TN
Beckman, Emily, Murfreesboro, TN
Behn, John, Columbia, TN
Bell, Janine, Drummonds, TN
Bell, Ramie, Memphis, TN
Bellamy, Flo, Mountain City, TN
Benedetti, Caroline, Knoxville, TN
Bennett, Teresa, Livingston, TN
Benshoof, Rob, Nashville, TN
Bentley, Marianne, Nashville, TN
Bertin, Hector, Whiteville, TN
Berton, Helene, Oxford, MS
Bevels, Terry, Fayetteville, TN
Bidwell, Troy, Knoxville, TN
Bishop, Ann, Millington, TN
Bishop, Mark, Clinton, TN
Blackman, Pat, Owens Cross Roads, AL
Blevins, Vicki, Bristol, TN
Blohm, Bruce, Chattanooga, TN
Bordenkircher, David, Nashville, TN
Boring, Rita, Mc Donald, TN
Bott, Margaret, Spring City, TN
Bourassa, Veronica, Evensville, TN
Bowden, Deanna, Brentwood, TN
Bowen, Dianne, Memphis, TN
Bowen, Nigel, Lakeland, TN
Bowers, Gary, Nashville, TN
Bowers, Joe, Santa Fe, TN
Bowman, Megan, Calhoun, GA
Bowman, Tim, Calhoun, GA
Bradfield, Susan, Franklin, TN
Bradley, Laura, Oxford, MS
Bradley, Rhonda, Crossville, TN
Bragg, Laurie, Huntsville, AL
Branham, Mary, Knoxville, TN
Brawner, Debbie, Nashville, TN
Brehmer, Rebecca, Knoxville, TN
Breon, David, Murfreesboro, TN
Brewer, Leann, Walland, TN
Brichetto, Joanna, Nashville, TN
Brinson, Solange, Memphis, TN
Bristow, Mary, Brentwood, TN
Brooks, Janet, Chattanooga, TN
Brooks, Janice, Memphis, TN
Brooks, Karl, Harrison, TN
Brooks, Ralph, Knoxville, TN
Brown, Forrest, Nashville, TN
Brown, Jason, Kingston, TN
Brown, Kathleen M, Summertown, TN
Brown, Shirley, Maryville, TN
Brown, Steve, Piney Flats, TN
Brown, Tracy, Lenoir City, TN
Brown-Hall, Jennifer, Greeneville, TN
Browning, Leah, Fairview, TN
Bryan, Jillian, Mosheim, TN
Bryson, Linda, Chattanooga, TN
Buckley, Helen, Chattanooga, TN
Buckley, Marguerite, Bristol, TN
Burford, Ellen, Senatobia, MS
Burgdorf, Jeri, Nashville, TN
Burks, John, Hixson, TN
Burks, Neely, Nashville, TN
Burleson, Tony, Maryville, TN
Burris, Heather, Rogersville, TN
Busby, Chris, Watertown, TN
Butler, David, Hermitage, TN
Byrne, C, Huntsville, AL
Caldwell, Tiffany, Amory, MS
Calton, Rhonda, Church Hill, TN
Calton, Valorie, Russellville, TN
Campbell, Jack, Madison, AL
Campbell, James Michael, Spring City, TN
Campbell, Nathan, Tullahoma, TN
Campbell, Shannon, Ringgold, GA
Capps, Stephanie, Nashville, TN
Caraway, Morgan, Chattanooga, TN
Carlough, Bob, Butler, TN
Caroenter, Jamie, Murfreesboro, TN
Carpenter, Stacy, Nashville, TN
Carr, John, Chapmansboro, TN
Carr, John, Nashville, TN
Carroll, Sandra, Shelbyville, TN
Carter, Julia, Huntsville, AL
Carter, Karen, Crossville, TN
Carter, Steve, Bell Buckle, TN
Casey, Paula, Clifton, TN
Cash-Procell, Gloria, Huntsville, AL
Caskey, Mark, Memphis, TN
Casteel, Mark, Knoxville, TN
Castle, Zachary, Nashville, TN
Cerutti, Chloe, Murfreesboro, TN
Chambers, Nicole, La Vergne, TN
Chance, Sherry, Lebanon, TN
Chandler, Gregory, Huntsville, AL
Chapdelaine, Perry, Ashland City, TN
Chasteen, Jessica, Kingston, TN
Cherich, Carol, Clarksville, TN
Chevedden, Judith, Spring Hill, TN
Christison, Nicole, Murfreesboro, TN
Christmas, Teresa, Bowling Green, KY
Clark, Donald, Pleasant Hill, TN
Claudio, Jessica, Hixson, TN
Clausen, Marlene, Chattanooga, TN
Clelland, Kellie, Memphis, TN
Cloud, Barbara, Nashville, TN
Coles, Nathan, Brentwood, TN
Collier, Janet, Spring City, TN
Comstock, Chuck, Johnson City, TN
Congelosi, Susan, Blowing Rock, NC
Cook, Anders, Knoxville, TN
Cook, James, Murfreesboro, TN
Cookston, Gary, Whitwell, TN
Coombs, Joyce, Corryton, TN
Cooper, Suzanne, Nashville, TN
Coppinger, June, Chattanooga, TN
Cordell, Ruth, Bell Buckle, TN
Corrigan, Dr. Peter L., Starkville, MS
Cosby, Cheryl, , TN
Costello, Michael, Knoxville, TN
Cotter, Trey, Chattanooga, TN
Counts, Kristina, Franklin, TN
Courtney, Susan, Andersonville, TN
Cowan, Margaret, Bristol, TN
Cox, Michael, Oakland, TN
Craft, Don, Huntsville, AL
Croft, Keith, Nashville, TN
Cross, William, Memphis, TN
Crow, Charles & Dinah, Cumberland City, TN
Crutcher, Buford, Harvest, AL
Cruze, Lynn, Bean Station, TN
Cunningham, Elizabeth, Cleveland, TN
Cunningham, Steve, Memphis, TN

Curl, Teresa, La Fayette, GA
Curtis, Anne, Chattanooga, TN
Dacus, Chris, Bell Buckle, TN
Dalton, Hunter, Morristown, TN
Daniel, Gail, Camden, TN
Darby, Michael, Knoxville, TN
Dare, Cheryl, Memphis, TN
Davis, Joanna, Murfreesboro, TN
Day, Ida, Knoxville, TN
Dean, Jeffrey, Bruceton, TN
Dean, Susan, Monteagle, TN
Decaprio, Alexis, Delano, TN
Delap, Ann, Knoxville, TN
Deshazer, William, Nashville, TN
Detmer, Carol Michler, Murfreesboro, TN
Devine, Jason, Nashville, TN
Dias, Renee, Nashville, TN
Dishman, Patricia, Nashville, TN
Dobbs, Jamey, Knoxville, TN
Dobson, Mary-Lynn, Rockwood, TN
Dodson, Carolyn, Signal Mtn, TN
Dollar, Julie, Chattanooga, TN
Donegan, Shahn, Hermitage, TN
Donegan, Teresa, Lebanon, TN
Donnell, Evans, Nashville, TN
Doochin, Dianne, Nashville, TN
Dornfeld, Robert And Sandra, Athens, TN
Dorsett, Gina, Flintstone, GA
Douglas, Susan, Huntingdon, TN
Dout, Ed, Chickamauga, GA
Draper, Jonathan, Nashville, TN
Draper, Karen, Murfreesboro, TN
Drew, Craig, Chattanooga, TN
Driscoll, Sondra, Maryville, TN
Drummond, Sarah, Knoxville, TN
Drumright, Chris, Murfreesboro, TN
Dube, Margaret, Memphis, TN
Duley, Caroline, Nashville, TN
Duncan, Donna, Lebanon, TN
Dunn, Larry, Cleveland, TN
Dunson, Debra, Spring Hill, TN
Easter, Darrel, Bartlett, TN
Echevarria, Mari T., Knoxville, TN
Ehlers, Allen, Nashville, TN
Elder, Binji, Nashville, TN
Elder, Harriet, Nashville, TN
Elfin, Julie, Knoxville, TN
Elkins, Judy, Puryear, TN
Elliott, Joan, Johnson City, TN
Ellis, Lynn, Knoxville, TN
Essary, Sharon, Knoxville, TN
Evans, Sheila, Church Hill, TN
Everhart, Aubrey, Bristol, TN
Faatz, Sharon, Chickamauga, GA
Faby, Ellen, Clinton, TN
Fairstein, Joel, Oak Ridge, TN
Farmer-Brown, Loretta, Memphis, TN
Faulkner, Susan, Nashville, TN
Fell, Samuel, Estill Springs, TN
Fidler, Gabriel, Maryville, TN
Fingerman, Robert, Monteagle, TN
Finney, Ellen, Franklin, TN
Fisher, Judy, Nashville, TN
Fishman, John, Huntsville, AL
Fister, Alan, Brentwood, TN
Fitzgerald, Marian, Maryville, TN
Fleming, Nick, Nashville, TN
fletcher, Ashley, Spring Hill, TN
Fletcher, Herman, Sevierville, TN
Forbes, C S, Harriman, TN
Foster, Rebecca, Nashville, TN
Fowler, Ben, Nashville, TN
Fowler, Jacqueline, Knoxville, TN
Fowles, Aaron, Memphis, TN
Franklin, Kathy, Kingsport, TN
Franklin, Margaret, Collierville, TN
Franklin, Yvette, Knoxville, TN
Frey, Adrienne, Franklin, TN
Fuller, Leslie, , TN
Fuller, Leslie, Memphis, TN
Furino Sr, Gary, Tazewell, TN
Gafni, Leah, Memphis, TN
Gallacher, C, Louisville, TN
Gallo, Susan, Chattanooga, TN
Gandulla, Luis, Oak Ridge, TN
Gardner, Kent, Elizabethton, TN
Garland, Pete, Signal Mountain, TN
Gassel, Elizabeth, Knoxville, TN
Gaudin, Timothy, Hixson, TN
Gayk, David, Knoxville, TN
gelbard, e, university, MS
George, David, Memphis, TN
George, Michael & Frances, Athens, TN
Giagnorio, Corinne, Chattanooga, TN
Gibson, Gordon, Knoxville, TN
Gillies, Phoenix, Murfreesboro, TN
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Goehl, William, Rogersville, TN
Goehler, Lee, Athens, AL
Goetze, Anne, Franklin, TN
Gourley, Sherry, Smyrna, TN
Graham, Brian, Arrington, TN
Graves, Emily, Memphis, TN
Green, Elizabeth, Pigeon Forge, TN
Green, Kathy, Murfreesboro, TN
Green, Patricia, Nashville, TN
Gregg, Judy, Kodak, TN
Gregory, Jessica, Knoxville, TN
Griffith, Gloria, Mountain City, TN
Gronendyke, Cassandra, Cookeville, TN
Grose, Tom, Nashville, TN
Groton, James, Oak Ridge, TN
Guenst, John, Franklin, TN
Gugino, Jack, Knoxville, TN
Gulick, Leslie, Sparta, TN
Gunter, Kalita, Erin, TN
Guyot, Shannon, Bartlett, TN
Hacker-Cerulean, Jeannie, Lupton City, TN
Hale, Dinsie, Murfreesboro, TN
Hall, Alan, Nashville, TN
Hall, Betsy, Mount Juliet, TN
Hamachek, Courtnay, Knoxville, TN
Hamilton, Chuck, Chattanooga, TN
Hamilton, Kirby, Rockwood, TN
Hamilton, Laura, Huntsville, AL
hamilton, robert, Lebanon, TN
Hammel, John, Pulaski, TN
Hanahan, Debra, Franklin, TN
Hanks, Thomas, Franklin, TN
Hans, David, Antioch, TN
Happel, Robin, Johnson City, TN
Hardesty, Marita, Kingston Springs, TN
Harmon, Patricia, Knoxville, TN

Harper, Rodney, Louisville, TN
Harrell, Elizabeth, Hixson, TN
Harrelson, David, Centerville, TN
Harrington, Renee, Springfield, TN
Harris, Karl, Collierville, TN
Harris, Ron, Morristown, TN
Hartert, Nathalie, Nashville, TN
Hartman, Jason, Clarksville, TN
Harvey, Janie, Knoxville, TN
Hatcher, Cindy, Bumpus Mills, TN
Hathcock, Susan, Lenoir City, TN
Hausler, Hadyn, Chattanooga, TN
Haverland, Michelle, Thorn Hill, TN
Hawkins, John, Nashville, TN
Heald, Mark, Pleasant Hill, TN
Heald, Mark And Jane, Pleasant Hill, TN
Helfman, Laura, Coalmont, TN
Hemmings, July, Hendersonville, TN
Henderson, Jenna, Nashville, TN
Henley, Gail, Madisonville, TN
Hensley, Bobbie, Greeneville, TN
Heppel, Carolyn, Memphis, TN
Herrmann, Lesley, Nashville, TN
Herron, Jane, Franklin, TN
Hewitt, Bobbie, Lenoir City, TN
Hill, Kathryn, Maryville, TN
Hilton, Taylor, Gallatin, TN
Hilton, Thomas, Mt Juliet, TN
Hipps, Barbara, Memphis, TN
Hoisington, Daniel, Nashville, TN
Holder, Carla, Harvest, AL
Holland, Jonathan, Crossville, TN
Holley, Terry, Knoxville, TN
Holmes, Sharon, Elizabethton, TN
Hood, Shelby, Franklin, TN
Hood, Shelby L., Franklin, TN
Hooten, Frances, Millington, TN
Hopper, Kerith, Lebanon, TN
Horn, Dane, Loretto, TN
Hornsby, Julie, Nashville, TN
Howes, Laura, Knoxville, TN
Hubbard, Amy, Knoxville, TN
Hubbard, Ralph, Clinton, TN
Hubbard, Ron L, Jasper, TN
Hudson, Alice, Lakeland, TN
Hughes, Gene, Johnson City, TN
Hughes, Karen, Knoxville, TN
Hughes, Melvin, Sparta, TN
Hunter, Sonja, Lebanon, TN
Hunter, Terry, Cullman, AL
Hutcheson, Brad, Chattanooga, TN
Hutcheson, Madalena, Portland, TN
Hyer, Nicholas, Starkville, MS
Ibur, Patty, Summertown, TN
Ihrke, Ashley, Clarksville, TN
Inness, Linda, Philadelphia, TN
Iovino, Teresa, Germantown, TN
Irvine, Charles, Knoxville, TN
Isackson, Celeste, Nashville, TN
Jackson, Ruth, Knoxville, TN
Jacques, David, Nashville, TN
Jaggers, Ronnie, Bowling Green, KY
Jaloszynski, Patricia, Maryville, TN
Janac, Cindy, Sevierville, TN
Jardine, Julia, Lebanon, TN
Jarrell, Todd, Nashville, TN
Jernigan, Pam, Oak Ridge, TN
Johnson, Andrew, Franklin, TN
Johnson, Andy, Franklin, TN
Johnson, Dianne, Ashland City, TN
Johnson, Savannah, Tullahoma, TN
Johnston, Jean, Decatur, TN
Johnston, Susan, Nashville, TN
Jones, Edward, Memphis, TN
Jones, Gloria, Dickson, TN
Jones, Travon, Jackson, TN
Joong, Wu, Murfreesboro, TN
Joranko, Joyce, Nashville, TN
Joslin, Tracy, Knoxville, TN
Judy, Rebecca, Knoxville, TN
Kalinowski, Catherine, Hixson, TN
Kaplan, Linda, Germantown, TN
Katims, Carl, Loudon, TN
Kays, Keith, Memphis, TN
Kendrick, Cindy, Knoxville, TN
Kennedy, Kimberly, Lancing, TN
Kennedy, Russell, Knoxville, TN
Kennedy, William And Virginia, Jonesborough, TN
Kent, Timothy, Knoxville, TN
Kevlin, Robyn, Springfield, TN
Kewatt, Lindy, Huntsville, AL
Key, Katherine, Knoxville, TN
Keyser, Donald, Johnson City, TN
Khalsa, Ajeet, Knoxville, TN
Kieran, Mark, East Ridge, TN
Kilby, Suzanne, Dickson, TN
Kilgore, Sandra, Greenback, TN
King, Greg, Mount Carmel, TN
King, Margaret, Cunningham, TN
Kinkead, Lane, Erwin, TN
Kitto, Sabrina, Johnson City, TN
Kittrell, Sarah, Knoxville, TN
Kluttz, Jenalee, Ooltewah, TN
Kneese, Kash, Hendersonville, TN
Knisley, Brianna, Knoxville, TN
Knowles, Robert, Lebanon, TN
Knudson, Kathy, Chattanooga, TN
Koban, Alan, Memphis, TN
Koczaja, Catherine, Franklin, TN
Kopkin, Zach, Boone, NC
Kornrich, William, Sneedville, TN
Kramer, Laura, Hermitage, TN
Kraus, Benjamin, Nashville, TN
Krebs, Sally, Sewanee, TN
Kryah, Damaris, Strawberry Plains, TN
Kulaw, Gary, Decatur, AL
Kunz, Daniela, Franklin, TN
Lampman, Gary, Hendersonville, TN
Lane, Ann, Huntsville, AL
Lane, Charles, Knoxville, TN
Laney, Joan, Memphis, TN
Langley, Robert, Kingston, TN
LaRue, Janey, Powell, TN
Latimer, Jim, Hendersonville, TN
Learch, Lynn, Louisville, TN
Lease, Anthony, Signal Mountain, TN
Lee, Carol, Knoxville, TN
Lee, George, Kingsport, TN
Lequire, Alan And Andree, Nashville, TN
Levin, Nell, Nashville, TN
Lewis, Frank, Booneville, MS
Lewis, Gloria, Brentwood, TN
Lindsay, Hilary, Nashville, TN
Lingerfelt, Susan, Athens, TN
Linn, Mary, Nashville, TN
Linville, Don, Erwin, TN

Lippard, Michael, Franklin, TN
Lipson, Steven, Nashville, TN
Lockhart, Kristy, Jasper, TN
Loller, Richard, Nashville, TN
Loller, Sherry, Nashville, TN
Lollis, Edward, Knoxville, TN
Long, Stephanie, Murfreesboro, TN
Lopez, Chris, Nashville, TN
Lott, Sheila, Jonesborough, TN
Lowry, Michael, Chattanooga, TN
Lucio, Robert, Memphis, TN
Lumsden, Caron, Germantown, TN
Lupton, Sylvia, Dandridge, TN
Lynn, James, Cookeville, TN
Lyons, Sharon, Allardt, TN
M, Amy, Rogersville, TN
M, Frances, Rogersville, TN
Maasberg, David, Vonore, TN
Mace, Charles, Nashville, TN
Mack, Roscoe, , TN
Magallanes, Matthew, Franklin, TN
Magnin, Michael, Nashville, TN
Maguire, Sean, Knoxville, TN
Malone, Annalea, Chattanooga, TN
Mann, Dorothy, Clarksville, TN
Mann, Margaret, Clarksville, TN
Marcec, Wen, Nashville, TN
Markum, Karen, Reliance, TN
Marshall, Trish, Nashville, TN
Mart, Leslie, Tupelo, MS
Martin, Chandra, Knoxville, TN
Martin, Ellen, Whitleyville, TN
Martinez, Lorraine, Indian Mound, TN
Marting, Diane, Oxford, MS
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Marziotti, James, Andersonville, TN
Masar, Jacki, Louisville, KY
Mattern, Daniell, Oxford, MS
Matthews, David, Nashville, TN
Maxwell, Bonnie, Tullahoma, TN
Mccabe, Bill, Eidson, TN
Mccall, Cyndi, Knoxville, TN
Mccallie, Tresa, Chattanooga, TN
Mccarl, Patricia, Hartsville, TN
Mccarty, Candace, Spring Hill, TN
Mccathie, Kelsey, Germantown, TN
McCombs, Genie and Bob, Kingston, TN
Mccoy, Rachel, Cordova, TN
McCrea, Sandra, Signal Mountain, TN
McGraw, Dave, Memphis, TN
McIntosh, Douglas, Clarksville, TN
McIntosh, Emily, Clarksville, TN
McIntosh, JoAnn, Clarksville, TN
McIntyre, Karen, Nashville, TN
McKennon, Henry, Huntsville, AL
Mckinney, Kathryn, Huntsville, AL
Mckown, Todd, Blountville, TN
McLean, Nancy, Nashville, TN
Mcmillin, Chester, Bartlett, TN
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Megill, Carrie, Murfreesboro, TN
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Mercieca, Charles, Huntsville, AL
Merical, Rick, Mooresburg, TN
Merrill, Rakim, Ashland City, TN
Meyer, Jean, Okolona, MS
Meyer, Roger, Chattanooga, TN
Michael, Genevieve, Maryville, TN
Miller, Brenda, Hendersonville, TN
Miller, Jena, Sevierville, TN
Miller, Jennifer, Hendersonville, TN
Miller, Lara, Knoxville, TN
Mills, Sharon, Chattanooga, TN
Minault, Kent, Knoxville, TN
Minnick, Judy, Madisonville, TN
Mitchell, Jan, Hendersonville, TN
Mitchell, Jonathan, Madison, AL
Mogul, Judith, Chattanooga, TN
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Montgomery, Joyce, Knoxville, TN
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Neilsen, Nancy, Maryville, TN
Nelson, Katherine, Nashville, TN
Neubauer, Karen, Huntsville, AL
Nevins, Laura, Burns, TN
Newberry, David Blane, Clarksville, TN
Newburn, Phyllis, Jackson, TN
Newburn, Pj, Jackson, TN
Newkirk, Linda, Huntsville, AL
Nichols, Donald, Pikeville, TN
Nichols, Eric, Memphis, TN
Nicks, Mara, Owensboro, KY
Noethen, Scott, Knoxville, TN
Noon, Gail Marie, Ringgold, GA
Norris, Adriana, Nashville, TN
Novo, Jennifer, Mount Juliet, TN
Nowell-Ilgner, Jane, La Vergne, TN
Oaks, Sara, Cordova, TN
O'Callaghan, Kieran, Clarksville, TN
O'Connor, Susan, Cookeville, TN
Ogden, Robert, Hohenwald, TN
O'Kelley, Shayna, Russellville, KY
Oliver-Moseley, Patti, Lancaster, TN
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organ, maureen, Whites Creek, TN
Orr, C, Sneedville, TN
Orr, Randy, Sneedville, TN
Osborne-Parris, Caitlyn, Murfreesboro, TN
Ottinger, Nathan, Greeneville, TN

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Pugh, Dorothy, Memphis, TN
Purser, Linda, Memphis, TN
Pyle, Edwin, Nashville, TN
Radford, Lee, Birchwood, TN
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Raspet, Richard, Oxford, MS
Rastall, Rodney, Memphis, TN
Ray, Evans, Tullahoma, TN
Raymer, Sarah, Lenoir City, TN
Reaves, Greg, Tullahoma, TN
Reece, Kenneth, Knoxville, TN
Reed, Betsy, Chattanooga, TN
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Rees, Jamesen, Chattanooga, TN
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Ress, Tom, Athens, AL
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Rhodes, Margaret, Knoxville, TN
Rhoton, Yvette, Memphis, TN
Riall, David, Chattanooga, TN
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Rigell, Juli, Maryville, TN
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Ringe, Axel, New Market, TN
Roath, C Ray, Mount Juliet, TN
Robbins, Lori, Southaven, MS
Robertson was, Nora, Johnson City, TN
Robinson, Eric, Memphis, TN
Rodman, Judy, Nashville, TN
Rogers, John, Loudon, TN
rookard, curt, Oak Ridge, TN
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Ross, Linda, Memphis, TN
Rowe, Sarah, Nashville, TN
Rowlett, Virginia, Knoxville, TN
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Runyan, Bill, Memphis, TN
Rushton, Emma, Nashville, TN
Russell, B, Madison, AL
Russell, Liane, Oak Ridge, TN
Sabbatini, Harriet, , TN
Sabbatini, Sallie, Memphis, TN
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Scheer, Steven, Germantown, TN
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Short, Nathan, Memphis, TN
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Sink, Jill, Nashville, TN
Skaggs, Richard, Knoxville, TN
Slack, Carol, Jackson, TN
Slattery, Megan, Nashville, TN
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Smith, Annetta, Memphis, TN
Smith, Ian, Memphis, TN
Smith, Karen, Cedar Hill, TN
Smith, Michael, Hendersonville, TN
Smith, Shana, Martin, TN
Snell, Barbara, Gallatin, TN
Snook, Lynda, Kingsport, TN
Soskel, Norman, Germantown, TN
Sparks, Cath, Nashville, TN
Spears, Hubert, Oxford, MS
Spence, Kelley, Nashville, TN
Spitalny, Cheri, Chattanooga, TN
Spooner, Megan, Chickamauga, GA
Sprouse, Nicholas, Bowling Green, KY
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Stanfill, Mark, Knoxville, TN
Stann, Dana, Nashville, TN
Stayton, Ken, Nashville, TN
Stebbins, Tracy, Starkville, MS
Steffek, Thomas, Memphis, TN
Steiner, Pamela, Ringgold, GA
Steitz, Jim, Gatlinburg, TN

Steitz, Jim, TN
Stephenson, Kenneth, Knoxville, TN
Stephenson, Nathaniel, Knoxville, TN
Stephenson, Tommi, Nashville, TN
Stevens, Catherine, Memphis, TN
Stokes, Allen, Clinton, TN
Stollberg, Horst, Blountville, TN
Stone, Darby, Harvest, AL
Strader, Bud, Rockwood, TN
Stranch, Grace, Nashville, TN
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Sturis, Robin, Crawford, TN
Sugg, Ben, Maryville, TN
Sumner, Michael, Germantown, TN
Swartz, Eric, memphis, TN
Swearengen, Catherine, Memphis, TN
Sweatt, Sweatt, Cookeville, TN
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Sykes, Kevin, Madison, TN
Talley, Don, Memphis, TN
Tan, Hiedi, Knoxville, TN
Tan, Hiediliza, Knoxville, TN
Tatum, Andrea, Martin, TN
Terre, Karen, Memphis, TN
Thamann, Rose, Knoxville, TN
Thayer, Rachel, Chattanooga, TN
Thomas, Elizabeth, Lenoir City, TN
Thomas, Lisa, Maryville, TN
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Thompson, Rosa, Culleoka, TN
Thornton, Reese, Newport, TN
Tidwell, Miranda, College Grove, TN
Tieck, Cynthia, Nashville, TN
Tift, Linda, Chapel Hill, TN
Tine', Tina, Knoxville, TN
Tipton, Samuel, Knoxville, TN
Tittle, Richard, Kingsport, TN
Tobey, Kathy, Nashville, TN
Tobey, Prentice, Sharps Chapel, TN
Tomlin, Curtis, Chattanooga, TN
Tracy, William, Nashville, TN
Trapp, Charlie, Memphis, TN
Tresp, Sister Rose Marie, Belmont, NC
Trotsky, Matt, Murfreesboro, TN
Trupiano, Joann, Sevierville, TN
Turco, Sharon, Germantown, TN
Turnbull, Jessica, Nashville, TN
Turner, Betty, Memphis, TN
Turner, Carroll, Ooltewah, TN
Turner, Gina, Memphis, TN
Turner, Jesse, Kingsport, TN
Turner, Paul, Kingsport, TN
Tursich, Anna, Sneedville, TN
Turvy, Chris, Franklin, TN
Umbarger, Sue, Summertown, TN
Utley, Linda, Camden, TN
VADEN, N0RMAN, Byhalia, MS
Vaden, Norman, Byhalia, MS
Valentine, Luke, Newport, TN
Valesky, Kathleen, Brentwood, TN
Vanacore, Sandi, Monterey, TN
Vandam, Scott, Roan Mountain, TN
Vaught, Kevin, Antioch, TN
VENEGAS, LISA, Nashville, TN
Vescovo, Kristen, Arlington, TN
Vi8, Cay8, TN
Vickers, Terry, Jonesborough, TN
Villeneuve, Michele, Kingsport, TN
Vinett, William, Nashville, TN
voorhis, Ken, Sevierville, TN
Wadkins, Jack, Tuscumbia, AL
Walden, Hannah, Scottsboro, AL
Walker 2nd, Joseph, Bartlett, TN
Wallace, Beth, Thorn Hill, TN
Wallace, Pam, Greeneville, TN
Walton, Paulette, Butler, TN
Wampler, Angela, Kingsport, TN
Wanger, Kathryn, Franklin, TN
Ward, Martha, Gatlinburg, TN
Ward, Yvonne, Evensville, TN
Warner, Teresa, Bon Aqua, TN
Warren, Grady, Lawrenceburg, TN
Warren, Patrick, Memphis, TN
Washburn, Jeffery, Dresden, TN
Wasilew, James, Louisville, TN
Watkins, Haleigh, Cookeville, TN
Watson, Austin, Goodlettsville, TN
Watson, Brady, Knoxville, TN
Weaver, Jessica, Nashville, TN
Webb, Sam, Knoxville, TN
Weber, Lori, Johnson City, TN
Wedekind, Moira, Maryville, TN
Wenger, Larry, Cleveland, TN
Werling, Alexa, Madison, AL
Werner, Rob & Mary Ellen, Cullman, AL
Wesche, Justin, Memphis, TN
West, Elizabeth, Pickwick Dam, TN
West, Rest, Oxford, MS
Westbrooks, Rickey, Hohenwald, TN
Wheeler, Cleveland, Soddy Daisy, TN
Wheetley, Kim, Chattanooga, TN
White, Carol, Scottsboro, AL
White, Reba, Chattanooga, TN
Whittaker, Nancy, Cordova, TN
Whittle, Alexander, Madison, TN
Wicker, Jessica, Birchwood, TN
Widmer, Leah, Starkville, MS
Wieland, Paul, Huntsville, AL
Wierschem, Rebecca, Knoxville, TN
Wilding, Joyce, Kingston Springs, TN
Wilkin, William, Nashville, TN
Wilkins, Matthew, Nashville, TN
Willett, Cynthia, Smyrna, TN
Williams, Elena, Memphis, TN
Williams, John, Nashville, TN
Williams, Marilyn, Cullman, AL
Williams, Patricia H, Nashville, TN
Williams, Susan, Halls, TN
Williams, Tamala, Athens, AL
Williams, Thomas, Bowling Green, KY
Williams, Wayne, Knoxville, TN
Williams, William, Clinton, TN
Williams-Mooradian, Kathleen, Nashville, TN
Wilson, Brian, Hixson, TN
Wilson, Linda, Eads, TN
Wilson, Martha & Glen, Brentwood, TN
Wilson, Wade, Oneida, TN
Winfield, Charlie, Arlington, TN
Winther, Evelyn, Knoxville, TN
Wohlgemuth, Jim, Nashville, TN
Wolfe, Vickie, Butler, TN
Woods, Rocquelle, Huntsville, AL
Woolf, Genesis, Mountain City, TN

Wrye, Susan, Nashville, TN
Wuichet, Charlotte, Amory, MS
Wyatt, John, Tellico Plains, TN
Yarber, Tammy, Kingsport, TN
Young, Melanie, Waterford, MS
Zielinski, Amy, Crossville, TN

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