Integrated Resource Plan 2025

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TVA

TENNESSEE VALLEY AUTHORITY

Integrated Resource Plan Draft Environmental Impact Statement

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Abstract: The 2025 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 affordable, reliable electricity; supports environmental stewardship; and fosters economic development in the Tennessee Valley between now and 2050. 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) Reference (without Greenhouse Gas Rule), (2) Higher Growth Economy, (3) Stagnant Economy, (4) Net-zero Regulation, (5) Net-zero Regulation Plus Growth, and (6) Reference (with Greenhouse Gas Rule). Five planning strategies were evaluated against the backdrop of these scenarios: (A) Baseline Utility Planning, (B) Carbon-free Innovation Focus, (C) Carbon-free Commercial Ready Focus, (D) Distributed and Demand-side Focus and (E) Resiliency Focus. The modeling process applied each strategy in each scenario, resulting in 30 core resource portfolios. For each unique scenario and strategy combination, the model solved for the lowest-cost portfolio. Combining the various scenarios and strategies generated potential resource portfolios to be analyzed using metrics that reflect least-cost planning principles and TVA's mission of energy, environmental stewardship and economic development.

The Environmental Impact Statement (EIS) assesses the natural, cultural, and socioeconomic impacts associated with the implementation of the 2025 IRP. The Baseline Utility Planning strategy is the No Action Alternative, and the remaining four strategies 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.

There is a need for new capacity in all scenarios to replace retiring and expiring capacity, support economic growth, and enable further electrification of the economy. Since the 2019 IRP, TVA has developed planning dates for retiring aging coal units as they reach end-of-life, expected by 2035. As of 2024, TVA operates four coal plants and the 2025 IRP includes planning assumptions for the phased retirement of these plants, some of which are pending further environmental review and/or TVA Board of Directors approval.

Comments on the draft IRP and EIS are due to TVA no later than November 26, 2024.

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List of Acronyms

Acronym	Description
°C	Degrees Celsius
°F	Degrees Fahrenheit
AC	alternating current
ACS	American Community Survey
Aero	aeroderivative
ALF	Allen Fossil Plant
B.P.	before present
BART	Best Available Retrofit Technology
BESS	Battery Energy Storage System
BRF	Bull Run Fossil Plant
Btu	British Thermal Units
CAA	Clean Air Act
CC	Combined Cycle
CCR	Coal Combustion Residuals
CCS	carbon capture and storage/sequestration
CEQ	Council on Environmental Quality
CFR	Code of Federal Regulations
CH_4	Methane
CO	carbon monoxide
CO_2	carbon dioxide
CO_2e	CO_2 equivalent emissions
CRN	Clinch River Nuclear
CT	Combustion Turbine
CUF	Cumberland Fossil Plant
CWA	Clean Water Act
CY	calendar year
DC	Direct Current
DER	Distributed Energy Resources
DO	dissolved oxygen
DOE	Department of Energy
DR	demand response
DSI	dry sorbent injection
DSM	Demand Side management
DSS	Distributed Solar Solutions
dV	deciview
EA	Environmental Assessment
EBCI	Eastern Band of Cherokee Indians
EE	energy efficiency

Acronym	Description
EIS	Environmental Impact Statement
EO	Executive Order
ESA	Endangered Species Act
EV	electric vehicles
FERC	Federal Energy Regulatory Commission
FGD	flue gas desulphurization
FONSI	finding of no significant impact
FRP	Flexibility Research Project
FY	Fiscal Year
GAF	Gallatin Fossil Plant
GHG	greenhouse gas
GP	Generation Partners
GPP	Green Power Providers
GW	gigawatt
GWh	gigawatt hours
HAP	Hazardous Air Pollutants
Hg	Mercury
HVAC	heating, ventilation, and air conditioning
HVDC	high voltage direct current
IEMP	Internal Energy Management Program
IPCC	Intergovernmental Panel on Climate Change
IRP	Integrated Resource Plan
JOF	Johnsonville Fossil Plant
kg	kilogram
KIF	Kingston Fossil Plant
kV	kilovolt
KWh	kilowatt-hours
LCA	life cycle analysis
LNB	low-NOx burner
LPC	Local Power Companies
LSC	low sulfur coal
m^2	square meters
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
MJ	megajoule
Mm	Mega-meters
MW	Megawatt

Acronym	Description
MWh	Megawatt-hour
NAAQS	National Ambient Air Quality Standards
NEPA	National Environmental Policy Act
NERC	North American Electric Reliability Corporation
NETL	National Energy Technology Laboratory
NFIP	National Flood Insurance Program
NHPA	National Historic Preservation Act
N_2O	Nitrous oxide
NO_2	nitrogen dioxide
NO_3	nitrate
NOI	Notice of Intent
NOx	nitrogen oxides
NPDES	National Pollutant Discharge Elimination System
NRC	Nuclear Regulatory Commission
NREL	National Renewable Energy Laboratory
NRHP	National Register of Historic Places
NWS	National Weather Service
OGC	Office of the General Counsel
PA	Programmatic Agreement
PAF	Paradise Fossil Plant
Pb	lead
PC	pulverized coal
PCB	polychlorinated biphenyl
PM	particulate matter
PM_{10}	Particulate matter less than 10 microns in size
$PM_{2.5}$	Particulate matter less than 2.5 microns in size
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
RCP	representative concentration pathway
RCRA	Resource Conservation and Recovery Act
REC	Renewable Energy Certificate
RFP	Request for Proposal
RIA	Renewable Investment Agreement
ROD	Record of Decision
RSO	Renewable Standard Offer
SC-GHG	Social costs of greenhouse gas
SCF	Standard cubic feet

Acronym	Description
SCPC	supercritical pulverized coal
SCR	selective catalytic reduction
SDTSA	state-designated tribal statistical areas
SF_6	Sulfur hexafluoride
SHF	Shawnee Fossil Plant
SHPO	State Historic Preservation Officer
SMR	small modular reactors
SNCR	selective non-catalytic reduction
SO_2	sulfur dioxide
SO_4	sulfate
SOC	Special Opportunities Counties
SSI	Solar Solutions Initiative
TCP	Traditional Cultural Properties
TVA	Tennessee Valley Authority
TWh	terawatt hours
U.S.	United States
U.S.C.	United States Code
USACE	U.S. Army Corps of Engineers
USDA	U.S. Department of Agriculture
USEPA	U.S. Environmental Protection Agency
USFWS	U.S. Fish and Wildlife Service
VOC	volatile organic compounds
WBN	Watts Bar Nuclear
WMA	Wildlife management area
WUTA	Water Use Tabulation 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 provide strategic direction for meeting the energy needs of the TVA region between now and 2050 across a variety of possible future scenarios.

TVA is the largest producer of public power in the United States. TVA provides wholesale power to 153 local power companies and directly sells power to 60 industrial and federal customers. TVA's power system serves approximately 10 million people in a seven-state, 80,000-square-mile region. TVA's PSA includes virtually all counties in Tennessee and portions of Alabama, Georgia, Kentucky, Mississippi, North Carolina, and Virginia. The TVA region shown in Figure 1-1 encompasses the PSA and the Tennessee River watershed.

As of FY 2023, TVA's generating assets include: three nuclear sites, 17 natural gas and/or oil-fired sites, four coal-fired sites, 29 conventional hydroelectric sites, one pumped-storage hydroelectric site, one diesel generator site, and nine operating solar installations. These assets have a summer net generation capability of 32,139 megawatts (MW). In addition, TVA maintains long-term agreements with third-party power producers totaling 7,421 MW and offers demand response programs that provide 1,701 MW of capacity. In total, TVA currently maintains 41,261 MW of capacity to meet the region's power supply needs. A new simple-cycle combustion turbine plant in Paradise, Kentucky, entered commercial operations in December 2023, adding 681 MW to the power system.

1.1 Purpose and Need for Integrated Resource Planning

Like other utilities, TVA prepares IRPs. This planning process includes evaluating the long-term demand for power in the TVA region, the resource options available for meeting that demand, the potential environmental, economic, and operating impacts of these options, and public involvement. In the mid-1990s, TVA developed a comprehensive IRP, Energy Vision 2020 IRP and EIS (TVA 1995) and has since prepared IRPs and associated EISs in 2011 (TVA 2011a), 2015 (TVA 2015), and 2019 (TVA 2019a).

TVA is developing the 2025 IRP and associated EIS to address regional and national changes within the utility marketplace. After a decade of flat electricity demand, the TVA region is now experiencing increasing demand for electricity driven by population, employment, and industrial growth, weather trends, and growing electric vehicle use. Also, TVA continues to experience increasing demand for carbon reductions and renewable energy options from residents and businesses in the region and those considering locating here, and advancements are being made in emerging clean energy technologies. Upon approval by the TVA Board of Directors (TVA Board), the 2025 IRP will replace the 2019 IRP (TVA 2019a). The purpose of the IRP 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 least-cost, system-wide basis to meet the future electrical energy needs of the TVA region while considering TVA's mission of energy, environmental stewardship, and economic development. Stakeholder input on what they would like to see in the future power system is integral to TVA's IRP process.

An updated IRP is needed to establish a strong planning foundation for the 2030s and beyond; inform TVA's next long-range financial plan; and provide strategic direction for how TVA will continue to provide affordable, reliable, resilient, and increasingly cleaner electricity to the approximately 10 million residents of the TVA region.

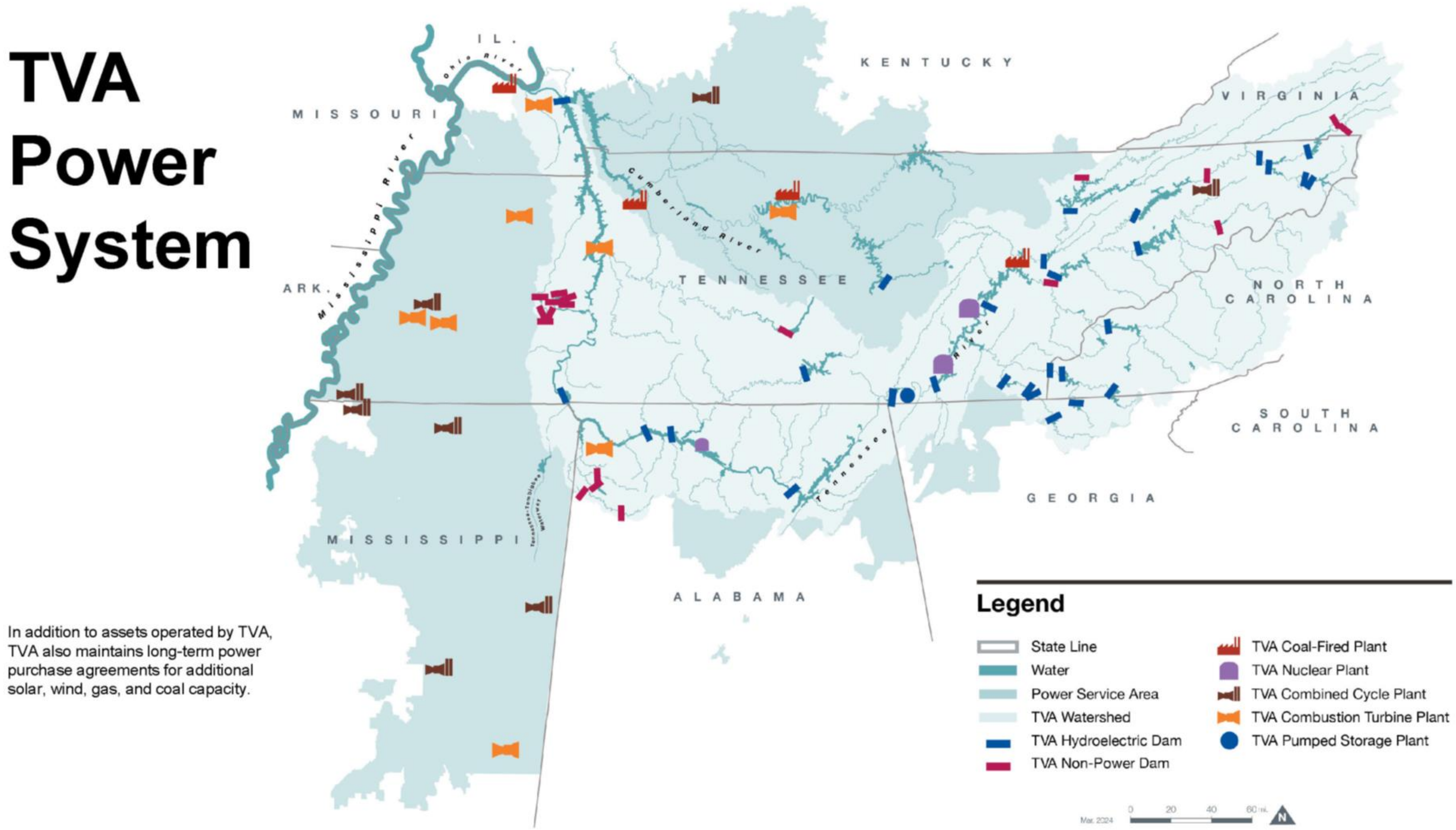


Figure 1-1: TVA PSA and Watershed

1.2 Statutory Overview

In addition to Section 113 of the Energy Policy Act of 1992 (least-cost, system-wide planning program requirements applicable to TVA), 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 (NEPA) 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 NEPA of 1969, as amended (42 United States Code §§ 4321 *et seq.*), regulations implementing NEPA promulgated by the Council on Environmental Quality (CEQ) (40 Code of Federal Regulations [CFR] Parts 1500 to 1508, as updated July 1, 2024), and TVA NEPA procedures (18 CFR part 1318).

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 that are likely to have significant environmental impacts, NEPA requires that an EIS be prepared. This process must include public involvement and analysis of a reasonable range of alternatives.

Due to the comprehensive nature of the IRP, TVA is completing a programmatic EIS to ensure compliance with NEPA, CEQ regulations, and TVA procedures (18 CFR 1318). 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. In a programmatic EIS, the environmental impacts of the alternative actions are addressed at a regional level, with some extending to a national or global level. TVA will address the site-specific effects associated with specific projects that are proposed to implement the IRP in subsequent tiered environmental reviews.

The IRP and EIS are developed with stakeholder involvement and public input. TVA used the input from the scoping period, summarized below, in development of the draft IRP and EIS. TVA also established the IRP Working Group, a diverse group of stakeholders who meet regularly to provide input and feedback on every aspect of the IRP. The draft IRP and EIS are being distributed to a broad range of individuals and groups; and federal, state, and local agencies for their review and comment. During the 60-day public comment period for the draft IRP and EIS (through November 26, 2024), TVA will conduct public meetings throughout the TVA region. Following the public comment period, TVA will respond to the comments received and incorporate any necessary changes into the final IRP and/or EIS prior to seeking TVA Board approval of recommendations.

The final IRP and EIS will be posted on TVA's website, and TVA will notify those who have requested notice, participated in the planning process, or submitted comments on the draft IRP and/or EIS. TVA will also submit the final IRP and EIS to the U.S. Environmental Protection Agency (USEPA), which will publish a Notice of Availability in the Federal Register. TVA intends to publish the final IRP and EIS in the spring of 2025.

The TVA Board will make the final decision no sooner than 30 days after the publication of the Federal Register Notice of Availability of the filing of the final IRP and EIS. The TVA Board will consider the analyses in the IRP and EIS when it makes a decision on the recommended power supply mix ranges, strategic portfolio direction through 2035, and key signposts to monitor. Following a decision by the TVA Board, 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 is considered environmentally preferable; and (5) if applicable, any associated mitigation measures, 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. In addition to these laws, TVA must comply with a variety of state and local requirements not included in Table 1-1.

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
Climate and Greenhouse Gases	• Executive Order (EO) 13990 – Protecting Public Health and the Environment and Restoring Science to Tackle the Climate Crisis
Wetlands and Waters	• Clean Water Act • EO 11990 – Protection of Wetlands • Wild and Scenic Rivers Act
Floodplains	• EO 11988 – Floodplain Management • EO 13690 – Establishing a Federal Flood Risk Management Standard
Endangered and Threatened Species	• Endangered Species Act • Migratory Bird Treaty Act • Fish and Wildlife Coordination Act • Bald and Golden Eagle Protection Act
Cultural Resources	• National Historic Preservation Act • Archaeological Resources Protection Act • Native American Graves Protection and Repatriation Act • American Indian Religious Freedom Act • EO 13007 – Indian Sacred Sites • EO 13175 – Consultation and Coordination with Indian Tribal Governments • EO 13287 – Preserve America
Environmental Justice	• EO 12898 – Federal Actions to Address Environmental Justice in Minority and Low-Income Populations • EO 14008 – Tackling the Climate Crisis at Home and Abroad • EO 14096 – Revitalizing Our Nation's Commitment to Environmental Justice for All
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
Infrastructure Planning and Sustainability	• Federal Power Act • American Rescue Plan • EO 14057 – Catalyzing Clean Energy Industries and Jobs Through Federal Sustainability • Inflation Reduction Act • Infrastructure Investment and Jobs Act

1.3 Relationship with Other NEPA Reviews

Numerous environmental documents and reviews are relevant to TVA's IRP and the current environmental review. These are briefly discussed below and are grouped by the type of action, program, or location. More information may be found at https://www.tva.com/nepa.

1.3.1 Programs, Plans and Policies

2019 Integrated Resource Plan (June 2019)

The 2019 IRP provides direction for how TVA will meet the long-term energy needs of the Tennessee Valley region and updates TVA's 2015 plan. This IRP and the associated EIS evaluated scenarios and strategies for providing electricity through 2038.

Changes to Green Power Providers Program Environmental Assessment (December 2019)

In this document, TVA evaluated changes to how TVA assists residential customers interested in solar installations and the December 31, 2019, closure of its Green Power Providers Program to new applications.

Diesel-fueled Generation in TVA Demand Response Program (February 2017)

In 2017, TVA issued a final Environmental Assessment (EA) and finding of no significant impact (FONSI) for authorizing the use of customer-owned diesel-fueled generators to provide backup generation during certain demand response events.

Natural Resource Plan (July 2020)

This plan guides TVA's natural resource stewardship activities, which primarily occur on TVA-managed public lands. 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 (May 2004)

In 2004, TVA established its current operating policy for the Tennessee River and reservoir system. The purpose of the Reservoir Operations Study was to determine whether changes in its reservoir operations policy will produce overall public value. This document addresses the operation of TVA's hydroelectric generation resources.

TVA Power Supply Flexibility Proposal (June 2020)

In this document, TVA evaluated the offering of flexible power generation options to its local power company customers (Valley Partners) that have entered into long-term partnership agreements with TVA.

TVA Solar Photovoltaic Projects (September 2014)

TVA is increasing the amount of renewable energy in its energy portfolio by constructing and operating solar photovoltaic systems and/or purchasing electricity from solar facilities being constructed within TVA's PSA. In September 2014, TVA documented the potential environmental effects of implementing small solar projects in this programmatic EA and FONSI.

1.3.2 Power Generation – Coal and Gas

Allen Fossil Plant (ALF)

TVA evaluated options for closure of the plant, including ash impoundments, in the ALF Ash Impoundment Closures EIS and ROD (2020), ALF Decontamination and Deconstruction EA and FONSI (2019), and ALF Emission Control Project EA and FONSI (2014).

Bull Run Fossil Plant (BRF)

BRF is retired, though its NEPA documents for various projects remain relevant, including the BRF Ash Impoundment Closure Project Supplemental EA and FONSI (2019), BRF Decontamination and Decontamination EA and FONSI (2023), BRF Landfill-Management of Coal Combustion Residuals EIS (2016), and BRF Potential Retirement EA and FONSI 2019.

Closure of Coal Combustion Residual Impoundments EIS (2016)

The Ash Impoundment Closure Programmatic EIS was used to support the implementation of TVA's goal to eliminate all wet coal combustion residuals (CCR) storage at its coal plants by closing CCR impoundments across the TVA system, and to assist TVA in complying with USEPA's CCR Rule. The EIS programmatically considers the impacts of the two primary closure methods. The ROD was issued in July 2016.

Colbert Fossil Plant

Documents available regarding retirement of this plant include a Decontamination and Deconstruction EA and FONSI (2016) and Colbert Ash Pond 4 Seismic Project EA and FONSI (2021).

Cumberland Fossil Plant (CUF)

Documents available for the retirement of the CUF include the Cumberland Retirement EIS and ROD (2023), CUF Wastewater Treatment Facility EA and FONSI (2019), CUF Management of Coal Combustion Residuals EIS and ROD (2019), and Access Road and Borrow Areas for CUF EA and FONSI (2017).

Gallatin Fossil Plant (GAF)

Documents available regarding activities for GAF include the GAF Borrow Site EA and FONSI (2018), GAF Bottom Ash Process Dewatering Facility EA and FONSI (2017), GAF Installation of Air Pollution Control Equipment and Associated Facilities EA and FONSI (2013), and Gallatin Surface Impoundment Closure and Restoration Project EIS and ROD (2020).

John Sevier Fossil Plant Deconstruction (2015)

The EA and FONSI for the deconstruction of the John Sevier Fossil Plant near Rogersville, Tennessee, were issued in 2015. The EA evaluates the potential environmental effects of 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.

Johnsonville Aeroderivative Combustion Turbine Project (2022)

In this document, TVA addressed the addition of 10 natural gas-fired Aero CTs at the Johnsonville Reservation in Humphreys County, Tennessee. The Aero CTs would generate approximately 550 MW and are expected to be in commercial operation by the end of 2024. An EA and FONSI were issued in 2022 for this project.

Johnsonville Cogeneration Plant (2015)

TVA 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. TVA issued the EA and FONSI in 2015.

Johnsonville Fossil Plant (JOF)

Documents available involving closure activities of JOF include the JOF Decontamination and Deconstruction EA and FONSI (2018) and JOF Proposed Actions (2018).

Kingston Fossil Plant (KIF)

Documents available regarding retirement activities for KIF include the KIF Borrow Site #3 EA and FONSI (2020), KIF Bottom Ash Dewatering Facility EA and FONSI (2016), KIF Landfill Expansion EA and FONSI

(2019), and KIF Retirement DEIS (2023). The Kingston Retirement final EIS was published in February 2024; the ROD was published in April 2024.

Paradise Fossil Plant (PAF)

Documents available regarding retirement activities for PAF include the Potential Retirement of PAF EA and FONSI (2019), PAF Units 1 and 2 – Mercury Air Toxics Standards Compliant Project EA and FONSI (2013), PAF Decontamination and Deconstruction EA and FONSI (2021), and the Management of Coal Combustion Residuals from the PAF EA and FONSI (2017). Additionally, following a CT modernization study in 2019, an EA and FONSI were issued in 2021 on Paradise and Colbert Combustion Turbine Plants.

Shawnee Fossil Plant (SHF)

Documents available regarding retirement activities for SHF include the Management of Coal Combustion Residuals from SHF EIS and ROD (2018), SHF Bottom Ash Process Dewatering Facility EA and FONSI (2016), and SHF Units 1 and 4 EA and FONSI (2014).

Widows Creek Fossil Plant

Documents available regarding closure activities of this plant include the Widows Creek Fossil Plant Deconstruction EA and FONSI (2016) and the Widows Creek Fossil Plant Soil Excavation and Gypsum Stack Closure EA and FONSI (2014).

1.3.3 Power Generation – Nuclear

Browns Ferry Nuclear Plant (BFN)

The BFN Subsequent License Renewal Final SEIS (2023) addresses the potential environmental effects associated with obtaining Nuclear Regulatory Commission (NRC) subsequent license renewals for an additional 20 years for Units 1, 2, and 3 located in Limestone County, Alabama. TVA issued a ROD in February 2024. Also available is the BFN Thermal Performance Program Cooling Tower Capacity Improvements EA and FONSI (2020).

Clinch River Nuclear Site (CRN) Advanced Nuclear Reactor Technology Park (2022)

In 2022, TVA issued a programmatic EIS and ROD for site preparation, construction, operation, and decommissioning of various facilities at an advanced nuclear reactor technology park in Oak Ridge, Roane County, Tennessee. The facilities containing one or more advanced nuclear reactors would have a cumulative output not to exceed 800 MW electric.

Fukushima Response Strategy (2013)

A final EA and FONSI were issued for implementing TVA's response strategy for NRC requirements following the March 2011 earthquake and tsunami that struck the Fukushima Daiichi electrical power station in Japan. The strategy addresses improving TVA's ability to maintain or restore core cooling, containment, and spent fuel pool cooling capabilities in the event of a severe accident.

Sequoyah Nuclear Plant Units 1 and 2 License Renewal Supplemental Environmental Impact Statement (2011)

In this Supplemental EIS, TVA reviewed the continued operation of the two units at the Sequoyah Nuclear Plant for an additional 20 years (between 2020 and 2041).

Watts Bar Nuclear Plant (WBN)

Documents available regarding the Watts Bar facility include the WBN Unit 2 Replacement of Steam Generators EA and FONSI (2017), and the WBN Independent Spent Fuel Storage Installation Facility EA and FONSI (2014).

1.3.4 Power Generation – Solar, Storage and Other Renewables

North Alabama Utility-Scale Solar Project (2022)

In 2022, TVA finalized the EIS and issued a ROD to construct and operate an alternating current solar facility, North Alabama Utility-Scale Solar Project, in Lawrence County, Alabama. The project would be the first TVA-owned utility-scale solar facility with approximately 200 MW of solar capacity.

Shawnee Project Phoenix Solar Facility EA and FONSI (2024)

In March 2024, TVA completed an EA for its pilot proposal to construct a solar facility at Shawnee Fossil Plant, utilizing a portion of an area where coal combustion residuals are being closed and managed in place. The project is known as Project Phoenix.

Vonore Battery Energy Storage System (BESS) and Associated Subsystem (2022)

TVA issued a final EA and FONSI associated with the construction and operation of a BESS and associated transmission and fiber improvements near an industrial complex in Vonore, Tennessee. The BESS and associated substation project, which will become operational in 2024, has a storage capacity of 40 MWh. The BESS pilot project will maximize learning about battery storage projects; target specific grid needs; assess grid resiliency and flexibility applications; and focus on lithium–ion chemistry. The project is consistent with TVA's 2019 IRP, which called for the evaluation of demonstration battery storage projects to gain operational experience as a near-term action.

Further information on other TVA solar, storage, and other renewable projects, listed in Table 1-2, can be found at https://www.tva.com/nepa.

Table 1-2: Other Solar, Storage, and Renewable Projects with NEPA Documents

Project Name	Year	Location
Five Western North Carolina Solar Farms – Hampton Solar Farm, Sweetwater Cove Solar Farm, Unnamed 1 MW Solar Farm, Carter Cove Solar Farm, Lance Cove Solar Farm	2014	Cherokee County, NC Clay County, NC Avery County, NC
Marshall Properties Solar Farm	2014	Blairsville, GA
General Mills Combined Heat and Power Project	2014	Murfreesboro, TN
Starkville Solar Facilities	2014	Oktibbeha County, MS
Pulaski Energy Park Expansion	2014	Giles County, TN
Purchase of Power Generated at Bristol, VA Sanitary Landfill	2014	City of Bristol's Sanitary Landfill, VA
River Bend Solar Project	2015	Colbert County, AL
Providence Solar Center	2016	Madison County, TN
Selmer North I & II Solar Projects	2016	McNairy County, TN
Wildberry Solar Center	2016	Fayette County, TN
Houston, Mississippi Solar Farms	2016	Chickasaw County, MS
Latitude Solar Center	2016	Hardeman County, TN
Jonesborough Solar Site	2017	Washington County, TN
Millington Solar Farm	2017	Shelby County, TN
Muscle Shoals Solar Project	2017	Colbert County, AL
Naval Air Station Meridian Solar Farm	2017	Lauderdale County, MS
Haywood Solar Farm	2017	Haywood County, TN
Memphis Solar Project	2018	Memphis, Shelby County, TN
Cumberland Solar Farm	2018	Limestone County, AL
Yum Yum Solar Project	2019	Fayette County, TN
Jackson Solar Project	2019	Jackson, Madison County, TN
Bellefonte Solar Energy Center Project	2020	Jackson County, AL
Elora Solar Energy Center Project	2020	Lincoln County, TN
Knoxville Utilities Board Solar Project	2020	Knox County, TN

Project Name	Year	Location
Horus Kentucky Solar Project	2021	Simpson County, KY
Skyhawk Solar Project	2021	Obion County, TN
Ridgely Energy Farm	2021	Lake County, TN
SR Bell Buckle Solar Project	2021	Bedford County, TN
SR McKellar Solar Project	2021	Madison County, TN
SR Millington II Solar Facility	2022	Shelby County, TN
SR Canadaville Solar Facility	2022	Fayette County, TN
Golden Triangle I & II Solar and Battery Energy Storage Project	2022	Lowndes County, MS
Graceland Solar Project	2022	Shelby County, TN
SR Puryear Solar Project	2024	Henry County, TN
Logan County Solar Project	2023	Logan County, KY
Gaynor Solar LLC – Volunteer Electric Cooperative Solar Project	2023	Pleasant Hill, Cumberland County, TN
Moore County Solar Project	2023	Moore County, TN
Optimist Solar and BESS Project	2023	Clay County, MS
Adamsville Solar Project	2024	McNairy and Hardin Counties, TN

1.4 Public Scoping

Scoping is a procedure that solicits public input to the NEPA process to ensure that: (1) issues are identified early and properly studied; (2) issues of little significance do not consume substantial time and effort; (3) the NEPA document is thorough and balanced; and (4) delays caused by an inadequate review are avoided. TVA's NEPA procedures require that the scoping process commence soon after a decision has been reached to prepare a NEPA review in order to provide an early and open process for determining the scope and for identifying the significant issues related to a proposed action.

Engagement in TVA's 2025 IRP officially began with a Notice of Intent (NOI) in the Federal Register that initiated a 45-day public scoping period from May 19 to July 3, 2023. In addition to publishing an NOI, TVA notified the public of the initiation of the IRP study in a variety of ways. TVA published information about the review and planning effort on the TVA webpage, notified the media, and sent notices to numerous individuals, organizations, and intergovernmental partners. The objective was to gather input from the public and key stakeholders to help frame the IRP study and identify future conditions, strategies, and resource options to be evaluated. The NOI also initiated the environmental review process for the IRP, consistent with the requirements of NEPA. The NOI included five scoping questions for consideration:

How do you think the demand for energy will change between now and 2050 in the TVA region?

- Should the diversity of the current power generation mix (e.g., nuclear, coal, natural gas, hydroelectric, renewable resources) change? If so, how?
- How should distributed energy resources be considered in TVA planning?
- How should energy efficiency and demand response be considered in planning for future energy needs, and how can TVA directly affect energy usage by consumers?
- How will the resource decisions discussed above affect the reliability, dispatchability (ability to turn on or off energy resources), and cost of electricity? Are there other factors of risk to be considered?

During the scoping period, TVA received 43 official comments through the online portal, email, and mail-in options. Comments were primarily received from states in the TVA region, with the balance from four other states and Washington, D.C. Of the 43 submissions, 22 comments were received from individuals, nine from businesses, 10 from civic or non-governmental organizations, and two from government agencies. In addition to comments formally submitted by the public, TVA reviewed several hundred statements posted by the public on several social media pages.

Public comments covered a broad spectrum of issues. Common themes were:

- Support and opposition for various types of power generation sources
- Increasing decarbonization efforts
- Promoting distributed energy resources
- Interest in energy efficiency and energy storage alternatives
- Feedback on the IRP process and need for transparency
- Importance of reliability and resilience in the face of increasing demand
- More attention to environmental justice communities
- Concern about climate change and environmental impacts

Commenters also provided advice on scenarios and strategies to explore and suggestions to improve public outreach and stakeholder involvement. Additional information on the scoping effort and comments received can be found in the Integrated Resource Plan Scoping Report on TVA's IRP website (www.tva.gov/irp).

1.5 Overview of Volumes 1 and 2

Volume 1 contains the draft 2025 IRP along with descriptions on the methodology and development of IRP recommendations. This works in conjunction with Volume 2 of this document, which contains the draft EIS. The EIS is a document required by NEPA that describes the environmental effects of proposed actions that may have a significant impact on the quality of the human environment.

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 (EE) and demand response (DR) programs; and the transmission system.

To meet the region's power supply needs, TVA currently maintains 41,261 megawatts (MW) of summer net dependable capability. TVA operates a generating asset portfolio of 32,139 MW, maintains long-term agreements with third-party power producers totaling 7,421 MW, and offers DR programs that provide 1,701 MW of capacity. Power generation by these facilities for the 2020-2023 fiscal years is summarized in Table 2-1. TVA operates a network of 16,334 miles of transmission lines and 573 substations, switching stations, and switchyards. This system transmits power from TVA and non-TVA generating facilities to 1,355 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 Environmental Impact Statement (EIS) is the summer net dependable capacity.

Table 2-1: Fiscal Year 2020-2023 Generation by Type from Both TVA Facilities and Purchased Power

Type of Generation	Generation in million kilowatt-hours per fiscal year (FY)			
	FY 2023[1]	FY 2022 [1]	FY 2021[1]	FY 2020 [1]
Nuclear	67,102	64,475	66,265	64,531
Coal	23,618	23,752	25,764	22,141
Natural Gas and/or oil-fired	48,170	54,611	44,126	42,822
Hydroelectric	14,654	16,477	18,510	19,543
Wind	3,754	4,383	3,919	3,839
Solar	1,381	1,023	468	250
Biomass	23	22	26	30
Brookfield Hydro[2]	461	-	-	-
Other Program Renewables[3]	628	713	700	665
TOTAL	159,791	165,456	159,778	153,821

Source: TVA 2023a, TVA 2022a, TVA 2021a, TVA 2020a
[1] Includes purchased power gas, coal fired and hydroelectric.
[2] TVA began purchases from the Brookfield Hydro facility in FY 2023.
[3] From contract renewable resources through historical renewable energy programs that consist of PPAs and energy purchased from qualifying facilities through TVA's Dispersed Power Production Program.

2.2 TVA Customers, Sales, and Power Exchanges

TVA sells power at wholesale to its 153 local power companies. In fiscal year (FY) 2023, it sold 157,311 million kilowatt-hours (kWh) of electricity; total revenue from these sales was $11.9 billion. Wholesale power is delivered to 153 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, serves approximately 421,000 electric customers and accounted for 9 percent of TVA's 2023 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. Revenues from LPCs accounted for approximately 91 percent of TVA's total operating revenues for 2023.

In addition to the LPCs, TVA sells power directly to 60 industries and federal installations. The direct 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 in the region. Revenues from direct served industries and federal installations accounted for approximately 7 percent of TVA’s total operating revenues in 2023. Since 2015, power sales to federal installations have decreased while sales to direct served industries have increased.

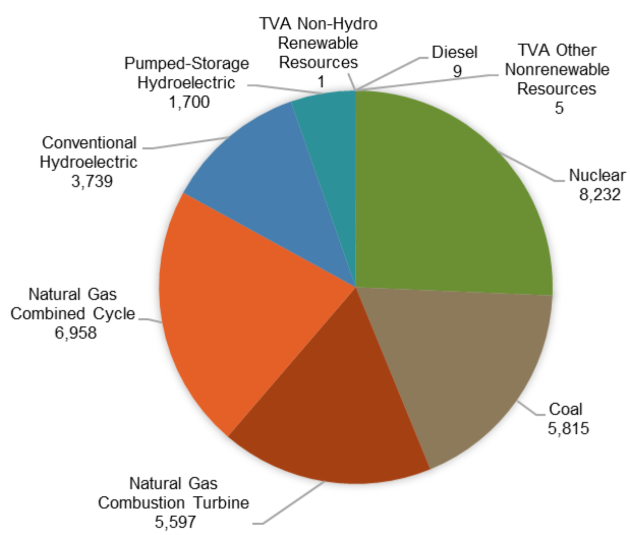
The TVA power service area (PSA) (Figure 1-1) was established by the TVA Act. The TVA Act restricts TVA from entering into contracts that would make TVA or its LPCs a source of power outside the area for which TVA or its LPCs were the primary source of power on July 1, 1957.

The 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 power throughout the TVA PSA.

In 2020, TVA began providing a flexibility option to LPCs that enter into a long-term partnership agreement. The flexibility option, named Generation Flexibility, allows these LPCs to locally generate or purchase up to approximately 5 percent of their average total hourly energy sales to meet their individual customers' needs. Revised Flexibility Agreements, made available to LPCs in August 2023, permit projects to be located anywhere in TVA's PSA, either connected to the LPC distribution system or TVA's transmission system, and make it easier for LPCs to partner in projects. As of August 2024, 147 LPCs have signed the long-term partnership agreement with TVA, and 102 of these LPCs have signed a Power Supply Flexibility Agreement.

2.3 TVA-Owned Generating Facilities

TVA owns and/or operates under long-term lease 32,139 MW of summer net generating capability (Figure 2-1).



Source: TVA 2023a

Figure 2-1: Fiscal Year 2023 TVA-Owned/Operated Summer Net Generating Capability, in Megawatts by Type of Generation

2.3.1 Coal-Fired Generation

As of September 2023, TVA had 24 active coal-fired generating units at four plant sites with a total summer net dependable capability of approximately 5,815 MW (Figure 1-1, Table 2-2). The coal-fired units range in size from 134 MW (Shawnee Units 1-9) to 1,235 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	2023 Summer Net Capability (MW)	Commercial Operation Date (First and Last Unit)	Boiler Type [1]	Emissions Controls [2]
Cumberland	2	2,470	1973	SCPC	FGD, LNB, SCR
Gallatin	4	976	1956, 1959	PC	FGD, SCR
Kingston	9	1,298	1954, 1955	PC	LNB (4 units), SCR, FGD
Shawnee	9	1,071	1953, 1955	PC	DSI, FGD (2 units), LSC, LNB, SCR (2 units), SNCR
Total Coal	24	5,815			

[1] PC – pulverized coal; SCPC – supercritical pulverized coal
[2] DSI – dry sorbent injection; FGD – flue gas desulfurization (“scrubber”); LNB – low-NOx burner; LSC – low sulfur coal, may be blended with high sulfur coal; SCR – selective catalytic reduction; SNCR – selective non-catalytic reduction.

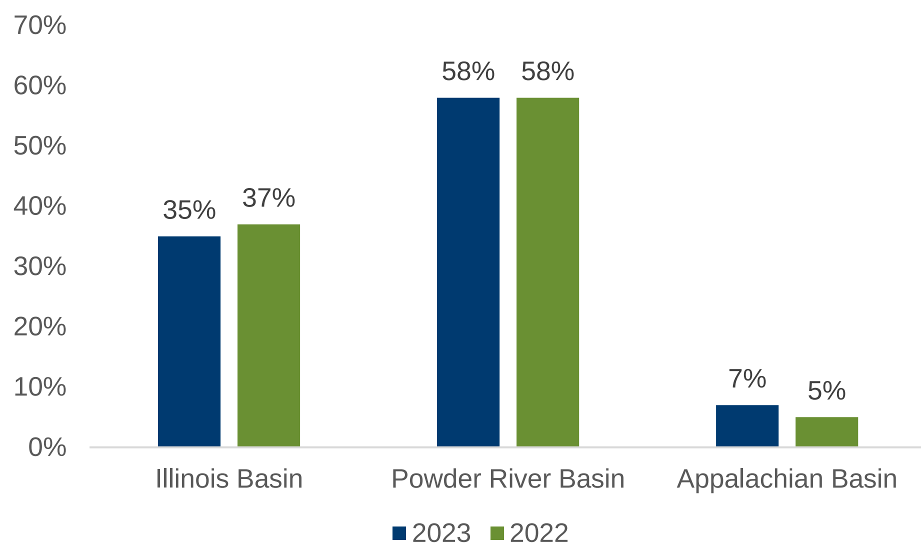
Since 2010, TVA has retired the 4-unit, 704-MW John Sevier Fossil Plant; the 8-unit, 1,499-MW Widows Creek Fossil Plant; the 126-MW, Unit 10 at Shawnee; the 10 coal-burning units, totaling 2,130 MWs, at Johnsonville Fossil Plant; the five coal-burning units, totaling 1,542 MWs, at Colbert Fossil Plant; the three coal-burning units, totaling 2,147 MWs, at Paradise Fossil Plant; the three coal-burning units, totaling 741 MWs, at Allen Fossil Plant and the 865-MW unit at the Bull Run Fossil Plant. In January 2023, TVA issued its Record of Decision to retire the two coal-fired units at Cumberland Fossil Plant by the end of calendar year (CY) 2026 and CY 2028. In April 2024, TVA issued its Record of Decision to retire the nine coal-fired units at Kingston Fossil Plant by the end of CY 2027.

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. 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 completed these actions, and the majority of the coal-fired unit retirements listed above were in response to the CAA Environmental Agreements. As of 2024, TVA still operates four coal plants, and the 2025 Integrated Resource Plan (IRP) includes planning assumptions for the phased retirement of these plants by 2035.

To maintain adequate generating capacity in the vicinity of some retired coal plants or units, TVA 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 in Section 2.3.3.

Fuel Procurement. TVA coal consumption has greatly decreased since 2010 because of the coal unit retirements described above, increased generation from other resources, and increased EE. Coal inventory increased in 2023 as compared to 2022. TVA experienced challenges in 2022 related to coal supply limitations and transportation challenges. Coal supply availability and transportation performance improved during the first quarter of 2023. Mild weather prior to late December 2022, which continued in the second through fourth quarters of 2023, required lower than forecasted coal-fired generation, enabling inventory stockpiles to increase, and current market conditions reflect an approximate balance between demand and available supply, due to weaker export markets and lower natural gas prices. TVA also invested in additional multi-year coal supply contracts to help provide stability in coal supply availability. These investments are expected to support fuel resiliency with TVA's overall coal supply. Coal consumption at TVA's coal-fired generating facilities during both 2023 and 2022 was approximately 12 million tons.

In recent years, TVA has obtained coal from the Appalachian Basin (Kentucky, Pennsylvania, Tennessee, West Virginia, and Virginia) and Illinois Basin (Illinois, Indiana, and Kentucky) regions in the eastern United States (U.S.) and from the Powder River Basin (Wyoming) region in the western U.S. TVA purchased coal by basin for 2023 and 2022 is shown in Figure 2-2.



Source: TVA 2023a

Figure 2-2: Fiscal Year 2023 and 2022 Coal Purchases by Mining Region

TVA purchases coal under both long-term (more than one year) and short-term (one year or less) contracts; 92 percent of 2023 purchases were with long-term contracts. During 2023, 47 percent of TVA's coal supply was delivered by rail, 14 percent was delivered by barge, and 39 percent was delivered by a combination of barge and rail. 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 four 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 8,232 MW (Figure 1-1, Table 2-3). 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 (NRC) for an extended power uprate at Browns Ferry, which was completed by the end of 2019.

Table 2-3: Characteristics of TVA Nuclear Generating Units

Facility	Units	2023 Summer Net Capability (MW)	Type	Commercial Operation Date (First and Last Unit)	Operating License Expiration
Browns Ferry	3	3,662	Boiling Water	1974, 1977	2033, 2034, 2036
Sequoyah	2	2,292	Pressurized Water	1981, 1982	2040, 2041
Watts Bar	2	2,278	Pressurized Water	1996, 2016	2035, 2055
Total	7	8,232			

TVA is seeking to renew all nuclear generation units' licenses for an additional 20 years. The subsequent license renewal application was submitted to NRC in January 2024 for the three units at Browns Ferry. TVA has an Early Site Permit to potentially construct and operate small modular reactors at TVA's Clinch River Nuclear Site in Oak Ridge, Tennessee, and in 2022, the TVA Board approved a programmatic approach to exploring advanced nuclear technology.

Fuel Procurement. TVA's seven nuclear units use a total of about 4 million pounds of natural uranium equivalent (U_{235}) per year. Converting uranium to nuclear fuel generally involves four stages: mining and milling of uranium ore to produce uranium concentrates; conversion of uranium concentrates to uranium hexafluoride gas; enrichment of uranium hexafluoride; and fabrication of the enriched uranium hexafluoride into fuel assemblies. TVA currently has sufficient enriched uranium and fabrication in inventory or under contract to provide all its requirements and future projects.

2.3.3 Natural Gas-Fired and Oil-Fired Generation

As shown in Table 2-4, TVA's natural gas-fueled fleet consists of 93 combustion turbine (CT) blocks at 10 sites (87 simple-cycle units, one cogeneration unit, and five idled units at the Allen Combustion Turbine Facility). The oldest CTs were completed in 1971 and the newest in 2023. Eight CTs are co-located at the coal-fired Gallatin plant site and 54 are at the sites of four now-retired coal plants (Allen, Colbert, Johnsonville, and Paradise). The remaining 31 CTs are located at five stand-alone plant sites. Some CT sites are also co-located with natural gas CC plants (Allen, Lagoon Creek, and Paradise). The individual CT units range in generating capacity from 15 MW (Allen CT Units 1-16) to 216 MW (Colbert CT Units 9-11 and Paradise CT Units 5-7). Eighty of the CT units are also capable of using fuel oil, and 71 are capable of quick start-up, reaching full generation capability in about 10 minutes. Commercial plant operations began on Colbert CT Units 9-11 in July 2023. Commercial plant operations began on Paradise CT Units 5-7 in December 2023. TVA has other ongoing projects at TVA's Johnsonville and Cumberland Sites.

TVA also has 14 natural gas-fueled CC units at eight sites, driven by a total of 21 combustion turbines units. At CC plants, electricity is first generated by CT units; the hot exhaust from the combustion turbines is then run through a heat recovery steam generator (HRSG) which creates steam to drive a steam turbine generator, greatly increasing overall plant output and efficiency. Three of the CC sites are adjacent to now-retired coal plants (Allen, John Sevier, and Paradise), and three are co-located with CT units (Allen, Lagoon Creek, and Paradise). The three-unit Caledonia plant is leased by TVA through a long-term agreement, and the other CC plants are owned by TVA. The arrangement of CTs and steam generators varies, with each steam generator paired with a CT at some plants while at others, two or three CTs drive a single steam generator. Some of the turbines at the newest CC plants can be operated in traditional CC mode, or as stand-alone quick-start CT units in the event of an outage to the steam turbine or HRSG. The total summer net capabilities are 5,680 MW for the CT units and 6,958 MW for the CC units.

Table 2-4: Characteristics of TVA Natural Gas-Fueled Plants

Facility	Combustion Turbine Units	Steam Turbine Units	2023 Summer Net Capability (MW)	Commercial Operation Date (First and Last Unit)	Oil Fueling Capability
Simple Cycle (CT)					
Allen	20	--	287	1971, 1972	Yes
Brownsville	4	--	438	1999	No
Colbert	11	--	1,041	1972, 2023	Yes/No
Gallatin	8	--	580	1975, 2000	Yes
Gleason	3	--	455	2000	No
Johnsonville[1]	20	--	1,111	1975, 2000	Yes
Kemper	4	--	292	2002	Yes
Lagoon Creek	12	--	884	2001, 2002	Yes
Marshall	8	--	592	2002	Yes
Paradise[2]	3	--	649	2023	No
CT Subtotal	93	--	5,680		
Combined Cycle (CC)					
Ackerman	2	1	713	2007	No
Allen	2	1	1,106	2018	No
Caledonia	3	3	819	2003	No
John Sevier	3	1	871	2012	Yes
Lagoon Creek	2	1	596	2010	No
Magnolia	3	3	951	2003	No
Paradise	3	1	1,100	2017	No
Southaven	3	3	802	2003	No
CC Subtotal	21	14	6,958		
Total Gas-Fueled	108	14	12,638		

[1] Johnsonville includes 19 units configured as simple-cycle CTs and one cogeneration unit, used to provide steam to a nearby facility.
[2] Three new simple-cycle combustion turbines entered commercial operations at Paradise in December 2023. These new units were not included in TVA's FY 2023 10-K, as it only included units operational as of September 30, 2023.

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 has decreased. In 2014, TVA used about 56 billion cubic feet 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 power purchase agreement (PPA). Since 2014, natural gas consumption has increased and has averaged 300 billion cubic feet over the past five years. Natural gas consumption was 290 billion cubic feet in 2019, 297 in 2020, 285 in 2021, 337 in 2022, and 299 in 2023.

Annual natural gas consumption can vary due to several factors, including deviations in weather demand, generation availability across primary generation sources, and price competition. TVA Power Operations added two CT peaking plants (Colbert and Paradise) in 2023, and the Johnsonville aeroderivative gas turbines are expected to be commercially available prior to the end of 2024. The addition of incremental capacity and the retirement of the Bull Run Fossil Plant should raise 2024 annual natural gas consumption. Incremental capacity represents the resources selected to fill the capacity gap, and it includes both resource additions and retirements.

TVA purchases natural gas from multiple suppliers on a daily, monthly, seasonal, and term basis. 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 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 9 MW of summer net capability. This plant, located in Meridian, Mississippi, consists of five units completed in 1998. These units are not currently dispatched for generation to the transmission grid. 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 Plant near Chattanooga, Tennessee, with a summer net capability of 1,700 MW. The 86-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 summer net capability of the TVA hydroelectric system is 5,439 MW; this includes 3,739 MW of conventional hydroelectric generation and 1,700 MW from Raccoon Mountain. Conventional hydroelectric plants range in size from the 4-unit, 7-MW Wilbur plant to the 21-unit, 631-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. Renamed the Hydro Life Extension Program, these modernization efforts have been completed on 65 out of 109 conventional hydroelectric units and the four pumped storage 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 made additional improvements and uprates to the Raccoon Mountain facility, which added 84 MW of pumped storage capacity. TVA continues to modernize its 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 approximately 1.0 MW of solar capability across nine operating small photovoltaic (PV) solar installations (Figure 1-1). Renewable resources are typically referred to in nameplate capacity, or maximum hourly generating capability. TVA has also been adding solar through power purchase agreements based on economics and to meet customer demand. TVA has long-term PPAs for 715 MW of operating solar nameplate capacity and has contracted for an additional 2,858 MW of solar nameplate capacity expected to come online over the next few years, including contracts signed in the latest procurement cycle.

Self-Directed Solar. During 2019, the TVA Board approved the opportunity for TVA to explore being directly involved in the development of a utility-scale solar project in Lawrence County, Alabama, contingent on the successful completion of environmental reviews under NEPA and other applicable laws. In 2021, TVA purchased land, and in 2022, the environmental review of the North Alabama Utility-Scale Solar Project was completed. The challenges affecting the U.S. solar industry (e.g., supply chain limitations, cost increases) are affecting this project. This has resulted in a delay in the estimated completion, with the project now expected to be complete by the end of 2027.

In November 2022, the TVA Board approved the opportunity for TVA to explore the development of an additional utility-scale solar project, contingent on successfully completing environmental reviews under NEPA and other applicable laws and obtaining the necessary state permits. The project would utilize TVA-owned land, deploying a solar cap system on the closed CCR facility at the TVA Shawnee Fossil Plant in Paducah, Kentucky.

2.4 Purchased Power

For FY 2021 through FY 2023, purchased power comprised 13 to 18 percent of TVA's total power supply. In FY 2023, TVA purchased 24,263 million kWh of power, which comprised 15 percent of its total power supply. Approximately 2 percent of this purchased power was purchased on the spot market, 6 percent through short-term PPAs, and 92 percent through long-term PPAs.

TVA has long-term PPAs for about 8,400 MW of generating capacity, with an additional 2,500 MW under contract but not yet online (TVA 2023a). The major PPA contracts/facilities, other than those that are part of specific programs, are listed in Table 2-5. Additionally, 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.

Under the Public Utility Regulatory Policies Act (PURPA), TVA is required to purchase energy from qualifying facilities at a price equal to what it would cost TVA to generate this energy itself or purchase this energy from another source. 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 80 MW or less and generates power through renewable (hydroelectric, wind or solar), biomass, waste, or geothermal resources. TVA fulfills this requirement through the Dispersed Power Production program. As of September 30, 2023, there were 955 generation sources, with a combined qualifying capacity of 285 MW, whose power TVA purchases through the Dispersed Power Production program. Most of this power is generated by a 45-MW cogeneration plant operated by International Paper in Lowndes County, Mississippi, and by a 30-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 and installed on or in association with municipal, institutional, and commercial buildings.

Since 2003, TVA has executed several Dispersed Power Production programs that issue contracts with PURPA qualifying facilities to promote and increase renewable energy. These programs have been developed and improved throughout the years leading to more efficient implementation practices.

Table 2-5: 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	AL	833	2032
Morgan Energy Center	Calpine Energy Services	AL	735	2027
Wansley Combined Cycle	Southern Company	GA	250	2024
Harris Combined Cycle	Southern Company	AL	500	2024
Bethlehem Energy Center	Calpine Energy Services	PA	500	2024
Sandersville Plant	Morgan Stanley	GA	292	2025
Firm Energy Contract	Morgan Stanley	GA	200	2023
Zion Energy Center	Calpine Energy Services	IL	495	2025
Lignite Coal				
Red Hills Power Plant	PurEnergy	MS	440	2032
Diesel				
McMinnville	City of McMinnville	TN	23	2029
Powell Valley	Powell Valley	TN	20	2031
University of Tennessee Martin	University of Tennessee	TN	8	2028
City of Ripley	City of Ripley	TN	8	2028
University of Mississippi	University of Mississippi	MS	20	2028
Mississippi State University	Mississippi State University	MS	26	2028
City of Scottsboro	City of Scottsboro	AL	10	2035
Wind				
Buffalo Mountain (Windrock)	Invenergy	TN	25	2024
Lost Lakes	EDPR	IA	101	2030
Caney River	ENEL Green Power North America	KS	201	2031
Pioneer Prairie	EDPR	IA	198	2031
White Oak	NextEra Energy Resources	IL	150	2031
Bishop Hill	Brookfield Renewable	IL	200	2032
Cimarron	NextEra Energy Resources	KS	165	2032
California Ridge	Brookfield Renewable	IL	200	2032
Solar				
West Tennessee Solar Farm	University of Tennessee	TN	5	2032
River Bend	NextEra Energy Resources	AL	75	2036
Millington	Silicon Ranch	TN	53	2038
Skyhawk	Origis Energy	TN	100	2043
Elora	NextEra	TN	150	2042
Muscle Shoals Solar	Orsted	AL	227	2041
McKeller	Silicon Ranch	TN	70	2038
Bell Buckle	Silicon Ranch	TN	35	2043
Biomass				
Chestnut Ridge Landfill Gas	Waste Management	TN	5	2031
Hydroelectric				
Cumberland Hydro	Department of Energy	TN, KY	402	2026
BSMH	Brookfield Smoky Mountain Hydropower LP	TN, NC	377	2024

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

Green Power Providers Program. 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 cost plus a premium rate via a generation credit on the participant's monthly bill via a 10-year PPA. 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_{DC} (direct current, DC) and included solar PV 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 GPP 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 $0.075/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 January 2024, the combined GP and GPP program had over 3,500 generating systems with a total nameplate capacity of about 108 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}. 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.

Renewable Standard Offer. In October 2010, TVA issued the Renewable Standard Offer (RSO) to promote the development of renewable energy in the TVA PSA. TVA's RSO program was designed for developers of new renewable energy projects greater than 50 kW and less than or equal to 20 MW in size located within the TVA region; and offered set prices and terms and conditions (or a "standard offer") to developers of small to mid-size renewable projects under long-term contracts up to 20 years to promote renewable generation from qualified sources. Qualifying fuel sources included solar PV, 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 2023, 23 RSO facilities with over 171 MW of generating capacity were operating. TVA may still seek and enter into additional long-term, negotiated PPAs for new landfill gas and digester gas-to-energy projects if they meet similar criteria used under RSO, plus additional, negotiated business case justifications.

Solar Solutions Initiative. 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 2023, the program had 56 operating facilities with a total capacity of about 37 MW.

Distributed Solar Solutions. 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 2023, the program has 11 facilities with a total capacity of about 20.6 MW operating.

Renewable Investment Programs. 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 2020, the RIA program was rebranded to Green Invest. FRP closed in January 2021. One project is operational (0.888 MW) with the Knoxville Utility Board, and one project is pending as of September 30, 2023.

Requests for Proposals and Awarded Contracts. Since 2017, TVA has issued Requests for Proposals (RFPs) for procurement of varying amounts of new renewable energy resources. Qualifying facilities have to be located within the TVA PSA or be capable of delivering energy to TVA through TVA’s interconnections with neighboring transmission systems. As a result of the proposals received, TVA then awards contracts. Below is a selection of some of the RFPs and subsequent contracts.

- **September 2017**. General RFP for new renewable energy resources. TVA awarded four contracts awarded to build 674 MW of new solar generation.
- **April 2019**. RFP for procurement of 200 MW of new renewable energy resources, including battery energy storage systems (BESS). TVA awarded six contracts to build 651 MW_{AC} (alternating current, AC) of new solar generation and 50 MW BESS.
- **March 2020**. RFP for procurement of 200 MW of new renewable energy resources. TVA awarded 8 contracts to build 1,030 MW_{AC} of new solar generation and 196 MW BESS.
- **June 2021**. TVA issued an RFP for procurement of 200 MW of new renewable energy resources. TVA awarded four contracts to build 160 MW of new solar generation.
- **July 2022**. TVA issued a carbon-free RFP for up to 5,000 MW of carbon-free energy resources with commercial operation dates between 2023 and 2029 including: solar, wind, hydroelectric, geothermal, biomass, nuclear, green gas, BESS paired with above resources, standalone BESS, and hybrid combinations of the aforementioned resources. In late 2023 and through August 2024, TVA signed six PPAs totaling 991 MW of solar generation and 220 MW of battery storage capacity that are expected to come online by the end of 2028.

TVA's current renewable programs and offerings include:

Small-scale Solutions. The Green Connect program connects residential customers interested in on-site solar PV and/or battery storage systems with qualified installers who agree to install to Green Connect program standards. These qualified installers, vetted members of TVA's Quality Contractor Network, are insured, licensed, and have completed program specific training. Participants have access to objective information before their project begins and the benefit of an installation verification to ensure their system was installed to Green Connect program standards.

Utility-scale Solutions. The Green Invest program matches customer demand with renewable supply through a Green Invest Agreement. The goal of the Green Invest program is to meet the long-term sustainability needs of customers at scale. TVA procures the needed renewable supply through a diversified approach, which could include a competitive procurement process, strategic partnerships, or construction of renewable facilities to meet these needs. As of September 30, 2023, more than 2,000 MW of renewable PPAs have been matched to customers through the Green Invest program. In addition, Generation Flexibility is a solution available to LPCs participating in TVA's Partnership Agreement and supports the deployment of up to 2,000 MW of distributed solar to provide clean, local generation.

Other Renewable Solutions. The Green Switch program allows customers to support solar renewable resources through purchasing renewable solar energy generated in the Tennessee Valley. The product is sold in blocks of 200 kWh or matches 100 percent of a customer's electricity usage (available through select LPCs).

During FY 2023, participants purchased 91,268 MWh through the Green Switch program. The Green Flex program gives commercial and industrial customers the ability to meet sustainability goals and to make renewable energy claims through Renewable Energy Certificates (RECs) from wind generation located outside TVA's PSA. During the year ended September 30, 2023, participants purchased approximately 650,000 RECs through the Green Flex program.

TVA tracks its renewable energy commitments and claims through the management of RECs. The RECs, which each represent one MWh of renewable energy generation, are principally associated with wind, solar, biomass, and low-impact hydroelectric. TVA continues to evaluate ways to adjust to customer preferences and requirements for cleaner and greener energy, including the acquisition of RECs from renewable purchased power that can be sold to customers to meet their needs. Overall, TVA will procure needed renewable supply through a diversified approach, which could include a competitive procurement process, strategic partnerships, or construction of renewable facilities to meet these needs.

2.5 Demand-Side Management Programs

TVA has had a portfolio of demand-side management (DSM) programs focusing on EE and DR for many years. 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. 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, DR 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 DSM portfolio is a combination of fully deployed mature programs, recently initiated programs, and programs under development. The following sections describe DSM programs that have operated since 2015.

2.5.1 Energy Efficiency Programs

TVA EnergyRight® program targets include: Business & Industry, Residential Services, and Electric Vehicles. The EnergyRight 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. The programs 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 153 LPCs. The development and implementation of many types of DSM programs are delivered through partnerships with participating LPCs, which requires coordination and close collaboration. The TVA EnergyRight portfolio is described in more detail below; information about programs is also available at http://www.energyright.com/.

TVA continues to make investments in its demand management portfolio as part of its commitment to meet the Tennessee Valley’s growing energy needs and to support a decarbonized and more resilient grid. As noted in TVA’s FY 2023 10-K, “energy efficiency programs…effectively reduced 2023 energy needs by about 2,100 net cumulative gigawatt hours or 1.3 percent [of total annual energy demand since program inception].” TVA is expanding its portfolio and plans to invest $1.5 billion in its demand management portfolio from 2024-2028. Over this five-year period, TVA anticipates approximately 2,200 GWh of net incremental EE savings and over 2,200 MW of total DR portfolio capacity in 2028.

Virtual Power Plant. TVA's Virtual Power Plant consists of EE and DR programs aimed at balancing system needs by lowering costs, shaping energy usage, increasing capacity, and decarbonizing the grid. These programs support helping end-use consumers save on their bills and reduce some of the need for new generation in the future and are offered to both end-use residential customers and businesses and industries. TVA anticipates additional demand management programs to be developed over the coming years to help support the future direction of the Virtual Power Plant.

Community Energy Efficiency Programs. TVA also has energy programming focused on expanding partnerships, improving program access, and catalyzing investment in communities where all individuals can benefit from TVA's resources. TVA's Community Energy Efficiency Programs include: (1) the Home Uplift Program, which completes home evaluations and makes high-impact home energy upgrades for qualifying homeowners at no cost to the homeowners, (2) the School Uplift Program, which assists schools with adopting strategic energy management practices, and (3) the Small Business Uplift Program, which assists small businesses located within underserved communities with energy evaluations and energy improvement investments provided by TVA at no cost to the small business.

Through its EnergyRight program, TVA realized 84 gigawatt hours (GWh), 37 GWh, and 118 GWh of EE savings in FY 2021, FY 2022, and FY 2023, respectively.

2.5.2 TVA Internal Programs

TVA's Internal Energy Management Program (IEMP) is a program under EnergyRight Business & Industry through which TVA identifies, funds, and implements energy and water conservation projects in TVA buildings. IEMP helps TVA meet energy and sustainability goals, lowers costs, improves safety, increases productivity and creates jobs. Through the program, TVA complies with EE 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 (EO), including EO 14008 Tackling the Climate Crisis at Home and Abroad (2021), and EO 14057 Catalyzing Clean Energy Industries and Jobs Through Federal Sustainability (2021). In FY 2022, highlights of the IEMP (TVA 2023b) included:

- $3.8M spent on improvements,
- $285,000 in annual savings,
- 3.35 GWh in energy savings, and
- 2,621 tons of carbon reduced.

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

TVA offers several Demand Response (DR) programs which are described below, except for Virtual Power Plant, which is described under EE programs.

Interruptible Power. Through the IP5 or IP30 program, which falls under ER, TVA offers financial incentives for participating businesses that agree to suspend a portion of their energy load when the power system is constrained. IP5 participants receive a monthly demand credit in exchange for load curtailment. IP30 participants receive a monthly demand credit along with an event-based energy credit in exchange for load curtailment. In FY 2022, highlights for Interruptible Power programs (TVA 2023b) included:

- 765 MW of Interruptible Power – 5 minutes' notice,
- 666 MW of Interruptible Power – 30 minutes' notice,
- 17 DR events,
- 34,573 MWh of energy saved, and
- 15,974 tons of carbon avoided.

Peak Power Partners. Through TVA's partnership with third-party administrator Enel X, TVA EnergyRight offers LPCs an easy way to administer the DR program. Participating businesses receive a financial incentive as well as expanded information on their energy usage. In FY 2022, highlights for Peak Power Partners programs (TVA 2023b) included:

- 54 MW of total capacity,
- 7 DR events,
- 1,343 MWh of total energy saved, and
- 621 tons of carbon avoided.

Voltage Optimization. TVA EnergyRight operates voltage optimization programs with local power companies that operate distribution feeder voltages in the lower half of the standard voltage range [KP23], thereby reducing energy consumption annually. In FY 2022, highlights for Voltage Optimization programs (TVA 2023b) included:

- 179 MW of total capacity,
- 6 DR events,
- 5,084 MWh of energy saved, and
- 2,349 tons of carbon avoided.

TVA DR programs provided 1,672 MW, 1,772 MW, and 1,441 MW of potential demand reduction through demand reduction in FY 2021, FY 2022, and FY 2023, respectively.

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 16,334 miles of transmission line; 573 substations, switchyards, and switching stations; and 1,355 individual customer connection points. The system connects to switchyards at generating facilities and transmits power from them at either 161 kilovolts (kV) or 500 kV to LPCs and direct 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 – 2,479 miles
- 345- and 230-kV lines – 150 miles
- 161-kV lines – 11,973 miles
- 138- and 115-kV lines – 221 miles
- 69-kV lines – 955 miles
- 46-kV lines – 540 miles
- 26- and 13-kV lines – 16 miles

The TVA transmission system has 69 interconnections with 13 neighboring electric systems and delivered approximately 157 billion kWh of electricity to TVA customers in 2023. These interconnections allow TVA and its neighboring utilities to buy and sell power from each other and to transmit power through their systems to other utilities. Pursuant to its Transmission Service Guidelines, TVA offers transmission services to eligible customers to transmit wholesale power in a manner that is comparable to TVA's own use of the transmission system. TVA has also adopted and operates in accordance with its published Transmission Standards of Conduct and separates its transmission function from its power marketing function. As a Balancing Authority, Distribution Provider, Generator Owner, Generator Operator, Planning Coordinator, Reliability Coordinator, Resource Planner, Transmission Owner, Transmission Operator, Transmission Planner, and Transmission

Service Provider, as those terms are defined for purposes of North American Electric Reliability Corporation (NERC) regulations, TVA is also subject to federal reliability standards that are set forth by the NERC and approved by FERC.

In recent years, TVA has built an average of about 65 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. Most of these new lines are 161 kV. Since 2008, TVA has completed two major 500-kV transmission lines, both in Tennessee. TVA has recently approved a 3.4-mile 500-kV transmission line to support the Memphis Regional Megasite development in west Tennessee, which will include a new Ford Motor Company electric vehicle (EV)/battery manufacturing facility (“BlueOval City”).

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 while integrating cleaner energy generating assets as coal units are retired. 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 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.

Additional transmission upgrades may be required to maintain reliability. Upgrades may include enhancements to existing lines and substations or new installations as necessary to provide adequate power transmission capacity, maintain voltage support, and ensure generating plant and transmission system stability. In addition to upgrades to maintain reliability, TVA’s Grid of Tomorrow initiative aims to increase grid flexibility to enable greater use of renewable resources such as solar, wind, and other forms of distributed generation. It also includes making data and communications upgrades as demonstrated by investments in the new Primary System Operations Center, energy management system, and fiber optic network.

In recognition of the challenges of integrating intermittent and inverter-based resources to the power system, TVA established the Future Grid Performance initiative. The primary goal is to maintain a stable and reliable grid while fostering the evolution of the energy system of the future, one of TVA's strategic elements of Operational Excellence. Secondary goals include improving processes to facilitate an evolving resource mix with new technologies, optimizing approaches and tools to ensure system stability and performance in the future grid, and evaluating and adopting new grid technologies. This initiative seeks to address grid needs to keep the grid reliable and stable as TVA transitions to an energy system that has a greater share of intermittent and inverter-based resources, such as renewables and battery storage, connected to the transmission system. In addition, TVA is working on various projects with universities, the Electric Power Research Institute, and others to help enable a dynamic and multi-directional grid. TVA is also working in partnership with LPCs to modernize their distribution systems by developing a shared vision and roadmap for transforming the TVA region’s transmission and distribution systems into an integrated regional grid. These initiatives support TVA’s decarbonization efforts while helping ensure TVA continues to achieve its mission to deliver affordable, reliable power. Investments in a modernized grid will help enable enhanced monitoring and control of TVA’s transmission and generation portfolio.

Integrated transmission planning is critical to accommodating load growth, expected retirements, and new generation resources in a safe, reliable, compliant, and cost-effective way. Preparing for local and regional load growth, as well as understanding when and where retirements will likely occur and new generation will be needed, are key inputs into transmission planning. As demand and supply change, TVA is incorporating enhancements to manage more complex two-way flows to support the grid of the future. Timing is key – and TVA will develop an integrated transmission plan, incorporating stakeholder input, that considers the strategic direction from the IRP and enables the timely and reliable evolution of the power system.

2.7 Electric Vehicles

Since 2018, TVA has been collaborating with state agencies, LPCs, automotive manufacturers, and other stakeholders to promote the adoption of EVs in the region by addressing the major market barriers facing consumers: improving charging infrastructure availability, setting innovative and supporting policies, expanding EV availability and offerings, and increasing consumer awareness. TVA and partners' shared goal is to support more than 200,000 EVs in the TVA region by 2028.

Fast Charge Network. TVA is collaborating with LPCs, state agencies, and other regional partners to develop a foundational, publicly accessible EV fast charging network. Once completed, the Fast Charge Network will include approximately 80 locations with 200 fast chargers aimed at improving and standardizing the customer experience by reducing charging times, with multiple station owners and site hosts across TVA's PSA. The new infrastructure would provide drivers with charging options such that they would never be more than 25 miles from a fast-charging location while traveling the interstates and major highways across the TVA region. TVA reviews each charging station installation in advance to address potential environmental effects and promote a consistent and positive customer charging experience. As of August 2024, there are:

- 62 participating local power companies,
- 76 sites contracted or completed,
- 35 sites opened, and
- 6 states participating.

EV Fleet Advisor. TVA's EV Fleet Advisor initiative is a pilot project that offers educational and consulting services for commercial businesses considering electrifying all or a portion of their vehicle fleets. TVA connects businesses to an experienced consultant who helps them plan for transitioning their vehicle fleet to electric. The pilot is targeting commercial vehicle fleets and applications and will help inform future offerings.

EV Ready New Home Construction. Through TVA's New Homes program, home builders that are part of the new homes network are eligible to receive incentives to build "EV Ready" new homes through the inclusion of a 240 Volt electrical circuit and receptacle (or full EV charging stations) in a garage or similar space intended for future EV use.

Consumer Education and Awareness. TVA is also increasing awareness and educating the public on electric transportation options. TVA has developed and shared an educational video series (entitled "In Charge: Life with an Electric Vehicle") on its website and social media to provide information and help customers prepare for EV adoption. In addition, the TVA website www.EnergyRight.com/EV addresses common EV myths, questions and concerns and provides information on maintenance, batteries, chargers, car types and other EV topics through online tools and blog informational resources.

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 Integrated Resource Plan (IRP) develops a least-cost plan that is consistent with TVA's requirements under Section 113 of the Energy Policy Act of 1992. The IRP objectives, including the least-cost planning principles, are described in Section 3.1 of Volume 1.

Multiple strategies, which represent business decisions within TVA's 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 long-term capacity plan through 2050 that is unique to each combination of strategy and scenario. A detailed description of the development and evaluation of the portfolios is in Section 3.8 of Volume 1.

3.1 Development of Scenarios

Based on the scoping comments, IRP Working Group input, and further analysis, TVA identified six scenarios for evaluation (Figure 3-1):

1 **Reference (without Greenhouse Gas Rule)**
Represents TVA's current forecast that reflects moderate population, employment, and industrial growth, weather-normal trends, growing electric vehicle use, and increasing efficiencies

2 **Higher Growth Economy**
Reflects a technology-driven increase in U.S. productivity growth that stimulates the national and regional economies, resulting in substantially higher demand for electricity

3 **Stagnant Economy**
Reflects rising debt and inflation that stifle consumer demand and business investment, resulting in weaker than expected economic growth and essentially flat electricity demand

4 **Net-zero Regulation**
Reflects the impact of the May 2023 draft Greenhouse Gas Rule that targets significant reductions in electric utility CO_2 emissions beginning in 2030 and potential future utility regulations striving for net-zero by 2050

5 **Net-zero Regulation Plus Growth**
Reflects the impact of the May 2023 draft Greenhouse Gas Rule and potential future utility regulations, along with substantial advancements in clean energy technologies, that spur economic growth and extensive electrification

6 **Reference (with Greenhouse Gas Rule)**
Reflects TVA's current forecast and incorporates the impact of the Greenhouse Gas Rule finalized in May 2024 that targets significant reductions in electric utility CO_2 emissions beginning in 2030

Figure 3-1: Key Characteristics of the Six Scenarios

Each of the scenarios has a unique set of uncertainties or attributes that are likely to change in the future. These include the demand for electricity, regional and national economic conditions, the market price of power, fuel prices, environmental regulations affecting electric utilities, electric vehicle (EV) and distributed generation adoption, market-driven energy efficiency (EE) adoption, and advancements in new clean energy technologies. The 2025 IRP's two net-zero regulation scenarios (Scenarios 4 and 5 – "Net-zero Regulation" and "Net-zero Regulation Plus Growth") are noteworthy, as they incorporate the U.S. Environmental Protection Agency's (USEPA) draft greenhouse gas (GHG) rule published in May 2023, which would require significant changes in the operation of existing and new fossil fuel plants. They also incorporate potential future regulations intended to drive toward net-zero greenhouse gas emissions from the power sector by 2050. Scenario 6 is a variation on the Scenario 1 Reference case that incorporates the impacts of the USEPA's recently finalized GHG rule published in May 2024, which was similar to the draft rule but did not include regulations for existing gas plants. These and other aspects of the scenarios are described in detail in Section 3.4 of Volume 1.

3.2 Alternative Strategies and Associated Capacity Expansion Plans

3.2.1 Development of Alternative Strategies

After review of the scoping comments and internal deliberation, TVA developed five planning strategies in coordination with the IRP Working Group. Strategy A, Baseline Utility Planning, is the No Action Alternative. The four other strategies represent action alternatives.

- Strategy A: Baseline Utility Planning (No Action Alternative)
- Strategy B: Carbon-free Innovation Focus
- Strategy C: Carbon-free Commercial Ready Focus
- Strategy D: Distributed and Demand-side Focus
- Strategy E: Resiliency Focus

Figure 3-2 provides key characteristics of the five alternative strategies. In Baseline Utility Planning, no energy resource types are promoted. The four alternative strategies promote certain energy resource types based on the focus in each strategy. After defining each strategy's key characteristics, three promotion levels – base (no incentive), moderate, and high – were determined to achieve the objectives of the strategy, as shown in Figure 3-3. Base reflects no level of promotion, while moderate and high apply increasingly greater levels of promotion. These promotion levels influenced the selection of the expansion 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.

A	**Baseline Utility Planning** Represents TVA's current outlook based on least-cost planning, incorporating existing programs and a planning reserve margin target. This reserve margin target applies in all strategies
B	**Carbon-free Innovation Focus** Emphasizes and promotes emerging, firm and dispatchable carbon-free technologies through innovation, continued research and development, and strategic partnerships
C	**Carbon-free Commercial Ready Focus** Emphasizes proven carbon-free technologies like wind, solar, and storage, at both utility-scale and through customer partnerships, along with strategic transmission investment
D	**Distributed and Demand-side Focus** Emphasizes existing and potentially expanded customer partnerships and programmatic solutions to reduce reliance on central station generation and promote virtual power plants
E	**Resiliency Focus** Emphasizes smaller units and the promotion of storage, along with strategic transmission investment, to drive wider geographic resource distribution and additional resiliency across the system

Figure 3-2: Key Characteristics of the Five Alternative Strategies

STRATEGY		UTILITY SCALE RESOURCES						DISTRIBUTED AND DEMAND-SIDE RESOURCES				
		Solar and Wind	Battery Storage	Long-duration Storage	Aero CTs and Recip Engines	Nuclear	CCS*	Distributed Solar	Distributed Storage	Combined Heat and Power	Energy Efficiency	Demand Response
A	Baseline Utility Planning	Base	Base	Base	Base	Base	Base	Base	Base	Base	Base	Base
B	Carbon-free Innovation Focus	Moderate	Moderate	Moderate	Base	High	High	Moderate	Moderate	Base	Moderate	Moderate
C	Carbon-free Commercial Ready Focus	High	High	High	Base	Base	Base	Moderate	Moderate	Base	Base	Moderate
D	Distributed and Demand-side Focus	Base	High	Base	High	Base	Base	High	High	High	High	High
E	Resiliency Focus	Base	High	Moderate	High	Moderate	Base	Moderate	Moderate	Moderate	Base	High

*Carbon capture and sequestration

Figure 3-3: Promotion Levels for Selected Energy Resources Associated with Each Strategy

3.2.2 Capacity Expansion Plans

The six scenarios forecasted varying levels of electricity demand, which drove varying levels of capacity requirements and need for incremental resources in each scenario. The planning model then applied the resource promotions identified for each strategy and solved for an optimal, least-cost portfolio for each unique scenario and strategy combination.

Capacity expansion plans are comprised of baseline firm supply plus incremental capacity change, or the total megawatts (MW) available to meet firm requirements. The following 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 MW and annual energy production is quantified in terawatt hours (TWh). The capacity expansion plans assume that all remaining coal facilities are expected to reach end-of-life by 2035 and are retired, in alignment with TVA's current planning assumptions or pursuant to regulatory requirements within the scenario studied. The forecasted capacity available from existing resources changes over the study window as generating units reach the end of their useful life and purchased power contracts expire (see Table 3-1 of Volume 1).

Key themes regarding capacity and expansion plans looking across all portfolios include:

- New capacity is needed in all scenarios to replace retiring and expiring capacity, support economic growth, and enable further electrification of the economy.
- Firm, dispatchable technologies are needed to ensure system reliability throughout the year.
- Solar expansion plays an increasingly substantial role, providing economic, carbon-free energy.
- Gas expansion serves broad system needs, with the potential for emerging carbon capture and hydrogen options to enable deeper decarbonization.
- Energy efficiency deployment reduces energy needs, particularly between now and 2035, and demand response programs grow with the system and the use of smart technologies.
- Storage expansion accelerates, driven by evolving battery technologies and the potential for additional pumped storage.
- Wind additions have the potential to add more diversity and carbon-free energy to the resource mix.
- New nuclear technologies, with continued advancements, can also support load growth and deeper decarbonization.

As other sectors of the economy electrify, almost all resource types – both supply and demand-side – will be required to meet system needs. In all scenarios, TVA would continue to provide affordable, reliable, resilient, and increasingly cleaner energy for the region for decades to come.

Total capacity expansion plans for 2035 are presented in Figure 3-4, grouped by scenario and segmented by resource type. Because of varying levels of forecasted demand, Scenario 3 (Stagnant Economy) portfolios have the lowest total capacity and Scenario 5 (Net-zero Regulation Plus Growth) portfolios have the highest total capacity. Scenario 6 (Reference with GHG Rule) is a variation on Scenario 1 that incorporates the recently finalized GHG Rule. Scenarios 4 and 5 assume the draft GHG Rule, potential future regulations driving to net-zero, and the broad application of new and developing technologies such as carbon capture and sequestration (CCS) and hydrogen blending. The strategy results within each scenario differ based on promotion of resources. Further information on capacity plans can be found in Volume 1, Chapter 4 and Appendix H.

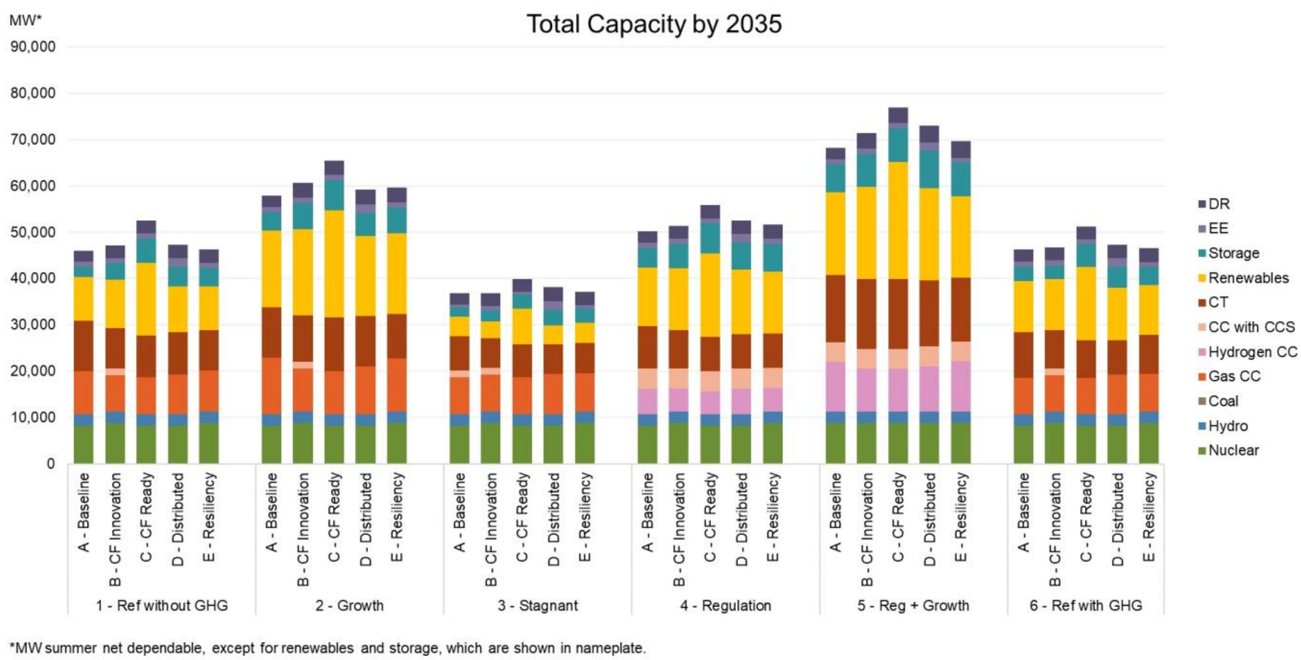


Figure 3-4. Total Capacity in 2035

Total energy plans for 2035 are presented in Figure 3-5, grouped by scenario and segmented by resource type. The energy plans represent the energy expected from the economic dispatch of the resources available in each capacity plan, shown in TWh. Energy patterns across scenarios and strategies generally vary for similar reasons, as noted in the discussion of capacity plans. Further information on energy plans can be found in Volume 1, Chapter 4 and Appendix H.

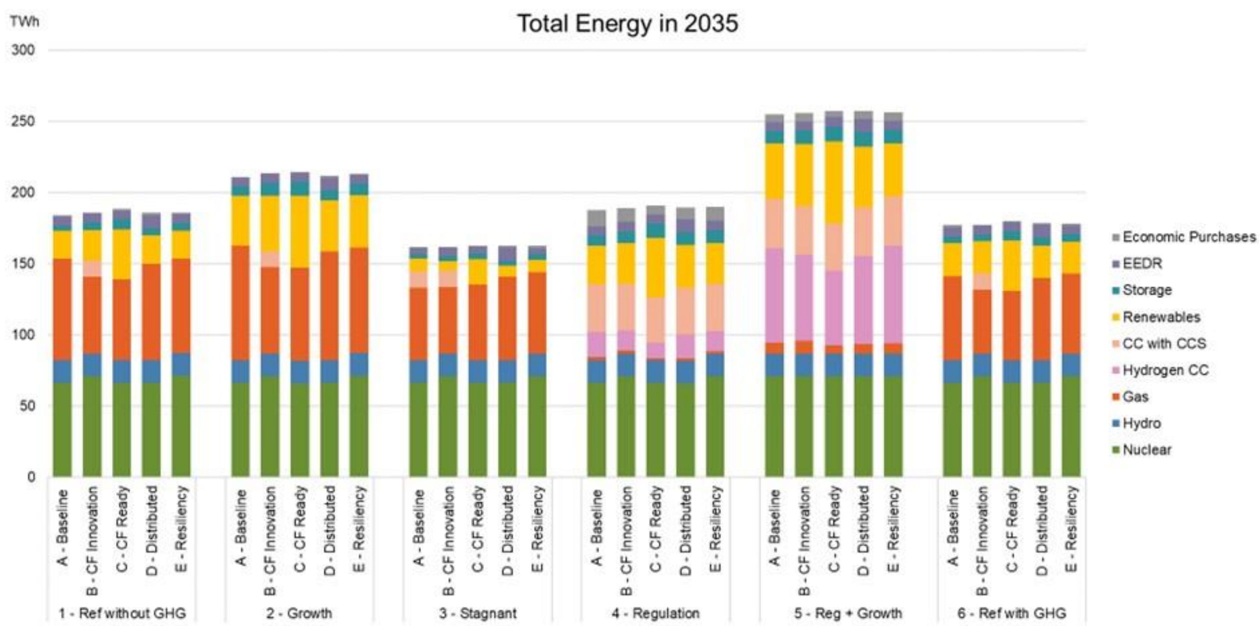


Figure 3-5. Total Energy in 2035

Total capacity expansion plans for 2050 are presented in Figure 3-6, grouped by scenario and segmented by resource type. Because of varying levels of forecasted demand, Scenario 3 (Stagnant Economy) portfolios have the lowest total capacity and Scenario 5 (Net-zero Regulation Plus Growth) portfolios have the highest total capacity. Scenario 6 (Reference with GHG Rule) is a variation on Scenario 1 that incorporates the recently finalized GHG Rule. Scenarios 4 and 5 assume the draft GHG Rule, potential future regulations driving to net-zero, and the broad application of new and developing technologies such as carbon capture and sequestration (CCS) and hydrogen blending. The strategy results within each scenario differ based on promotion of resources. Further information on capacity plans can be found in Volume 1, Chapter 4 and Appendix H.

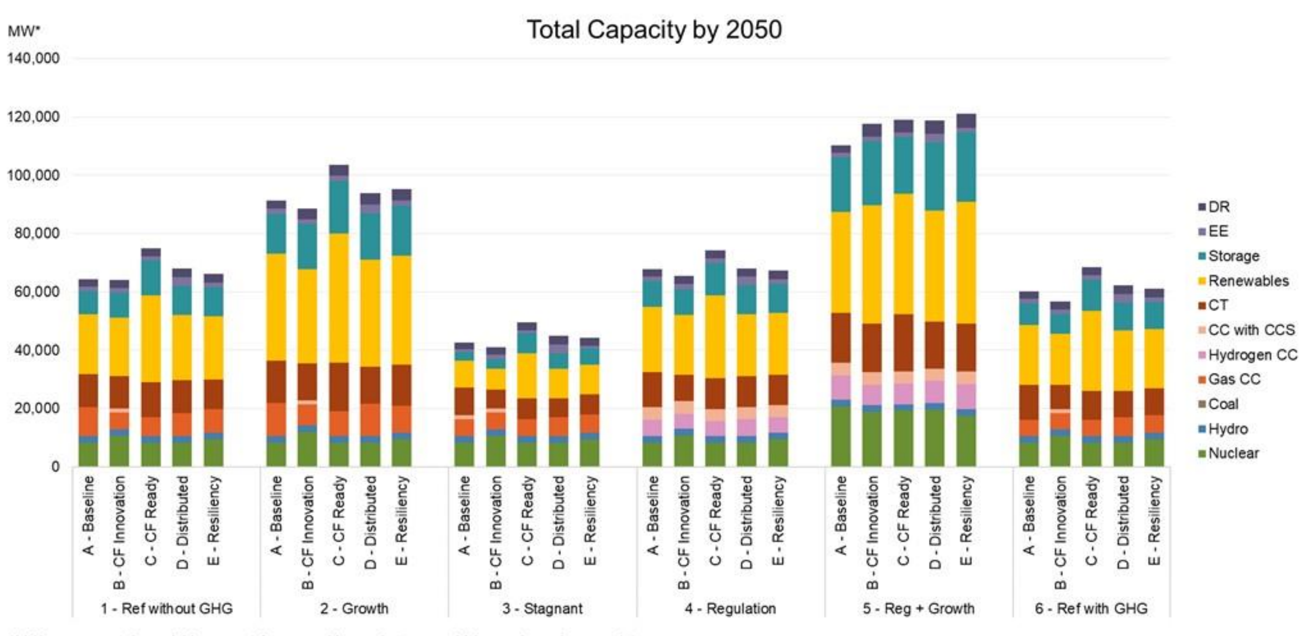


Figure 3-6: Total Capacity Plans in 2050 (MW Summer Net Dependable Capacity, Renewables and Storage in Nameplate)

Total energy plans for 2050 are presented below, grouped by scenario and segmented by resource type. The energy plans represent the energy expected from the economic dispatch of the resources available in each capacity plan, shown in TWh. Energy patterns across scenarios and strategies generally vary for similar reasons as noted in the discussion of capacity plans. Further information on energy plans can be found in the Volume 1, Chapter 4 and Appendix H. Figure 3-7 compares the total energy plans for all portfolios in 2050.

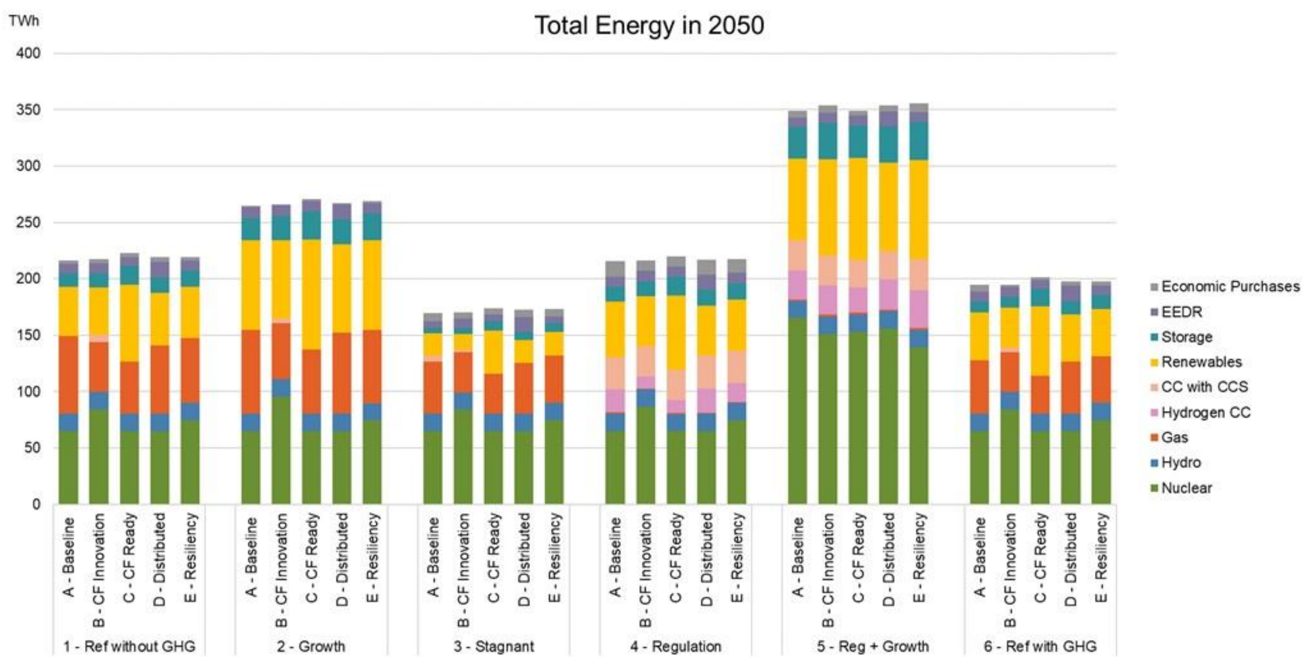


Figure 3-7: Total Energy Plans in 2050 (terawatt hours)

3.2.3 Potential Retirement of TVA Generating Facilities

Several TVA facilities have units that are being considered for retirement during the planning period. Retirement of the Cumberland and Kingston coal plants has been evaluated in recent environmental reviews, with units expected to retire as replacement capacity comes online over the next five years. By 2035, TVA expects to retire the remaining coal fleet (Gallatin and Shawnee Fossil Plants). In addition, based on unit age, TVA expects some of its oldest gas CC plants to reach end-of-life in the late 2030s and 2040s.

The following sections describe in general the activities that would occur upon potential retirement of these facilities.

3.2.3.1 Natural Gas Plants

Decommissioning is the performance of activities required to ready a facility for deactivation. Key decommissioning activities at natural gas-fired CT and CC facilities 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, demineralized 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 with the intention of leaving the plant 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.

Decommissioning may also include the demolition of structures or infrastructure and the preparation and reclamation of the site for future use.

3.2.3.2 Coal Plants

TVA is evaluating the impact of retiring the balance of the coal-fired fleet by 2035, and that evaluation includes environmental reviews, public input, and TVA Board approval. Official retirement decisions or major plant modifications, such as the installation of environmental controls or adaptations for co-firing, for remaining coal facilities are subject to environmental review pursuant to the National Environmental Policy Act (NEPA).

In 2022, TVA completed its environmental review of the impacts associated with the potential retirement of Cumberland and the construction and operation of facilities to replace part of that generation. As noted in Section 2.3.1 above, TVA decided in January 2023 to retire the two coal-fired units at Cumberland, which accounted for 2,470 MW of TVA's summer net capability as of September 30, 2023. TVA plans to replace generation for one unit with a 1,450 MW CC plant that is expected to be operational by the end of calendar year (CY) 2026 when the first coal unit is scheduled to be retired. The second unit is scheduled to be retired by the end of CY 2028, and in May 2023, TVA published the notice of intent to conduct an EIS to study potential environmental impacts associated with the proposed construction and operation of facilities to replace part of that generation.

In early 2024, TVA completed its environmental review of the impacts associated with the potential retirement of Kingston Fossil Plant and the construction and operation of facilities to replace the retired generation facility. As noted in Section 2.3.1 above, TVA issued its decision in April 2024 to retire the nine units at Kingston (1,298 MW of summer net capability as of September 30, 2023) by the end of CY 2027. TVA plans to replace generation by constructing and operating a CC facility that is paired with an aeroderivative CT plant, a solar site, and battery storage facility on the Kingston Site, providing a total of 1,500 MW of power.

The service lives for Gallatin Fossil Plant and Shawnee Fossil Plant were shortened in a new depreciation study implemented during the first quarter of 2022 to reflect current planning assumptions established in TVA's May 2021 Aging Coal Fleet Evaluation. TVA expects to retire the plants by 2035 but will prepare environmental reviews pursuant to NEPA prior to any official retirement decisions.

For coal plants or units selected for retirement, TVA would cease most plant operations and reduce plant staff at the time of retirement. 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 information 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 with the intention of leaving the plant 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.

Decommissioning may also include the demolition of structures or infrastructure and the preparation and reclamation of the site for future use.

3.3 Modeling Results Based on Strategy

Each strategy was run with each scenario, creating 30 unique modeling results, or portfolios (Figure 3-8). Overall, present value of revenue requirements (PVRR) and total resource costs (TRC) are highest in Scenario 5, which has the highest load growth, and lowest in Scenario 3, which assumes load remains essentially flat.

System average cost is lowest overall in Scenario 3, as fewer new resources are needed with a flat load forecast, and it is highest in Scenario 4 due to costs to meet assumed net-zero CO_2 regulations. All portfolios include timeline, technological, transmission, and/or market depth uncertainty and execution risks, which are amplified by load growth and regulatory impacts. Timeline risks would be greatest in the highest growth scenarios (2 and 5). A full list of each of the environmental parameters of the 30 portfolios can be found in Appendix C.

STRATEGIES	SCENARIOS					
	1 Reference without GHG Rule	2 Higher Growth Economy	3 Stagnant Economy	4 Net-zero Regulation	5 Net-zero Regulation Plus Growth	6 Reference with GHG Rule
A Baseline Utility Planning	1A	2A	3A	4A	5A	6A
B Carbon-free Innovation Focus	1B	2B	3B	4B	5B	6B
C Carbon-free Commercial Ready Focus	1C	2C	3C	4C	5C	6C
D Distributed and Demand-side Focus	1D	2D	3D	4D	5D	6D
E Resiliency Focus	1E	2E	3E	4E	5E	6E

Figure 3-8: 2025 IRP Core Portfolios

Existing coal plants are expected to retire by 2035, and no new coal plants were selected in any of the cases. All strategies lead to reductions in direct carbon dioxide (CO_2) emissions and intensity, especially in net-zero regulatory scenarios (Scenarios 4 and 5). Intensity expresses environmental impacts in terms of how they relate to average total energy for each portfolio, which allows for a better comparison across all portfolios. Results for the various scenarios are clustered, as the scenario that materializes for forecasted load and regulatory impacts was the primary driver of cost and CO_2 profiles. Reductions in 2035 CO_2 intensity from a 2005 baseline ranged from 73 percent to 82 percent in Scenarios 1, 2, 3, and 6 and averaged above 90 percent in Scenarios 4 and 5 with assumed regulatory impacts. Reductions in 2050 CO_2 intensity from a 2005 baseline ranged from 78 percent to 87 percent in Scenarios 1, 2, 3, and 6 and averaged above 98 percent in Scenarios 4 and 5 with assumed regulatory impacts. Waste intensity would be largely similar across the strategies, as all portfolios assume similar estimated end-of-life dates for coal plants.

Firm, dispatchable gas resources are selected in all cases to support system reliability, with relative magnitudes mainly driven by forecasted load in the scenarios. Typically, CC plants run more frequently, and CT plants are used to meet energy needs during peak hours. Scenarios 1, 2, 3, and 6 portfolios have a relatively equal mix of gas CCs and frame CTs, complemented by aero CTs and RICE. Gas CC capacity is highest in Scenario 2 and lowest in Scenario 3. Gas CT capacity is highest in Scenarios 2 and 5 and lowest in Scenario 3 due to higher and lower levels of load growth, respectively. In Scenarios 4 and 5 that assume increasing carbon regulation and declining hydrogen prices, hydrogen CCs and CCs with CCS are selected, with the hydrogen CCs burning a hydrogen-blended fuel in line with the requirements outlined in the draft GHG Rule. Also in Scenario 4, some Gas CCs were retired earlier than estimated end-of-life dates driven by assumed CO_2 emissions penalties.

Renewable nameplate additions are prevalent across the portfolios. Renewable resources like solar and wind are typically referred to in nameplate capacity, or maximum hourly generating capability. Additions of renewable resources are primarily solar, and they vary with load growth and strategic emphasis. Renewable capacity is highest in Scenarios 2 and 5 that have higher load projections. Hydroelectric generation and capacity were slightly higher in all portfolios with the selection of hydroelectric uprates. Storage capacity, which is a combination of short and long duration options, increases in all portfolios and is also highest in Scenarios 2 and 5. Average EE and DR additions were relatively similar in magnitude across the scenarios, with alternative strategies including various levels of promotion of these demand-side programs.

3.3.1 Strategy A: Baseline Utility Planning (No Action Alternative)

Strategy A, Baseline Utility Planning, represents fundamental least-cost planning. No specific resource types are promoted beyond existing programs. Resources are modeled and chosen economically to meet the reserve margin constraint for reliability. Planning reserve margins are included for summer and winter peak seasons, and they apply in all strategies. These targets are developed separately from the IRP by employing an industry best-practice 1-in-10-year loss-of-load expectation level of reliability.

As Strategy A applies no resource promotions, it is the lowest cost strategy overall, and it has less reduction in CO_2 intensity on average than the alternative strategies that promote lower carbon resources. Strategy A portfolios have the highest natural gas generation and the lowest land use on average across the strategies.

See Section 4.8.1 of Volume 1 for more information about Strategy A performance.

3.3.2 Strategy B: Carbon-free Innovation Focus

Strategy B, Carbon-free Innovation Focus, emphasizes developing emerging technologies that are firm and dispatchable, meaning that they can be reliably and predictably turned on and off to meet demand. These technologies include advanced nuclear, carbon capture and sequestration, long duration storage, and demand response. Under this strategy, TVA would increase efforts in research and development to advance and deploy these new carbon-free technologies. This could be executed through partnerships with other organizations, such as universities, research labs, and startups, to share resources and expertise.

Strategy B is the most expensive strategy overall, as it would require upfront investments in clean energy technology innovation, and it achieves similar decarbonization levels as Strategy C over the long term. Technological risks are greatest in portfolios with more reliance on new clean energy technologies, and Strategy B portfolios have the highest amount of new nuclear and CC with CCS expansion.

See Section 4.8.2 of Volume 1 for more information about Strategy B performance.

3.3.3 Strategy C: Carbon-free Commercial Ready Focus

Strategy C, Carbon-free Commercial Ready Focus, emphasizes proven carbon-free technologies like wind, solar, and storage, at both utility-scale and through customer partnerships, along with strategic transmission investment. Under this strategy, TVA would focus on promoting these renewable generation technologies that are mature and commercially viable today, potentially allowing for faster deployment of carbon-free resources. Partnerships like TVA's existing Green Invest program, as well as strategic transmission investments, facilitate renewable growth. Storage technologies are essential enablers for renewable deployment, improving system integration and providing firm, dispatchable capacity.

Strategy C, which focuses on carbon-free commercial ready technologies, is the second lowest in cost and achieves the fastest near-term reductions in CO_2 intensity. Strategy C portfolios have the highest renewable and storage additions. With the largest solar buildouts under this strategy, transmission risks and land use are greatest. Water consumption intensity is lowest as higher renewable generation displaces thermal generation.

See Section 4.8.3 of Volume 1 for more information about Strategy C performance.

3.3.4 Strategy D: Distributed and Demand-side Focus

Strategy D, Distributed and Demand-side Focus, emphasizes existing and potentially expanded customer partnerships and programmatic solutions to reduce reliance on central station generation and promote virtual power plants. Under this strategy, TVA would incentivize customers to install distributed generation and participate in DSM programs. Distributed generation includes distributed solar, storage, and combined heat and power, and DSM options include energy efficiency and demand response programs. Program design would need to ensure that the incentive structure is balanced and fair, so that it does not disrupt the grid or lead to higher costs for other non-participating customers. The aggregation of these distributed and demand-side solutions would create virtual power plants, which can reduce the need for additional utility-scale resources.

Strategy D is the second most expensive strategy with respect to Total Resource Cost, which includes consumer investment in distributed generation and more efficient end-use technologies. EE and DR additions are highest in Strategy D, which promotes these resources. Strategy D portfolios generally rank in the middle for most other metrics.

See Section 4.8.4 of Volume 1 for more information about Strategy D performance.

3.3.5 Strategy E: Resiliency Focus

Strategy E, the Resiliency Focus Strategy, emphasizes the promotion of smaller units of all resource types, making the system more resilient and able to recover more quickly from disruptions. Strategic investments in the transmission system could allow for wider geographic distribution and the promotion of storage to drive additional resiliency throughout the system. Under this strategy, TVA would shift its focus from large, centralized power plants to smaller generation units that could be more widely distributed geographically, which would reduce large unit contingencies and enhance reliability. A geographically diverse fleet with a variety of fuels would increase resiliency and fuel assurance through reduced risk from localized fuel supply disruptions. TVA would promote the use of energy storage, such as batteries and pumped storage. Batteries could be strategically located across areas of the grid and respond quickly to support resiliency needs.

Strategy E portfolios generally rank in the middle across the metric categories. Strategy E portfolios have increased nuclear generation with the addition of SMRs. They also include the highest amount of smaller gas and storage units, supporting resilient operations with the potential for broader geographical distribution.

See Section 4.8.5 of Volume 1 for more information about Strategy E performance.

3.4 Summary 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.

While the total amount of energy generated during the 2025-2050 planning period is, by design, similar across the alternative strategies for each scenario, the way this energy is generated varies across strategies (Figure 3-4 through Figure 3-7). This is a result of the differences between the alternative strategies and their focus on different energy resources as described in Section 3.2 and Volume 1 Section 3.5. Emissions of air pollutants, the intensity of greenhouse gas emissions, and generation of coal waste would decrease under all strategies, due to the retirement of all coal facilities in all strategies by 2035.

The environmental impacts do not differ as much between strategies as they do between scenarios, as the scenario that materializes for forecasted load and regulatory impacts is the primary driver of environmental profiles. For most environmental resources, the impacts would be greatest in Scenario 2, Higher Growth Economy, and would be lowest under Scenarios 4 and 5 (Net-zero Regulation scenarios). Across the scenarios, Strategy C achieves the fastest near-term decarbonization, while Strategies B and C achieve similar levels of decarbonization over the long term. Water consumption intensity is lowest on average in Strategy C, which has the highest levels of renewable generation that displace thermal generation. Land use intensity varies with the level of solar buildout in each portfolio and is highest in Strategy C.

The environmentally preferable alternatives are Strategies B and C, which emphasize carbon-free resources and achieve similar CO_2 emissions reductions over the planning horizon. These strategies have tradeoffs across other environmental metrics, with higher water consumption in Strategy B and higher land use in Strategy C.

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. The primary study area is the TVA power service area (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. TVA's power system serves approximately 10 million people in the seven-state, 80,000-square-mile region. All but one of TVA's hydroelectric plants, as well as all its nuclear plants, are located in the Tennessee River watershed. Its coal-fired plants are in the Tennessee River watershed as well as along the Cumberland and Ohio rivers (Figure 1-1). Natural gas and fuel oil-fired generators are located at 17 sites. Nine operating small photovoltaic (PV) solar installations are located within the TVA PSA. 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 United States (U.S.) Army Corps of Engineers' (USACE) hydroelectric plants in the Cumberland River drainage basin. Some of these plants are in the TVA region, and the others are in southern Kentucky north of the TVA region.

For some resource issues, such as air quality, climate change, and renewable energy resources, impacts may extend beyond the TVA region. For most resources, the primary study area consists of the 181 counties and two independent cities where TVA is a major provider of electric power.

4.2 Air Quality

4.2.1 Regulatory Framework for Air Quality

The Clean Air Act (CAA), as amended, is the comprehensive law that addresses 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, except for 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 six criteria pollutants regulated under the NAAQS, air quality nationwide has been improving for several decades (Table 4-1). 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 because 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 2022. 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 (NOx; including NO_2) and SO_2. Ozone is not directly emitted by any source; it is formed by a chemical reaction between NOx 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.

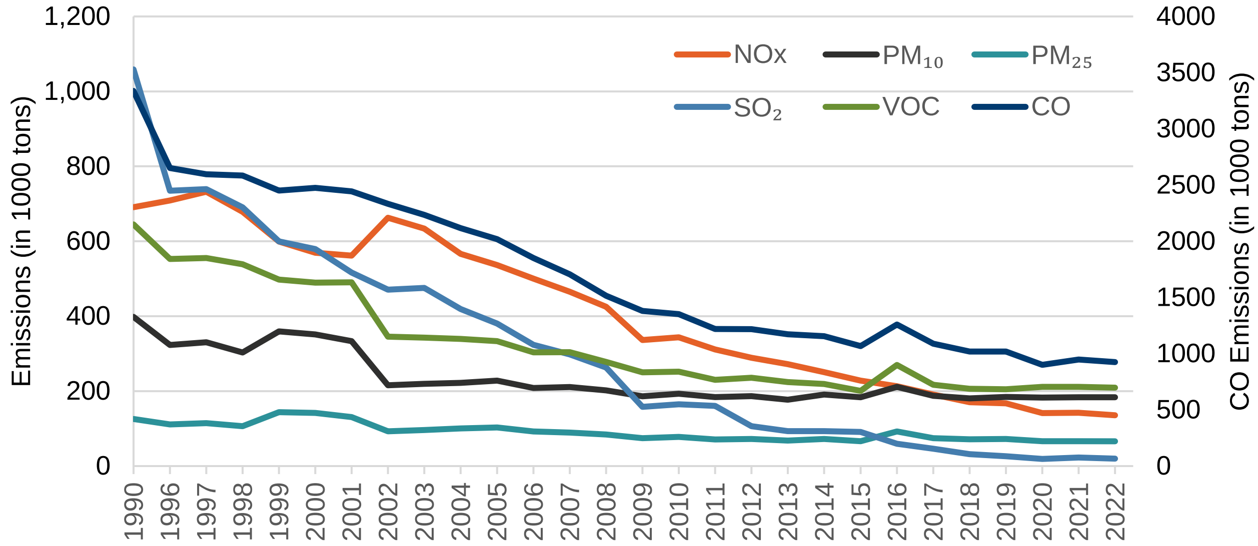
Table 4-1: Percent Change in Ambient Concentrations of Air Pollutants in the United States, 1980-2022

Air Pollutant	1980 to 2022	1990 to 2022	2000 to 2022	2010 to 2022
Carbon Monoxide	-88	-81	-67	-27
Lead	--	--	--	-88
Nitrogen Dioxide (annual)	-66	-60	-52	-27
Nitrogen Dioxide (1-hour)	-65	-54	-38	-21
Ozone (8-hour)	-29	-22	-17	-7
PM_{10} (24-hour)	---	-34	-30	-21
$PM_{2.5}$ (annual)	---	---	-42	-21
$PM_{2.5}$ (24-hour)	---	---	-42	-16
Sulfur Dioxide (1-hour)	-94	-90	-85	-75

Source: USEPA 2023a

Improvement in air quality has been realized in TVA's PSA 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 PSA 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 PSA. Figure 4-1 shows the trend lines of Tennessee pollutant emissions from 2002 through 2022, based on data obtained from USEPA's National Emissions Inventory website at https://www.epa.gov/air-emissions-inventories/air-pollutant-emissions-trends-data (USEPA 2023b).



Source: USEPA 2023b

Figure 4-1: Trends in Emissions of Air Pollutants in Tennessee, 2002-2022

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 NOx.

TVA's emissions reductions are responsible for much of the statewide Tennessee stationary source SO_2 and NOx 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 24,532 tons in 2022, a decrease of 97 percent.

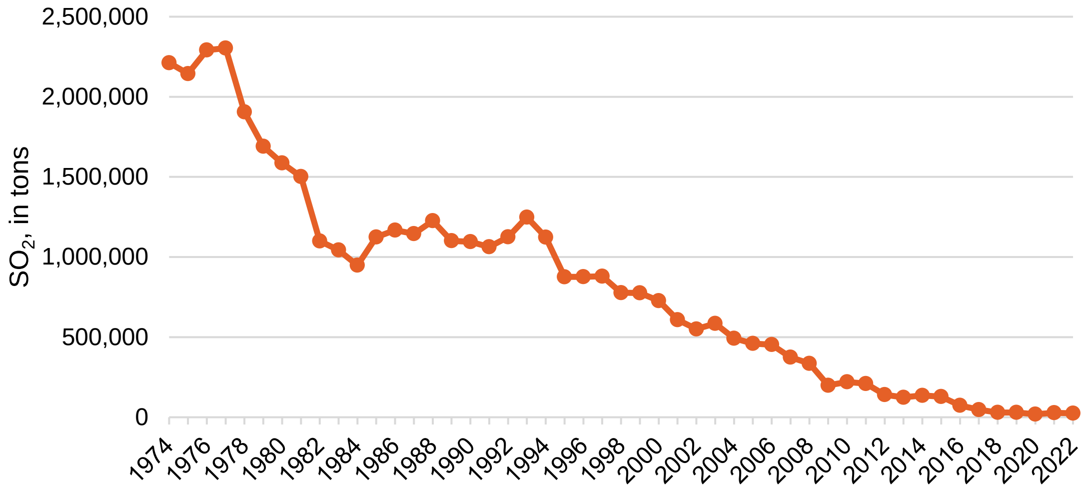
Utility sector NOx emissions in Tennessee, primarily attributed to TVA, increased from 240,359 tons in 1990 to 283,464 tons in 1997, before decreasing for the next two decades to 17,048 tons in 2022, a decrease of 94 percent from the 1997 peak.

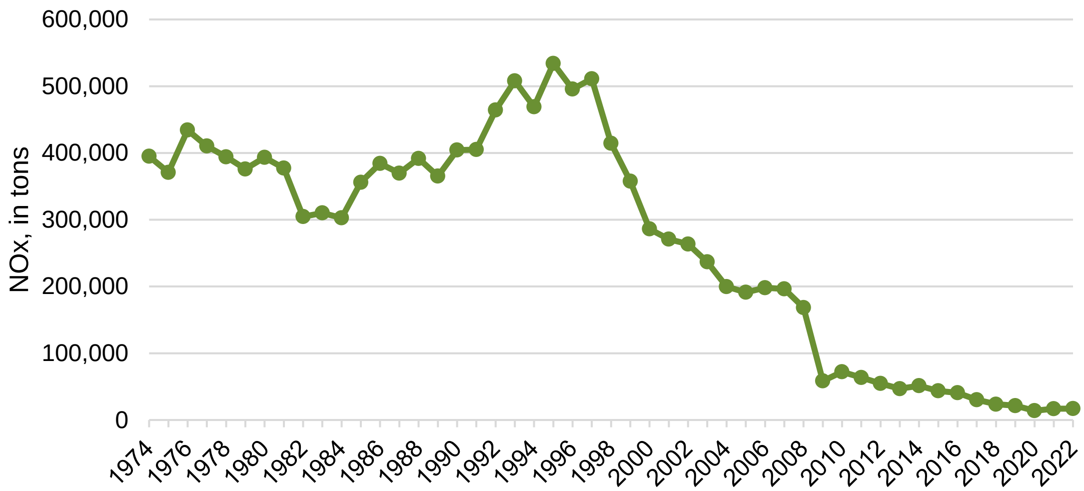
Nationally, electric utility emissions have fallen to the point where they no longer represent the largest emitting sector for the pollutants of primary focus. According to data from the 2014 National Emissions Inventory, on-road vehicles produce more than half (52 percent) of all NOx emissions in Tennessee (147,638 tons per year) and non-road vehicles produce 9 percent of all NOx 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.

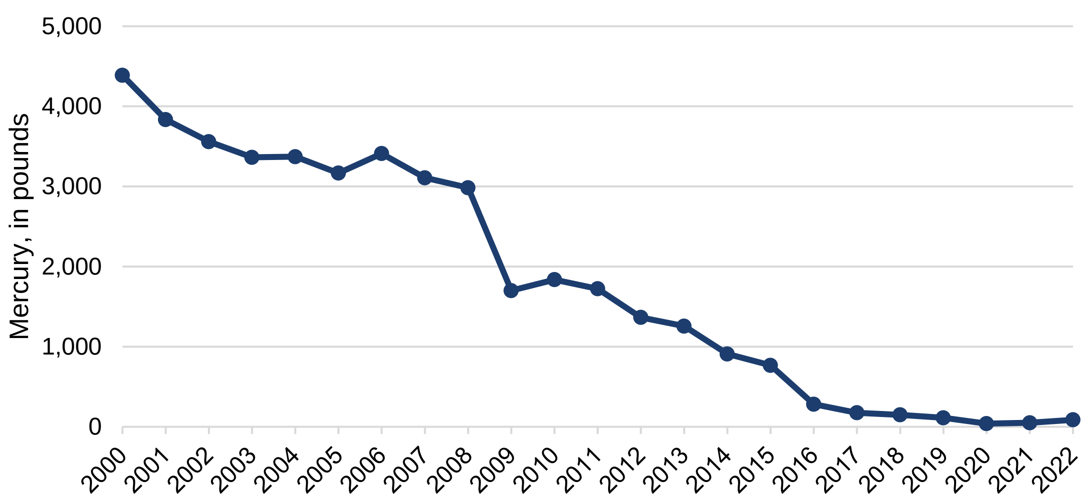
4.2.3 TVA Emissions

4.2.3.1 TVA System-Wide Emissions

The trends in TVA's reported SO_2, NOx, and mercury emissions are shown in Figure 4-2. These data represent emissions from TVA's facilities across its entire PSA.







Source: TVA 2024

Figure 4-2: TVA Emission Trends for SO_2, 1974-2022 (top), NOx, 1974-2022 (middle), and Mercury, 2000-2022 (bottom)

4.2.3.2 Emissions from Coal 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 five years (2018-2022). Table 4-2 also shows the annual emissions by plant in tons, and emission rates in units of pounds per megawatt-hour (lbs/MWh).

Table 4-2: Five-Year (2018-2022) Average Emissions of Coal Units Considered for Future Retirement

Facility and Units	Generation (MWh)	SO_2 (5-yr average)		NOx (5-yr average)		Mercury (5-yr average)	
	5-year avg.	tons/yr	lbs/MWh	tons/yr	lbs/MWh	lbs/yr	lbs/GW-hr
Shawnee 1-9	6,164,634	13,908	4.5	7,013	2.3	17.95	2.91E-03
Kingston 1-9	3,175,421	1,655	1.0	1,191	0.7	17.22	5.42E-03
Gallatin 1-4	4,441,408	1,645	0.7	1,203	0.5	21.65	4.87E-03
Cumberland 1-2	10,021,450	7,301	1.5	3,952	0.8	16.71	1.67E-03
Total	23,802,914	24,509	8.0	13,359	4	74	0.015

4.2.4 Hazardous Air Pollutants

Hazardous Air Pollutants (HAPs) are toxic air pollutants that 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 that 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 NOx emissions, as coal use has decreased and as coal and gas-fired electric generating units are fitted with better emissions controls.

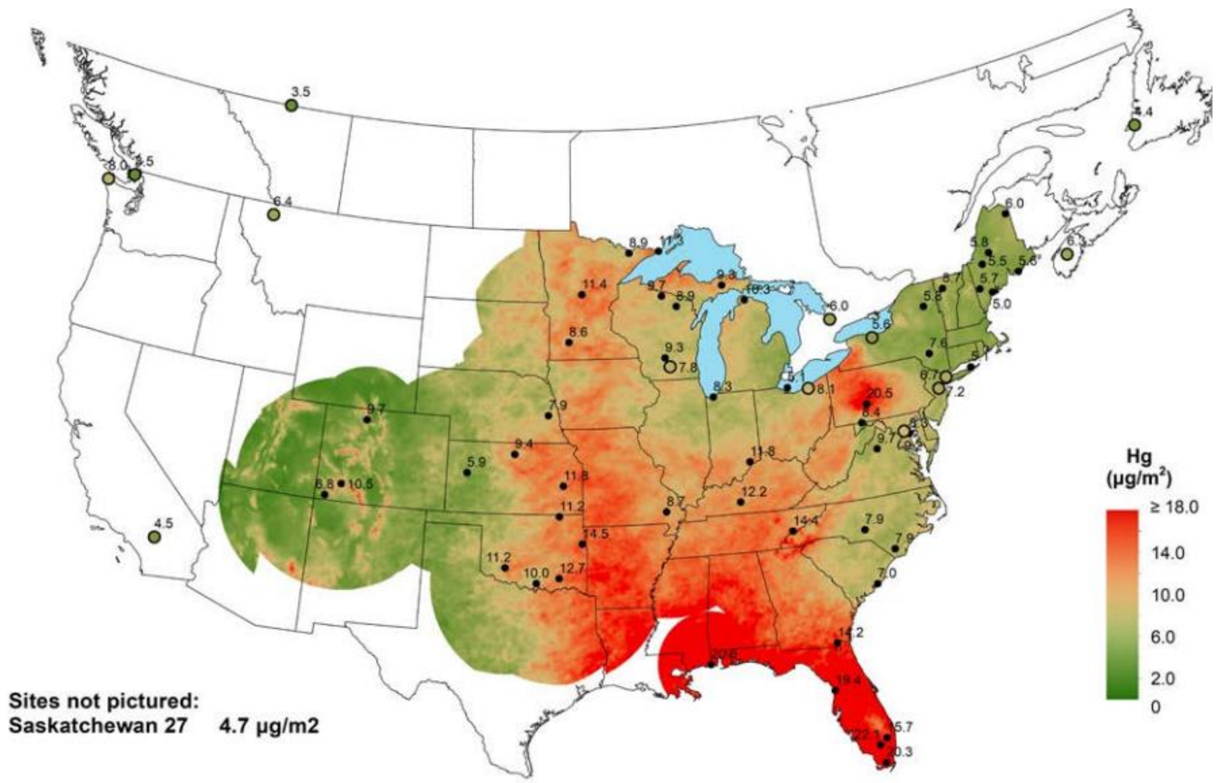
4.2.5 Mercury

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. Worldwide, artisanal and small-scale mining produce the highest level of man-made methyl-mercury (37.7 percent), followed by coal combustion (21 percent), non-ferrous metal production (15 percent), and cement production (11 percent) (USEPA 2023c).

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 January 2017, USEPA and the Food and Drug Administration issued a final 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).

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 because mercury emissions tend to be deposited globally, rather than locally, with most of the deposition occurring in precipitation. In 2017, mercury emissions were reported at approximately 4 tons, an 86 percent reduction compared to 2010 levels, with a 96 percent and an 81 percent reduction in acid gas hazardous air pollutants and non-mercury metals respectively (USEPA 2023d).

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.



Source: NADP 2023

Figure 4-3: Total Wet Mercury Deposition in the United States in 2022

TVA mercury emissions have decreased 98 percent from 4,388 pounds in 2000 to 94 pounds in 2022 (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 from 90 miles to approximately 15-25 miles due to air pollution from various sources (USEPA 2023e). 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 dV unit is used to establish thresholds under visibility rules in 40 Code of Federal Regulations (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 improvements have 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 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, Joyce Kilmer-Slick Rock Wilderness, 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.

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 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 dV on average for the worst 20 percent of days and the best 20 percent of days. From 1990 to 2023, there was a 50 percent improvement in the visibility on the worst days and a 48 percent improvement on the best days (FLMED 2023). 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.

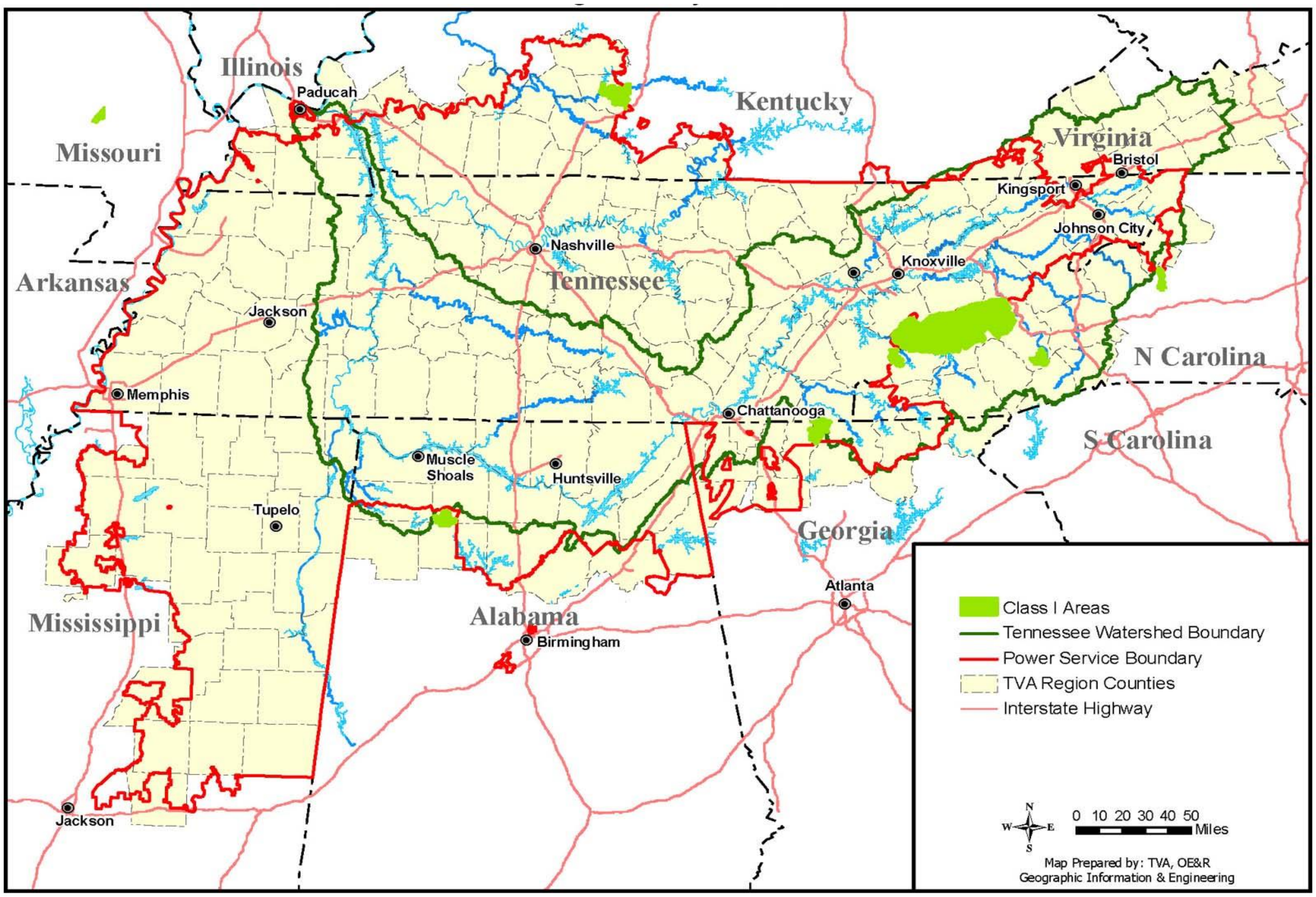
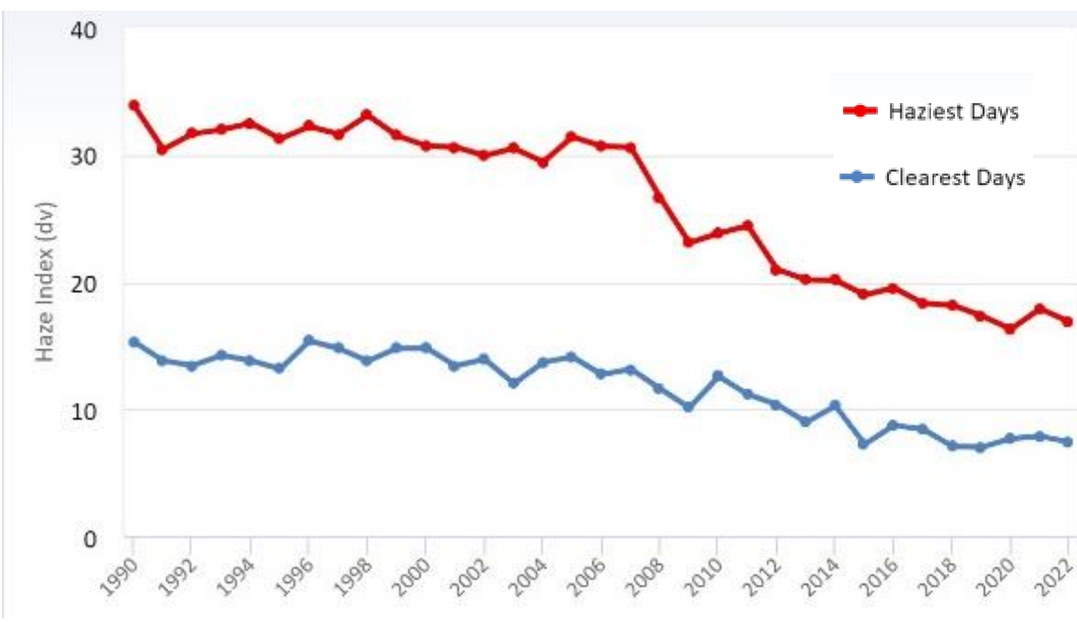


Figure 4-4: The TVA Power Service Area and Class I Areas



Source: FLMED 2023
Note: Smaller dV values indicate better visibility.

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, 1990-2023

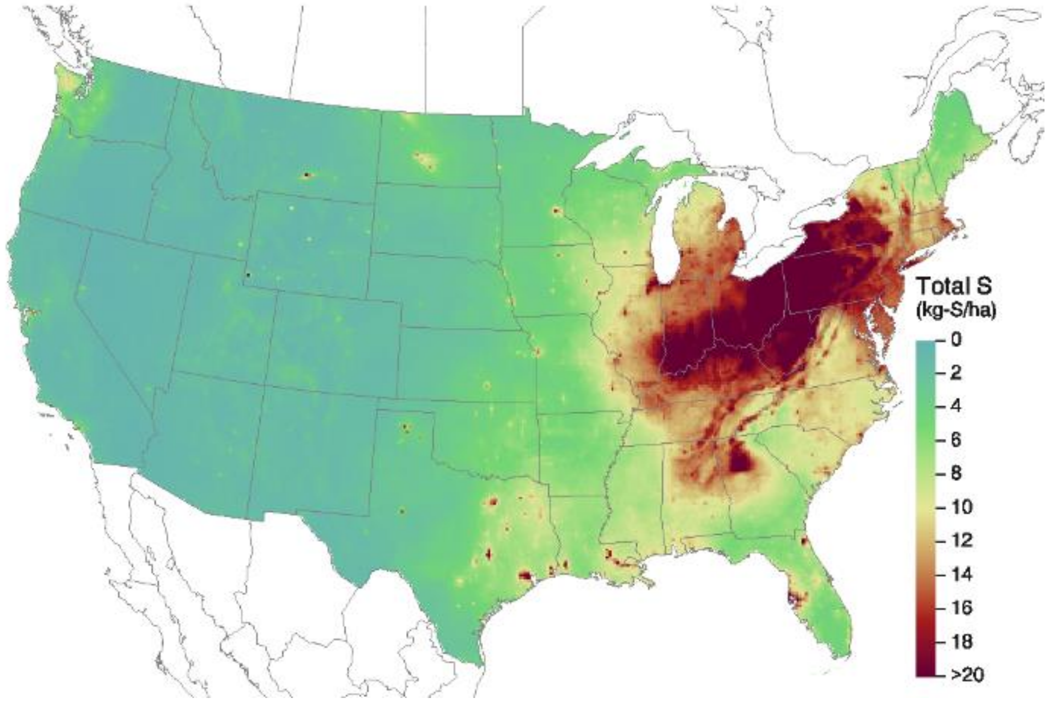
4.2.7 Acid Deposition

Acid deposition, also called acid rain, is primarily caused by SO_2 and NOx 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 U.S. was approximately 5.0 (Charlson and Rodhe 1982).

Based on the data reflected in Figure 4-1, on emissions for the state of Tennessee, together with TVA emissions data in Figure 4-2, as of 2017, the TVA SO_2 emissions were greater than those of the state of Tennessee and TVA NOx emissions totaled less than 14 percent of statewide total emissions. As stated above in 2022, TVA's SO_2 emissions in Tennessee have decreased by 97 percent since 1990 and its NOx emissions in the state have decreased by 94 percent from their peak level in 1997. Emissions from utilities across the eastern U.S. have also decreased significantly, and emissions from mobile sources have started a substantial downward trend as well in the past decade or more.

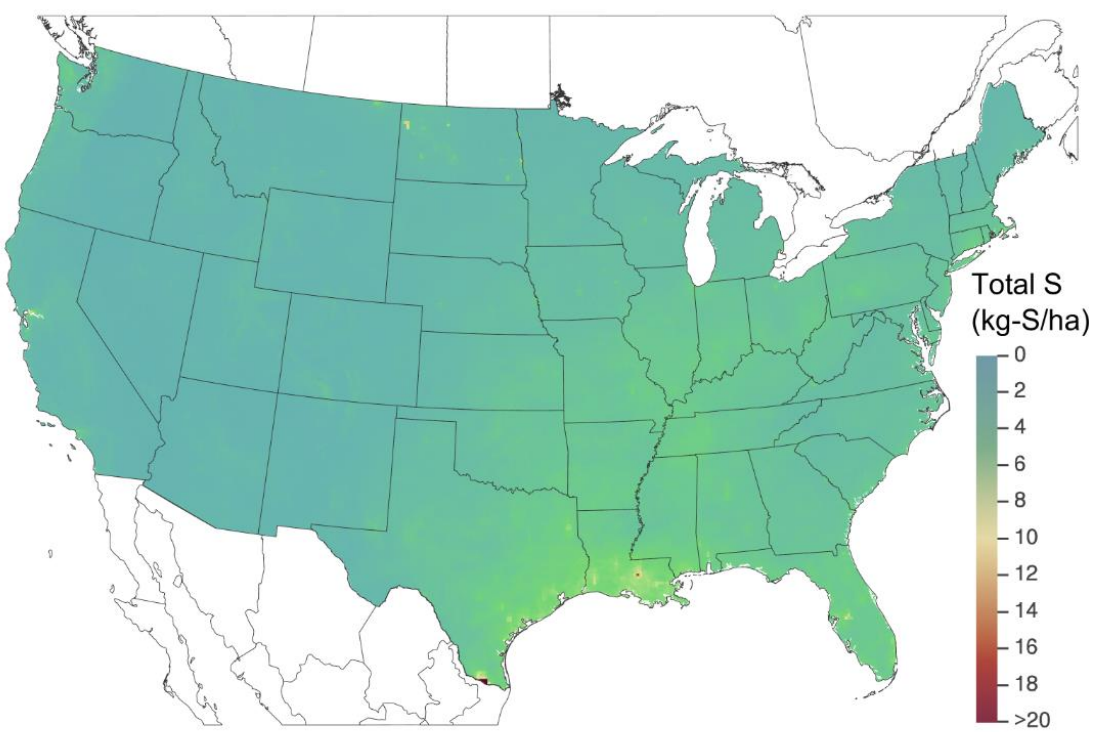
The 1990 CAA Amendments established the Acid Rain Program to reduce SO_2 and NOx emissions and the resulting acid deposition. Since this program was implemented in 1995, reductions in SO_2 and NOx emissions have contributed to significant reductions in acid deposition, concentrations of $PM_{2.5}$ and 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 2021 (most recent data available) across the U.S. (USEPA 2023f). Similar reductions in nitrate deposition have also occurred over the 2006 to 2023 period. Even by the year 2000, deposition of sulfate and nitrate was decreasing across the U.S., 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.



Source: USEPA 2023f

Figure 4-6: Year 2000 Total Sulfate Deposition



Source: USEPA 2023f

Figure 4-7: Year 2021 Total Sulfate Deposition

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, frequent severe thunderstorms, infrequent tornado events, infrequent snow, and infrequent impacts from tropical storms, primarily in the form of heavy rainfall. 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.

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 2020) and projected changes in climate during this century, based on the Fourth National Climate Assessments (4th NCA) and Fifth National Climate Assessments (5th NCA; USGCRP 2017, USGCRP 2023) and related sources. Identifying recent trends in regional climate parameters such as temperature and precipitation is a challenge 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 2021). The climate normals described below are for the most recent period of record, 1991–2020. 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 Climate Normals and Trends

Temperature. Observed average monthly temperatures for the TVA region during 1991–2020 ranged from 40.0 degrees Fahrenheit (°F) in January to 79.7°F in July (Table 4-3). These data show considerable year-to-year variability with an overall warming trend of 0.5-0.6°F (0.3-0.4 degrees Celsius [°C]) per decade for 1991–2020. 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 Figure 4-8, Figure 4-9, and Figure 4-10. Both annual average temperature and annual average winter temperature showed increases (0.45°F/100 years and 1.05°F/100 years, respectively) since the 1890s. The annual average summer temperature showed a small, long-term increase of 0.06°F/100 years.

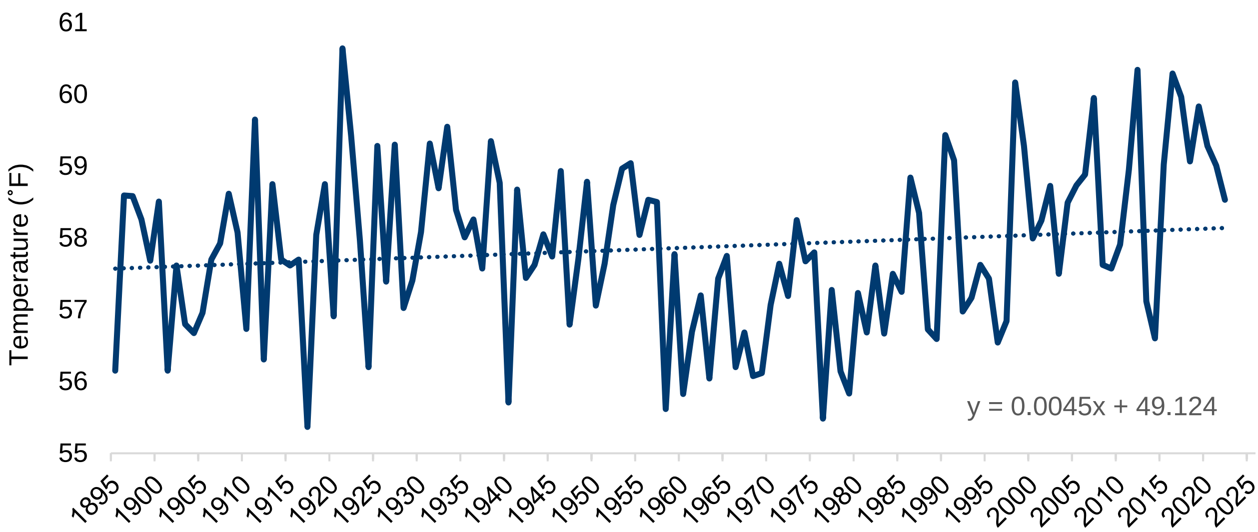
For additional information regarding the historical weather data and trends used in the development of IRP scenario load forecasts, see Volume 1, Appendix B.

Table 4-3: Monthly, Seasonal and Annual Temperature Averages for Six NWS Stations in the TVA Region, 1991–2020

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
˚F	40.0	43.9	51.6	60.5	69.0	76.5	79.7	78.9	72.9	61.5	50.1	42.9
˚C	4.5	6.6	10.9	15.8	20.5	24.7	26.5	26.0	22.7	16.4	10.1	6.0

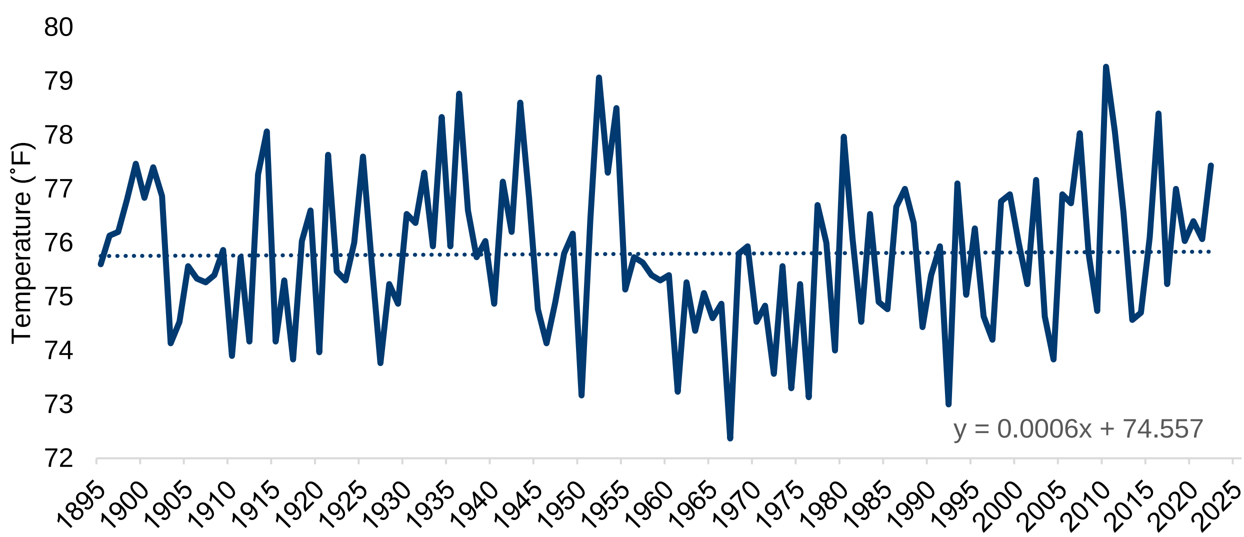
	Winter	Spring	Summer	Fall	Annual
˚F	42.2	60.4	78.4	61.5	60.6
˚C	5.7	15.8	25.8	16.4	15.9

Source: NWS 2023



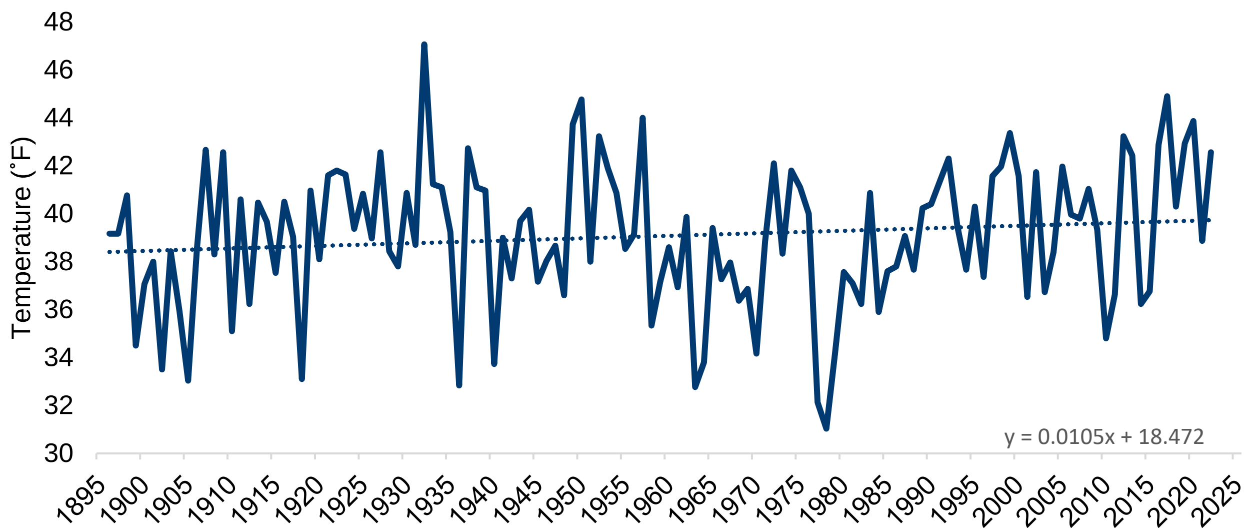
Source: WRCC 2023
Note; The dashed line is the trend based on least squares regression analysis.

Figure 4-8: Annual Average Temperature (°F) in Tennessee, 1895–2022



Source: WRCC 2023
Note: The dashed line is the trend based on least squares regression analysis.

Figure 4-9: Annual Average Summer Temperature (°F) in Tennessee, 1895–2022



Source: WRCC 2023
Note: The dashed line is the trend based on least squares regression analysis.

Figure 4-10: Annual Average Winter Temperature (°F) in Tennessee, 1896–2022

Precipitation. The observed average annual precipitation in the Tennessee River watershed during 1890–2019 was 51 inches; monthly averages range from 3.01 inches in October to 5.35 inches in March (Table 4-4). The wettest locations in the TVA region occur in southwestern North Carolina, and the driest locations are in northeast Tennessee (NACSE 2024). There has been a decrease in the frequency and intensity of certain cold season events such as snowfalls, and estimates show that the Southeast is at an increased risk for extreme precipitation and flooding events (USGCRP 2023).

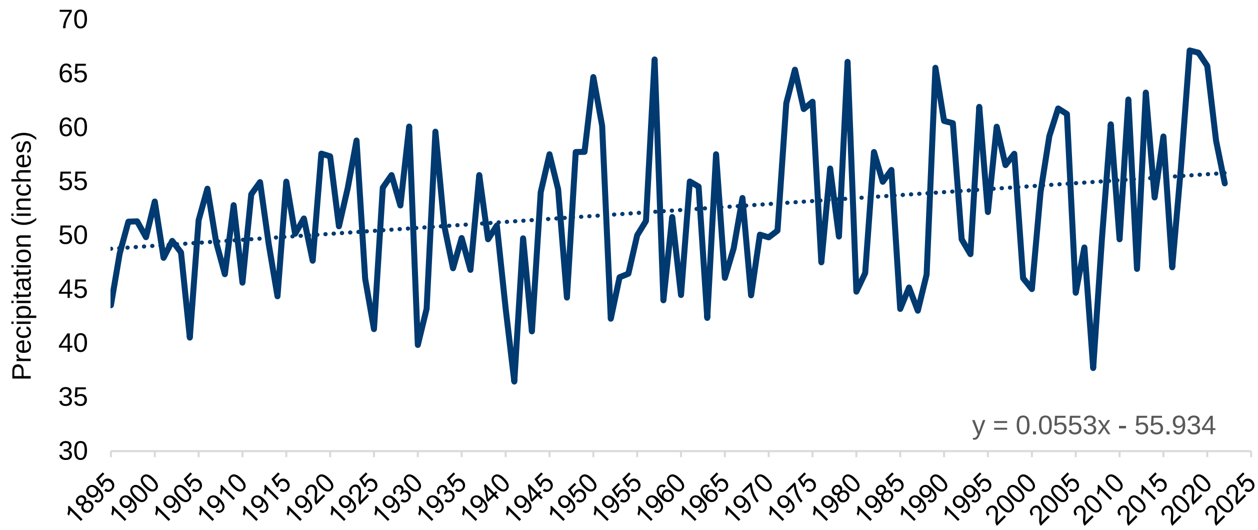
Table 4-4: Monthly, Seasonal, and Annual Precipitation Averages in the Tennessee River Watershed for 1890-2023

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Inches	4.71	4.68	5.35	4.39	4.27	4.13	4.76	4.02	3.41	3.01	3.74	4.81
Centimeters	11.96	11.89	13.59	11.15	10.85	10.49	12.09	10.21	8.66	7.65	9.50	12.22

	Winter	Spring	Summer	Fall	Annual
Inches	14.20	14.01	12.91	10.16	51.28
Centimeters	36.07	35.59	32.79	25.81	130.26

Source: TVA 2020b

Figure 4-11 shows Tennessee annual total precipitation for the period 1895 through 2022. These data show that over this period of record, the average annual precipitation has increased at an average rate of around 11 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.



Source: WRCC 2023
Note: The dashed line is the trend based on least squares regression analysis.

Figure 4-11: Annual Average Precipitation in Tennessee, 1895-2022

4.3.2 Greenhouse Gas Emissions

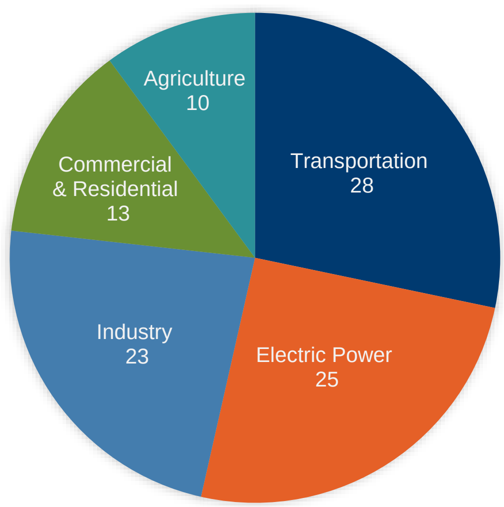
The sun is the primary source of energy for the Earth's climate. About 30 percent of the sun's energy that reaches Earth is reflected back to space by clouds, gases and small particles in the atmosphere. The remainder is absorbed by the atmosphere and the surface (Walsh et al. 2014a). Changes in global scale climate are primarily in response to processes that alter the balance between incoming solar energy and outgoing energy from the Earth. In the surface-albedo feedback, which quantifies the fraction of sunlight reflected by the surface of the Earth, increasing temperatures melts the ice over land and bodies of water. This exposes the darker surface underneath, which absorbs more energy, thereby contributing to further warming, rather than reflecting it, which would contribute to temperature decrease (USGCRP 2023). 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) (Galloway et al. 2014). Climate change impacts are already seen in the deterioration of such ecosystems, which increases risks to human populations. These risks are projected to grow with additional warming and atmospheric CO_2 (USGCRP 2023).

Similar to the glass in a greenhouse, certain gases, primarily CO_2, nitrous oxide, methane, hydroflurocarbons, perflurocarbons 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 (Walsh et al. 2014a) in a phenomenon known as the "greenhouse effect." Though some halogenated gases have decreased due to ozone-depletion policies, the atmospheric abundance of many of these well-mixed greenhouse gases have continued to increase (USGCRP 2023). The 2022 global average of atmospheric CO_2 set a record high at 417.06 parts per million (ppm). This was a 2.13-ppm increase from 2021, marking the 11th year in a row where CO_2 in the atmosphere increased by over 2 ppm (NOAA 2023). 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 (Walsh et al. 2014a), as it factors into the intensity of precipitation extremes (USGCRP 2023). Quantifying the effect of feedback loops on global and regional climate is the subject of ongoing data collection and active research (Walsh et al. 2014a).

The magnitude of the warming induced by the greenhouse effect depends largely on the amount of GHG accumulating in the atmosphere (Walsh et al. 2014b). 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 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. Methane, 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 2022 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 and 25 percent, respectively, of nationwide GHG emissions in 2021, with industrial sources, commercial and residential buildings, and agriculture each representing successively smaller portions of the total.



Source: USEPA 2023g

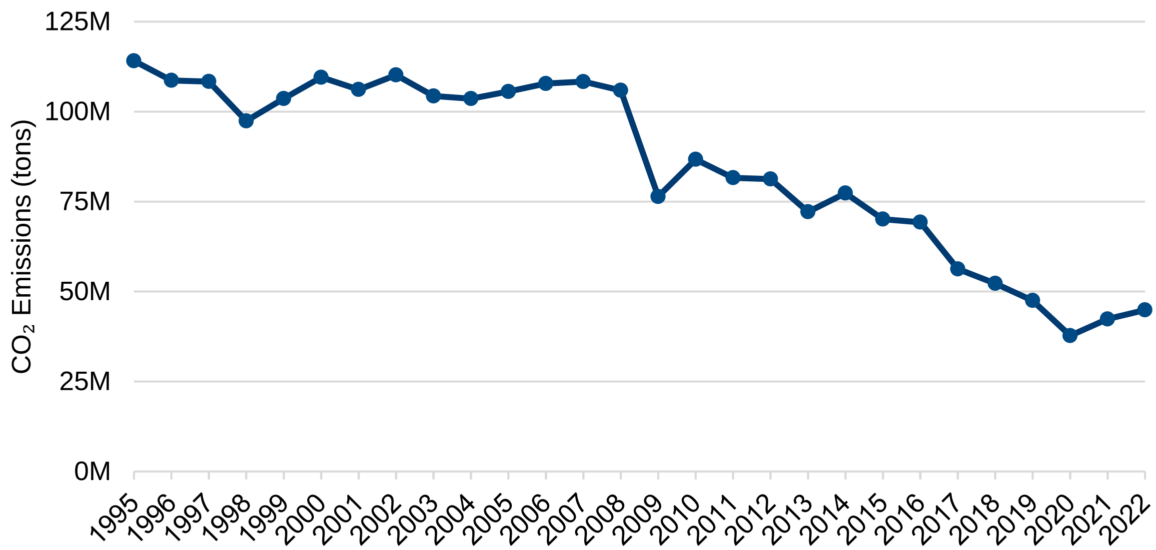
Figure 4-12: U.S. 2021 GHG Emissions by Economic Sector - Percent

According to 2021 data from the U.S. Energy Information Administration, transportation comprises 49.3 percent 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 2023a).

TVA and the Baker School of Public Policy and Public Affairs at the University of Tennessee – Knoxville (UTK) collaborated on a Valley Pathways Study (UTK 2024), informed by stakeholder input. This study established a greenhouse gas (GHG) baseline for the region and looked across economic sectors such as transportation, industry, agriculture, and building emissions to evaluate potential paths for achieving a competitive and clean economy by 2050. In 2019, the Valley region generated an estimated 200 million metric tons of carbon dioxide equivalent (CO_2-eq) across all sectors of the economy, or about 3 percent of U.S. GHG emissions, which aligns to population percentage. According to the study, transportation contributed the largest share at 36 percent, and the electricity sector represented 27 percent of the total emissions.

4.3.2.1 TVA System-Wide Emissions

As of 2022, CO_2 emissions from the TVA power system have decreased by 60.68 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. In terms of lbs/MWh, TVA's CO_2 emission rate averaged 658.06 (lbs/MWh) for 2022, including that of owned and purchased power. This is significantly lower than the 2021 USEPA eGRID national rate of 852.3, as well as the regional rate of 931.586 (TVA 2022b).



Source: TVA 2022b

Figure 4-13: CO_2 Emissions (million tons) From Generation of Power Marketed by TVA, 1995-2022

4.3.3 Forecast Climate Trends

The modeled projections of temperature and precipitation cited here are from the Fourth and Fifth National Climate Assessment (NCA) published by the U.S. Global Change Research Program (USGCRP 2017, USGCRP 2023). The publications cite 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 per square meter (m^2) of radiative forcing in 2100.

Climate change continues to exhibit the same trends in the Southeast with virtually no exception from what was reported in the 4th NCA (USGCRP 2023). For the Southeast, 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 will be 3.4°F higher than recent climate normals by mid-century with temperatures 4.4°F higher by late century (USGCRP 2017). Additionally, the 5th NCA predicts that future climate change impacts (under RCP4.5) may cause billions of dollars' worth of damages to U.S. transportation infrastructure by 2050, with especially high cost in the Southeast, which also faces some of the highest economic risk related to energy infrastructure damage (USGCRP 2023). The 4th NCA 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 (USGCRP 2017).

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 (USGCRP 2017). Direct annual climate damages are projected to be especially large in the Southeast, with overall agricultural yield expected to decrease as well (USGCRP 2023). 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 (USGCRP 2017).

Climate models are generally unreliable 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 (USGCRP 2017). However, the 5th NCA (see Figure 2-4 of that report) provides projections for changes in seasonal precipitation across North America by comparing present day (2002-2021) precipitation totals to that of the first half of the last century (1901-1960). In the last two decades, the Southeast has received more precipitation in the fall but seen drier conditions in the spring and summer (USGCRP 2023).

4.3.4 Climate Adaptation

TVA has adopted a Climate Action Adaptation and Resiliency Plan (TVA 2021b) that establishes adaptation planning goals and describes the challenges and opportunities a changing climate may present to its mission and operations. The goal of TVA's adaptation planning process is to ensure that TVA continues to achieve its mission and program goals and to operate in a secure, effective, and efficient manner in a changing climate (TVA 2021b).

TVA manages the effects of climate change on its mission, programs, and operations within its environmental management processes. TVA's Environmental Policy (TVA 2023c) provides objectives for an integrated approach related to providing affordable, reliable, resilient, and increasingly cleaner energy, supporting sustainable economic growth and engaging in proactive environmental stewardship. The policy includes commitments to reduce carbon intensity and emissions, supporting cleaner energy sources, investing in renewable energy solutions, and encouraging partners and customers to improve environmental performance (TVA 2023c). In 2022, TVA achieved a 50 percent carbon intensity reduction from 2005. TVA has a potential path to an approximate 80 percent reduction by 2035 and aspires to be net-zero by 2050.

TVA's Climate Action Adaptation and Resiliency Plan (TVA 2021b) specifies that each TVA major planning and decision-making 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 (TVA 2021b).

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 national criteria for the management of CCR produced by electric utilities. The CCR Rule requires groundwater monitoring and addresses the potential risks of coal ash contaminants migrating into groundwater when groundwater protection standards are statistically exceeded. On May 18, 2023, the USEPA proposed changes to the CCR regulations for inactive electric utilities, referred to as “legacy CCR surface impoundments.” The USEPA has collected public comments on this proposal, but the proposed rule has not been finalized.

4.4.1.2 TVA Region Aquifers

Three basic types of aquifers occur in the TVA region: alluvial, sand (composed primarily of sand with lesser amounts of gravel, clay, and silt), and fractured bedrock (primarily carbonate but non-carbonate also present). Groundwater movement in alluvial and 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 rock 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 4-5). These aquifers generally align with the major physiographic divisions of the region.

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 4-5). 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 4-5: Aquifer, Well, and Water Quality Characteristics in the TVA Region

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.
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.

Note: gpm = gallons per minute
Source: Webbers 2003

4.4.1.3 Causes of Degraded Groundwater Quality

Causes of degraded groundwater quality may 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., CCR) 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. Capping and covering controls and prevents rainfall infiltration. Depending on hydrogeologic and geologic conditions, storage of waste in unlined landfills and surface impoundments 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.

4.4.2 Surface Water

The quality of the TVA region's surface waters – its streams, rivers, lakes, and reservoirs – is critical to the 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] 2022) 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) 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.

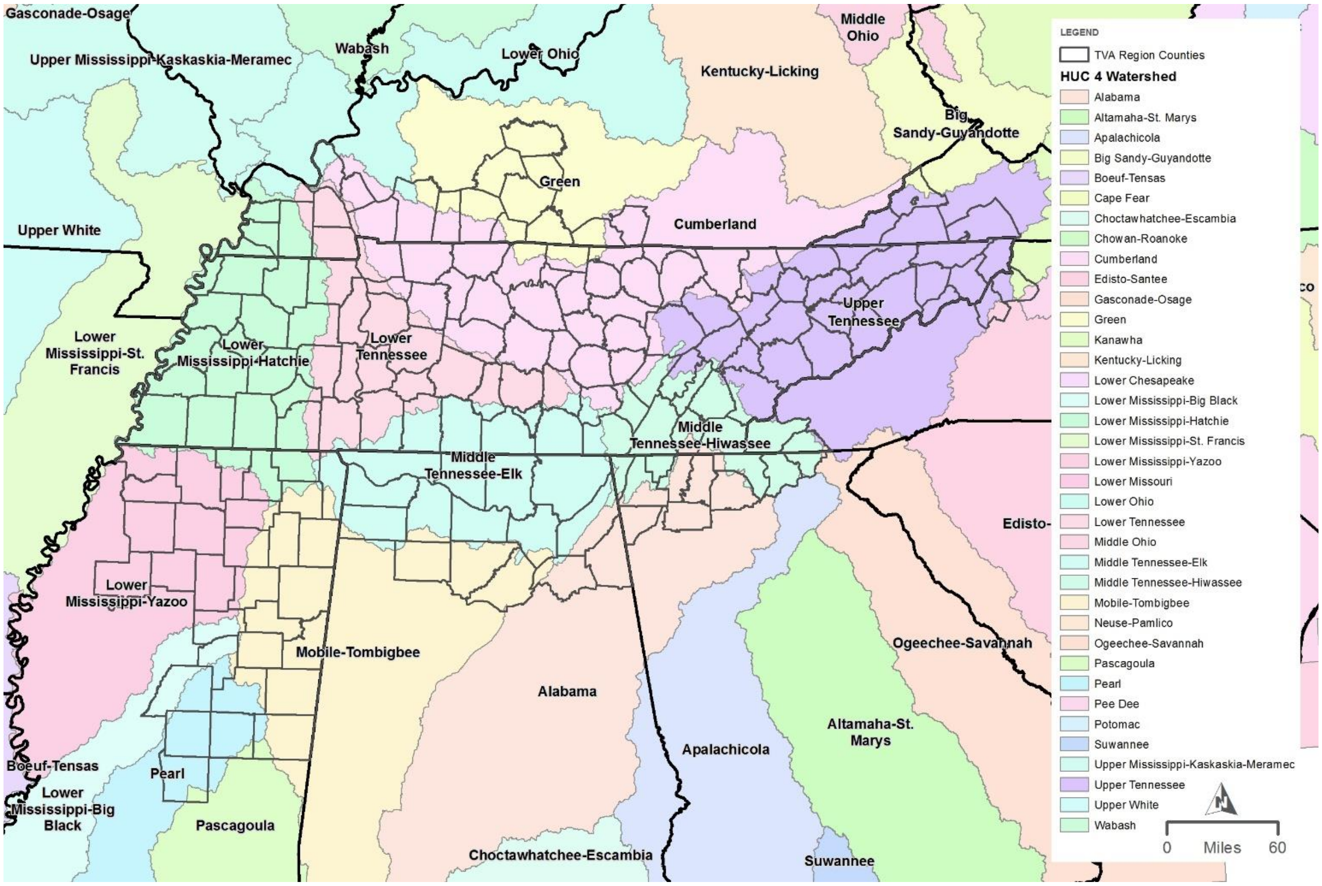


Figure 4-14: Major Watersheds Within TVA Region

Major water quality concerns within the Tennessee River 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. 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 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). 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. Ecological ratings, major areas of concern, and fish consumption advisories are listed in Table 4-6.

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

Table 4-6: Ecological Health Ratings, Major Water Quality Concerns, and Fish Consumption

Reservoir	Ecological Health Rating – Score	Latest Survey Date	Concerns	Fish Consumption Advisories
Apalachia	Fair – 70	2021	--	Mercury (NC statewide advisory)
Bear Creek	Fair – 60	2020	DO[1]	Mercury (dam forebay area)
Beech	Fair – 62	2021	DO	Mercury
Blue Ridge	Good – 83	2020	--	Mercury, PCBs[2]
Boone	Fair – 69	2022	DO, chlorophyll, bottom life, sediments	PCBs[2], chlordane
Cedar Creek	Fair – 69	2020	DO	Mercury (dam forebay to 1 mile upstream of dam
Chatuge	Fair – 59	2021	DO	PCBs, mercury
Cherokee	Poor – 57	2021	DO, bottom life	None
Chickamauga	Good – 82	2021	--	Mercury (Hiwassee River from Highway 58 (river mile 7.4) upstream to Highway 11 (river mile 18.9))
Douglas	Fair – 60	2016	DO, bottom life	None
Fontana	Fair – 71	2022	bottom life	Mercury
Fort Loudoun	Good – 73	2021	bottom life	PCBs, mercury (upstream U.S. 129)
Fort Patrick Henry	Fair – 67	2022	Chlorophyll	None
Guntersville	Fair – 75	2022	--	Mercury (Widows Creek, Sequatchie River; Long Island Creek and Town Creek embayments)
Hiwassee	Fair – 63	2021	DO, bottom life (forebay only)	Mercury (NC Statewide advisory)
Kentucky	Good – 79	2021	Chlorophyll (Big Sandy only)	Mercury (State of Kentucky statewide advisory; State of Tennessee, Big Sandy River and Beech Creek embayment)

Reservoir	Ecological Health Rating – Score	Latest Survey Date	Concerns	Fish Consumption Advisories
Little Bear Creek	Fair – 69	2020	DO	Mercury (dam forebay area)
Melton Hill	Fair– 66	2022	bottom life	PCBs
Nickajack	Good – 82	2022	--	PCBs (Nickajack Reservoir); PCBs and chlordane (Chattanooga Creek)
Normandy	Poor – 55	2022	DO, chlorophyll	Mercury
Norris	Fair – 68	2020	DO	Mercury (Clinch River portion)
Nottely	Poor – 47	2020	DO, chlorophyll	Mercury
Parksville/ Ocoee #1	Poor – 55	2020	DO, sediments	PCBs
Pickwick	Good – 74	2022	chlorophyll	Mercury (vicinity of TRM 230; Bear Creek, Big Nance Creek, Cane Creek, and Little Bear Creek embayments)
South Holston	Fair - 63	2021	DO, bottom life	Mercury (Tennessee portion)
Tellico	Fair – 64	2021	bottom life	PCBs
Tims Ford	Poor – 55	2016	DO, bottom life	None
Watauga	Good - 73	2021	DO	Mercury
Watts Bar	Fair - 71	2022	DO, chlorophyll, bottom life (forebay only)	PCBs
Wheeler	Fair - 68	2021	DO, chlorophyll, bottom life	Mercury (Vicinity of TRM 296; Flint Creek, Limestone Creek, and Round Island Creek embayments); PFOS (TRM 296-303; Bakers Creek and Fox Creek embayments)
Wilson	Fair - 60	2022	DO, bottom life (forebay only)	Mercury (Big Nance Creek embayment)

Source: TVA 2024a
Notes: DO = Dissolved Oxygen; PCB = Polychlorinated biphenyls; PFOS = Perfluorooctane sulfonate; TRM = Tennessee River Mile

Other Major River Systems

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

4.4.2.3 Causes of Degraded Surface Water Quality

Causes of degraded surface water quality may 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 (the removal of foreign substances from the atmosphere by precipitation) 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 may be permitted for discharge to surface waters. These include condenser cooling water, cooling tower blowdown, ash transport water, metal-cleaning wastewaters, and various low volume wastes, including sumps and drains. CC 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 as required by regulations. Discharges at coal and natural gas plants are regulated by permits issued by the state under the NPDES program, which may require treating the waters prior to discharge. Analytical monitoring and periodic monitoring ensure there are no adverse effects to the receiving water or to aquatic life. Discharges from coal plants may also include those from regulated CCR storage areas as a result of seepage into groundwater which could potentially enter surface waters. See Section 4.7.1 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).

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 updates of the Effluent Limitation Guidelines rule on November 3, 2015, and October 13, 2020, that revised and strengthened the technology-based effluent limitations guidelines and standards for discharges from steam electric power plants. The final rules set 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 four decades. Generally, the 2015 and 2020 final rules established new requirements for wastewater streams from the following processes and byproducts associated with steam electric power generation: flue gas desulfurization (FGD), fly ash transport, bottom ash transport, flue gas mercury control, gasification of fuels such as coal and petroleum coke, combustion residual leachate, and non-chemical metal cleaning. The 2015 and 2020 rules phase 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) high recycle rates for bottom ash transport water, and zero discharge of pollutants in fly ash transport water that must be incorporated into the plants' NPDES permits. The 2020 rule also established several new subcategories that provide separate compliance pathways based on unit operation and asset operating plans. This included less stringent requirements for High FGD flow plants (i.e., Cumberland Fossil Plant), electric generating units (EGUs) that will cease burning coal by December 31, 2028, and low utilization EGUs.

On March 29, 2023, USEPA proposed "Supplemental Effluent Limitations Guidelines and Standards" that would apply to FGD wastewater, bottom ash transport water, and combustion residual leachate. This proposed rule would require zero discharge for all pollutants in FGD wastewater and bottom transport water and impose numeric limits for mercury and arsenic in combustion residual leachate. It would also eliminate the less stringent requirements for high flow facilities and low utilization EGUs. However, USEPA has not proposed changing the less restrictive subcategory for EGUs permanently ceasing the combustion of coal by December 31, 2028. Limitations that are more stringent than the current requirements would apply as soon as possible (as determined by the permitting authority) but no later than December 31, 2029. The applicability date for other requirements would remain as soon as possible (as determined by the permitting authority) but no later than December 31, 2025.

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.

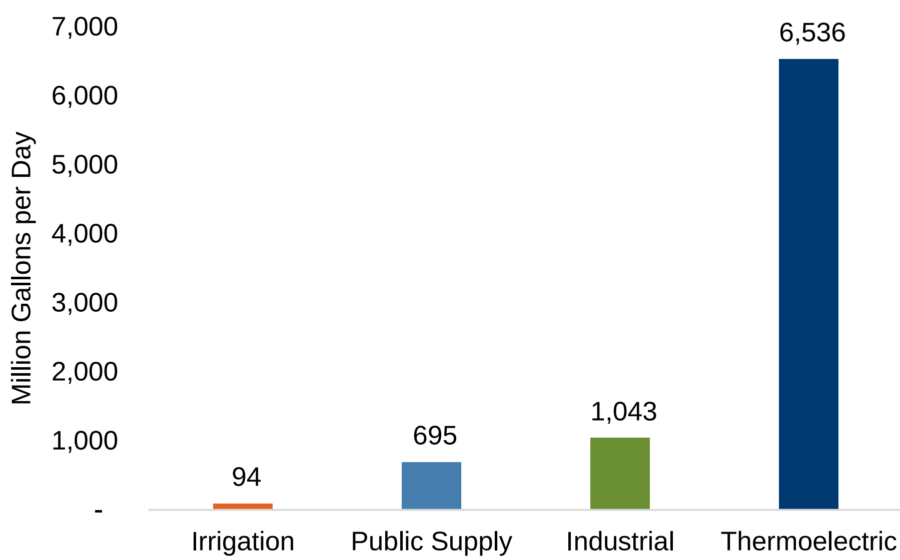
Fuel Cycle Impacts. The extraction, processing, and transportation of fuel can affect water quality. Runoff and other discharges from coal and uranium mines, natural gas well sites, and from fuel processing facilities can discharge sediment and other pollutants into surface waters. These discharges are 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.

4.4.3 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. The Tennessee River Basin, which is about half of the TVA PSA, is one of the most intensively used basins in the contiguous United States as measured by intensity of freshwater withdrawals in gallons per day per square mile. While the withdrawal rate is high, the basin has a low consumptive use by returning over 95 percent of the withdrawals back for downstream use (Sharkey and Springston 2022).

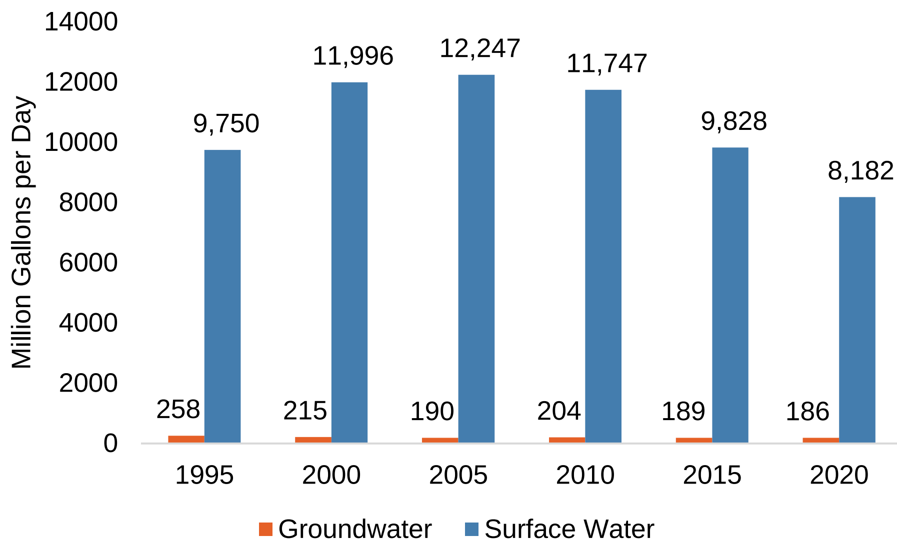
Off-stream water use in the Tennessee River watershed is categorized as thermoelectric power, industrial, public supply, and irrigation. Water use is summarized by source of water (surface water or groundwater) and location of withdrawal (reservoir catchment area). Water returns to the watershed are used to estimate consumptive use.

Total water withdrawals in 2020 were estimated to average 8,368 million gallons per day (MGD) and the 2020 total withdrawal rate was 16.5 percent lower than it was in 2015. This was largely due to a reduction in thermoelectric withdrawal of 20.5 percent (Sharkey and Springston 2022). Of the total withdrawal, 97.8 percent, or 8,182 MGD came from surface water. Groundwater supplied the remaining 2.2 percent, or 186 MGD. Return flow totaled 7,965 MGD, or 95.2 percent of total withdrawal. Total net water demand was 403 MGD, or 4.8 percent of total withdrawal. Water withdrawals for 2020 by category are shown in Figure 4-15. Groundwater and surface water withdrawals in the Tennessee River Basin from 1995 to 2020 are shown in Figure 4-16.



Source: Sharkey and Springston 2022

Figure 4-15: 2020 Water Withdrawals by Category in the Tennessee River Basin



Source: Sharkey and Springston 2022

Figure 4-16: Groundwater and Surface Water Withdrawals in the Tennessee River Basin, 1995 to 2020

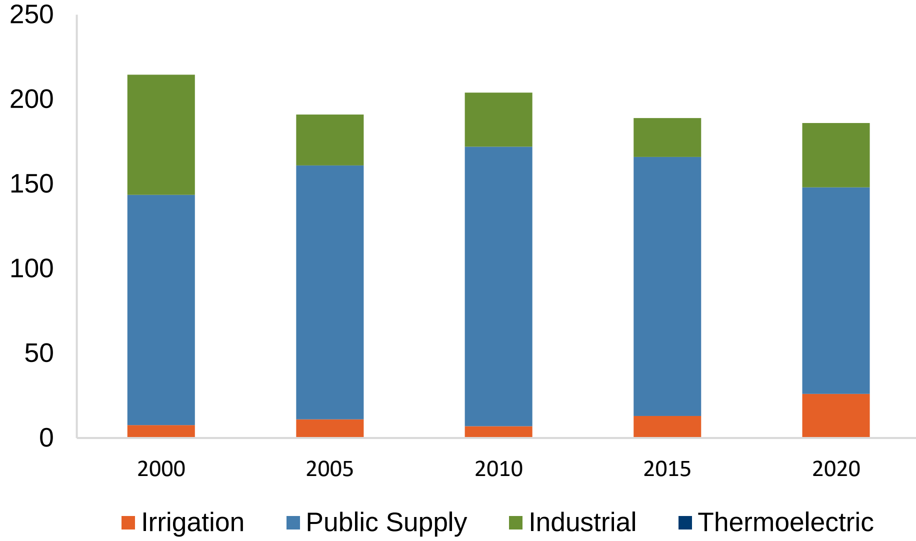
Since 1995, the Tennessee River Basin's public water supply has been sourced primarily from surface water. In 2020, public supply water was comprised of 82.4 percent surface water and 17.6 percent ground water. Total surface water withdrawals in the Tennessee River Basin have been decreasing since 2005.

4.4.3.1 Groundwater Use

The use of groundwater to meet public water supply needs vary 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.

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. The dominance of groundwater uses 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 CC plants, which use groundwater for industrial purposes (e.g., fire protection and cooling) are in this area.

The largest use of groundwater is for public water supply, shown in Figure 4-17, which includes data for the Tennessee River Basin. Approximately 17.6 percent of the water used for domestic supply and 27.2 percent of water used for irrigation in the Tennessee River Basin is groundwater. Groundwater is also used for industrial, mining, livestock, and aquaculture purposes. Total groundwater use for public water supply in 2020 was 122 MGD in the Tennessee River Basin. Groundwater withdrawal for industrial use in the Tennessee River Basin was 38 MGD, or 3.6 percent of total industrial withdrawal. Groundwater use for irrigation was 26 MGD, or 27.2 percent of total irrigation use. Wheeler-Wilson was the Water Use Tabulation Area (WUTA) with the highest groundwater withdrawal, at 43 MGD (Sharkey and Springston 2022). Groundwater use has shown a decreasing trend from 1995 to 2020, except for 2010. In 2020, groundwater withdrawals reached its lowest level since 1995.

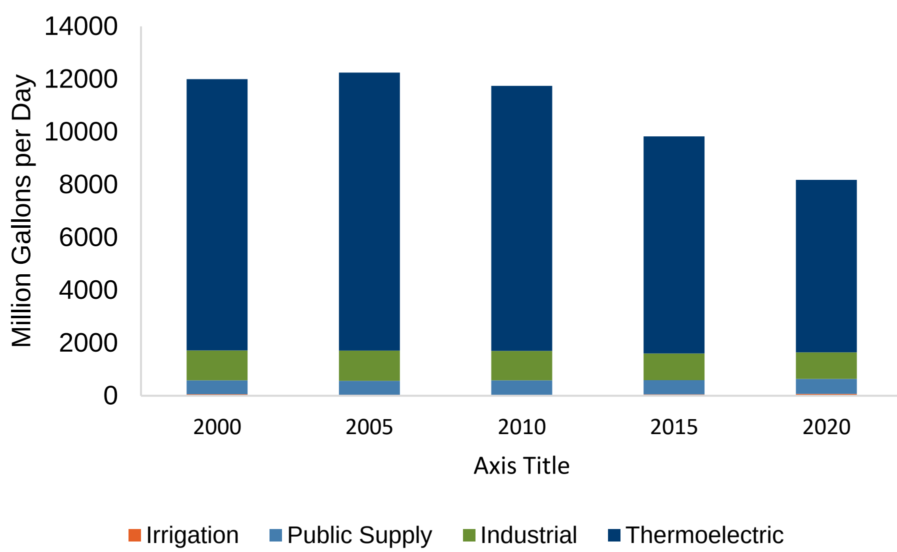


Source: Sharkey and Springston 2022

Figure 4-17: Groundwater Use by Category in the Tennessee River Basin, 2000 to 2020

4.4.3.2 Surface Water Use

Most of the water used for thermoelectric, public supply, aquaculture, and industrial uses is surface water. In 2020, the total surface water use in the Tennessee River Basin was 8,182 MGD. Surface water supplied the entire thermoelectric withdrawal of 6,536 MGD. Surface water was the source for 1,005 MGD, or 96.4 percent of the industrial withdrawal; 573 MGD, or 82.4 percent of the public water supply withdrawal; and 68 MGD, or 72.8 percent of the irrigation withdrawal. Wheeler-Wilson was the WUTA with the highest surface withdrawal, at 3,520 MGD (Sharkey and Springston 2022). Surface water continued to supply most of the water used in the watershed in 2020. Except for the 2020 public supply, surface water withdrawals by source have remained relatively constant over the 2000 to 2020 period. As metropolitan areas within the TVA region increase in population, water use for public supply in these areas have increased. Figure 4-18 includes data for surface water uses in the Tennessee River Basin.



Source: Sharkey and Springston 2022

Figure 4-18: Surface Water Use by Category in the Tennessee River Basin, 2000 to 2020

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.

Total 2020 thermoelectric withdrawal in the Tennessee River Basin was 6,536 MGD, of which 6,463 MGD, or 98.9 percent, was returned. The largest WUTA withdrawal was 3,294 MGD from the Wheeler-Wilson WUTA. This accounted for 50.4 percent of total thermoelectric withdrawal. The Wheeler-Wilson withdrawal was used to generate 33,105 million kilowatt hours of electricity, or 40.2 percent of the total power generated in the Tennessee River watershed (Sharkey and Springston 2022). The largest withdrawal within the Wheeler-Wilson WUTA was Browns Ferry Nuclear Plant in Limestone County, Alabama. The second largest WUTA withdrawal was from the Watts Bar-Chickamauga WUTA, which comprised 2,601 MGD, or 39.8 percent of total thermoelectric withdrawal. The Watts Bar-Chickamauga WUTA withdrawal was used to generate 39,602 million kilowatt hours of electricity, or 48.1 percent of the total power generated in the Tennessee River watershed (Sharkey and Springston 2022).

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 gallons (gal)/MWh to a low of about 23,000 gal/MWh (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 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.

The average percent of total withdrawal for thermoelectric use between 2000 and 2015 was 83.8 percent. Thermoelectric withdrawal in 2020 was 20.5 percent lower than it was in 2015, and the percent of total withdrawal in 2020 dropped to 78.1 percent (Sharkey and Springston 2022).

In 2000 and 2005, the thermoelectric unit water requirement for power generation was 39 gallons per kilowatt-hour (gal/KWh). It rose in 2010 to 42 gal/KWh and remained nearly the same in 2015. In 2020, the thermoelectric unit water requirement for power generation dropped to 29 gal/KWh. From 2015 to 2020, there was an increase in thermoelectric power generation of 16.9 percent. However, during the same period, there was a 20.5 percent reduction in water withdrawal. Changes in cooling technology, closure of three fossil plants, conversions to combined cycle plants, and increased hydrogeneration due to increased rainfall led to the decrease in the thermoelectric unit water requirement in 2020 (Sharkey and Springston 2022).

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.

The Federal Power Act requires hydropower projects with licenses to provide conditions for the protection, mitigation and enhancement of fish and wildlife that are consistent with agency recommendations, such as those of the U.S. Fish and Wildlife Service (USFWS).

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).

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 some of its generating facilities.

4.5 Land Resources

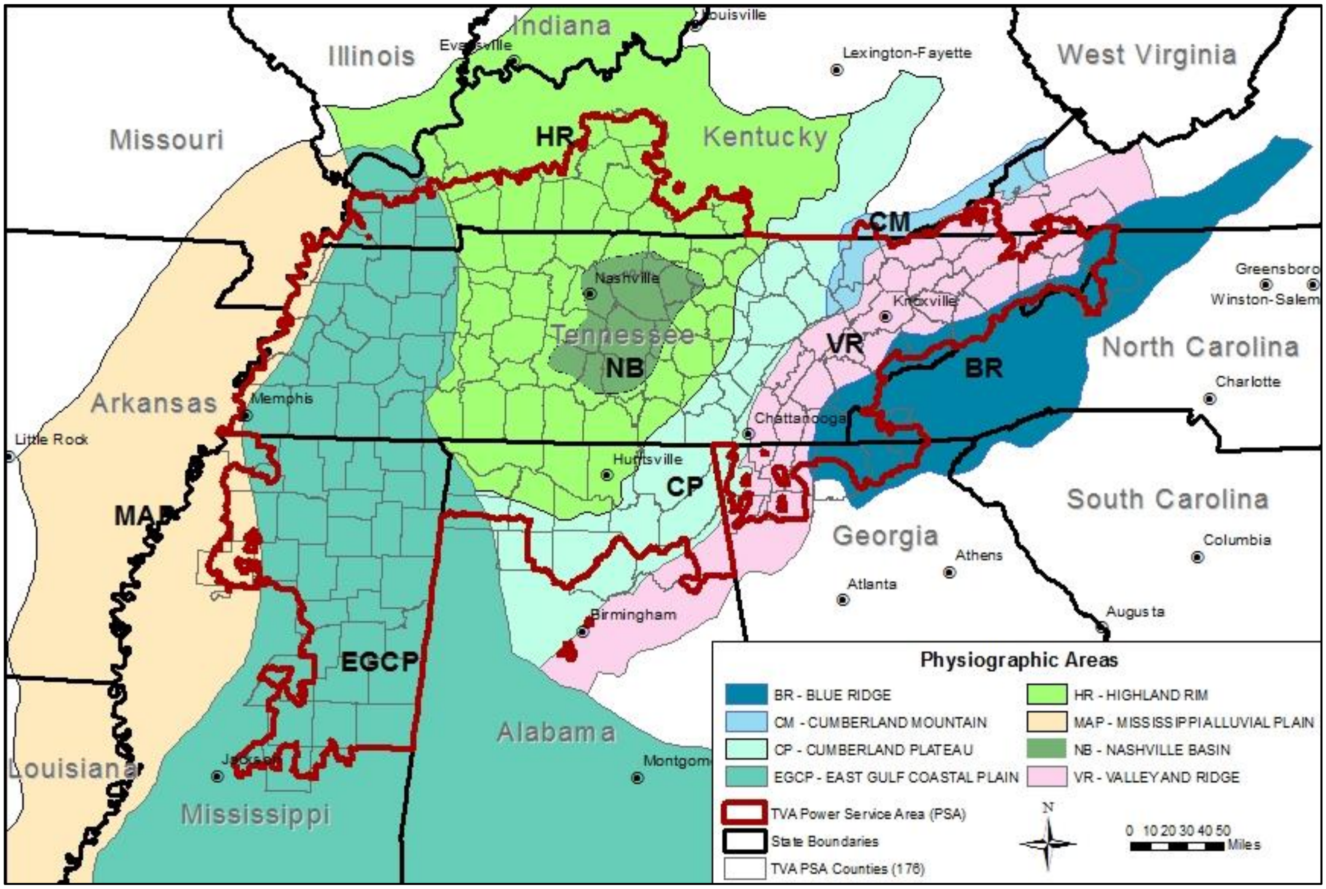
This section describes the land resources in the TVA region that could be affected by the alternative strategies. The potentially affected land resources include geology, vegetation and wildlife, endangered and threatened species, wetlands, parks, managed areas and ecologically significant sites, land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

4.5.1 Geology

The TVA region encompasses portions of the following major physiographic provinces and physiographic sections (Figure 4-19) (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.



Source: Adapted from Fenneman (1938).

Figure 4-19: Physiographic Areas of TVA Region

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 4-19). The Cumberland Plateau rises about 1,000 to 1,500 feet above the adjacent provinces and is formed by layers of near horizontal Pennsylvanian sandstones, shales, conglomerates, and coals, and 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 the limestone 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 4-19). 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 Inflation Reduction Act of 2022 includes clean energy provisions aimed at reducing U.S. GHG emissions by 40 percent by 2030 (DOE 2022a). The Infrastructure Investment and Jobs Act, known as the Bipartisan Infrastructure Law, includes $6.5 billion over five years in carbon management funding, including funding for commercial capacity carbon capture, utilization, and storage (DOE 2022b). Coupled with TVA's aspiration to achieve net-zero carbon emissions by 2050, the Inflation Reduction Act of 2022 and the Bipartisan Infrastructure Law provide a pathway toward carbon management.

Carbon capture, use, transport, and storage provide carbon management by reducing net GHG emissions. Globally, more than a quarter billion tons of CO_2 have been captured and stored to date in 2023. The sequestration (i.e., capture and permanent storage) of CO_2 from large stationary industrial sources such as natural gas processing and coal-fired power plants is an important potential 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 minimize net emissions. In 2022, a total of 12 CCS projects were operational in the U.S. with 100 projects in development (NETL 2015, DOE 2023a).

Few power plant CCS projects are currently operating and the technology for commercial scale CCS continues to develop. In January 2023, there were 417 carbon capture, storage, and combined capture and storage projects globally. Of these, 177 projects were located in the U.S., including 29 terminated projects. In January 2023, 24 CCS projects were in the vicinity of the TVA region, with projects in Alabama, Kentucky, Mississippi, North Carolina, and Virginia. Further, only 54 of U.S. CCS projects were tied to power plants and only 11 of those were in the vicinity of the TVA region (NETL 2023).

Geologic CO_2 storage involves capturing and separating the CO_2 from the power plant exhaust; purifying and compressing the CO_2; and transporting the supercritical CO_2 by pipeline to the storage site where it is pumped through wells into deep geological formations. At temperatures exceeding 87.98 °F (31.1 °C) and pressures exceeding 72.9 atmospheres, CO_2 becomes supercritical, requiring much less volume for storage of this liquid-like material. Supercritical CO_2 remains in the supercritical condition at depths below 2,600 feet, where natural temperatures and fluid pressures exceed the critical point for CO_2 at most places on earth. 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 stops and the wells are permanently sealed and monitored (NETL 2010a, NETL 2015).

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. Necessary conditions for storage of CO_2 include a reservoir with sufficient injectivity along with a seal to prevent migration. Natural seals helping trap CO_2 include impermeable formations (such as shale) that provide a confining zone, which prevents migration of injected CO_2 from its underground injection site. Over time, fractured or porous sedimentary basins can become saturated with oil, gas, or brine; thus, making these formations possible CO_2 storage sites. In the central and Southeastern U.S., deep saline formations, unmineable coal seams, basalt formations, and oil and gas fields have the best potential to store CO_2 from large point sources. Although oil and gas fields have been characterized more extensively than saline formations, deep saline formations followed by unmineable coal seams (and organic-rich shales), basalt formations, and oil and gas fields have the greatest potential in the TVA region for CO_2 storage (NETL 2010a, NETL 2015). A brief description of each of these formations, as well as its storage potential in and near the TVA PSA, is given below.

In 1997, the U.S. Department of Energy (DOE) launched the CCS Program (NETL 2015). In 2003, the DOE's National Energy Technology Laboratory (NETL) awarded cooperative agreements to seven Regional Carbon Sequestration Partnerships to identify and evaluate carbon sequestration in different regions of the country (NETL 2018). Areas studied include parts of the Southeast and the Illinois Basin area of Illinois, Indiana, and Kentucky. Experimental CO_2 injection projects have included enhanced coalbed methane recovery in Marshall County West Virginia and enhanced oil/gas recovery in the Black Warrior Basin of Alabama (NETL 2015).

Since January 2021, DOE has invested in over a hundred projects advancing carbon capture, use, transport, and storage. In 2022, the U.S. captured and geologically stored 20 million metric tons of CO_2. By 2030, DOE anticipates this domestic capacity to expand to 128 million metric tons. DOE-funded carbon capture, utilization, and storage activities include bench scale tests in North Carolina, multiple research endeavors at the University of Kentucky, and various efforts at Tennessee's Oak Ridge National Laboratory (Intensified, Flexible, and Modular Carbon Capture Demonstration 2020-2022, Porous Catalyst Polymers for CO_2 Capture and Conversion 2021-2024, Integrated Process for Direct Air Capture and Conversion of CO_2 2020-2023, and Direct Air Capture with Building Handling Equipment 2020-2022) (DOE 2023a, DOE 2023b).

Saline Formations. Saline formations are layers of porous rock saturated with brine (saline water with a high concentration of dissolved solids). 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 must contain at least 10,000 parts per million dissolved solids and must include a regionally extensive cap rock of one or more layers of non-porous rock, thus preventing the upward migration of injected CO_2. In addition, saline formations 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 2015).

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 bed and therefore does not need to be in the supercritical phase. In addition, coal preferentially absorbs CO_2 over methane and 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 2015).

Organic-Rich Shales. Organic-rich shales in the Illinois Basin also offer the potential for storing CO_2, including its use for enhanced methane recovery. Like unmineable coal seams, organic-rich shales preferentially absorb CO_2 over methane and the injected CO_2 can be used to displace coalbed methane. Also, like unmineable coal seams, the occurrence of suitable 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 (NETL 2015).

Basalt Formations. With widespread coverage of the earth's surface, basalt formations provide another potential storage area for CO_2 sequestration. The magnesium and calcium silicates in basalt reacts with the injected CO_2 forming stable carbonate minerals and thus permanently isolates the CO_2 from the atmosphere. While chemical reactivity with injected CO_2 is high, primarily along fracture zones and in the interflow zones (regions between successive basalt flows), reactions with CO_2 are slow, taking hundreds to thousands of years. The distribution of basalt formations in the continental U.S. includes vast swathes of the pacific Northwest and the Southeast (NETL 2010a, NETL 2015).

Oil and Gas Fields. Mature oil and gas fields/reservoirs are considered good storage formations because they held crude oil and natural gas for thousands to millions of years. Their storage characteristics are 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 has been used for over 40 years to 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 2015).

The Kemper County integrated gasification combined cycle 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 (DOE 2010, NETL 2015). 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 4-19):

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. This provides space for a biodiverse TVA Region, with about 5,000 species of plants, 16 species of reptiles, 29 species of amphibians, 180 species of breeding birds and 40 species of mammals occurring and being monitored in Tennessee alone (NRCS 2024a, TWRA 2015, TBRC 2023). 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. Executive Order (EO) 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. EO 13751 – Safeguarding the Nation from the Impacts of Invasive Species amends EO 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). Funding to address these biological threats has been provided in regulatory actions throughout the years, most recently in the 2021 Infrastructure Investment and Jobs Act, also known as the Bipartisan Infrastructure Law, and the Inflation Reduction Act of 2022.

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 EO 13186 – Responsibilities of Federal Agencies to Protect Migratory Birds. The MBTA and EO 13186 address most native birds occurring in the U.S. The MBTA makes the incidental taking, killing, or possession of migratory birds, their eggs, or nests unlawful, except as authorized under a valid permit. EO 13186 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 on migratory bird conservation with the USFWS. TVA is currently in consultation with USFWS for the development of a memorandum of understanding under EO 13186.

Aside from federal and state laws regulating the hunting, trapping or other capture, and possession of some species, most wildlife other than birds and aquatic species (Section 4.4.4) generally receive no legal protection in inland areas.

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 subtype. 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 from forest and agriculture to developed land has increased steadily since data has been recorded (NRCS 2024a). 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 are 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 was 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. 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 Southern Appalachian region; smaller numbers are found in the other ecoregions (NatureServe 2024). 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, invasive plants, 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 2023h).

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 birds dependent on grassland and forest have shown decreases in their numbers by 30 to 60 percent (NABCI 2022). Across North America, 54 percent of grassland-breeding birds qualify as birds of conservation concern because of declining populations (USFWS 2021). 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 28 inland species of birds breeding in the TVA region are considered to be of conservation concern, with eight coastal species also possibly occurring within the region (USFWS 2021). 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 a species.

Global amphibian declines have been well documented but declines in amphibian populations specific to the TVA region have also 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. For amphibians, diseases such as chytridiomycosis and snake fungal disease, caused by *Ophidiomyces ophiodiicola*, have led to population declines and decreasing biodiversity (Allender et al. 2015; Scheele et al. 2019). Populations of bats have been observed dying off in the TVA region after the introduction of a novel pathogen causing white nose-syndrome (see Section 4.5.3.2).

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, 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.

Several plants designated by the USDA as noxious weeds under the Plant Protection Act occur in the TVA region: hydrilla, giant salvinia, giant hogweed, cogongrass, itchgrass, 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. Giant hogweed generally occurs near stream bank areas as water is an important link to giant hogweed establishment and proliferation. Cogongrass is an upland plant present in several TVA region counties in Alabama and Mississippi. It occurs on and near several TVA transmission line rights-of-way and can be spread by line construction and maintenance activities. Itchgrass grows in generally disturbed and agricultural areas, as well as roadsides. Tropical soda apple has been reported from a few counties in the TVA region and primarily occurs in agricultural areas.

There are 58 additional invasive plants considered to be an established or emerging threat that occur on or near TVA generating facilities and transmission line rights-of-way (TN-IPC 2023). 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. In recent years, the non-native eelgrass Rockstar Hybrid has displaced native aquatic plants in several TVA reservoirs.

Invasive terrestrial animals at TVA generating facilities that require occasional 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 United States Code [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 and additional species classified as “in need of management,” “state protected,” etc.

4.5.3.2 Endangered and Threatened Species in the TVA Region

Thirty-three species of plants and 103 species of animals in the TVA region are listed under the ESA as endangered or threatened or formally proposed for such listing by the USFWS (USFWS 2023a). One additional species in the TVA region has been identified by the USFWS as a candidate for listing under the ESA. Candidate species receive no statutory protection under the ESA but, by definition, may warrant future protection. Eight additional species have been proposed for listing as threatened or endangered. Across the TVA region, there are also 45 areas designated as critical habitat essential to the conservation of listed species. In addition to the species listed under the ESA, about 1,070 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 (TVA 2024b).

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, and snail darter) or their listing status has been downgraded from endangered to threatened (e.g., large-flowered skullcap and small whorled pogonia). However, some of the listed species with populations continue to decline due to a multitude of factors. The formerly common northern long-eared bat was listed in 2015 under the ESA as threatened and upgraded to an endangered listing in 2022 due to recent dramatic population declines caused by white-nose syndrome. The formerly common tricolored bat is expected to be listed as endangered under the ESA in 2024 with the little brown bat to follow in the coming years due to the same pathogen. 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 the Vicinity of TVA Generating Facilities

In addition to ESA-listed species within the TVA region, several species not listed on the Information for Planning and Consultation (IPaC) for the TVA region are known to 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 (40 CFR § 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 includes wetlands, unless authorized by a permit issued by the USACE. The scope of this regulation includes most construction activities in wetlands. EO 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 7,769 acres of wetlands are mapped on the National Wetlands Inventory (NWI) dataset within TVA transmission line rights-of-way (USFWS 2023b). Due to periodic clearing, the rights-of-way 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 1-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 EO 11988 – Floodplain Management.

4.5.5.1 Regulatory Framework for Floodplains

TVA adheres to the requirements of EO 11988, Floodplain Management. The objective of EO 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." The EO 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 EO 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).

EO 13690, Establishing a Federal Flood Risk Management Standard and a Process for Further Soliciting and Considering Stakeholder Input, was reinstated by President Joe Biden in May 2021. However, implementation of EO 13690 is still in development at the national level. TVA is working with other federal agencies to develop consistent implementing plans for these EO requirements and may update its implementing plan when federal guidance is finalized. TVA currently incorporates floodplain analyses with respect to the 500-year floodplain in alignment with EO 13690, in addition to EO 11988.

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 (FEMA) 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 EO 11988 in conjunction with TVA's Section 26a or land use approvals, or both.

4.5.6 Parks, Managed Areas, and Ecologically Significant Sites

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 PSA 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. Wildlife management areas (WMAs) that are managed by the Tennessee Wildlife Resources Agency (TWRA) are also located on some TVA property, including portions or full parts of Owl Hollow Mill WMA, Chickamauga WMA, Watts Bar WMA, Paint Rock WMA, Rankin Bottom WMA, Nolichucky WMA, Beech River WMA, and more, with other WMA's abutting TVA property (TWRA 2023, TVA 2023d). TVA transmission line rights-of-way cross seven National Park Service units, nine National Forests, six National Wildlife Refuges, and numerous state wildlife management areas, state parks, and local parks (TVA 2018c).

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 4.4 percent of the TVA region is water, primarily lakes and rivers (USDA 2020). This proportion has increased slightly since 1982 (when monitoring was started), primarily due to the construction of small lakes and ponds. About 5.7 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 9 percent is classified as developed and 80 percent as rural (USDA 2020). Rural undeveloped lands include farmlands (19 percent of the rural area) and forestland (about 42 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 almost three percent between 2012 and 2017 (USDA 2020).

Approximately 53 percent of the TVA region is forested (USGS 2021). 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.

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 17.8 and 15.2 percent, respectively, of rural, non-federal land in 2017 (USDA 2020). Both cropland and pastureland have decreased in area since 1982; however, the rate of cropland and pastureland loss in Tennessee has declined (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, wheat, corn, and cotton. The major farm commodities by sales are cattle and calves, poultry and eggs, grains and beans, cotton, and nursery products (USDA 2019).

Although the area of irrigated farmland is small (6.4 percent of farmland), it increased by 25 percent from 1987 to 2017 (USDA 2019). 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 Kentucky, Tennessee, North Carolina, and Virginia show minor decreases in the percentage of farms using irrigation; however, in most cases, the acres of irrigated farmland have 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 in Alabama, Georgia, Kentucky, and Mississippi and decreases in North Carolina, Tennessee, and Virginia (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 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 2024). 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.

Prime Farmland. 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 23 percent of the TVA region is classified as prime farmland (NRCS 2024b). An additional roughly 4 percent of the TVA region would be classified as prime farmland if drained or protected from flooding.

Forest Management. About 50 percent of the forestland in the TVA region is classified as timberland (USDA Forest Service 2024), 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 13.5 percent of timberland is in public ownership, which includes national forests, state and local lands, and other federal lands. About 87 percent is under private ownership, which includes both corporations and non-corporate owners. 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.

4.5.8 Cultural Resources

Cultural resources include prehistoric and historic archaeological sites, districts, buildings, structures, and objects. Cultural resources are considered historic properties if included in, or considered eligible for inclusion in, the National Register of Historic Places (NRHP), a designation maintained by the National Park Service. 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:

A. Property is associated with events that have made a significant contribution to the broad patterns of our history.

B. Property is associated with the lives of persons significant in our past.

C. Property embodies the distractive characteristics of a type, period, or method of construction or represents the work of a master, or possesses high artistic values, or represents a significant and distinguishable entitle whose components lack individual distinction.

D. Property has yielded, or is likely to yield, information important in prehistory or history.

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.

In November 2019, TVA executed a Program Alternative Programmatic Agreement (PA) with the Advisory Council on Historic Preservation, federally-recognized Indian tribes, and SHPOs in Alabama, Georgia, Kentucky, Mississippi, North Carolina, Tennessee, and Virginia. The PA lays out a standardized internal review process for routine undertakings unlikely to have an adverse effect on architectural and archaeological cultural resources. The bulk of these undertakings are 26a permits for activities along the Tennessee River and its tributaries. TVA also reviews projects at its various office facilities, general operations, and transmission infrastructure.

To ensure compliance with the various regulatory and legal requirements, TVA launched its Cultural Resource Management System (CRMS) in April 2022. This GIS-based, interactive data storage system developed by TVA, is used to manage the documentation of archaeological and architectural surveys, consultations, historic architectural resources, historic properties, and the 12,000+ archaeological sites that have been recorded on TVA reservoir lands and the hundreds additional sites that have been identified in transmission line rights-of-way. Other recent initiatives for TVA cultural resource management include the TVA Stone Feature Management Plan; a Tribal Consultation Action Plan; a Memorandum of Understanding Regarding Interagency Coordination and Collaboration for the Protection of Indigenous Sacred Sites; a Best Practices Guide for Federal Agencies Regarding Tribal and Native Hawaiian Sacred Sites; Electric Vehicle Charging Station Exemption; and the Historic Transmission Assets in Tennessee PA.

4.5.8.2 Archaeological Resources

The Tennessee Valley is one of the most archaeological rich regions in the U.S. People first spread into this area at least as early as 14,000 years ago as part of a rapid population expansion following a wave of migration from eastern Asia. The Valley has been populated by humans ever since. The earliest well-documented groups here are known by the iconic stone artifact known as a Clovis point, made by Paleoindian people between

13,500 and 12,000 years ago who hunted wild horses and other now-extinct large animals such as wooly mammoths, *Bison antiquus*, and giant ground sloths. At that time, glaciers covered all of Canada and most of the U.S., advancing as far as the present course of the Ohio River until approximately 12,000 years ago, when global temperatures rose rapidly. This led to the extinction of many large mammal species, range changes for others, and re-organization of biozomes. As the steppe and coniferous forest in the Valley gave way to deciduous forests and warm prairies, humans settled into different ecosystems to exploit wild plant foods, hunt game such as white-tailed deer, bear, and turkeys, and to fish and collect freshwater mollusks.

Archaeologists have identified cultural adaptations that vary over space and through time and given them names that may correspond, loosely at least, to past cultures. In the Tennessee Valley, cultural chronology before the European invasion is 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., or AD 900-1,500) periods. Archaic peoples are known for collecting tree nuts and freshwater mussels, seasonal movements over the landscape to collect different kinds of resources as they became available, and a relatively dispersed population. By the Woodland period, the harvest of certain wild plant foods intensified, leading to cultivation and, eventually, domestication. Woodland people mostly lived in permanent or semi-permanent villages, carried out long-distance trade networks, developed elaborate rituals, made fired-clay pots and vessels, and buried their dead in large, conical-shaped earthen mounds. During the Mississippian period more complex social systems developed, based on maize-based agriculture, with large polities headed by powerful chiefs. When Hernando de Soto arrived on the Gulf shores of Alabama with 400 soldiers and began a years-long trek through the forests and swamps of Mississippi, North Carolina, Georgia, and Tennessee, they encountered large populations living in towns with plazas surrounded by houses, public buildings, and ceremonial mounds, defended by warriors with weapons capable of piercing Spanish chain mail. Tragically, the Spaniards inadvertently infected native peoples with diseases that had never been known in North America, leading to pandemics that spread like wildfire and decimated native populations coast to coast. Little is known about the particulars of this period, but by the late 17th century Mississippian chiefdoms had been replaced by, or reorganized into, the tribes that we know today as the Cherokee, Creek, Chickasaw, Choctaw, Seminole, and Shawnee. With the expansion of the English colonies, these and all the other native groups living in the eastern U.S. were gradually pushed into remnants of their former territories while forming, breaking, and re-forming alliances with the British, the French, the Spanish, and later the Americans. First British, and later Americans brought enslaved Africans to do the hard work of running farms and plantations. Although history has recorded events in our country since the earliest contact with Europeans, history is incomplete and much of what we know about the past 500 years comes from, or is enhanced by, archaeological evidence.

For over 80 years, TVA has been actively engaged in identifying archaeological resources on TVA lands and easements. In the 1930s and 1940s, under authority of the Antiquities Act of 1906, TVA completed large regional surveys in all the lands to be affected by the planned reservoir projects and excavated dozens of major archaeological sites. The work continued in the 1960s and 70s with the construction of reservoir projects such as Normandy and Tims Ford under the Reservoir Salvage Act, and during planning for the several nuclear projects that TVA pursued. The National Historic Preservation Act was passed in 1966; Section 106 of this Act requires federal agencies to consider the potential effects of their undertakings on historic properties, including significant archaeological sites. TVA began complying with this Act once it was passed, but compliance became more systematic in the late 1980s after the Advisory Council on Historic Preservation published regulations implementing Section 106 (36 CFR Part 800.1-16). These regulations created a process for agencies to identify historic properties, evaluate project effects on those properties, and avoid, minimize, or mitigate adverse effects, all in consultation with State Historic Preservation Officers, Indian tribes, and others with an interest in the project. Today, TVA completes some level of identification and evaluation of archaeological sites as Section 106 compliance in connection with 26a permits, easements, reservoir operations, conveyance of transmission system resources, new construction, power purchase agreements (in particular, for solar arrays), maintenance and operation of generating facilities and transmission system, nuclear plant relicensing, economic development projects, and other actions.

TVA maintains digital records of all archaeological sites identified on TVA property, as well as sites identified during phase I surveys off TVA land, such as surveys in connection with transmission line projects, in its Cultural Resources Management System (CRMS). Identifying and managing archaeological resources requires careful documentation of the location, nature, and condition of each archaeological resource. Since this information is sensitive, it also requires taking steps to ensure that the information is protected. Whenever a TVA action has the potential to adversely affect a sensitive resource TVA's preference, and that of TVA's consulting parties, is to avoid the site, and if avoidance is not feasible, to minimize the effects through design changes and/or best management practices. In rare instances avoidance is not possible, and in those cases the adverse effects are mitigated by the scientific collection of valuable data from the site before the site is damaged or destroyed. Mitigation consists of the scientific excavation of the site, archiving the data, and conserving the artifacts, all in consultation with SHPOs and other appropriate consulting parties. 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; a large Woodland and Mississippian site in the West Batesville-North Oakland transmission line project; and the Riverton economic development project.

4.5.8.3 Historic Architectural Resources

Historic architectural resources—sites, structures, buildings, objects, and districts that are either 50 years of age or older or are exceptionally significant—are found throughout TVA's PSA and the Tennessee River watershed. Those historic architectural resources are either eligible for listing or listed in the NRHP, and can include houses, barns, and public buildings. Many of the generating plants, corporate offices, and recreation facilities owned, leased, or otherwise occupied by TVA are also historic properties.

Fifty-nine percent of TVA's inventoried facilities (excluding transmission assets) are at least 50 years of age or older. Of those that are historic, 83 percent are historic properties—listed in or eligible for listing in the NRHP. TVA's 70 generating facilities are comprised of hydroelectric, fossil, nuclear, gas, and solar facilities. Eighty-four percent of TVA's historic generating facilities are also historic properties. All of TVA's hydroelectric projects are historic properties (listed in or eligible for listing in the NRHP); one of these, Wilson Dam, is listed as a National Historic Landmark. In addition to hydroelectric plants, two TVA fossil plants (Shawnee and Bull Run, now retired) are historic properties; the remaining fossil plants are either no longer extant or have been determined ineligible due to a lack of integrity because of modifications and alterations. Only one nuclear plant (Browns Ferry) is a historic property. None of TVA's gas or solar facilities are historic properties. The large number of TVA's historic generating facilities that remain historic properties poses a unique challenge as TVA aims to balance preservation and retention of historic fabric and character-defining features with safe and efficient energy production to meet the growing demand for electricity.

In addition to generation, TVA's facilities also include historic corporate offices (Knoxville and Muscle Shoals) and non-power dams, including two systems of smaller dams for recreation and flood control and NRHP-listed Normandy and Tellico Hydroelectric Projects. Transmission assets were excluded from this discussion, given TVA's on-going programmatic efforts to evaluate these resources.

In FY 2019, TVA initiated a multi-year project to develop a comprehensive inventory for historic architectural resources on TVA land and adjacent to TVA transmission lines. Surveys and assessments continue to grow the inventory. In addition to conducting surveys, the inventory project includes adding historic architectural resource records in TVA's CRMS. The addition of this data not only improves efficiency of Section 106 project reviews, but also serves as a planning tool for the management of TVA's historic properties. Additionally, in FY 2023, TVA began fieldwork for systematic updates of NRHP documentation as a part of the inventory project for the first of several groups of NRHP-listed hydroelectric projects. Additional updates are anticipated to continue through 2031.

In 2019, TVA began development of a complete history of TVA's transmission system. Once finalized, this document will support a consistent assessment of TVA's historic transmission assets. In 2023, TVA entered into a new Programmatic Agreement with the Tennessee SHPO about the cultural resource management of historic transmission assets in Tennessee. In this PA, TVA agreed to update the NRHP documentation for nine hydroelectric dams, create a TVA Transmission Digital Museum, and document the history of transmission office buildings. Part of the agreement stipulates that TVA will track all projects on historic transmission assets in Tennessee, document any adverse effects, and explain how they were resolved through the mitigation outlined in the agreement.

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 2018c). 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., 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 1 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 wind resources 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 (14.3 miles per hour) or greater at a height of 50 meters 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-meter 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-

meter height in the southern Appalachian Mountains. Measured annual wind speeds at nine representative privately owned sites ranged from 4.4 meters per second on the Cumberland Plateau in northwest Georgia to 7.3-7.4 meters per second 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. 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; the windfarm facility is located in the Cumberland Mountains (see Section 2.4).

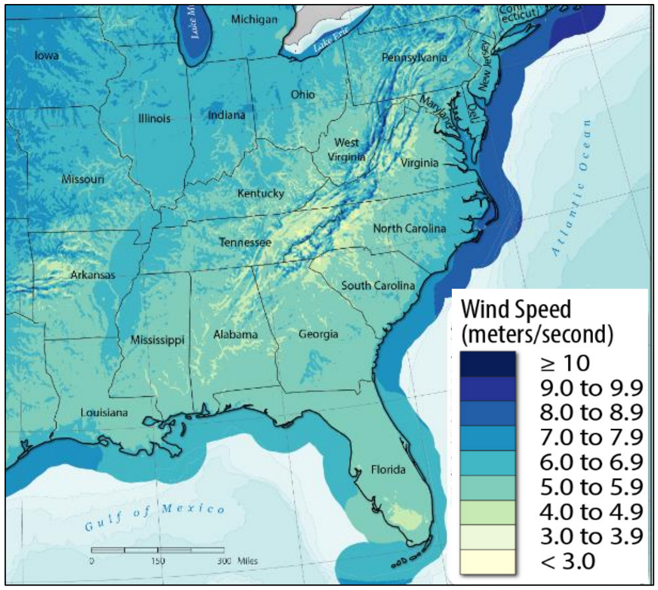
More recent wind assessments have shifted from a power class rating to increased focus on wind speed and potential capacity factor, and to hub heights of 80 meters (262 feet) and 100 meters (328 feet) above ground. Tower heights of 80-140 meters (262-460 feet) are more representative of recently installed wind turbines (DOE 2023c). This re-evaluation showed an increased potential for wind generation in the western portion of the TVA region (Figure 4-20, Figure 4-21). Offshore wind projects continue to be a viable option for renewable energy production. The DOE Wind Energy Technologies Office currently lists Tennessee’s potential wind capacity at 116,000 megawatts (MW) at 80 meters (DOE 2024a). Wind projects are often based on several factors including cost, zoning laws, environmental regulations, and local support of the project. Transmission factors and interconnection continue to be important variables within and outside of the TVA PSA when evaluating new renewable energy projects. TVA continues to evaluate new opportunities for wind development through ongoing research and development, and power purchase agreement offerings.

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). Currently, TVA purchases power from seven wind farms that are outside of the TVA PSA and one wind farm inside the TVA PSA. 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 Integrated Resource Plan (Volume 1 Section 3.6).

In 2018, Tennessee passed statewide regulations for wind turbines, which included minimum setbacks from property lines, noise limits at property lines and dwellings, as well as decommissioning costs for facility removal (TDEC 2023). These regulations make it more difficult and expensive to complete large-scale wind and solar installations. There is also increasing community pushback on commercial solar and wind farm development across the U.S. as projects are announced and moved through the permitting process (Young 2016).

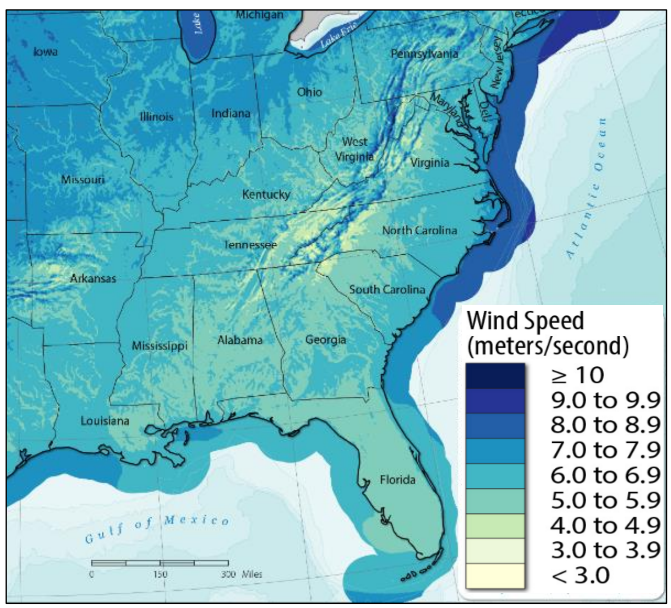
DOE’s Office of Energy Efficiency & Renewable Energy released the Land-Based Wind Market Report: 2023 Edition. According to this report, the second largest resource type added to the electrical grid in 2022 was wind capacity at 22 percent of added resources. The Southeast continues to have significantly less wind capacity than many regions. Profitability and domestic supply chain concerns lead to reduced investment in wind infrastructure, but the Inflation Reduction Act has provided increased potential for growth in wind turbine installations due to additional investments in lower carbon technologies. Wind technology has continued to progress with advancements in capacity allowing for lower quality wind sites to develop. This is represented by the increased number of projects and expansion of wind turbine capacity in the U.S.

DOE’s Wind Technology Office provides a high-level assessment for theoretical wind potential for each state. Theoretical wind potential does not include many significant factors but helps assess the overall viability of wind technology application across the United States. Other significant factors such as public response, mandated offsets, and site-specific factors often reduce the potential and likelihood of deployment of wind turbines. Based on the current state of wind technology, TVA’s Western territory is the most likely region to develop wind energy. Higher hub height allows access to more consistent wind conditions and may close the economic gap for development. TVA actively seeks proposals from developers to deploy renewables. TVA has noted recent increases in the number of projects in regions with similar wind profiles to the TVA region. It is anticipated that additional projects will be developed that have more favorable wind developer profitability. Land usage is a principle environmental aspect which requires thorough and early community engagement. Additional challenges for siting include transportation logistics, due to the larger wind turbine designs, and additional costs associated with the connection of new projects to the existing energy grid.



Source: Adapted from NREL 2017.

Figure 4-20: Wind Resource Potential of the Eastern and Central U.S. at 80 meters above ground

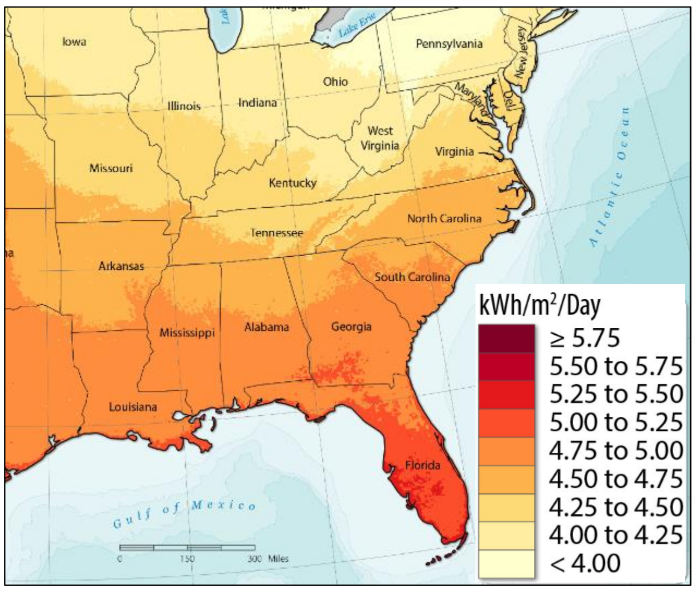


Source: Adapted from NREL 2017.

Figure 4-21: Wind Resource Potential of the Eastern and Central U.S. at 100 meters above ground

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 4-22 shows the average annual total solar resource for the region based on 1998 to 2016 data. All current and foreseeable solar generation in the TVA region is flat plate 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 National Renewable Energy Laboratory (NREL 2018). 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 toward 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. TVA continues to evaluate a variety of PV installations across the PSA, although land availability, construction cost, community restrictions, interconnection, and transmission factors often limit the land available for these projects.



Source: Adapted from NREL 2018.

Figure 4-22: Solar Photovoltaic Generation Potential in the TVA Region

Because PV is the most abundant renewable resource, it is difficult to accurately assess a feasible potential total value for the TVA region. Factors that impact solar deployment at all scales include cost, land availability, community support, and transmission/interconnection constraints. Although solar resources in the TVA region are plentiful, particularly in West Tennessee, North Mississippi, and North Alabama (Figure 4-22), both storage options (short-term and medium-term) and the solar deployments that would power them (small and large scale) would need to be economically feasible for the companies undertaking those projects.

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, although that number will be much smaller in reality due to several factors such as shading, cost, and infrastructure. 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.

In a recent office of Energy Efficiency and Renewable Energy study (EERE 2023), predicted electricity demand is expected to grow by 30 percent from 2020 to 2035 due to increased electrification (i.e. vehicles, buildings, and industry), but ground-based solar systems would require only 0.5 percent of the surface area of the contiguous U.S. along with other technologies to achieve zero carbon emissions. There is also an increasing focus on integrating solar panels with different land uses, such as parking structures, agrovoltaics, and on water (canals, ponds etc.), where there are benefits to both facilities. As with any electrical generation project, transmission and interconnection factors will be an important consideration.

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 hydroelectric turbines and associated equipment. To date, this program has increased TVA's hydroelectric generating capacity by about 15 percent. This capacity increase qualifies as renewable energy under most renewable portfolio standards.

With 43 plants in service in the U.S., pumped storage hydropower accounts for 93 percent of the current grid storage, and its capacity is growing about as fast as all other types of storage combined. There was an estimated 21.9 gigawatts of storage capacity of 553 GWh in 2019, and pumped storage hydropower is considered one of the lowest cost technologies for 4-16 hours duration storage. In the U.S., there are 67 pumped storage hydropower projects in various stages of development with a total capacity of 52.5 gigawatts in 21 states (EERE 2021).

TVA is preparing an environmental impact statement (EIS) to evaluate increasing pumped storage hydropower capacity within its PSA. The EIS will evaluate new pumped storage hydropower facilities at two locations in Jackson County, Alabama, and expansion of the existing Raccoon Mountain Pumped Storage Plant in Marion County, Tennessee.

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 2018, TVA facilities produced approximately 20,884 tons of non-hazardous solid waste. This quantity decreased to approximately 17,351 tons in 2022. 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. 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 4-7). The decrease in tonnage from coal plants between 2020 and 2021 was due to closure of fossil plants. 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 Trans Cycle in Pell City, Alabama, and Waste Management's Emelle, Alabama, facility for disposal.

Table 4-7: Annual Quantities (in tons) of Hazardous Wastes Generated by Routine Operations at TVA Facilities, 2020-2022

Year	Type of Facility					
	Coal Plant	Nuclear Plant	Hydroelectric Plant	Natural Gas Plant	Other	Total
2020	34.3	5.0	15.9	0.0	31.5	86.7
2021	24.0	9.1	6.9	0.04	15.2	55.2
2022	5.5	1.9	4.4	0.08	23.3	35.2
Annual Average	21.27	5.34	9.08	0.04	23.34	59.06

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), which have been historically used in insulating fluids in electrical equipment. PCB items are typically shipped to Trans Cycle Industries in Pell City, Alabama, and Waste Management in Emelle, Alabama.

Used oil is considered a waste if not recycled. 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 is recycled annually. Used oil containing 50 or greater 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 2022, approximately 58.7 tons of universal waste were generated and recycled by TVA.

Wastes generated from renewable sources generally fall into these categories of wastes and do not require special management. The generation of wastes from operations of renewable facilities is small. Wastes result from the decommissioning of wind or solar facilities. As solar generation increases, the commercial recycling of PV panels has increased, allowing the recovery of high-value materials that are used in PV modules (e.g., silicon, indium, silver, tellurium, copper). However, it is estimated that in the U.S. less than 10 percent of PV modules are sent to recyclers; most modules are disposed of in landfills (Curtis et al. 2021). During decommissioning, wind turbines are typically landfilled and associated infrastructure are typically recycled.

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 flue gas desulfurization (FGD) residue. The properties of these wastes (also known as CCR) 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 similar to 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).

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 FGD systems at the Cumberland and Kingston Fossil Plants use limestone as the reagent to bond with the sulfur, producing hydrated calcium sulfate ($CaSO_42H_2O$), also known as synthetic gypsum. The gypsum and fly ash from these systems are stored separately, allowing ready marketing of these materials for beneficial use in production of wallboard and ready-mix concrete, respectively. The 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 CCR at Gallatin and Shawnee are combined in a single dry waste stream.

During 2022, TVA produced approximately 1.5 million tons of CCR, with approximately 40 percent being gypsum, 25 percent being fly ash, 8 percent being bottom ash, and 27 percent being dry scrubber product (Table 4-8). Of the 1.5 million tons, 1.2 million tons, or 80 percent, were utilized or marketed. From 2019 to 2021, on average, TVA utilized or marketed approximately 1.1 million tons of CCR per year, 61 percent of the total CCR produced during this time. Additionally, from 2013 to 2016, TVA utilized or marketed approximately 1.2 million tons of CCR on average per year, which was 30 percent of the total CCR produced during this time. Thus, while the total quantity of CCR utilized or marketed has remained relatively consistent, the proportion utilized or marketed has increased markedly (30 to 80 percent). The reduced total production of CCR results from coal plant retirements. TVA fly ash is utilized as a replacement for Portland cement in ready mix concrete. TVA gypsum is used to produce wallboard and cement. The uses for TVA boiler slag include abrasives and blasting agents. Opportunities for reuse of the combined fly ash and FGD residue CCR produced at Gallatin and Shawnee are currently very limited.

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

Table 4-8: TVA Coal Combustion Residual Production and Utilization, 2018-2022

Material	CCR in Tons									
	2018		2019		2020		2021		2022	
	Prod.	Util.	Prod.	Util.	Prod.	Util.	Prod.	Util.	Prod.	Util.
Fly Ash	607,820	292,377	453,825	356,084	388,338	307,775	452,847	263,408	384,782	253,902
Bottom Ash	174,102	1384	167,778	0	125,717	3858	157,740	16,684	122,312	19,951
Boiler Slag	125,005	62,925	75,346	52,667	13,368	20,578	0	0	0	0
Gypsum	1,157,337	580.494	987,805	606,479	779,660	967,071	872,486	812,258	610,298	952,834
Dry Scrubber Product	347,728	0	506,186	0	245,265	0	374,487	0	413,679	0

Note: Prod. = production; Util. = utilization

The CCR that is not sold for reuse is stored in landfills and inactive impoundments at or near coal plant sites. As of early 2024, TVA operates four coal-fired plants (Cumberland, Gallatin, Kingston, and Shawnee). All four of the facilities have been converted to dry storage and disposal, and TVA is in the process of closing the CCR surface impoundments.

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 that 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, which are 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. On average, TVA's seven operating nuclear units produce 250 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 contacted radioactive materials. 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. At nuclear plants, these wastes consist of solids such as:

- filters, including 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.

Dry active wastes, which typically have low radioactivity, are presently shipped to a processor in Oak Ridge, Tennessee, for compaction and then to a disposal facility in Clive, Utah. Wet active wastes with low radioactivity are shipped to the Energy Solutions Clive disposal facility in Utah or Waste Control Specialists in Texas. Table 4-9 lists the amounts of low-level waste produced at TVA nuclear plants between 2015 and 2022.

Table 4-9: Low-Level Radioactive Waste Generated at TVA Nuclear Plants (cubic feet)

	2015	2016	2017	2018	2019	2020	2021	2022
Browns Ferry	55,543	81,630	68,589	103,439	89,448	64,677	95,138	106,788
Sequoyah	31,590	36,695	16,094	22,234	33,554	17,700	27,949	17,101
Watts Bar	24,112	8,140	4,065	36,207	19,416	21,400	26,183	57,746
Total	111,244	126,465	88,748	161,880	142,418	103,777	149,270	181,635

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 4-10 shows the mixed waste sent for disposal from TVA sites during 2015–2022.

Table 4-10: Mixed Waste Generated at TVA Nuclear Plants and Other Facilities (kg)

	2015	2016	2017	2018	2019	2020	2021	2022
Browns Ferry	0	0	4,645	0	0	0	0	0
Sequoyah	0	0	2.3	0	0	0	0	0
Watts Bar	0	0	0	0	0	0	0	0
Power Service Shops	0	0	0	0	0	0	0	0
Total	0	0	4,647	0	0	0	0	0

4.8 Socioeconomics

This section describes social and economic conditions in the TVA region. It presents and compares qualitative and quantitative data from varying geographies 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, the 2020 decennial census, and the most current population estimates from the 2022 American Community Survey (2018 – 2022 5 Year estimates). These data were obtained utilizing USCB American FactFinder and USCB TIGER Products. Spatial data for figures were obtained through USCB TIGER Products and ESRI. Other quantitative and qualitative data were gathered from TVA staff, 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 is given as a baseline for comparison to smaller parts of the PSA. The TVA PSA considered for socioeconomics consists of 181 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 B-1 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 2000). 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 2022 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. Finally, demographic variables for the TVA PSA are compared with those of Division 6 and the nation.

On March 11, 2020, the novel coronavirus COVID-19 pandemic was declared by the World Health Organization. The pandemic affected the main components of population change; natural increase (or decrease) related to the number of births and deaths within the population, and net migration gain (or loss). As a result, population trends were altered in both rural and urban America, producing a patchwork of population loss and gain across the country.

4.8.1.1 Population

As shown in Table 4-11, the estimated population of the TVA PSA was 9.8 million in 2010 and 10.5 million in 2022, a 7.4 percent increase. During the same time period, population in Division 6 and in the U.S. increased 5.2 percent and 7.0 percent respectively. The rate of population growth was greater in the TVA PSA as compared to the Division and the nation (USCB 2010, USCB 2022a).

Table 4-11: Population Data for the TVA PSA, TVA MSAs, Division 6, and U.S.

Area	2010 Population	2020 Population	2022 Population	% Increase 2010 – 2020	% Increase 2010 – 2022	% of TVA PSA Pop., 2022
United States	309,338,421	331,449,281	331,097,593	7.1	7.0	--
Division 6 (East South Central)	18,459,846	19,402,234	19,413,645	5.1	5.2	--
TVA PSA	9,810,629	10,520,062	10,540,347	7.2	7.4	--
MSAs in TVA PSA						
Bowling Green, KY	159,309	179,639	180,624	12.8	13.4	1.7
Chattanooga, TN-GA	529,196	562,647	564,466	6.3	6.7	5.4
Clarksville, TN-KY	261,619	320,535	322,949	22.5	23.4	3.1
Cleveland, TN	115,913	126,164	126,479	8.8	9.1	1.2
Dalton, GA	142,315	142,837	143,096	0.4	0.5	1.4
Decatur, AL	153,949	156,494	156,218	1.7	1.5	1.5
Florence-Muscle Shoals, AL	147,260	150,791	151,599	2.4	2.9	1.4
Huntsville, AL	419,279	491,723	493,980	17.3	17.8	4.7
Jackson, TN	130,031	180,504	180,446	38.8	38.8	1.7
Johnson City, TN	199,010	207,285	207,442	4.2	4.2	2.0
Kingsport-Bristol-Bristol, TN-VA	309,494	307,614	308,386	-0.6	-0.4	2.9
Knoxville, TN	838,748	879,773	884,359	4.9	5.4	8.4
Memphis, TN-AR	1,326,280	1,337,779	1,335,804	0.9	0.7	12.7
Morristown, TN	114,219	142,709	143,196	24.9	25.4	1.4
Nashville- Davidson-Murfreesboro-Franklin, TN	1,675,757	1,989,519	1,990,873	18.7	18.8	18.9
TVA MSA TOTALS	6,522,379	7,176,013	7,189,917	10.0	10.2	68.2

Source: USCB 2010, USCB 2020, USCB 2022a

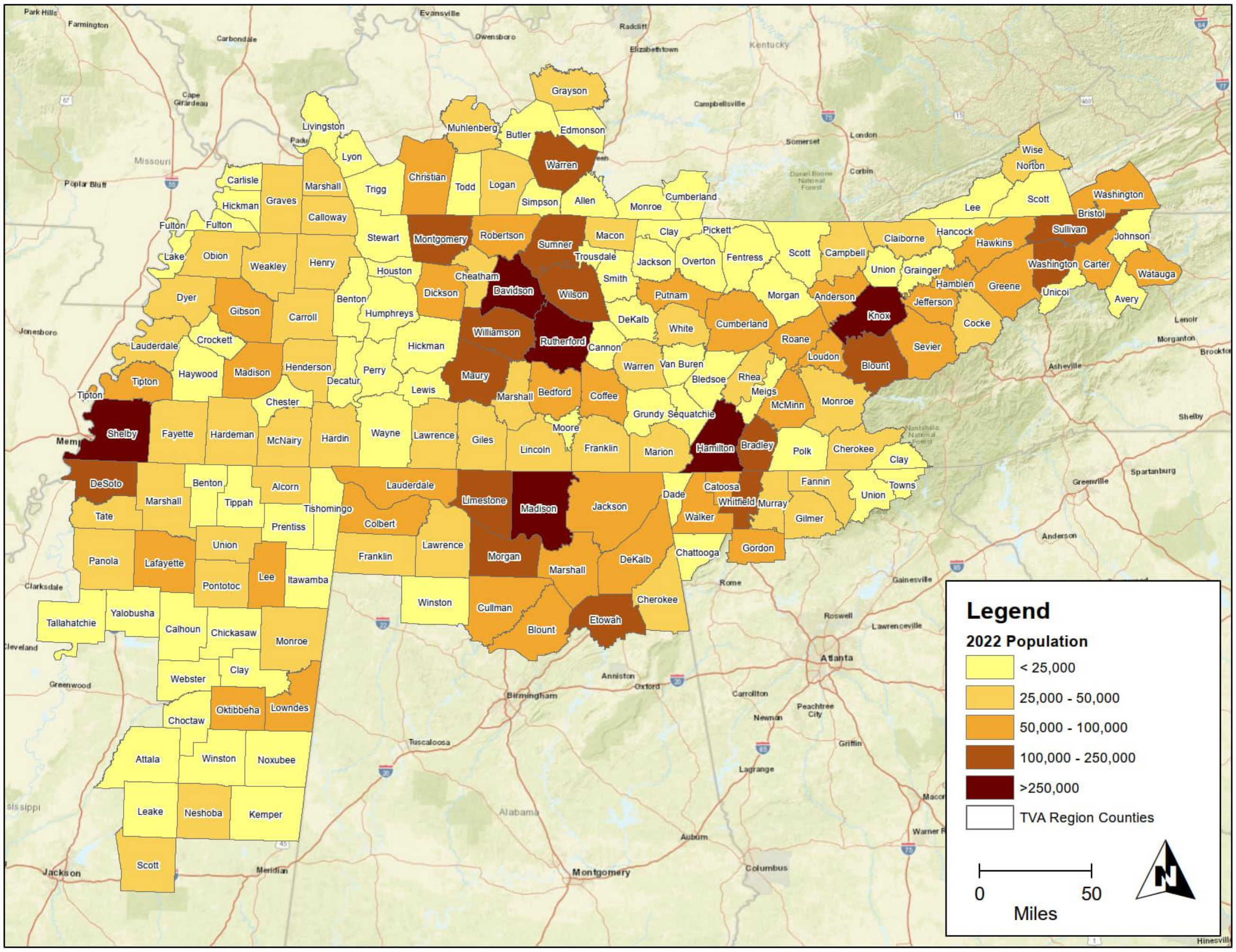
However, in more recent years, the rate of population increase has declined in the TVA PSA, Division 6, and the nation. The annual rate of population growth in the TVA PSA declined from 0.72 percent between 2010 and 2020 to 0.1 percent between 2020 and 2022. In the nation, population decreased from 331.4 million at the 2020 decennial census, to 331.0 million in 2022. Growth in Division 6 was flat during the same period (USCB 2010, USCB 2020, USCB 2022a). Between 2022 and 2040, the annual rate of population growth in the TVA PSA is projected to be 0.69 percent, greater than the projected growth rate of the nation of 0.4 percent (CBER 2022, GOPB 2023, KSDC 2022, SDC MS 2024, NC OSBM 2023, TN SDC 2022, Cooper Center 2022, USCB 2023a).

Population varies greatly among the counties in the TVA PSA as shown in Figure 4-23. 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.

As shown in Table 4-11, an increasing proportion of the total population of the TVA PSA, 66.5 percent in 2010 and an estimated 68.2 percent in 2020 and 2022, lives in USCB-defined metropolitan statistical areas[1]. Two of these areas were estimated to have populations greater than one million in 2022: Nashville, 1.9 million, and Memphis, 1.3 million. The Knoxville and Chattanooga MSAs were estimated to have populations of

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

approximately 884,000 and 564,000, respectively. These four MSAs accounted for 45 percent of the TVA PSA's population in 2022 (USCB 2010, USCB 2020, USCB 2022a).



Source: USCB 2023b, USCB 2020

Figure 4-23: Variation in Population of Counties in the TVA PSA

While the proportion of the TVA region's population living in metropolitan areas was estimated to be lower than the national average of about 80 percent, the proportion has been increasing, and this trend appears likely to continue in the future. This is reflective of a decades-long nationwide trend of urbanization, characterized by a decline of population in rural areas and an increase in metropolitan areas. Population increase in metropolitan areas may be attributed to a combination of internal growth, outward expansion to include new growth or integration of communities previously existing outside the urban area, and in-migration of young adults seeking lifestyle and employment opportunities (USCB 2023c, Frey 2019). As a result, residential populations in the urban core areas of several cities in the TVA PSA have increased, including the largest cities. A notable exception to this trend is Memphis, Tennessee, which experienced a 4 percent decline in population between 2010 and 2022 (Bellow 2023).

The COVID-19 pandemic caused a major opposing shift in the migration flows of most states as people moved from metropolitan areas to rural counties to avoid exposure to the virus. A shift to remote work as many businesses remained closed potentially influenced geographic mobility. As a result, population grew in rural counties during the pandemic, especially in Southern states. Most people moved to rural areas within their state of origin (Melotte 2023, USDA 2022).

Southern states within the TVA PSA - including Alabama, Georgia, North Carolina, and Tennessee - also benefit from another decades-long migration pattern of northeast residents moving to southern states. Many are seniors of the large Baby Boomer generation seeking a warmer climate, lower cost of living, housing opportunities, and a favorable tax environment. Others are opportunity-seeking young adults of the equally large Millennial generation, who form the backbone of labor forces and consumer bases. According to the Tennessee State Data Center, the population of both metropolitan and rural counties in Tennessee increased during and after the pandemic, resulting in widespread gains across the state (TN SDC 2022, Frey 2019).

4.8.1.2 Demographics

As shown in Table 4-12, the median age in the TVA PSA was 41.4 years in 2022, an increase from the median age of 37.9 years in 2010. In 2022, the TVA PSA had a higher population of people over 65 years of age (17 percent) as compared to Division 6 or the nation as a whole, which had 16.8 percent and 16.5 percent, respectively. The percentage of people identifying themselves as white was 73.3 percent in the TVA PSA, greater than Division 6 and the U.S., which were 70.4 percent and 58.9 percent, respectively (USCB 2022a, USCB 2022b, USCB 2022c).

Table 4-12: 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	38.5	58.9	16.5	89.1
Division 6	38.9	70.4	16.8	88.2
TVA PSA	41.4	73.3	17.0	88.1

Source: USCB 2022a, USCB 2022b, USCB 2022c

As shown in Table 4-12, of the TVA PSA population 25 years old or older, approximately 88 percent held a high school diploma, equivalency diploma, or higher degree in 2022. This percentage is similar to Division 6 (88 percent) and the U.S. as a whole (89 percent) (USCB 2022c).

4.8.2 Sociocultural Characteristics

This subsection describes historical and cultural characteristics of USCB Division 6, which encompasses the majority of TVA's PSA. 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 described in this subsection. Following the 2020 Census, the USCB changed the way urban areas are defined, and released a new list of urban areas. USCB-defined urban areas comprise a densely settled core of census blocks that have at least 2,000 housing units or a population of at least 5,000. This includes adjacent territory containing non-residential and commercial uses. Rural areas are defined as all population, housing and territory not included within an urban area. In general, population density of urban areas has increased from 2,343 persons per square mile in 2010 to 2,553 in 2020 (USCB 2023c).

4.8.2.1 Historical and Cultural Characteristics

Rural lifestyles dominated the Southeast until the mid- to late 20th 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 2023e). 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 and encompasses parts of Alabama, Georgia, Kentucky, Maryland, Mississippi, New York, North Carolina, Ohio, Pennsylvania, South Carolina, Tennessee, and Virginia, and all of West Virginia. The Appalachian Regional Commission (ARC) was created in 1965 "to address the persistent poverty and growing economic despair of the Appalachian Region" (ARC 2023a). 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 (ARC 2015). More recently, the region has incorporated manufacturing and professional service industries into its economy, and in 2021, the poverty rate of individuals declined to 14.5 percent, approximately 2 percent higher than the national rate of 12.6 percent (ARC 2021). Of the 423 counties in the Appalachian Region, 107 (25.3 percent) were classified as rural (defined as counties that are neither part of nor adjacent to a metropolitan area). Note that the United States Census Bureau uses a different definition of rural as discussed in Section 4.8.2). Of the 26.3 million people that live in Appalachia, almost 2.5 million, or nearly 10 percent of residents, live in rural counties. Mississippi, Kentucky, and Virginia have the highest concentration of rural counties (ARC 2023b). However, pockets of the Appalachian population live near or in major metropolitan areas.

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 69,983 farms on nearly 11 million acres were active across Tennessee in 2017. Between 2012 and 2017, the number of new farmers as well as the age of active farmers have increased. Market value of agricultural products sold increased 5 percent. Market value of agricultural products sold directly to consumers increased nearly 82 percent (American Farmland Trust 2023).

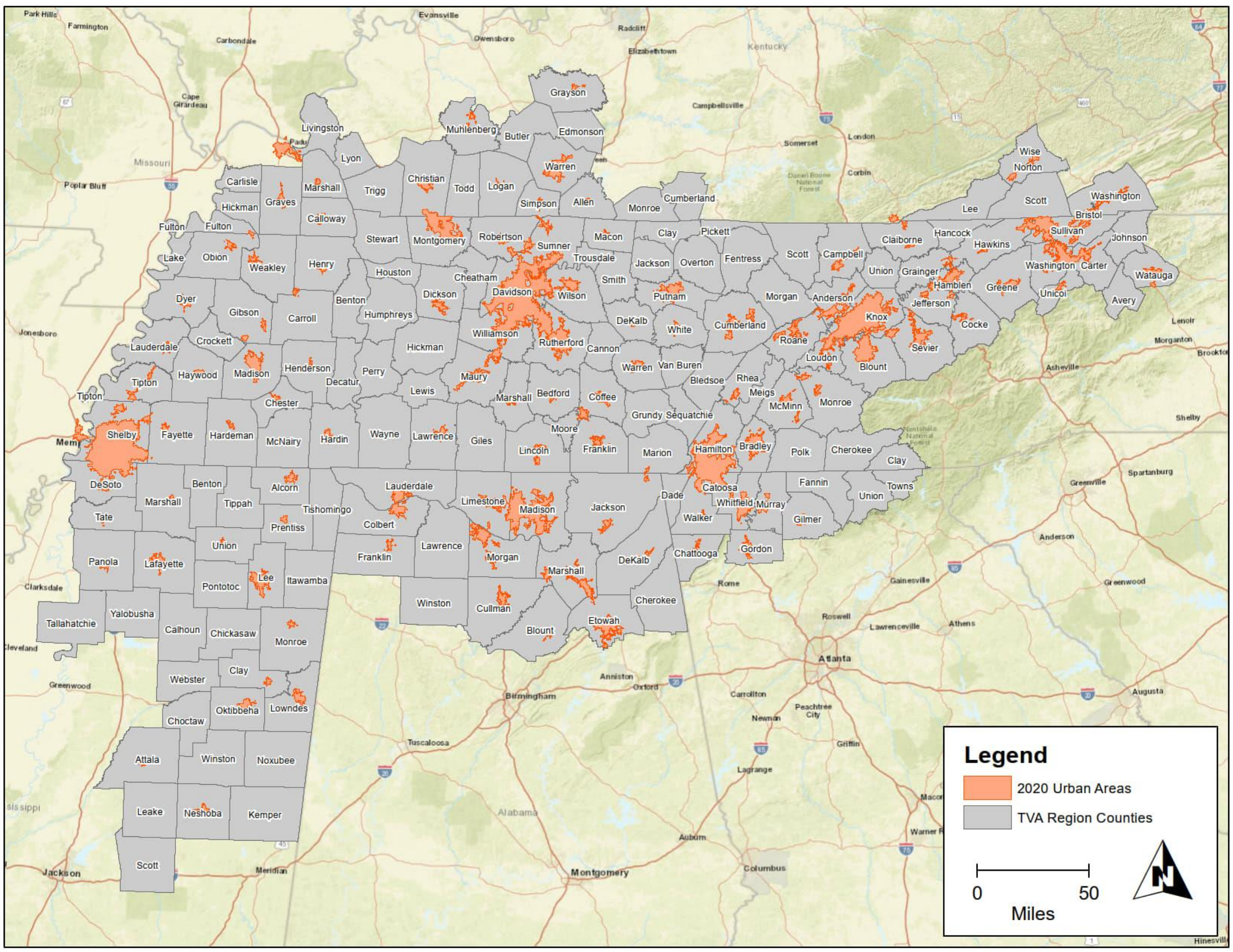
Resource extraction, especially in relation to coal, remains an important aspect of the economies in portions of the Appalachian region and the Mid-South subregion (USEIA 2023b). Many people in these areas have been employed in coal extraction for decades and often have generational connections to coal 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 2022). In recent years, TVA has obtained coal from the Appalachian Basin (Kentucky, Pennsylvania, Tennessee, West Virginia, and Virginia) and Illinois Basin (Illinois, Indiana, and Kentucky) regions in the eastern United States (U.S.) and from the Powder River Basin (Wyoming) region in the western U.S. (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

As shown in Figure 4-24, the TVA PSA included 120 separate USCB-designated urban areas in 2020. Urban areas composed approximately 5 percent of the TVA PSA and contained nearly 56 percent of the population (USCB 2023d, USCB 2023b). This is compared with the U.S. as a whole, where approximately 80 percent of the population resided within approximately 3.1 percent of the total land area in 2020. Across Division 6, approximately 59 percent of the population lived in urban areas (USCB 2023c, USCB 2024, Visual Capitalist 2020).

USCB considers all portions outside of designated urban areas to be rural areas. In 2020, approximately 95 percent of the TVA PSA was considered rural, accounting for almost 44 percent of the population in the TVA PSA (USCB 2023b, USCB 2023d). Twenty percent of the U.S. population was considered rural in the same year (USCB 2024).



Source: USCB 2023b, USCB 2023e

Figure 4-24: Urban and Rural Areas in the TVA PSA

In 2022, the three most populous counties in or partially within the TVA PSA were Shelby, Davidson, and Knox counties, Tennessee as shown in Table 4-13. Each county had a population greater than 430,000 residents, and greater than 50 percent of land was classified as urban in the 2020 Census (USCB 2023d). 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 and Knox counties increased 13.3 percent and 11.4 percent respectively between 2010 and 2022, while the population of Shelby County decreased 0.1 percent (USCB 2010, USCB 2022a).

In 2022, the three least populous counties in or partially within the TVA PSA were Pickett County, Tennessee, and Carlisle and Hickman counties, Kentucky, as shown in Table 4-13. The entirety of these counties was considered rural areas in 2020, as defined by the USCB (USCB 2023d). The population of each county declined between 2010 and 2022. The population of Hickman County decreased the most (8.4 percent); while the population of Carlisle and Pickett declined in population 6.3 percent and 0.7 percent, respectively (USCB 2010, USCB 2022a).

Table 4-13: Population Data for the Most/Least Populous Counties in the TVA PSA

Geography	2010 Population	% Urban Population, 2010	2020 Population	% Urban Population, 2020	% Land classified as Urban, 2020	2022 Population	% Increase 2010 – 2022
Shelby County, TN	927,644	97.2	929,744	96.6	50.9	926,440	-0.1%
Davidson County, TN	626,681	96.6	715,884	96.9	58.6	709,786	13.3%
Knox County, TN	432,226	89.1	478,971	90.8	54.8	481,406	11.4%
Pickett County, TN	5,077	0.0	5,001	0.0	0.0	5,042	-0.7%
Carlisle County, KY	5,104	0.0	4,826	0.0	0.0	4,782	-6.3%
Hickman County, KY	4,902	0.0	4,521	0.0	0.0	4,491	-8.4%

Source: USCB 2010, USCB 2022a, USCB 2023d

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

The gross domestic product (GDP) for the TVA region for FY 2023 was estimated at $685.5 billion, based on Bureau of Economic Analysis GDP data by state and Bureau of Labor Statistics county level employment data. In 2022, 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 trade. For the U.S., these were: (1) educational services, health care, and social assistance industries; (2) professional, scientific, management, administrative, and waste management industries; and (3) retail trade (USCB 2023f). TVA revenues in FY 2023 were $12.1 billion, representing about 1.8 percent of the total TVA region economy.

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 years, this has occurred to a greater degree for the nation overall than for the TVA region, in the TVA PSA manufacturing jobs still employ 14.6 percent of the civilian working population, second among industrial sectors (USCB 2023f). 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.

TVA plays an important role in the regional economy through its Economic Development program. TVA works to attract new businesses to the Tennessee Valley, engage with communities and existing companies to grow the economy, and partner with state, regional, and local economic development organizations to amplify job growth and capital investment in the region (TVA 2022c). TVA offers site selection services, incentives, research and technical assistance to help companies locate, stay, and expand existing operations in the Tennessee Valley (TVA 2020c). Development efforts target six key markets: aerospace and defense, automotive and mobility technologies, clean technologies, food and industrial technologies, information systems and security and life sciences (TVA 2023f). Table 4-14 shows the amount of capital investment by TVA for FY 2019 through FY 2023.

Table 4-14: TVA Capital Investment Between 2019 and 2023

Fiscal Year	Capital Investment (in billions of U.S. dollars)
2019	$8.9
2020	$8.6
2021	$8.8
2022	$10.2
2023	$9.2
Total	$57.0

Source: TVA 2019b, TVA 2022c, TVA 2023f, TVA 2020d, TVA 2021c

4.8.3.2 TVA-Contributions to State Economies and Revenues

TVA produces approximately 92 percent of the electricity generated in Tennessee, a state that ranks 30th in the nation for total energy production, and seventh in the nation for production of hydroelectric power (USEIA 2023c, USEIA 2023e). TVA operations at Browns Ferry Nuclear Plant near Athens, Alabama is the major reason Alabama ranks fifth in the nation for nuclear power production (USEIA 2023d).

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 4-15 shows the amount of tax equivalent payments to states for TVA fiscal years 2019 through 2022.

Table 4-15: Tax Equivalent Payments by TVA to States Where TVA Produces Power or Acquired Lands

State	Tax Equivalent Payments (in millions of U.S. dollars, rounded)				
	2019	2020	2021	2022	2023
Alabama	$85.8	$87.6	$79.3	$82.6	$97.8
Georgia	$9.0	$9.2	$8.4	$8.5	$10.1
Illinois	$.40	$.40	$.30	$.40	$.40

State	Tax Equivalent Payments (in millions of U.S. dollars, rounded)				
	2019	2020	2021	2022	2023
Kentucky	$38.9	$34.4	$29.7	$31.8	$40.0
Mississippi	$41.9	$42.8	$38.2	$39.3	$47.2
North Carolina	$3.1	$3.4	$3.0	$3.1	$3.9
Tennessee	$367.3	$372.8	$339.5	$345.1	$410.0
Virginia	$1.3	$1.2	$1.1	$1.1	$1.3

Source: TVA 2019b, TVA 2020e, TVA 2021d, TVA 2022d

4.8.3.3 Employment

In 2022, the participation rate of the civilian labor force, defined as the percentage of the population aged 16 or more that is either working or actively looking for work, was estimated to be 5.1 million, or 60.1 percent, in the TVA PSA. In comparison, the participation rate of the civilian work force was less than the nation (62.2percent) but more than Division 6 (59.2 percent). The unemployment rate in the TVA PSA was 5.0 percent, lower than the nation (5.3 percent) and Division 6 (5.3 percent) during the same time period. There was considerable geographic variation in unemployment rates with adjacent counties sometimes having large differences. Unemployment rates across the TVA PSA range from a low of 0.8 percent in Trousdale County, Tennessee, located within the Nashville-Davidson-Murfreesboro-Franklin, Tennessee, metropolitan area, to a high of 14.1 percent in the rural county of Kemper County, Mississippi (USCB 2023f).

In 2022, the TVA PSA and Division 6 had similar percentages of people employed in various occupations as shown in Table 4-16. The TVA PSA had a higher percentage of employees in production, transportation, and material moving fields (17.7 percent) as compared to the nation (13.1 percent) (USCB 2023f).

Table 4-16: 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, Maintenance	Production, Transportation, Material Moving
United States	41.0	16.8	20.5	8.7	13.1
Division 6	33.6	16.1	20.8	9.1	17.5
TVA PSA	36.5	15.7	20.9	9.2	17.7

Source: USCB 2023f

As discussed in Section 4.8.3.1, TVA's Economic Development program fosters job growth throughout the PSA by forming partnerships with state, regional, and local economic development organizations. TVA's efforts bring greater opportunities for businesses and working people in the cities and rural communities it serves. Table 4-17 shows the number of TVA assisted jobs between 2019 and 2023. New and retained job numbers reported by TVA are certified and provided to TVA by TVA customers, defined as an entity that purchases or distributes power from TVA. New jobs are defined as newly created, paid positions (including contract jobs) at a facility of a TVA customer. Retained jobs are paid positions (including contract jobs) at a facility of a TVA customer that were created prior to the current TVA fiscal year and that continue to be filled in the current TVA fiscal year (TVA 2023f).

Table 4-17: TVA-Assisted Jobs Between 2019 and 2023

Fiscal Year	New Jobs	Retained Jobs	Total Jobs
2019	21,400	45,100	66,500
2020	19,000	48,000	67,000
2021	22,550	58,350	80,900
2022	26,500	40,000	66,500
2023	12,275	46,125	58,400

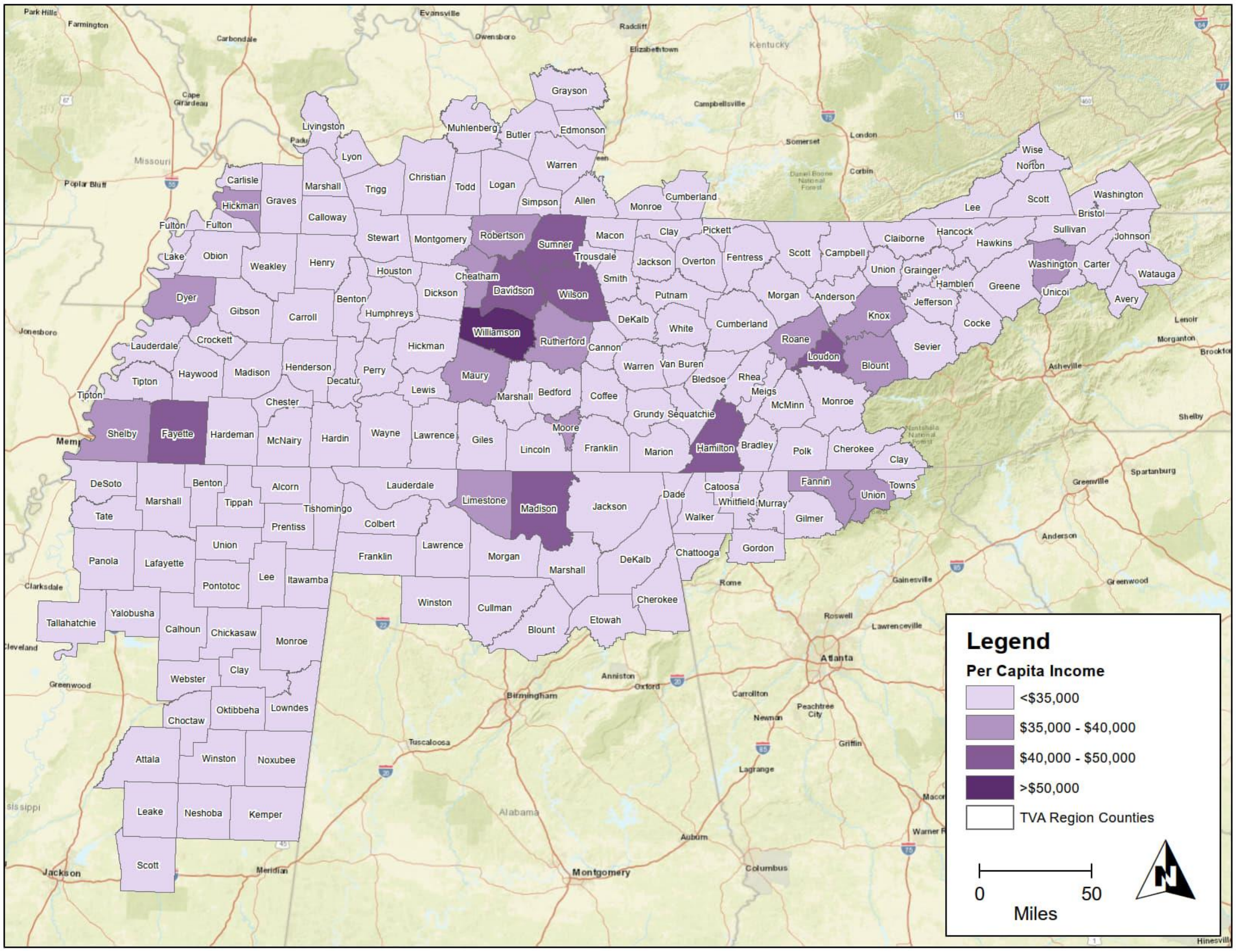
Source: TVA 2018d, TVA 2019c, TVA 2020d, TVA 2021c, TVA 2022e, TVA 2023f

TVA Regional Employment

TVA employs a total of 5,118 people at 62 generating facilities throughout its PSA. Browns Ferry Nuclear Plant, near Athens, Alabama, accounts for just over 26 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

In 2022, per capita income in the TVA PSA ranged from $19,695 (Lake County, Tennessee) to $61,451 (Williamson County, Tennessee). Only five counties in the TVA PSA had incomes above the nation’s per capita income of $41,261. Four of the five were located in Tennessee (Williamson County, Davidson County, Wilson County, and Hamilton County). One county was located in Madison County, Alabama. Each of these counties were located within a metropolitan area. Per capita income in Division 6 was $33,716. Within the TVA PSA, only 29 counties had per capita income greater than the Division, indicating that higher per capita income concentrates in few areas in the TVA PSA. Figure 4-25 illustrates the differences in per capita income rates of TVA-region counties (USCB 2023f).



Source: USCB 2023f, USCB 2023b

Figure 4-25: Per Capita Incomes of TVA PSA Counties

4.9 Environmental Justice

In May 2024, the Council on Environmental Quality (CEQ) revised its regulations implementing NEPA (40 CFR Parts 1500-1508) to codify provisions relating to the consideration of communities with environmental justice concerns during agency decisionmaking. CEQ defines environmental justice as the just treatment and meaningful involvement of all people, regardless of income, race, color, national origin, Tribal affiliation, or disability, in agency decision making and other Federal activities that affect human health and the environment (40 CFR 1508.1(m)).

These CEQ regulations implement Executive Orders addressing environmental justice. EO 12898, Federal Actions to Address Environmental Justice in Minority Populations and Low-Income Populations, directed federal agencies to identify and address "disproportionately high and adverse human health or environmental effects" of their actions on minority and low-income populations (i.e., environmental justice [EJ] communities). While EO 12898 does not create any binding obligations on TVA, TVA nevertheless routinely considers EJ during its NEPA review processes. EO 14096 (2023), Revitalizing our Nation's Commitment to Environmental Justice for All, builds upon and reinforces the federal government's commitment to deliver EJ to all communities across America. Potential environmental justice-related impacts are analyzed in accordance with CEQ regulations to identify and address as appropriate disproportionate and adverse human health or environmental effects of federal programs, policies, and activities on communities with environmental justice concerns.

CEQ guidance for applying EO 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 2022 poverty threshold for an individual was $13,590 and the official poverty rate for the U.S. as a whole in 2022 was 11.5 percent (USCB 2023g, USDHHS 2022).

CEQ guidance 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. 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.

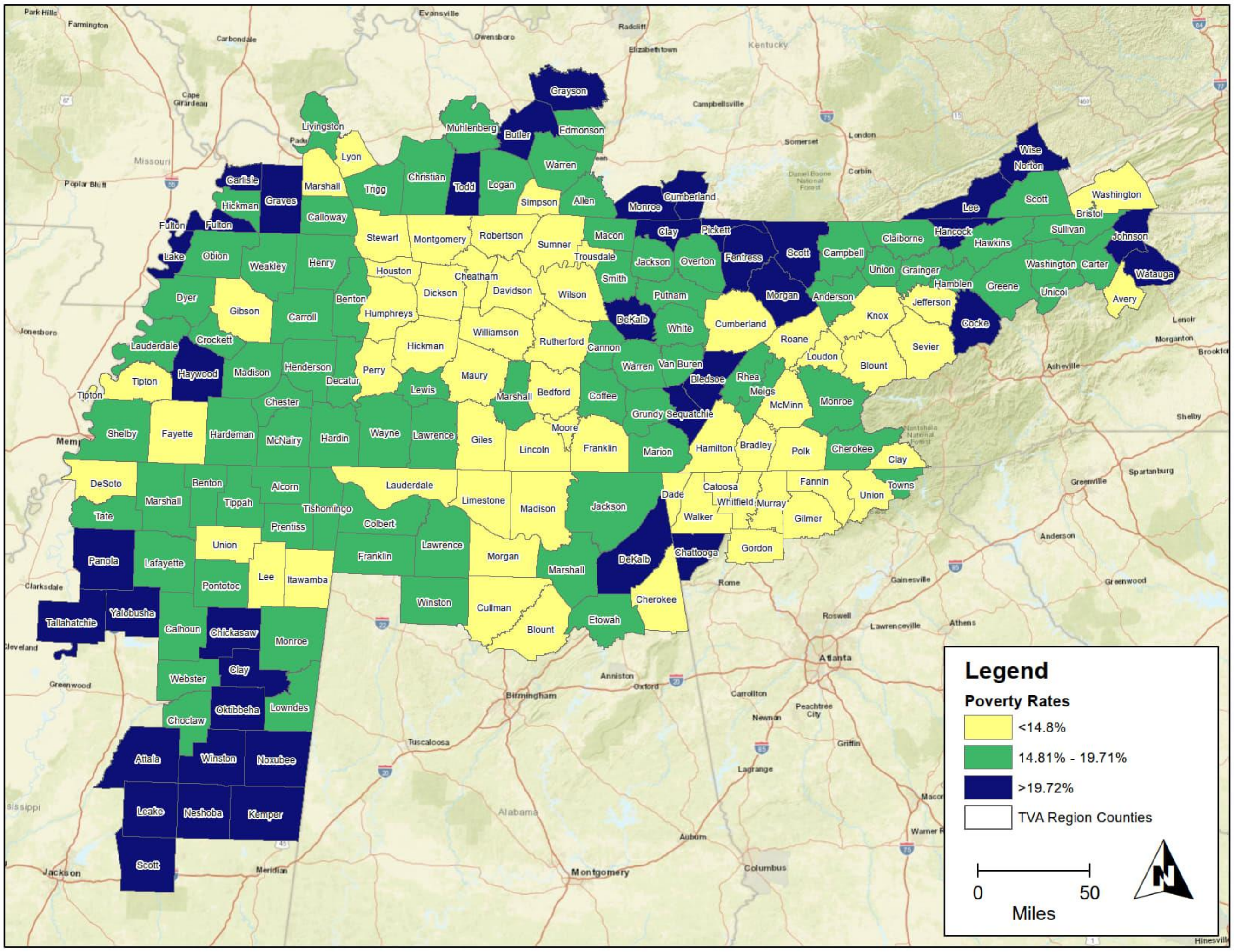
The TVA PSA considered for environmental justice consists of 181 counties and two independent cities in seven states, including all counties in Tennessee and portions of Alabama, Georgia, Kentucky, Mississippi, North Carolina, and Virginia (see Appendix B-1 for a complete list of counties considered). 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 disproportionate environmental and human health effects may be the greatest. Minority populations were identified using the 2022 American Community Survey (2018 – 2022 5 Year estimates) for each of the 181 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 14.8 percent. Additional low-income populations were identified at the census tract level using poverty rates reported in the 2022 American Community Survey (ACS; USCB 2023e).

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 2000).

4.9.1 Low-Income Populations

In 2022, the percentage of the TVA PSA population living below the poverty level was 14.8 percent. Within the TVA PSA 124 counties and two independent cities had poverty rates above the PSA average, as illustrated in Figure 4-26. The 2022 ACS estimates for per capita income and the percentage of the population living in poverty for PSA counties are included in Appendix B-2 (USCB 2023e).

A total of 1,196 census tracts in 178 counties or independent cities and seven states had poverty rates above the TVA PSA average. Low-income census tracts are in all but five counties of the TVA PSA. The per capita income levels and poverty rates from the 2022 ACS are included in Appendix B-3 (USCB 2023h).



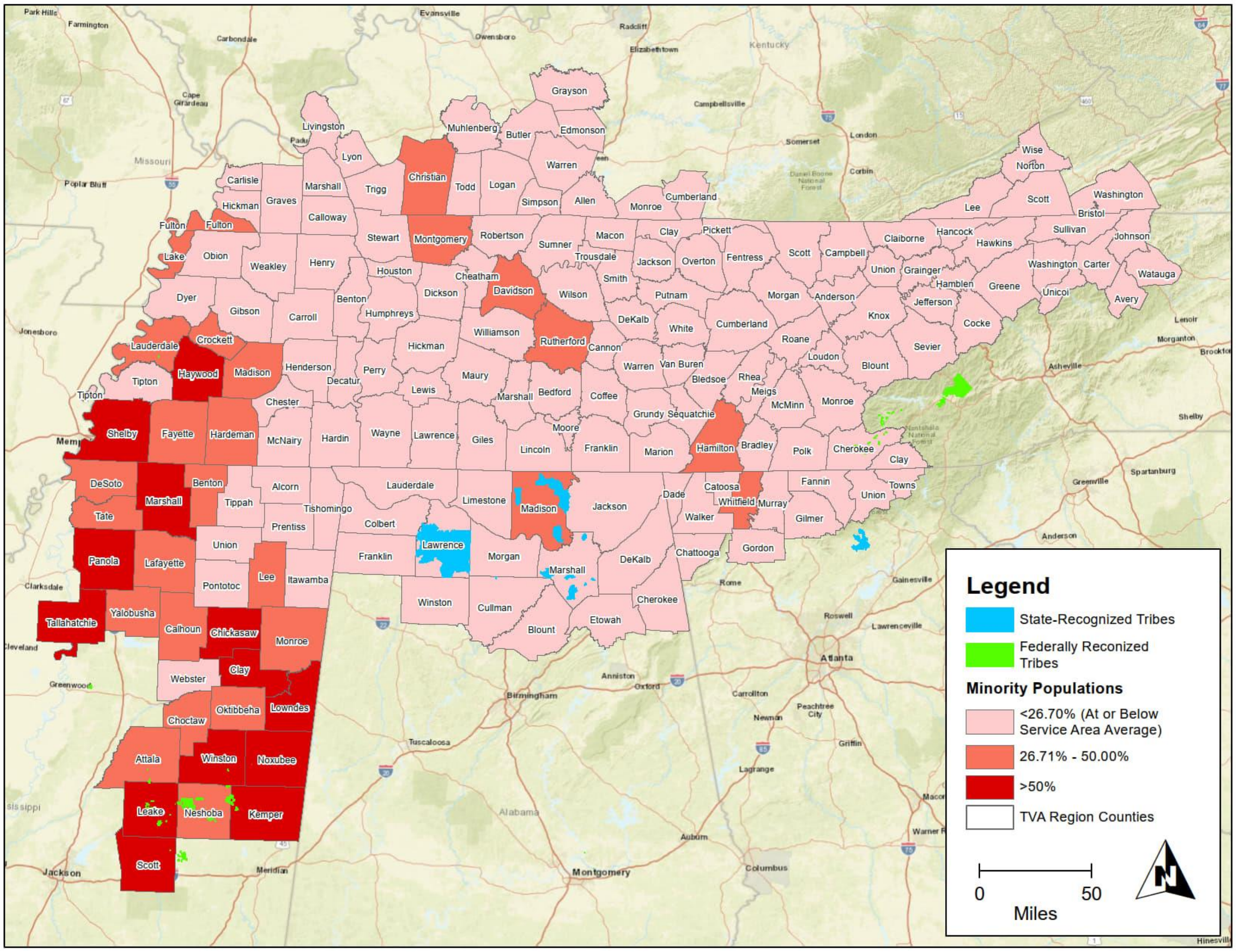
Source: USCB 2023f, USCB 2023b

Figure 4-26: Poverty Rates of Counties in the TVA PSA

4.9.2 Minority Populations

In 2022, the minority population in the TVA PSA was 26.7 percent. As shown in Figure 4-27, 13 counties in the PSA had minority populations that exceeded 50 percent, well above the TVA PSA average. These included Haywood and Shelby counties in Tennessee and Lowndes, Winston, Chickasaw, Scott, Leake, Marshall, Panola, Clay, Tallahatchie, Kemper, and Noxubee counties in Mississippi. The minority percentages of each county are shown in Table 4-18. In these areas, the African American population composed the highest percentage of the population, averaging 52 percent (USCB 2022b).

An additional 38 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 B-4 (USCB 2022b).



Source: USCB 2022b, USCB 2023b

Figure 4-27: Minority Populations at the County Level in the TVA PSA

Three state-designated tribal statistical areas (SDTSA) are extant in the TVA PSA in northern Alabama and considered part of the minority population (USCB 2022b). These consist of the Cherokee Tribe of Northeast Alabama SDTSA in Marshall 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 in Figure 4-27.

Table 4-18: Counties in the TVA PSA with Minority Populations Exceeding 50 Percent

Geography	2022 Population	2022 Minority (%)	Black or African American (%)	American Indian, Alaskan Native (%)	Asian (%)	Native Hawaiian, Pacific Islander (%)	Some other race (%)	Two or more races (%)	Hispanic or Latino (%)
Division 6	19,413,645	29.6	20.0	0.2	1.5	0.0	0.3	2.7	4.8
TVA PSA	10,540,347	26.7	15.7	0.2	1.6	0.1	0.3	2.9	6.0
TVA PSA Counties									
Chickasaw County, MS	17,024	50.9	43.7	0.0	0.2	0.0	0.0	1.9	5.1
Clay County, MS	18,598	62.0	60.0	0.0	0.0	0.0	0.0	1.8	0.2
Kemper County, MS	8,980	66.6	61.8	3.8	0.0	0.0	0.0	0.2	0.8
Leake County, MS	21,335	52.3	39.8	5.7	0.4	0.0	0.0	1.4	5.1
Lowndes County, MS	58,547	50.0	44.5	0.1	1.1	0.0	0.4	1.5	2.4
Marshall County, MS	33,980	52.9	45.5	0.0	0.1	0.0	0.5	2.4	4.3
Noxubee County, MS	10,261	74.4	73.6	0.4	0.0	0.0	0.0	0.2	0.3
Panola County, MS	33,157	53.1	49.6	0.1	0.3	0.4	0.1	1.9	0.6
Scott County, MS	27,943	51.3	35.6	0.1	0.1	0.0	0.2	3.5	11.8
Tallahatchie County, MS	12,621	65.1	61.4	0.0	0.1	0.0	0.2	1.5	1.9
Winston County, MS	17,741	50.4	46.7	0.5	0.1	0.0	0.0	1.6	1.5
Haywood County, TN	17,806	56.3	50.0	0.0	0.1	0.0	0.4	1.4	4.3
Shelby County, TN	926,440	65.5	53.6	0.1	2.9	0.0	0.3	1.9	6.8

Source: USCB 2022b

4.9.3 Federally Recognized Tribes

The federal government has a unique relationship and trust responsibility to federally recognized Indian Tribes (Tribes). TVA upholds this responsibility and consults with Tribes on a government-to-government basis. TVA must consult with Tribes on programs and undertakings pursuant to the American Indian Religious Freedom Act, Archaeological Resources Protection Act, Native American Graves Protection and Repatriation Act, NHPA, and other laws, executive orders, and presidential memoranda.

With respect for tribal sovereignty and self-determination, TVA regularly consults with over 20 federally recognized Tribes that have religious and cultural interests in TVA's PSA. Many of the Tribes with whom TVA consults were subject to forcible relocation to Indian territory (now Oklahoma), mandated by the Federal government in the Indian Removal Act of 1830. Currently, the majority of these Nations are headquartered in the state of Oklahoma, and they retain strong ties to their ancestral homelands. Two federally recognized Tribes – the Eastern Band of Cherokee Indians (EBCI) in southwestern North Carolina and the Mississippi Band of Choctaw Indians (MBCI) in east central Mississippi – still reside in the Tennessee Valley.

In response to EO 13175 Tribal Consultation and Strengthening Nation-to-Nation Relationships signed by President Joseph Biden in January 2021, TVA collaborated with federally recognized Tribes in the preparation of detailed action plan to implement the policies and directives of the Presidential Memorandum. TVA committed to provide land to Tribes for the reburial of Ancestors and Ancestral items in the Tennessee Valley. In consultation with the Tribes, TVA executed a memorandum of agreement to outline the roles and responsibilities to implement this commitment. TVA is also committed to the protection of and tribal access to sacred sites and signed a memorandum of understanding for Coordination and Collaboration for the Protection of Indigenous Sacred Sites. A best practices guide for federal agencies was developed in consultation with Tribes and the Sacred Sites Interagency Working Group in December 2023.

Resources available on TVA's Tribal Relations website include a current list of Tribes with interest in TVA lands, TVA's Tribal Consultation Action Plan developed in response to EO 13175, the executed memorandum of agreements and memorandum of understandings and best practices guide for sacred sites developed in collaboration with Tribes.

In addition to the above, TVA is responsible for the management of many culturally significant sites and landscapes that are considered sacred by Tribes and has implemented projects to better manage and protect Indigenous sacred sites. TVA has developed multiple mutually beneficial partnerships and projects that raise awareness and promote Tribal Sovereignty, sacred sites and Indigenous Knowledge including Archaeological Survey Partnerships, Native Plant Partnership, Tribal Cultural History Project, Sacred Site Management Plans and Tribal Engagement events.

The two tribes residing in the Valley are shown in Figure 4-27. These sovereign nations are part of the minority population in the TVA PSA. The EBCI has approximately 13,000 tribal members. About 60 percent live on the 56,000-acre Qualla Boundary, land held in trust for the Tribe by the federal government located in western North Carolina. Tribal lands span Swain and Jackson counties, with smaller parcels in Cherokee, Graham and Haywood counties (DOJ 2024, Cherokee Chamber of Commerce 2024). The MBCI has approximately 10,000 tribal members, located on 35,000 acres in east central Mississippi, spanning 10 counties. Neshoba County is the largest of the reservation areas, and the location of the Tribe’s headquarters. The MBCI is a major contributor to the state's economy and provides permanent full-time jobs for over 5,000 employees (Choctaw.org 2024a, Choctaw.org 2024b, RRT 2024).

In a 2017 study, the Center for Disease Control found that compared with other racial or ethnic groups, American Indians have a “lower life expectancy, lower quality of life, and are disproportionately affected by many chronic conditions” (CDC 2018). Demographic characteristics of Tribal Nations EBCI and MCBI located within the TVA PSA is shown in Table 4-19.

Table 4-19: Demographics of Federally Recognized Tribal Nations in the TVA PSA

	Eastern Band of Cherokee Indians (EBCI)	Mississippi Band of Choctaw Indians (MBCI)
Population	7,930	7,384
Percent of Population under 5 years	4.9	9.0
Percent of Population between ages 25 and 54	32.1	37.29
Percent of Population 65 and over	17.4	8.7
Median Age	37.7	28.3
Percent of Population between ages 25 and 54	32.1	37.29
Graduated high school or higher, 25 years old and over	83.8	72.7
Attained bachelor’s degree or higher, 25 years old and over	14.0	8.2
Military veterans in the civilian population 18 years and over	8.2	5.7
Population 16 years and over in labor force	2,875	2,917
Percent Employed Population 16 years and over in the labor force	91.3	89.4
Unemployment Rate	8.7	10.6
Employed in service occupations	32.2	43
Median household income	44,925	39,955
Percent of Individuals Living below the Poverty Level	21.0	42.8
Occupied Housing Units	3,324	1,976
Percent of owner-occupied units	73.0	79.8
Median Housing Value	137,900	71,800
Percent of civilian noninstitutionalized population with health insurance	62.3	65.6
Percent of civilian noninstitutionalized population with no health insurance	37.7	34.4

Source: USCB 2022d, USCB 2022e

4.9.4 TVA Programs and Environmental Justice

TVA continues to contribute and direct substantial resources to programs that are consistent with the mission and principles of EO 14008 *Tackling the Climate Crisis at Home and Abroad*. Examples include, but are not limited to the following:

- Home Uplift – provides home weatherization upgrades free of charge to qualified households in an effort to reduce energy costs and improve household conditions in underserved communities. TVA solicits internal and external stakeholder engagement on the issue of low-income energy equity and the development of residential energy programs. TVA has sought key stakeholder feedback through deliberative outreach to valley-wide collaborative teams that include local power companies and a variety of stakeholder groups. TVA is partnering with community groups and consulting firms to provide objective third-party reviews of Home Uplift processes to ensure TVA reaches target audiences. One hundred percent of the benefits will be realized by underserved communities.
- School Uplift – supports public schools in underserved communities in the region by offering energy efficiency training and grants that reduce energy costs and improve the quality of the learning environment.
- Small Business Uplift – Piloted in 2021 as Community Centered Growth, the program helps local businesses in underserved communities make smart energy choices that improve facilities, save money, decreases energy use and reduces carbon emissions. The program targets businesses in counties with National Opportunity Zones as identified by census data and demographic factors such as income and population.
- Strategic Energy Management – Piloted as Save it Forward, this program is available to large industrial businesses and teaches them to use and operate their equipment in a more efficient manner. Participants are encouraged to reinvest 50 percent of their energy savings back into the local community. TVA tracks reinvestment into underserved communities.
- Workforce Development – Piloted as Building Futures, this program creates learning opportunities for skilled green jobs and includes a focus on minority participation in TVA's Quality Contractor Network. Contractors recruited through TVA workforce development programs may be eligible to work in TVA's residential and commercial energy programs.
- Generating Justice: Pro Bono Opportunities Program is an initiative supported by TVA's Office of the General Counsel (OGC) designed to reduce the gap in civil legal access to justice for low-income communities within the seven-state region and across the country. Attorneys and other professionals from OGC and TVA work in collaboration with community organizations, federal agencies and law firms across the country contributing time and skills at no charge.
- Connected Communities – this funding opportunity is directed at towns, main streets, neighborhoods, and cities that use data and technology-driven innovations to offer improved services to people and businesses. Together with partners, TVA funds projects in focus areas of Broadband and Digital Literacy, Economic Empowerment, Energy and Environmental Justice, and Enhanced Community Resiliency.

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 4-28 shows the 102 counties located in the TVA PSA that were considered SOC in 2024.

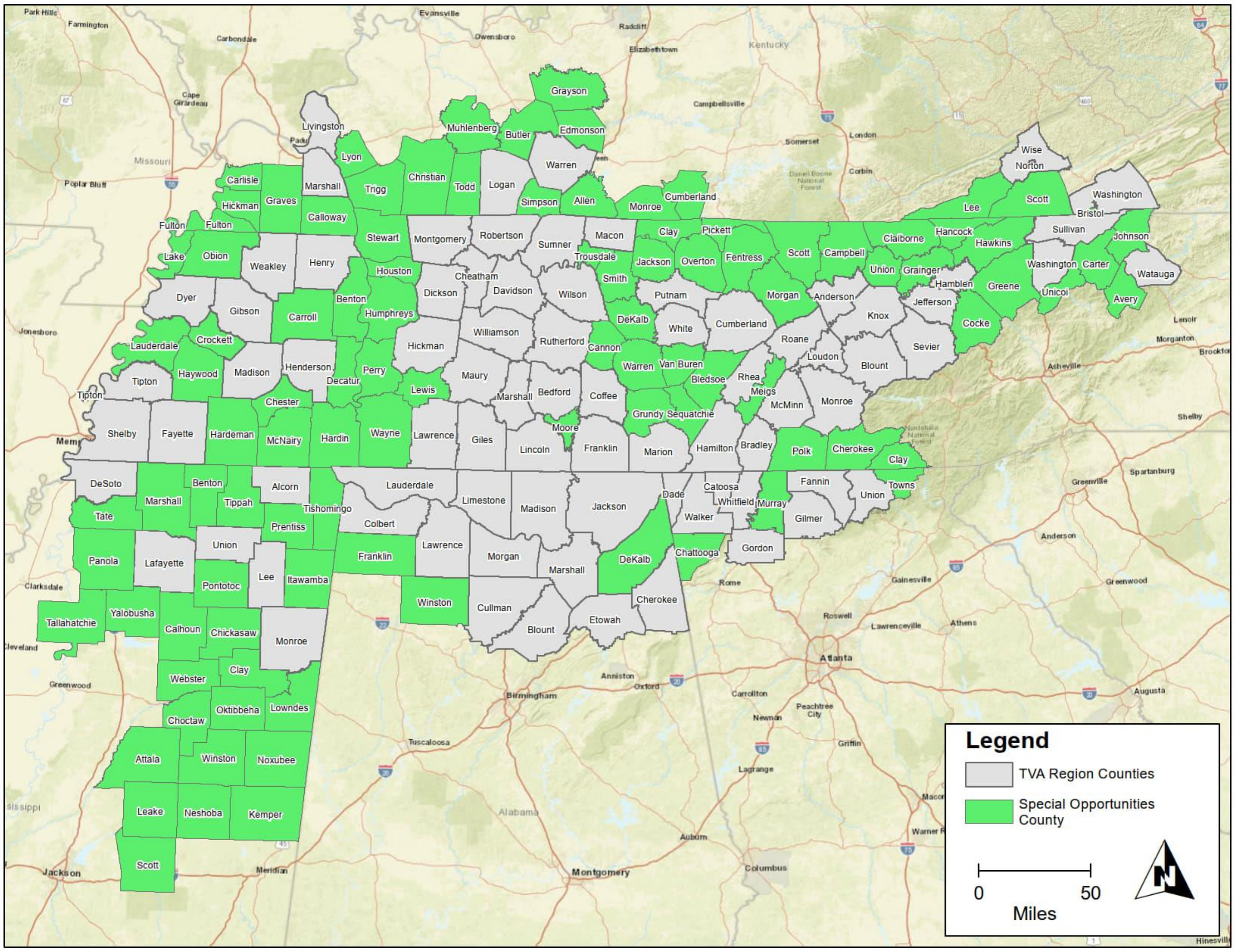


Figure 4-28: 2024 Special Opportunities Counties, as Designated by TVA

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. Indicators considered herein include minority, low-income, linguistic isolation, and age distribution population characteristics sourced from ACS 2017-2021, as shown in Table 4-20. For comparison purposes, EJSCREEN data is also provided for associated states and the U.S.

EJSCREEN data for the 16 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 Bellefonte Nuclear in Alabama, and Cumberland Fossil and John Sevier CC in Tennessee, demonstrate higher percentages of low-income populations than their associated states. Eight of the 16 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 (USEPA 2023i). Appendix B-4 presents minority percentages for each county in the TVA PSA, including those in which the plants are located (see also Figure 1-1).

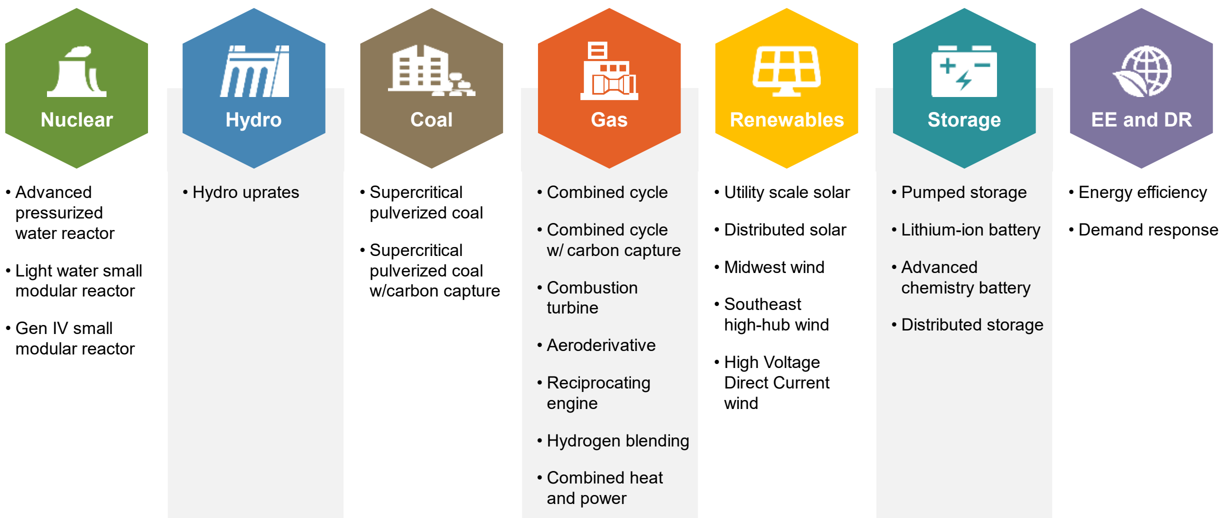
Table 4-20: Environmental Justice Population Characteristics for Selected TVA Power Plants

Geography / Plant	Minority (%)	Low-Income (%)	Linguistically Isolated (%)	Under Age 5 (%)	Over Age 64 (%)
U.S.	39	31	5	6	17
Alabama	38	38	1	6	18
Bellefonte Nuclear	14	48	0	3	15
Colbert CT	11	31	0	2	37
Kentucky	16	37	1	6	17
Shawnee Fossil	13	35	0	6	13
Mississippi	45	43	1	6	17
Ackerman CC	17	24	0	4	23
Caledonia CC	20	22	0	5	16
Magnolia CC	12	33	0	7	28
Southaven CC	77	47	1	6	14
Tennessee	28	35	2	6	17
Allen CC, CT	99	55	0	1	23
Cumberland Fossil	17	38	0	11	17
Gallatin Fossil, CT	13	20	1	10	13
John Sevier CC	5	46	1	7	24
Johnsonville CT	12	29	0	6	15
Kingston Fossil	10	32	0	3	23
Lagoon Creek CC	30	41	0	8	20
Sequoyah Nuclear	4	24	0	7	17
Watts Bar Nuclear	2	41	0	7	25

Source: USEPA 2023i

5 Anticipated Environmental Impacts

This chapter describes the anticipated environmental impacts of the alternative strategies and their associated portfolios. The chapter addresses the general process TVA uses to site new power facilities and the potential environmental impacts of the continued operation of TVA's supply-side 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 major supply-side generation resource types considered in the Integrated Resource Plan (IRP) include nuclear, hydroelectric, coal, gas (including natural gas and hydrogen), renewables, and storage (Figure 5-1). The chapter then describes the environmental impacts of distributed and demand-side resource types, including distributed generation, distributed storage, 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.



Hydro - hydroelectric

Figure 5-1: Overview of TVA 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 (PSA) 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 and proximity to floodplains; proximity to parks, natural areas 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, floodplains, waterways, wetlands and historic properties. TVA also provides for and encourages participation by potentially affected landowners in this screening process.

TVA is not responsible for 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 pipeline companies who are responsible for constructing and operating the pipeline. Construction and operation of natural gas pipelines are subject to various state and federal environmental requirements, depending on how and where constructed. If a pipeline is built specifically to serve a new TVA plant, TVA would evaluate the potential environmental impacts.

The results of the site screening process, as well as the potential impacts of the construction and operation of generating and transmission facilities at the screened alternative locations, are described in comprehensive environmental review documents made available to the public, consistent with the requirements of the National Environmental Policy Act (NEPA). During this environmental review process, TVA consults with the appropriate State Historic Preservation Office on the potential impacts to historic properties and, as necessary, with the United States (U.S.) Fish and Wildlife Service (USFWS) and relevant state agencies on the potential impacts to federal and/or state endangered and threatened species and their designated critical habitats.

Independent power producers, from whom TVA purchases power under long-term PPAs, typically use a site screening process like 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 NEPA and other environmental laws and regulations, and TVA conducts comprehensive environmental reviews of generating facilities that independent power producers propose to construct in order to provide power to TVA under long-term PPAs.

5.2 Environmental Impacts of Supply-Side Resource Options

Because the locations of most future generating facilities are not known during the Integrated Resource Planning process, this assessment focuses on general impact areas, i.e., it is not location specific. TVA will address the site-specific effects associated with specific projects that are proposed to implement the IRP in subsequent tiered environmental reviews. Impact areas are described generally below and in detail in the following subsections.

Air Quality. The potential impacts to air quality are described by the direct emissions of sulfur dioxide (SO_2), nitrogen oxides (NOx), and mercury, 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 25-year planning period.

Climate and Greenhouse Gases (GHG). GHG emissions are assessed for both direct emissions of carbon dioxide (CO_2), from the combustion of non-renewable carbon-based fuels, and life cycle GHG emissions, which include direct and indirect emissions of CO_2, methane (CH_4), and nitrous oxide (N_2O). 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 technology-specific resource estimates provided to TVA by the National Renewable Energy Laboratory (NREL), based off its seminal Life Cycle Analysis (LCA) Harmonization Project (see Section 5.5.2 and Appendix D for additional information). GHG emissions are provided for all four life cycle phases and broken out by the three primary greenhouse gasses of concern (CO_2, CH_4, and N_2O). Indirect emissions produced during the upstream, ongoing non-combustion, and downstream phases are calculated using emission factors provided by NREL, which are based on either installed capacity (in kW) or per unit of electricity generated (in kWh). 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.

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 well as by major river basin and whether from surface or groundwater sources.

Land Resources. 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, endangered and threatened species, cultural resources (e.g., archaeological sites and historic structures), land use, prime farmland, visual/aesthetic resources, managed and natural areas, recreation, and aquatic resources. While this analysis assumes that the potential for impact increases with the land area affected, the kind of impact and its potential severity would 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 mine lands, 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, nuclear, coal, wind, solar photovoltaic (PV), and conventional hydroelectric. The large land requirements for hydroelectric include the reservoirs, which typically have other uses; note that TVA is only considering uprates to its existing hydro facilities in the IRP, not new reservoirs). The topic of land intensity is further covered in Volume 1, Appendix J.

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.

Solid and Hazardous 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.

Socioeconomics. Generally, socioeconomics in the TVA PSA are impacted by larger trends throughout the U.S. The planned retirements of facilities may result in the loss of local employment, however, to the growth of employment opportunities in the regional economy, employees may find alternative employment in other industries. Therefore, minimal environmental impacts to socioeconomic resources are anticipated.

Environmental Justice. The TVA PSA contains minority and low-income populations subject to consideration as potential environmental justice communities of concern. Potential adverse health effects to communities will be determined by a future site-specific analysis of environmental impacts.

Following is a discussion of the environmental attributes of the generation options. Typical environmental characteristics of new supply-side resources selected in the capacity expansion plans are listed in Table 5-1. Some 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 3.6 of Volume 1 and Section 2.1 of Volume 2. 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

Resource Option[1]		Summer NDC or Nameplate (MW)	Summer Full-Load Heat Rate (Btu/kWh)	Storage Efficiency (%)	CO_2 Emissions (lbs/MWh)	SO_2 Emissions (lbs/MWh)	NOx Emissions (lbs/MWh)	Hg Emissions (lbs/MWh)	Process Water Use (Gallons/MWh)	Process Water Consumption (Gallons/MWh)	Facility Land Requirements (Acres/MW)	Facility Land Requirements Permanently Disturbed (Acres)
Nuclear	APWR	1,150	10,132	-	-	-	-	-	1,289	859	0.40	460
Nuclear	SMR - Light Water (First-of-a-Kind)	285	10,713	-	-	-	-	-	719	539	0.63	180
Nuclear	SMR - Light Water (Nth-of-a-Kind)	285	10,713	-	-	-	-	-	719	539	0.63	180
Nuclear	SMR - Gen IV (reactor / with storage)	345/ 500	8,308	-	-	-	-	-	719	539	0.63/ 0.08	229
Hydro	Hydro Uprates	200	-	-	-	-	-	-	-	-	-	-

Resource Option[1]		Summer NDC or Nameplate (MW)	Summer Full-Load Heat Rate (Btu/kWh)	Storage Efficiency (%)	CO_2 Emissions (lbs/MWh)	SO_2 Emissions (lbs/MWh)	NOx Emissions (lbs/MWh)	Hg Emissions (lbs/MWh)	Process Water Use (Gallons/MWh)	Process Water Consumption (Gallons/MWh)	Facility Land Requirements (Acres/MW)	Facility Land Requirements Permanently Disturbed (Acres)
Coal	Coal Supercritical Pulverized	650	10,548	-	1,160	0.333	1.194	2.98E-09	82,445	329	0.69	449
Coal	Coal Supercritical Pulverized with CCS	650	10,548	-	116	0.333	1.194	2.98E-09	82,445	329	0.69	449
Gas	CC - 2x1x1	1,430	6,665	-	397	-	0.081	-	250	195	0.08	114
Gas	CC with CCS - 2x1x1	1,430	7,832	-	40	-	0.081	-	250	195	0.08	114
Gas	Frame CT- 4x	884	10,087	-	590	-	0.363	-	130	130	0.10	88
Gas	Aero CT - 20x	1,060	9,392	-	548	-	0.337	-	130	130	0.08	85
Gas	RICE - 24x	426	8,607	-	504	-	0.310	-	130	130	0.15	64
Solar	Solar Single-Axis Tracking (nameplate capacity)	50	-	-	-	-	-	-	-	-	7.30	365
Wind	Wind - MISO	200	-	-	-	-	-	-	-	-	0.80	160
Wind	Wind - Valley High-hub	200	-	-	-	-	-	-	-	-	1.00	200
Wind	Wind - HVDC	200	-	-	-	-	-	-	-	-	0.80	160
Storage	Pumped Storage	1,600	-	81	-	-	-	-	-	-	0.88	1,408
Storage	Battery - Lithium-ion (4-hour)	50	-	85	-	-	-	-	-	-	0.08	4
Storage	Battery - Advanced Chemistry (8-hour)	50	-	85	-	-	-	-	-	-	0.08	4

[1] APWR – Advanced Pressurized Water Reactor; SMR – Small Modular Reactor; Hydro – Hydroelectric power sources; CCS – Carbon Capture and Sequestration; CC – Combined Cycle; CT – Combustion Turbine; RICE – Reciprocating Internal Combustion Engine; MISO – Midcontinent Independent System Operator; HVDC – High Voltage Direct Current

[2] Solar, wind and storage are in nameplate.

5.2.1 Fossil-Fueled Generation

5.2.1.1 Coal – Existing Facilities

TVA currently operates 24 coal-fired generating units at 4 plant sites (see Section 2.1.1). Flue gas desulfurization (FGD) systems for SO_2 control and selective catalytic reduction (SCR) systems for NOx emissions control have been installed at 17 of these units. The plants with these FGD and SCR systems include TVA's largest coal units and total about 6,000 megawatts (MW) of generating capacity. The remaining coal-fired units use other methods to reduce SO_2 and NOx emissions including the use of low-sulfur coal, low-NOx burners, and selective non-catalytic NOx reduction systems.

While the life cycle GHG emissions for individual 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 equivalent emissions (CO_2e) per gigawatt hour (GWh) (961 kilograms per megawatt hour [kg/MWh]) for pulverized coal boilers without advanced emissions control systems, comparable to seven of the Shawnee units. The National Energy Technology Laboratory (NETL 2010b) calculated a life cycle GHG emission rate of 1,226 tons CO_2e/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. NETL (2010c) calculated a life cycle GHG emission rate of 1,045 tons CO_2e/GWh (948 kg/MWh) for a supercritical pulverized coal plant (SCPC) equipped with an electrostatic precipitator, FGD and SCR, comparable to the Cumberland plant.

For the 2025 IRP, TVA partnered with NREL to source life cycle greenhouse gas emission factors for use in a system-wide greenhouse gas life cycle assessment (see Section 5.5.2). Existing coal resources were split between subcritical designation, including Kingston, Gallatin, and Shawnee, and supercritical designation which included Cumberland (Table 5-2). The largest source of life cycle GHG emissions from these coal plants is CO_2 from coal combustion, accounting for more than 80 percent of GHG emissions across all life cycle phases. The ongoing non-combustion phase contains the second largest source of life cycle GHG emissions, accounting for emissions associated with coal mining, coal transportation, and other ongoing activities required to keep the plant fueled and operational. The two primary GHG emissions in the ongoing non-combustion phase are CO_2 and CH_4. For additional information, see Section 5.5.2 and Appendix D.

Table 5-2: Coal Emissions Factors by Phase

Electric Power Technology	One-Time Upstream GHG (CO_2e), g/kW	Ongoing Annual Combustion GHG (CO_2e), g/kW-hr	Ongoing Annual Non-Combustion GHG (CO_2e), g/kW-hr	One-Time Downstream GHG (CO_2e), g/kW
Coal, Supercritical	867,240	Emissions Calculated Separately[1]	10	67,100
Coal, Subcritical	708,246	Emissions Calculated Separately[1]	4.9	67,100

[1]Emissions are determined in the GHG LCA using individual plant heat rates and estimated carbon content of the fuel (~210 lbs/mmBtu for coal, depending on fuel basin)

The Red Hills plant in Mississippi, operated by a private entity under a long-term PPA with TVA, 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 mountaintop removal, in Appalachia (USEPA 2005, Palmer et al. 2010). In recent years, TVA has greatly reduced its use of coal from the Appalachian Basin, obtaining only about 7 percent of its coal from this source in 2023. 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 CCR 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

Existing coal facilities are expected to be retired by 2035, and no new coal facilities were selected in any of the IRP portfolios.

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 are described in several Environmental Impact Statements (EISs) and Environmental Assessments (EAs; see Section 1.3). Natural gas-fired plants do not emit SO_2 or mercury, and direct emissions of NOx (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.

In the system-wide greenhouse gas life cycle assessment conducted by TVA and NREL (Section 5.5.2), existing and new gas resources were split between combined cycle (both natural gas and hydrogen fueled), combined cycle with carbon capture, and simple cycle Frame CT designations (Table 5-3). The largest source of life cycle GHG emissions from gas plants without carbon capture is CO_2 from natural gas combustion. The ongoing non-combustion phase contains the second largest source of life cycle GHG emissions, accounting for emissions associated with gas extraction, gas transportation, methane leakage, and other ongoing activities required to keep the plant fueled and operational. The two primary GHG emissions in the ongoing non-combustion phase are CO_2 and CH_4. For the 2025 IRP, NREL performed an updated literature review for natural gas plants which include carbon capture, and the results of this review are reflected in the emission factor values. For additional information, see Section 5.5.2 and Appendix D.

Table 5-3: Natural Gas and Hydrogen Emissions Factors by Phase

Electric Power Technology	One-Time Upstream GHG (CO_2e), g/kW	Ongoing Annual Combustion GHG (CO_2e), g/kW-hr	Ongoing Annual Non-Combustion GHG (CO_2e), g/kW-hr	One-Time Downstream GHG (CO_2e), g/kW
Combined Cycle	100,000	Emissions Calculated Separately[1]	62.00	4,070
Combined Cycle with Carbon Capture	1,352,700	Emissions Calculated Separately[1]	106.75	4,086
Hydrogen CC	100,000	Emissions Calculated Separately[1]	28.90	4,070
Combustion Turbine	64,790	Emissions Calculated Separately[1]	70.00	2,600

[1]Emissions are determined in the GHG LCA using individual plant heat rates and estimated carbon content of the fuel (~117 lbs/mmBtu for gas)

One of several areas of concern regarding 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 compared with coal. Other studies have shown the life cycle carbon footprint of electricity generation from shale gas is like (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_2e/MJ), Barnett shale (12.4 grams CO_2e/MJ), and Marcellus shale (14.5 grams CO_2e/MJ) gas production than for conventional onshore (10.3 grams CO_2e/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.

The risk to water resources posed by shale gas production is another environmental issue that has been the subject of numerous studies. In a Congressionally mandated study of the impact of fracking on water resources, the U.S. Environmental Protection Agency (USEPA 2016) 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

Natural gas resource options in the IRP include CC, CC with carbon capture and sequestration (CCS), frame CT, aeroderivative (Aero) CT, reciprocating internal combustion engine, and combined heat and power. All new gas units were assumed to be hydrogen capable with required blending according to proposed GHG rule in the net-zero regulation scenarios (Scenarios 4 and 5). Hydrogen co-firing with natural gas is a newer technology that can reduce carbon emissions through the addition of hydrogen to natural gas, with benefits including reduced emissions, increased efficiency, and its compatibility with current infrastructure (Abdin 2024). Splitting hydrogen is often highly energy intensive and the source of hydrogen has a direct impact on its carbon footprint, with renewable energy derived hydrogen having a lower carbon footprint compared to natural gas derived hydrogen. Technology is advancing that allows for the sequestration of carbon during the natural gas derived hydrogen process, which may lower the carbon footprint. There are several different processes that can produce hydrogen, including thermochemical, electrolytic, direct solar water splitting, and biological, which are at various stages of development and deployment (DOE 2024b).

Land area requirements for 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. 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.

The 2025 IRP approach to evaluating life cycle GHG emissions for natural gas-fired resources is further detailed in Sections 5.2.1.3, 5.5.2, and in Appendix D.

TVA’s experience with constructing natural gas generation plants is generally consistent with these studies. TVA has reviewed numerous environmental review documents that address the construction of new natural gas plants to provide additional information on potential impacts associated with new natural gas plants. Table 5-4 includes generic construction impacts data (averages) associated with NEPA reviews of six TVA projects between 2010 and 2022 (Allen Fossil Plant Emission Control Project; Paradise and Colbert CT Plants; Cumberland Fossil Plant Retirement; John Sevier Fossil Plant; and Johnsonville Aeroderivative CT Project). The data includes associated pipeline infrastructure but excludes associated new transmission line construction. In each case, TVA constructed a new plant at or near an existing TVA facility; construction at previously disturbed sites typically reduces impacts to the environment. The actual effects of future projects may vary greatly, with greater or lesser effects based on the nature and size of a particular project.

The construction of these TVA plants directly affected an average of 253 acres or approximately 0.4 acres per MW. Of the six projects, the land requirements varied greatly, with the smallest project affecting only 51 acres (0.07 acres per MW). Many of the impacts were temporary in nature and/or were mitigated in some manner. These projects historically have impacted an average of about 25 acres of floodplains (0.04 acres per MW) and 126.3 acres of prime farmland (0.02 acres per MW) and have required the clearing of 137.8 acres of forest (0.21 acres per MW). Aquatic impacts include 0.4 acres (0.0003 acres per MW) of wetlands and forested wetlands affected. Half of the projects affected streams, with impacts to an average of 2,433 linear feet (0.003 linear feet per MW) of streams. Further, half of the projects affected migratory birds of concern, and four of the six projects affected federally listed endangered or threatened species (e.g., bat habitat impacts). The cultural and social impacts include four out of six projects impacting parks and public lands to some degree, with the same number of projects resulting in negative visual effect in the area. There were no reported impacts on historic properties.

Table 5-4: Generic Construction Effects of Natural Gas Generation Plants (TVA Projects 2010-2022)

Land Use Effects	
Land Requirements	Average of 253.4 acres per project Range: 51 to 583.7 acres Average of 0.4 acres per MW Range 0.07 to 0.54 acres per MW
Floodplain Impacted (Acres)	Average of 25 acres per project Range: 0 to 150 acres Average of 0.04 acres per MW Range: 0 to 0.1 acres per MW 17% (1 of 6) of natural gas projects resulted in floodplain impacts
Prime Farmland Converted	Average of 126.3 acres per project Range: 0 to 73.3 acres Average of 0.02 acres per project Range: 0 to 0.07 acres per MW 33% (2 of 6) of natural gas projects resulted in prime farmland conversion
Land Cover Impacts	
Forest Cleared	Average of 137.8 acres per project Range: 0 to 696.2 acres Average of 0.21 acres per MW Range of 0 to 0.48 acres per MW 83% (5 of 6) of natural gas projects in forest clearing
Wetland Effects	
Wetland Area Affected	Average of 0.4 acres per project Range: 0 to 2.3 acres Average of 0.0003 acres per MW Range: 0 to 0.0016 acres per MW 50% (3 of 6) of natural gas projects affected wetlands
Forested Wetland Area Cleared	Average of 0.04 acres per project Range: 0 to 2.1 acres Average of 0.0003 acres per MW Range of 0 to 0.0014 acres per MW 33% (2 of 6) of natural gas projects resulted in forested wetland clearing

Stream Effects	
Stream Effects	Average of 2,433.3 linear feet per project Range of 0 to 14,018 linear feet Average of 0.003 linear feet per MW Range of 0 to 9.7 acres per MW 50% (3 of 6) of natural gas projects affected streams
Biological Effects	
Endangered and Threatened Species	66.6% (4 of 6) of natural gas projects affected federally listed endangered or threatened species or species proposed or candidates for listing
Migratory Bird Effects	50% (3 of 6) of natural gas projects resulted in effects to migratory birds of conservation concern
Cultural & Social Effects	
Historic Properties	None of the six natural gas projects affected eligible Historic Properties
Parks and Public Lands	66% (4 of 6) of natural gas projects affected parks and public lands
Visual Effects	66% (4 of 6) of natural gas projects resulted in visual effects
Environmental Justice	May vary based on location

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 (See Section 1.3). 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, with three facilities either operational or under construction. This process, widely used outside the U.S., can require less than 3 percent the energy of the gaseous diffusion process. 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 (DOE) inventories diluted to commercial reactor fuel also reduces GHG emissions.

In the system-wide greenhouse gas life cycle assessment conducted by TVA and NREL (Section 5.5.2), existing and expansion nuclear resources were split between traditional, large-scale nuclear reactors and small modular reactor (SMR) designations (Table 5-5). The largest source of life cycle GHG emissions from these plants is CO_2 from the Upstream phase. The Downstream phase contains the second largest source of life cycle GHG emissions, accounting for emissions associated with plant decommissioning. For additional information, see Section 5.5.2 and Appendix D.

Table 5-5: Nuclear Emissions Factors by Phase

Electric Power Technology	One-Time Upstream GHG (CO_2e), g/kW	Ongoing Annual Combustion GHG (CO_2e), g/kW-hr	Ongoing Annual Non-Combustion GHG (CO_2e), g/kW-hr	One-Time Downstream GHG (CO_2e), g/kW
Nuclear	483,552	NA	12	175,000
Nuclear SMR	483,552	NA	12	175,000

NA - Not applicable

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

Nuclear resource options available for selection include advanced pressurized water reactors, as well as light water and generation IV SMRs. 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 2008) 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 except for water use (water withdrawn for cooling or other uses and then returned to the source) and water consumption (water withdrawn but not returned to its source). 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 (NRC). 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 2025 IRP approach to evaluating life cycle GHG emissions for nuclear resources is further detailed in Sections 5.2.2.1, 5.5.2, and in Appendix D.

The impacts of constructing and operating a SMR plant would be generally like 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 are described by NRC in the April 2019 Final EIS (NRC 2019) and by TVA in its July 2022 final Programmatic EIS for a new SMR plant at TVA's Clinch River Site in Roane County (TVA 2022f). 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

As more consumers and businesses are seeking cleaner energy and solar resources have become cost-competitive, TVA is increasing its renewable energy portfolio. TVA's current renewable energy portfolio is dominated by the hydroelectric facilities at its dams and with PPAs for wind and solar energy, the latter of which is a rapidly growing component of the portfolio (see Sections 3.3 and 3.4). The following sections provide an overview of the environmental impacts of renewable generation from hydroelectric, wind, solar, and biomass facilities. The renewable resource options available for selection in the IRP include utility scale solar, distributed solar, High Voltage Direct Current (HVDC) wind, Midwest wind, and Southeast high-hub wind.

These changes support the broad electrification and carbon emission reduction efforts prevalent in other sectors of the economy. However, TVA will not sacrifice reliability at any time, which means that TVA must make certain operational decisions at times to keep the system reliable, possibly impacting annual performance on carbon emissions. Therefore, while TVA continues to lower GHG emissions, there will be fluctuations in TVA's emission numbers resulting from changes in the power supply mix, weather impacts, economic conditions, and generating unit performance.

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.

In the system-wide greenhouse gas life cycle assessment conducted by TVA and NREL (Section 5.5.2), all existing and new hydro resources utilized the same emission factor estimates (Table 5-6). The largest source of life cycle GHG emissions from hydroelectric plants is CO_2 from the Upstream phase, representing emissions occurring during plant construction, including raw material extraction. For additional information, see Section 5.5.2 and Appendix D.

Table 5-6: Hydroelectric Emissions Factors by Phase

Electric Power Technology	One-Time Upstream GHG (CO_2e), g/kW	Ongoing Annual Combustion GHG (CO_2e), g/kW-hr	Ongoing Annual Non-Combustion GHG (CO_2e), g/kW-hr	One-Time Downstream GHG (CO_2e), g/kW
Hydroelectric	1,100	NA	1.9	0

NA - Not applicable

The TVA hydroelectric generating system consists of 29 hydroelectric dams with 109 conventional hydroelectric generating units, the majority of which are on the Tennessee River and its tributaries. These 29 dams provide 3,739 MW of summer net capability. TVA manages the Tennessee River system via these dams in an integrated manner, which includes managing minimum river flows and minimum depths for navigation, reducing flood damage, generating low-cost hydroelectric power, maintaining flows that support habitat for fish and other aquatic species, maintaining water supply, and providing recreational opportunities for the Tennessee Valley. In addition, having cool water available helps TVA to meet thermal compliance and support normal operation of TVA's nuclear and fossil-fueled plants, while oxygenating water helps fish and other aquatic species remain healthy. TVA releases excess water (spills) through its dams to reduce flood damage to the Tennessee Valley. TVA typically spills only when all available hydroelectric generating turbines are operating at full capacity and water must still be released from a dam.

TVA's Hydro Life Extension Program, which replaced the Hydro Modernization Program, began in 2021 with a focus on recovering and preserving TVA's extensive hydroelectric fleet, improving efficiency and flexibility, and ensuring long-term reliability of this vital clean energy asset. Hydroelectric generation will continue to be an important part of TVA's energy supply in the future. It plays a vital role in carbon reduction initiatives, the ability to integrate other renewables into the power portfolio, and TVA's ability to meet changing customer preferences for cleaner energy sources. These modernization efforts have been completed on 65 out of 109 conventional hydroelectric units, resulting in an increase in capacity of 444 MW and 5 percent efficiency without increasing footprint or emissions.

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 2005). 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 hydroelectric modernization are minimal, and there is typically no additional long-term conversion of land.

The 2025 IRP approach to evaluating life cycle GHG emissions for hydro resources is further detailed in Sections 5.2.3.1, 5.5.2, and in Appendix D.

New hydroelectric pumped storage, which is partially discussed in Section 5.2.4, is one of several technologies that TVA is exploring as part of its decarbonization efforts to ensure the reliability and resiliency of the grid. TVA is currently developing a Pumped Storage Hydroelectric EIS that would evaluate the potential for incremental pumped storage at three sites across the TVA system. Proactively completing the environmental review of all three potential sites would position TVA to shorten the timeline for incremental pumped storage if the sites are included and approved in future plans. New pumped storage could be available by 2033.

While potential exists for hydropower generation in undeveloped stream reaches, this would be disruptive and have large environmental impacts. As a result, hydroelectric expansion options are limited to unit uprates as per Volume 1. The hydroelectric uprates expansion option was developed based on TVA's Hydro Life Extension Program assessments and is specific to opportunities across the TVA system. These expansions could involve major construction projects, although most construction activities would occur on the dam reservations.

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 (Section 2.4). TVA currently purchases power from eight wind farms. TVA has completed environmental assessments for wind farms in Tennessee and Kansas (TVA 2011b, TVA 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.

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 1 MW/494 acres for windfarms constructed between 1998 and 2016. A very small proportion of this wind farm area is disturbed directly, 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 several 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 during and post-construction, and mortality of birds and bats from collision with turbines. The rates at which displacement or fatalities or injuries occur can be dependent on species (habitat requirements, typical flight path height, etc.). Injuries and collisions have been shown to be due to both the height of turbines as well as the motion. In addition to direct impacts to the immediate area impacted by the wind turbines, indirect effects can occur in the surrounding areas, such as habitat avoidance for bats and birds increasing in closer proximity to turbines, with measurable effects on birds up to 674 meters away (Barré et al. 2018, Marques et al. 2019). Bats can also die from trauma induced by air pressure changes caused by the rotating turbines (BLM 2005, Baerwald et al. 2008). Mortality and collision rates for both birds and bats are difficult to determine accurately, given limits to data accessibility and varying methods for data collection; therefore, impacts are likely underestimated (Allision et al. 2019, Schippers et al. 2020, Choi et al. 2020).

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 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 Midcontinent Independent System Operator [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 and areas of HVDC wind resource options), where one study found a mortality rate of 1.2 bats/turbine/year (0.8/MW) (Arnett et al. 2008). 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, Goldenberg et al. 2021).

The USFWS 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). Other mitigation measures for reducing collisions continue to be studied, including painting turbines, texturing them, using acoustic deterrents, and operational curtailment (May et al. 2020, TCU 2019, Romano et al. 2019, Smallwood and Bell 2020).

Wind turbines produce no direct emissions of air pollutants or GHGs. In the system-wide greenhouse gas life cycle assessment conducted by TVA and NREL (Section 5.5.2), all existing and new wind resources utilized the same emission factor estimates (Table 5-7). The largest source of life cycle GHG emissions from wind plants is CO_2 from the Upstream phase, representing emissions occurring during plant construction, including raw material extraction. For additional information, see Section 5.5.2 and Appendix D.

Table 5-7: Wind Emissions Factors by Phase

Electric Power Technology	One-Time Upstream GHG (CO_2e), g/kW	Ongoing Annual Combustion GHG (CO_2e), g/kW-hr	Ongoing Annual Non-Combustion GHG (CO_2e), g/kW-hr	One-Time Downstream GHG (CO_2e), g/kW
Wind	619,000	NA	0.74	14,000

NA - Not applicable

5.2.3.4 Wind – New Facilities

Three options exist and were modeled for possible expansion of wind energy generation, defined primarily where they are sited. The three wind resource options are MISO, Southeast High-Hub, or HVDC. MISO wind primarily comes from wind farms in the Midwest. For the in-Valley option, higher hub heights are necessary due to the relatively lower wind speeds in the region. The HVDC option would use a direct current (DC) bulk transmission system. The HVDC transmission system would reduce power losses that are typical of the more common alternating current (AC) transmission systems. The HVDC option would require a third party to permit and build a new transmission line, meaning this option would provide energy later than the other options. These potential expansions are covered further in Volume 1, Appendix E. The 2025 IRP approach to evaluating life cycle GHG emissions for wind resources is further detailed in Sections 5.2.3.3, 5.5.2, and in Appendix D.

TVA anticipates the developers of wind farms would follow USFWS guidelines (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 PSA 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 owns approximately 1 MW of solar capability across nine operating solar installations. Through several programs, TVA purchases renewable power (primarily solar, some biomass) totaling 322 MW of capability. TVA has long-term power purchase agreements for 715 MW of operating solar nameplate capacity and has contracted for an additional 2,858 MW of solar nameplate capacity expected to come online over the next few years, including contracts signed in the latest procurement cycle. TVA obtains renewable energy credits from these sites, and the existing agreements extend through the late 2030s to early 2040s.

TVA assessed the potential impacts of small PV facilities in a programmatic environmental assessment (TVA 2014) 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 long-term soil productivity or the ability to resume agricultural production once the PV facilities are removed when employing best practices (Cleveland and Sarkisian 2019). The construction of the PV facility frequently affects local scenery, but this effect 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 the system-wide greenhouse gas life cycle assessment conducted by TVA and NREL (Section 5.5.2), all existing and new solar resources utilized the same emission factor estimates (Table 5-8). The largest source of life cycle GHG emissions from solar plants is CO_2 from the Upstream phase, representing emissions occurring during plant construction, including raw material extraction. For additional information, see Section 5.5.2 and Appendix D.

Table 5-8: Solar Emissions Factors by Phase

Electric Power Technology	One-Time Upstream GHG (CO_2e), g/kW	Ongoing Annual Combustion GHG (CO_2e), g/kW-hr	Ongoing Annual Non-Combustion GHG (CO_2e), g/kW-hr	One-Time Downstream GHG (CO_2e), g/kW
Solar	1,630,000	NA	9.4	37,800

NA - Not applicable

Land requirements and impacts for PV facilities vary greatly and depend on the type of installation and the type of land that would be impacted. 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 sun) 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), a review of 13 operating and proposed PV facilities in the TVA PSA, and 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}) for fixed-tilt systems and 7.3 acres/MW_{DC} (8.6 acres/MW_{AC}) for single-axis tracking systems. As noted in Table 5-1, the facility land requirement assumed by TVA as an environmental characteristic was 7.3 acres/MW, which is consistent with these past studies and within the range of PV land use requirements identified in recent industry and academic literature. Bolinger and Bolinger (2022) estimated that 5.56 acres of land is required for each MW of solar power generation, and the Solar Energy Industries Association (2023) identified 10 acres/MW as a reasonable maximum for solar facilities.

5.2.3.6 Solar – New Facilities

New facilities for both utility-scale solar and distributed solar were considered in Volume 1. New utility-scale solar is increasing, in part driven by customers' demand through TVA's Green Invest Program. As electricity demand is expected to grow, research shows that ground-based solar systems would require only 0.5 percent of the surface area of the contiguous U.S. along with other technologies to achieve zero carbon emissions (EERE 2023). The impacts of new solar generating facilities included in the capacity expansion plans are expected to be like 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. Expansion options for TVA include large single-axis tracking units.

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 PSA. In 2019, TVA estimated that 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).

The 2025 IRP approach to evaluating life cycle GHG emissions for solar resources is further detailed in Sections 5.2.3.5, 5.5.2, and in Appendix D.

In 2024, TVA reviewed NEPA documents it has completed addressing solar construction projects between 2014 and 2023 (see Appendix E for the list of NEPA documents). Information gathered is generally consistent with these studies, with many TVA projects varying greater in size (from 2.0 to 12.2 acres per MW). Table 5-9 includes data from 44 NEPA documents addressing the average potential effects of 47 solar projects. These figures are associated with TVA's experience reviewing the potential effects of numerous past projects. As seen in the ranges included in the table, the effects of individual projects may vary greatly, with greater or lesser effects based on the nature and size of a particular project.

Over 80 percent of these projects resulted in effects to prime farmland and, on average, 104.9 acres of forests have been cleared (2.0 acres per MW). Aquatic impacts include 0.2 acres (0.007 acres per MW) of wetlands affected and an average of 2,433 linear feet (5.4 linear feet per MW) of streams affected. For almost all projects, TVA identified some effect to visual resources from the solar project.

Further discussion into the possible land use impacts of solar can be found in Section 5.5.5.

Table 5-9: Generic Construction Effects of Solar Generation Facilities (TVA Projects 2014-2023)

Land Use Effects	
Land Requirements (Acres of Solar Installation within a Site)	Average of 7 acres per MW Range 2.0-12.2 acres per MW Total acreage of projects: 17,257 acres
Floodplain fill per MW (Acres)	Average of 0.07 acre per MW Range: 0-1.5 acres per MW
Prime Farmland conversion	81% of solar projects resulted in prime farmland conversion
Land Cover Effects	
Forest cleared	Average of 104.9 acres per project Range: 0-850 acres Average of 2.0 acres per MW Range of 1.0-13.2 acres per MW
Wetland Effects	
Area affected	Average of 0.21 acres per project Range: 0-3.9 acres Average of 0.007 acres per MW Range: 0–0.25 acres per MW
Forested wetland area cleared	Average of 0.33 acres per project Range: 0-4.26 acres Average of 0.01 acres per MW Range of 0-0.25 acres per MW
Stream Effects	
Stream effects	Average of 873 linear feet per project Range of 0-14,987 linear feet Average of 5.4 LF per MW Range of 0-41 acres per MW
Biological Effects	
Endangered and Threatened Species	48% of solar projects affected federally listed endangered or threatened species or species proposed or candidates for listing
State-Listed Species	48% of solar projects affected State-Listed endangered, threatened, or special concern species
Cultural and Social Effects	
Historic Properties[1]	3% of projects affected historic properties
Parks and Public Lands	7% of projects affected parks and public lands
Visual Effects	99% of solar projects resulted in visual effects (based on a review of 31 of the 45 projects)

[1]Additional consultation for individual projects would be required and additional consultation with State Historic Preservation Officers and Tribes would be completed for site-specific activities.

5.2.3.7 Biomass – Existing Facilities

TVA purchases electricity generated from landfill gas and wood waste (see Section 2). The environmental impacts of this generation are beneficial overall, 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.

Biomass facilities are also addressed in the system-wide greenhouse gas life cycle assessment conducted by TVA and NREL (Section 5.5.2). The largest source of life cycle GHG emissions from biomass plants is CO_2 from the Upstream phase, representing emissions occurring during plant construction, including raw material extraction (Table 5-10). For additional information, see Section 5.5.2 and Appendix D.

Table 5-10: Biomass Emissions Factors by Phase

Electric Power Technology	One-Time Upstream GHG (CO_2e), g/kW	Ongoing Annual Combustion GHG (CO_2e), g/kW-hr	Ongoing Annual Non-Combustion GHG (CO_2e), g/kW-hr	One-Time Downstream GHG (CO_2e), g/kW
Biomass	1,960	NA	6.02	35

NA - Not applicable

5.2.3.8 Biomass – New Facilities

The potential supply of biomass 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. Therefore, TVA is not further pursuing expansion via biomass at this time.

5.2.4 Energy Storage

5.2.4.1 Energy Storage - Existing Facilities

TVA operates one large storage facility. The Raccoon Mountain Pumped Storage Plant has four generating units with a generating capability of 1,700 MW. TVA's Raccoon Mountain facility occupies about 1,050 acres and utilizes approximately 386,470 gallons of water per MWh of generation. Although Raccoon Mountain uses a large volume of water, none of this water is consumed and the only loss is from evaporation. The Raccoon Mountain Pumped Storage Plant's four generating units provide critical flexibility to the TVA system by storing water at off-peak times for use when demand is high.

In conjunction with several solar contracts, TVA has contracted for 370 MW of battery storage expected to come online in the next few years, including contracts signed in the latest procurement cycle. Also, TVA is constructing a 20-MW battery facility in Vonore, Tennessee, to gain direct operational experience with battery storage operation.

In the system-wide greenhouse gas life cycle assessment conducted by TVA and NREL (Section 5.5.2), all existing and new pumped storage resources utilized the same emission factor estimates (Table 5-11). The largest source of life cycle GHG emissions from pumped storage plants is CO_2 from the Upstream phase, representing emissions occurring during plant construction, including raw material extraction. For additional information, see Section 5.5.2 and Appendix D.

Table 5-11: Pumped Storage Emissions Factors by Phase

Electric Power Technology	One-Time Upstream GHG (CO_2e), g/kW	Ongoing Annual Combustion GHG (CO_2e), g/kW-hr	Ongoing Annual Non-Combustion GHG (CO_2e), g/kW-hr	One-Time Downstream GHG (CO_2e), g/kW
Pumped Hydroelectric	310	NA	1.8	7

NA - Not applicable

GHG emissions from generation are a function of the GHG intensity of the electricity used in the pumping mode. The IRP's life cycle analysis incorporates forecasted generation from other TVA plants stored by the pumped hydro facility as a part of the underlying energy production forecast for each portfolio. 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 2022 CO_2 intensity of 658 lbs/MWh, the operation of Raccoon Mountain, as well as that of a future pumped storage facility, would emit about 855 lbs of CO_2/MWh. This emission rate would decrease over time with the reduction in CO_2 intensity occurring under all alternatives.

5.2.4.2 Energy Storage - New Facilities

Storage resource options available for selection in the IRP include pumped storage, lithium-ion battery, advanced chemistry battery, and distributed storage (Volume 1, Appendix E.12). The pumped storage option would use reversible turbine generators to pump water into a higher altitude reservoir during periods of excess power or use water flowing from the upper to lower reservoir to power the turbines when energy is needed (Section 5.2.3.2). Two different types of battery storage technologies were modeled. Lithium-ion is the prevalent technology today, and it is best suited for shorter storage duration, so a four-hour, 50-MW version was modeled. Advanced chemistry battery storage technologies are developing that would enable longer durations of storage, so a 10-hour, 50-MW version was modeled. Storage efficiency is modeled for all options due to the energy losses inherent in the conversion process and the loss of water during storage. Storage efficiency represents the efficiency of one cycle (i.e., pumping/releasing water, charging/releasing battery power). Compressed air energy storage was not considered for the 2025 IRP.

The operational impacts of a new 1,600-MW pumped storage plant are expected to be like 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.

The 2025 IRP approach to evaluating life cycle GHG emissions for pumped storage resources is further detailed in Sections 5.2.4.1, 5.5.2.4, and in Appendix D.

Utility-scale battery storage facilities are assumed to resemble current storage systems using lithium-ion batteries, which typically consist of batteries, supervisory and power management system, heating and air conditioning (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 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). The 2018 Final Generic EIS (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 Resource Conservation and Recovery Act (RCRA) regulations and best management practices.

In the system-wide greenhouse gas life cycle assessment conducted by TVA and NREL (Section 5.5.2), all currently contracted and new battery storage resources utilized the same emission factor estimates (Table 5-12). The largest source of life cycle GHG emissions from battery facilities is CO_2 from the Upstream phase, representing emissions occurring during plant construction, including raw material extraction. For additional information, see Section 5.5.2 and Appendix D.

Table 5-12: Battery Emissions Factors by Phase

Electric Power Technology	One-Time Upstream GHG (CO_2e), g/kW	Ongoing Annual Combustion GHG (CO_2e), g/kW-hr	Ongoing Annual Non-Combustion GHG (CO_2e), g/kW-hr	One-Time Downstream GHG (CO_2e), g/kW
Battery	527,000	NA	0	98,900

NA - Not applicable

Similar to pumped storage, GHG emissions from battery generation are a function of the GHG intensity of the electricity used when charging. The IRP's life cycle analysis incorporates forecasted generation from other TVA plants stored by the batteries as a part of the underlying energy production forecast for each portfolio.

5.3 Environmental Impacts of Energy Efficiency and Demand Response Resource Options

The sources of environmental impacts from the proposed expansion of TVA's EE and DR programs under the alternative strategies include the following:

- The reduction in or avoidance of generation resulting from EE measures. This reduction is incorporated into the alternative strategies assessed in Section 5.5 and highlighted benefits of EE and DR programs are in Section 2.5.
- 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 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 generation of solid waste resulting from building retrofits and the replacement of appliances, HVAC equipment, and other equipment to reduce energy use are addressed in Section 5.5.6.
- Adverse impacts to historic buildings from building retrofits that result in changes in their external appearance and associated historic integrity.

Programmatic environmental reviews of EE programs have been conducted by DOE (2015a) for the Hawai'i Clean Energy Initiative and by the Rural Utilities Service (USDA 2012) for its Energy Efficiency and Conservation loan program. DOE (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.

Most EE programs require that participating individuals and organizations pay a portion of the costs of their EE measures. Low-income residents frequently have a reduced ability to pay these costs and therefore are less likely to participate in such programs, creating potential environmental justice concerns. TVA programs focused on investment in low-income communities, such as Home Uplift, can help mitigate these concerns. In addition, many low-income residents live in rental housing, and there are few EE programs targeting rental single-family and multi-family housing. Environmental justice is addressed in Section 5.5.8.

Further information on these programs can be found in Volume 1, Appendix G.

5.4 Environmental Impacts of Transmission Facility Construction and Operation

As described in Volume 1 (Appendix C), all the alternative strategies would require strategic investments in transmission, which would result in the construction of new or upgraded transmission facilities. Table 5-13 provides a list of generic effects of these construction activities, based on TVA's past experience completing similar projects. This list was compiled by reviewing project planning documents for TVA transmission construction activities completed from 2005 through 2023. A total of 470 projects were included in this review (see Appendix E for a list of these projects). The actual effects of future projects are likely to vary greatly, with greater or lesser environmental effects based on the nature and size of a particular project.

TVA builds an average of 65 miles of new transmission lines per year along with several new substations and switching stations to increase capacity/reliability and serve new customers. The anticipated amount of construction for 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 a local power company (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.

All strategies include timeline, technological, transmission, and/or market depth uncertainty and execution risks, which are amplified by load growth and regulatory impacts. Scenarios 2 and 5 included the highest levels of forecasted load growth, which would drive the most extensive transmission upgrades (and associated environmental impacts) to both serve this additional load and interconnect new generation resources. Large resource additions like nuclear and natural gas plants typically require more robust transmission buildouts, including items like new substations and longer transmission lines for interconnection, along with significant upgrades to existing transmission assets in the local area. Localized environmental impacts associated with transmission would be expected to be greater for larger plants.

Inverter-based resources such as solar and battery storage (expected under all strategies but amplified in Strategy C) are typically more geographically dispersed and have a smaller capacity output per plant. These resources require relatively fewer traditional transmission upgrades per installation, typically resulting in fewer localized environmental impacts associated with transmission actions. However, the size and dispersed nature of these resources makes the scale of new and upgraded transmission projects more complex on a per MW basis compared to larger generating plants. Also, inverter-based resources typically require supplemental reactive resource transmission projects to ensure system stability and reliability that are not required for spinning generation. As the deployment of inverter-based solar and battery storage increases on the TVA system, the likelihood of more extensive network upgrades increases, given the growing interdependence of each system modification, thereby increasing the potential for associated environmental impacts.

The retirement of generating facilities, such as coal plants, can also result in the need for new or upgraded transmission facilities 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 (DOE 2015b).

Table 5-13: Generic Effects of Transmission System Construction and Maintenance Activities (TVA Projects 2005-2023)

	Transmission Lines	Substations and Switching Stations
Land Use Impacts		
Land requirements	Average of 14.6 acres/line mile, range 3.03 – 100	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; 1% affected floodplains
Prime farmland converted	0	Average of 7.9 acres; range 0 – 29.1; 2.3% affected prime farmland
Land Cover Impacts		
Forest cleared	Average of 5.15 acres/line mile for new lines; range 0 – 46.15; 23% cleared forest	Average of 4.27 acres; range 0 – 50; 3% cleared forest
Wetland Impacts		
Area affected	Average of 2.51 acres/line mile for new line; range 0 – 70.58; 29% affected wetlands Average of 1 acre/line mile of existing line; range 0 – 18.3; 15% affected wetlands	Average of 0.6 acres; range 0 – 1.84; 1% affected wetlands
Forested wetland area cleared	Average of 1.78 acres line/mile; range 0 – 44.5; 19% affected forested wetlands Average of 0.01 acres/line mile of existing line; range 0 – 18.3; 15% affected forest wetlands	-
Stream Impacts		
Stream crossings	Average of 2.89 per mile of new line; range 0 – 50; 25% crossed streams Average of 2.89 per mile of existing line; range 0 – 6.67; 11% crossed streams	Not Applicable
Forested stream crossings	Average of 0.96 per mile of new line; range 0 – 17.65; 13% crossed forested streams Average of 0.06 per mile of existing line; range 0 – 2.5; 1% crossed forested streams	Not Applicable
Endangered and Threatened Species	35 (7.8%) of 450 projects affected federally listed endangered or threatened species, or species proposed or candidates for listing 71 (15.7%) of 453 projects affected state-listed endangered, threatened, or special concern species	
Historic Properties	45 (10%) of 451 projects affected historic properties	
Parks and Public Lands	50 (12.3%) of 408 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.

As stated in Section 1.4 of Volume 1, TVA intends to develop an integrated transmission plan that considers the strategic direction from the IRP and the system investments required to facilitate future power supply needs.

5.5 Environmental Impacts of Alternative Strategies and Associated Capacity Expansion Plans

Following is a discussion of the impacts of each alternative strategy on air quality, climate and greenhouse gases, water resources, land resources, fuel consumption, solid and hazardous waste, and TVA-region socioeconomics and environmental justice over the 25-year, 2025-2050 planning period. A full list of the environmental parameters of the 30 portfolios can be found in Appendix C. The bar charts and time-series graphs in the following sections 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. The environmental impacts of all alternative strategies and scenarios are largely impacted by the retirement of coal facilities by 2035, which will lead to decreased emissions of air pollutants, the intensity of greenhouse gas emissions, and generation of coal waste, with some achieving or approaching zero. For most environmental resources, the impacts would be greatest in Scenarios 2, Higher Growth Economy, and sometimes 5, Net-zero Regulation Plus Growth, and would be lowest under Scenario 3, Stagnant Economy. Overall, the impacts between strategies did not differ as much as between scenarios, with most strategies having similar impacts on average.

Alternative Strategies:
A – Baseline Utility Planning
B – Carbon-Free Innovation Focus
C – Carbon-Free Commercial Ready Focus
D – Distributed and Demand-side Focus
E – Resiliency Focus

Scenarios:
1 – Reference (without GHG Rule)
2 – Higher Growth Economy
3 – Stagnant Economy
4 – Net-zero Regulation
5 – Net-zero Regulation Plus Growth
6 – Reference (with GHG Rule)

Air Quality, Climate, and Greenhouse Gases. All alternative strategies would result in significant long-term reductions in emissions of SO_2, NOx, and mercury. 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, would decrease under all alternative strategies. 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 would 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 would likely have small but beneficial impacts on the potential for associated climate change.

Water Resources. The volume of water used by thermal generating facilities, (i.e., nuclear, coal, and CC facilities) would decrease between 2025 and 2050 under all alternative strategies. There is a noticeable difference in water consumption between the strategies, with Strategy B, Carbon-free Innovation Focus, requiring the most water, and Strategy C, Carbon-free Commercial Ready Focus, requiring the least. Water withdrawal remains similar among the strategies. 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.

Land Resources. Land resources displayed a difference between strategies, with Strategy C, which focuses on carbon-free technologies such as solar, using more land than the remaining strategies. For all portfolios but one (3B), at least 90 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 battery storage facilities.

Fuel Consumption. All strategies lead to the eventual omission of coal as a fuel source. Fuel consumption changes little across strategies, though shows marked differences between scenarios, which may reflect changes in policy and investments. Slight differences between strategies can be seen for natural gas consumption, with Strategy A, Baseline Utility Planning (the No Action Alternative), using the most natural gas resources. Hydrogen fuel consumption is only modeled for Scenarios 4 and 5.

Solid and Hazardous Waste. All alternative strategies would result in long-term reductions in the production of CCR due to the retirement of coal plants/units by 2035, wherein all CCR production reduced to zero. The quantity of CCR produced during the 2025-2050 planning period shows little variation between alternative strategies. It varies much more between the scenarios associated with each strategy and is greatest with Scenario 2 and lowest with Scenario 3. Full retirement of coal, CC, and CT plants (Section 3.2.3) would primarily result in a decrease in solid and hazardous waste produced.

Socioeconomics and Environmental Justice. Socioeconomic impacts, as quantified by the change to per capita income of TVA PSA residents that is attributable to the cost of operating of the TVA power system, are minimal across all strategies. The differences in annual per capita income and employment of residents of the TVA PSA 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.

5.5.1 Air Quality

All alternative strategies would result in significant long-term reductions in total emissions and emission rates of SO_2, NOx, and mercury (Table 5-14, Figure 5-2, Figure 5-3, Figure 5-4; Appendix C). A large portion of these reductions, especially for SO_2 and mercury, result from the retirement of coal plants. The planned retirement of facilities account for the trends in emissions through 2033 portrayed in Figure 5-2, Figure 5-3, and Figure 5-4. After 2033, emissions of SO_2 and mercury cease with the retirement of coal facilities. Emission trends diverge after 2033 due to increased differences between the strategies. The effects on air quality from the partial and entire retirement of CT, CC, and coal facilities are included in the following discussion.

Variations in emissions of SO_2 and mercury in 2031 to 2033 are due to fewer regularly scheduled coal plant outages during this period. The variation is followed by the absence of emissions for 2034 in SO_2 and mercury, resulting from full retirement of facilities. NOx emissions also decrease in 2034 due to the retirements. There is some variation in emissions among the associated strategies; however, this variation is much smaller than the differences between the scenarios (Figure 5-5, Figure 5-6, Figure 5-7). Emissions are greatest under Scenario 2 and lowest under Scenario 3.

Table 5-14: Average Total, Annual, and Percent Reduction of Emissions of SO_2, NOx, and Mercury by Alternative Strategy

	Alternative Strategy						
	A – Baseline	B	C	D	E	Scenario 1 Range	Extended Range
SO_2							
Total emissions 2025-2033, tons	148,481	149,621	145,939	146,001	148,547	159,557 – 166,806	72,985 – 207,150
Annual emissions, tons	17,468	17,602	17,169	17,177	17,476	10,793 – 28,679	65 – 30,182
Percent reduction 2025-2033	62.3	63.8	60.2	59.3	58.3	51.0 – 60.7	35.3 – 99.8
NOx							
Total emissions 2025-2050, tons	189,289	177,892	173,754	176,267	178,743	179,562 – 198,886	122,455 – 226,533
Annual emissions, tons	7,280	6,849	6,683	6,779	6,875	3,102 – 20,194	1,894 – 22,135
Percent reduction 2025-2050	81.8	85.8	86.0	84.6	84.5	79.4 – 83.3	77.8 – 89.8
Mercury							
Total emissions 2025-2033, pounds	458	459	449	444	456	443 – 466	219 – 639
Annual emissions, pounds	57.2	57.4	56.2	55.5	57.0	19.4 – 100.9	2.1 – 117.1
Percent reduction 2025-2033	79.8	80.6	78.5	78.1	77.4	73.8 – 78.7	47.8 – 96.8

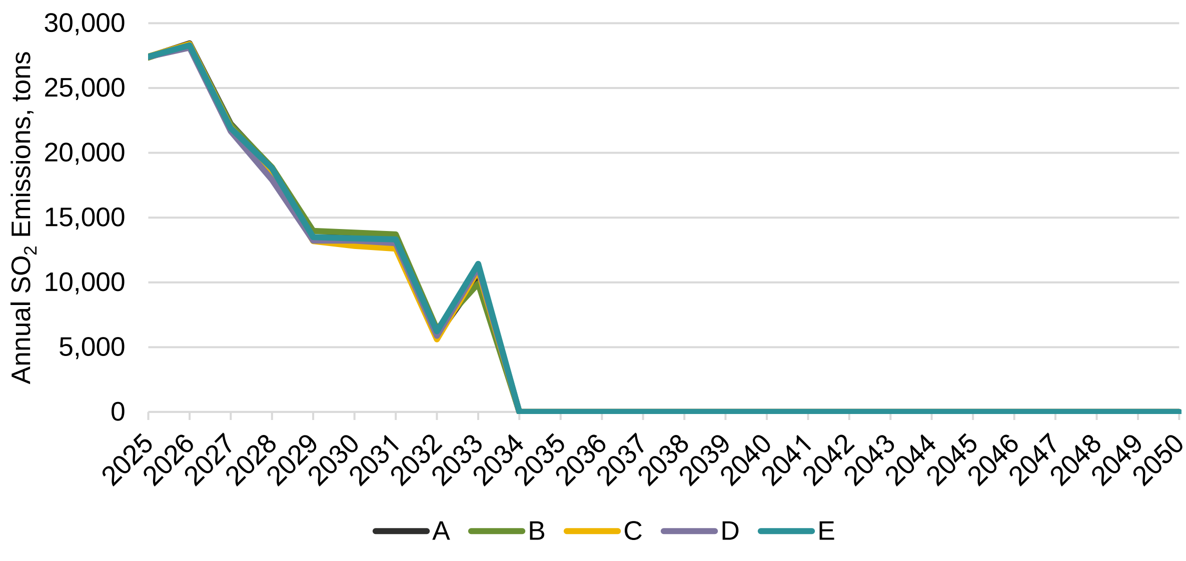


Figure 5-2: Trends in Emissions of SO_2 by Alternative Strategy Based on Averages of the Six Scenarios

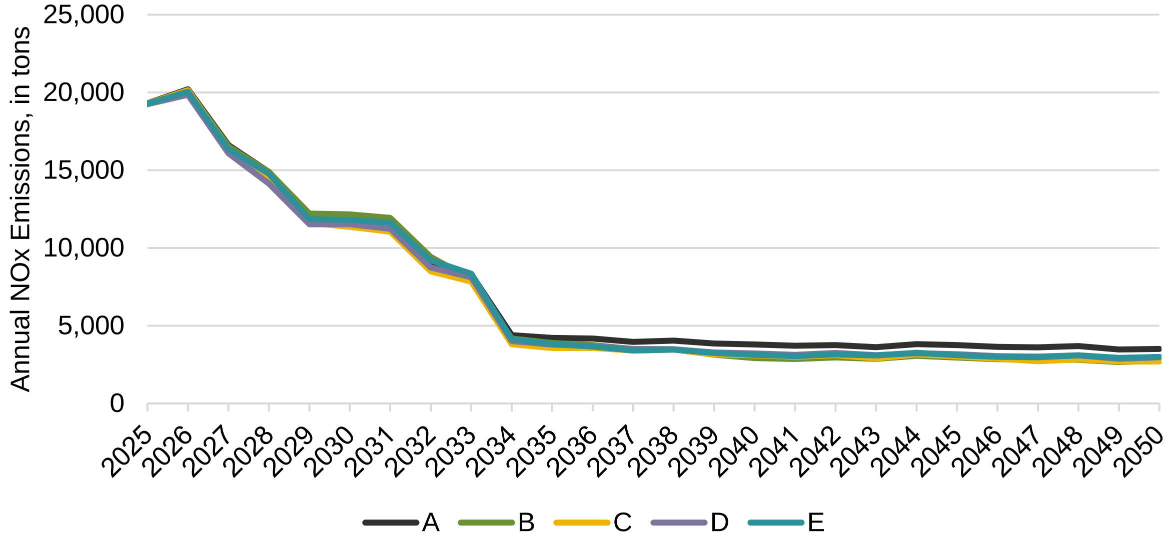


Figure 5-3: Trends in Emissions of NOx by Alternative Strategy Based on Averages of the Six Scenarios

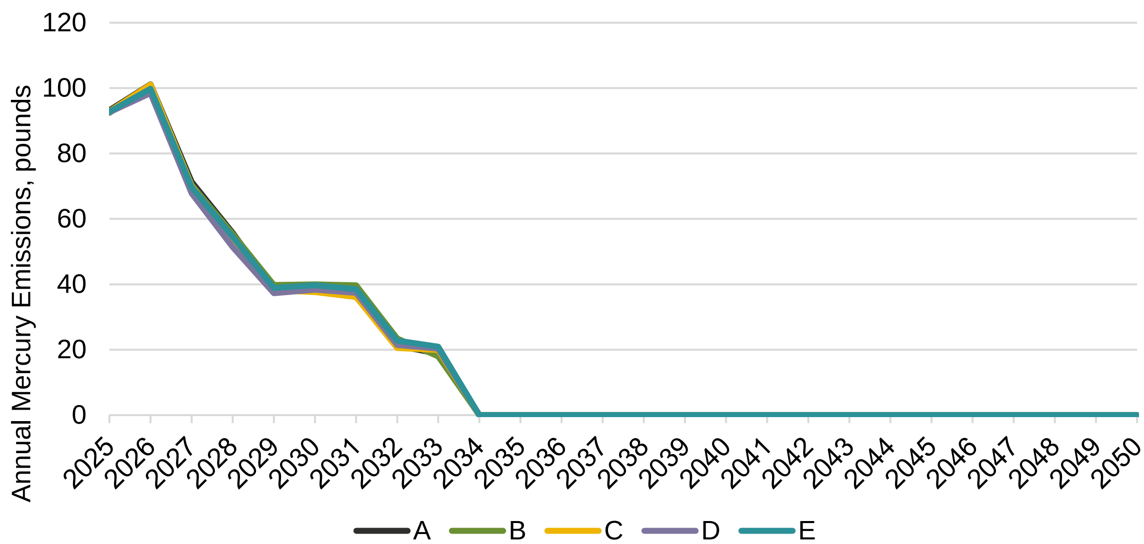
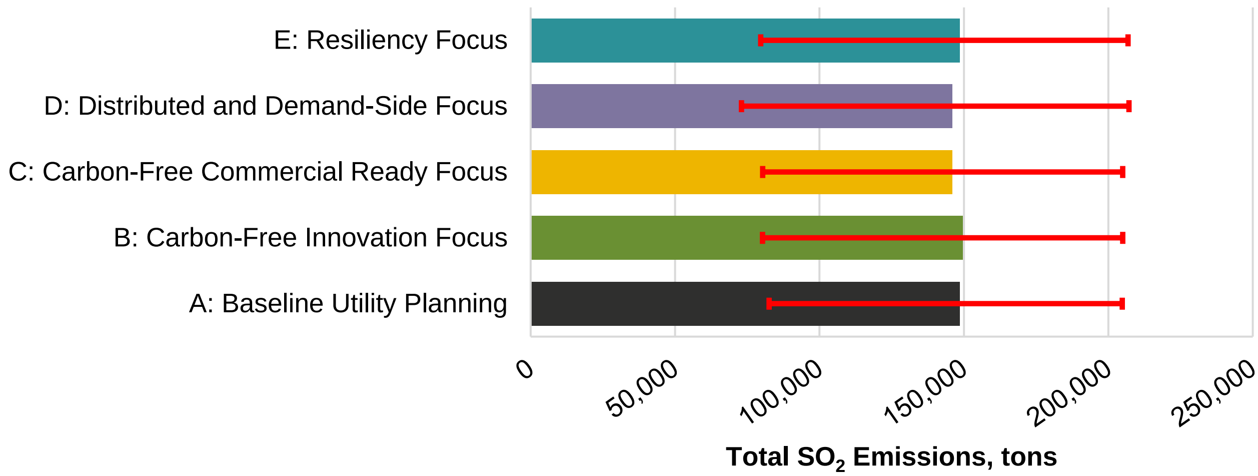
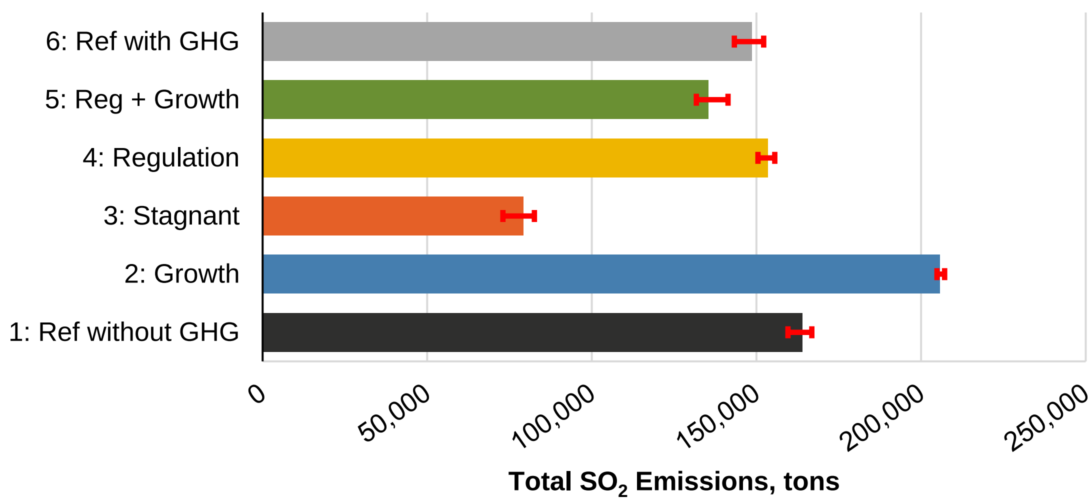
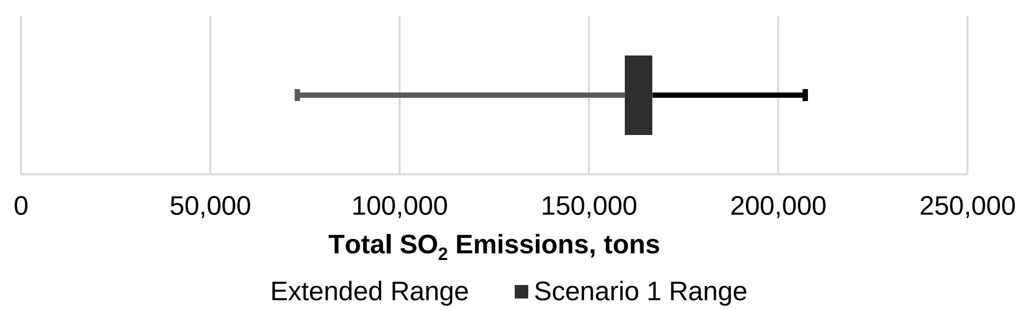


Figure 5-4: Trends in Emissions of Mercury by Alternative Strategy Based on Averages of the Six Scenarios

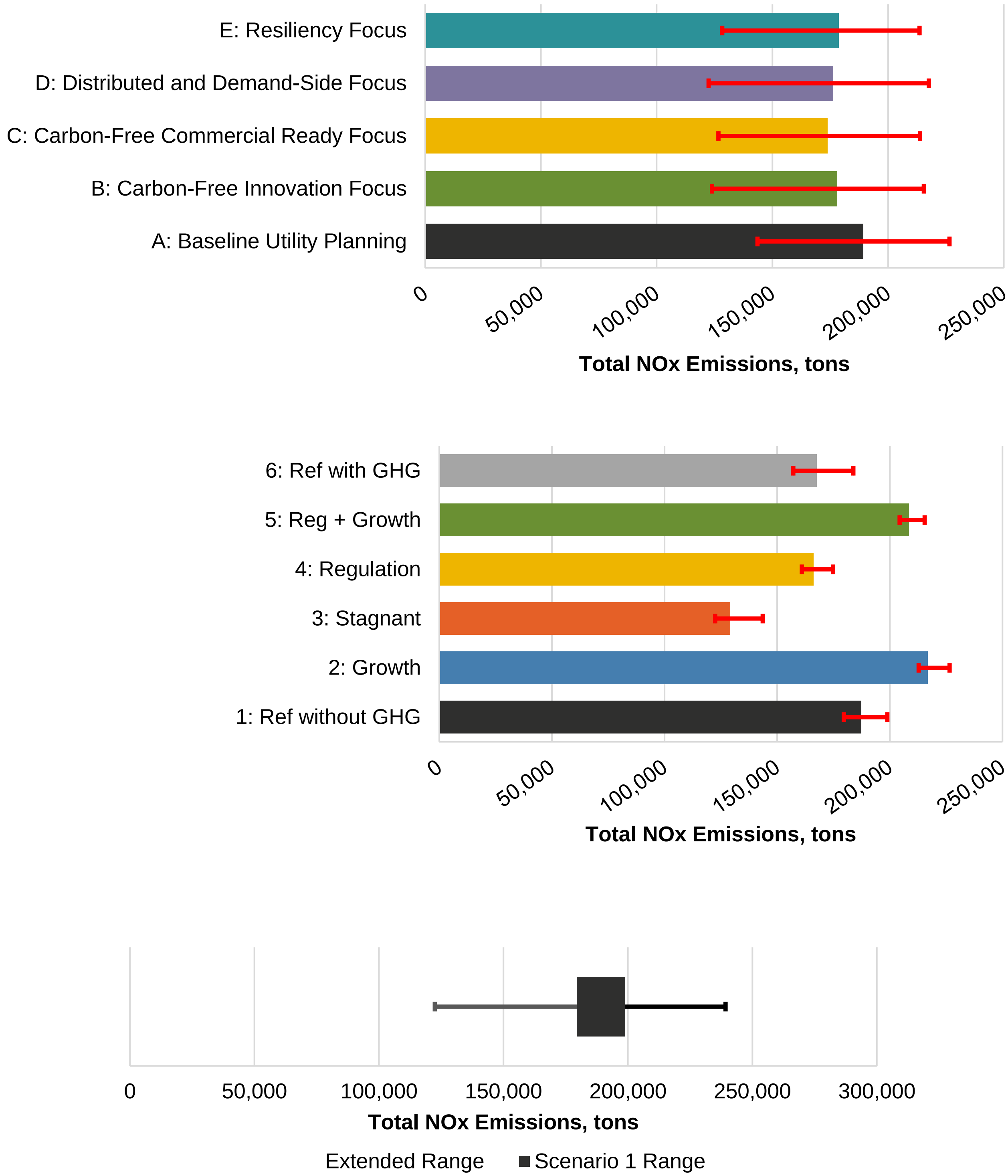






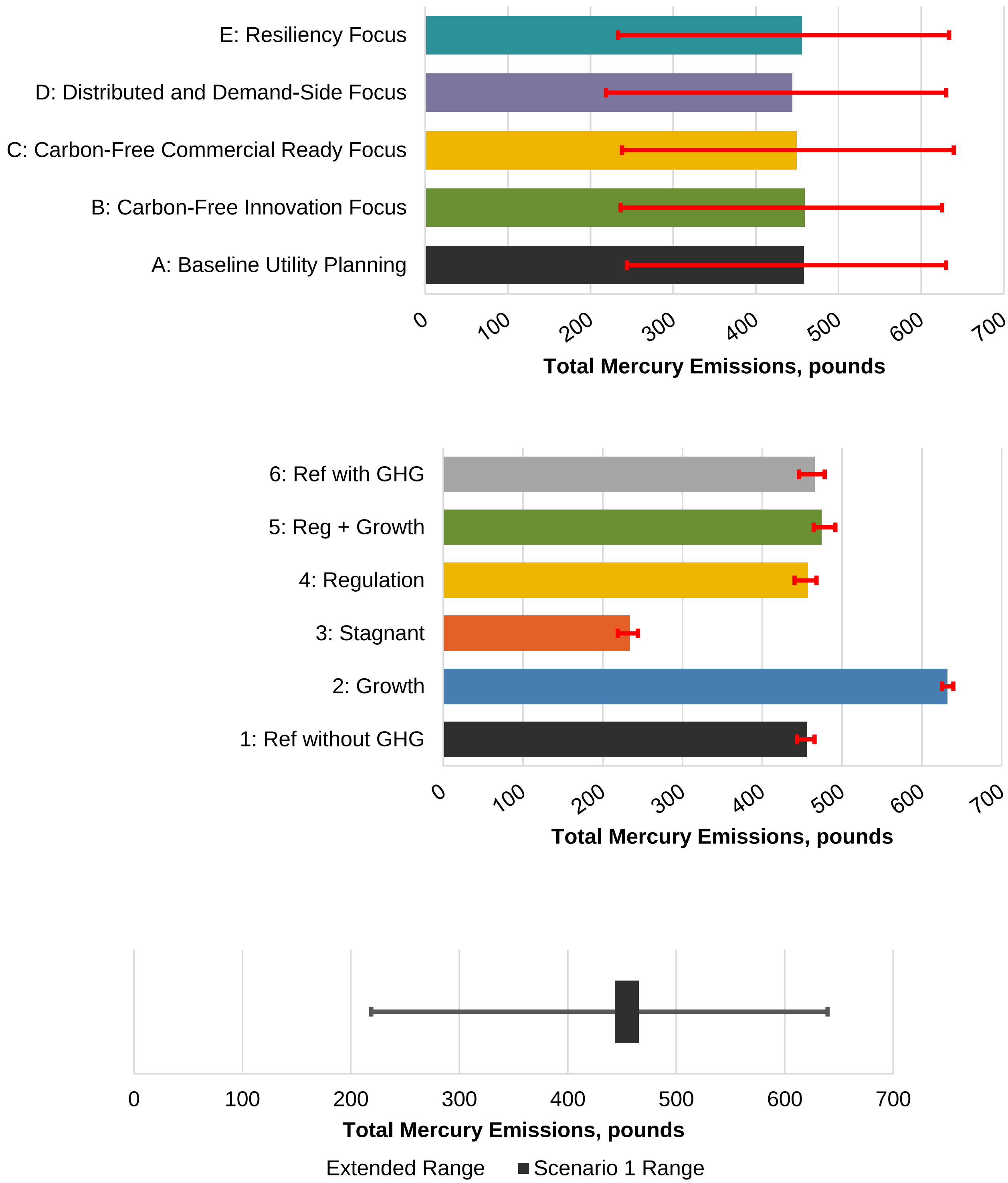
Note: The error bars in the top and middle charts indicate the maximum and minimum values for the scenarios associated with each alternative strategy, and the strategies associated with each scenario.

Figure 5-5: Total 2025-2050 Emissions of SO_2 by Alternative Strategy (top), Scenario (middle), and the Range for Scenario 1 as well as the Extended Range to Encompass All Scenarios and Strategies (bottom)



Note: The error bars in the top and middle charts indicate the maximum and minimum values for the scenarios associated with each alternative strategy, and for the strategies associated with each scenario.

Figure 5-6: Total 2025-2050 Emissions of NOx by Alternative Strategy (top), Scenario (middle), and the Range for Scenario 1 as well as the Extended Range to Encompass All Scenarios and Strategies (bottom)



Note: The error bars on the top and middle charts indicate the maximum and minimum values for the scenarios associated with each alternative strategy, and the strategies associated with each scenario.

Figure 5-7: Total 2025-2050 Emissions of Mercury by Alternative Strategy (top), Scenario (middle), and the Range for Scenario 1 as well as the Extended Range to Encompass All Scenarios and Strategies (bottom)

The overall reductions in emissions under each strategy show relatively little variation (Table 5-14). Emission reductions for SO_2 and mercury were greatest under Strategy B, Carbon-free Innovation Focus, followed by Strategy A, Baseline Utility Planning. NOx reductions, however, are greatest for Strategies B and C; this is largely due to the carbon-free focus under these strategies.

The reductions in SO_2, NOx and mercury emissions would continue recent trends in emissions of these air pollutants under all alternative strategies. Reductions would result in further small decreases in regional ambient concentrations of SO_2 and sulfate (a component of acid deposition), regional haze, and fine particulates. TVA emissions of NOx would also decrease since their 1995 peak by about 99 percent under all strategies. Although this continued decrease would 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.

5.5.2 Climate and Greenhouse Gases

5.5.2.1 Direct Combustion GHG Emissions

Total and annual direct combustion emissions of GHG in terms of CO_2, as well as CO_2 emission rates – also referred to as CO_2 intensity – decrease under all alternative strategies (Table 5-15, Figure 5-8, Figure 5-9, Appendix C) in the future. The variation among the strategies for both CO_2 emissions and emissions rates are relatively small and much less than the variation among the scenarios associated with each strategy (Figure 5-10 and Figure 5-11).

Strategy A, Baseline Utility Planning (the No Action Alternative), has the greatest CO_2 emissions and CO_2 emissions rate and the least reductions. Strategy B, Carbon-free Innovation Focus, has the lowest CO_2 emissions and emission rates. Within each strategy, Scenario 2 has the highest CO_2 emissions and emission rates, followed by Scenario 1 and 6. Scenario 4 has the lowest rate, followed by Scenarios 5 and 3. The overall trends for both CO_2 emissions and emission rates are very similar, with the percent reductions somewhat greater for emission rates. Emissions increase through 2026 due to increased coal and gas generation resulting from near-term increases in load occurring prior to planned coal plant retirements. The decreases following 2026 are primarily due to the phased retirement of the existing coal fleet as each plant reaches anticipated end of life as well as increased generation from lower-carbon or carbon-free resources.

As compared to the baseline condition, Strategies B, C, D, and E would result in greater reductions of GHG emissions as shown in Table 5-15.

Table 5-15: Average 2025-2050 CO_2 Emissions and Emissions Rates, and Percent Emissions Changes by Alternative Strategy

	Alternative Strategy						
	A – Baseline	B	C	D	E	Scenario 1 Range	Extended Range
Total CO_2 emissions 2025-2050, million tons	724	625	641	660	668	720 – 875	382 – 985
Average Annual CO_2 emissions, thousand tons, 2025-2050	27,831	24,023	24,647	25,401	25,705	27,678 – 33,663	14,707 – 37,869
Percent CO_2 emissions reduction, 2025-2050	67.3	76.8	75.9	72.5	73.2	46.7 – 62.8	44.9 – 97.4
Average Annual CO_2 emissions rate, lbs/MWh, 2025-2050	315	273	280	302	296	322 – 388	173 – 388
Percent CO_2 emissions rate reduction, 2025-2050	70.3	78.8	78.4	73.3	75.3	52.8 – 66.9	52.8 – 98.3

	Alternative Strategy						
Percent Total CO_2 emissions reduction compared to Baseline, 2025-2050	--	13.7	11.4	8.7	7.6	--	--

Notes:
1. Reference Case Range is the minimum and maximum values of scenario 1 for all alternatives.
2. Extended Range is the minimum and maximum values of all the scenarios across all alternatives.

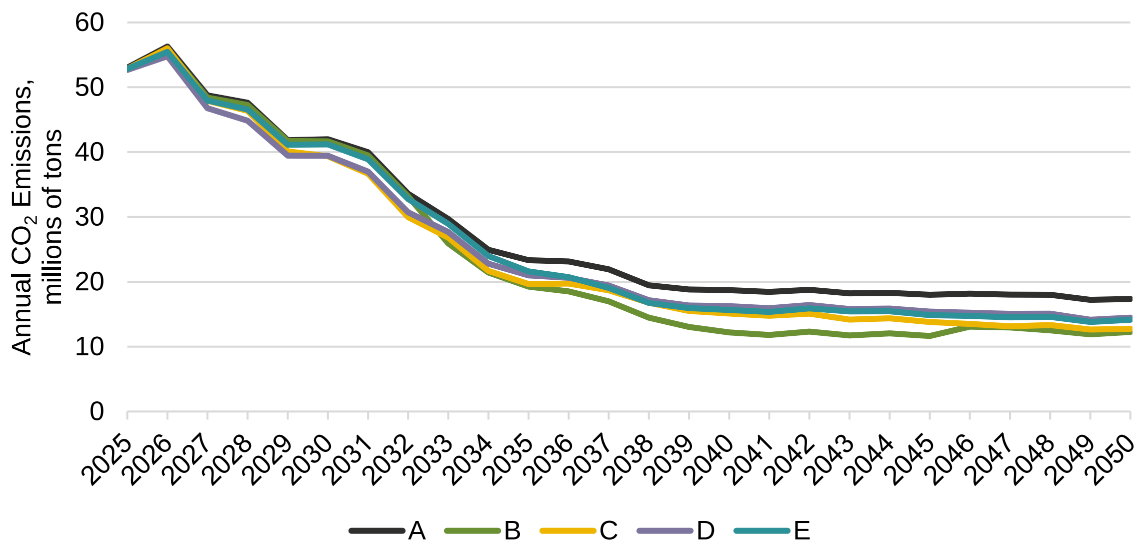


Figure 5-8: 2025-2050 Trends in Emissions of CO_2 by Alternative Strategy Based on Averages of the Six Scenarios

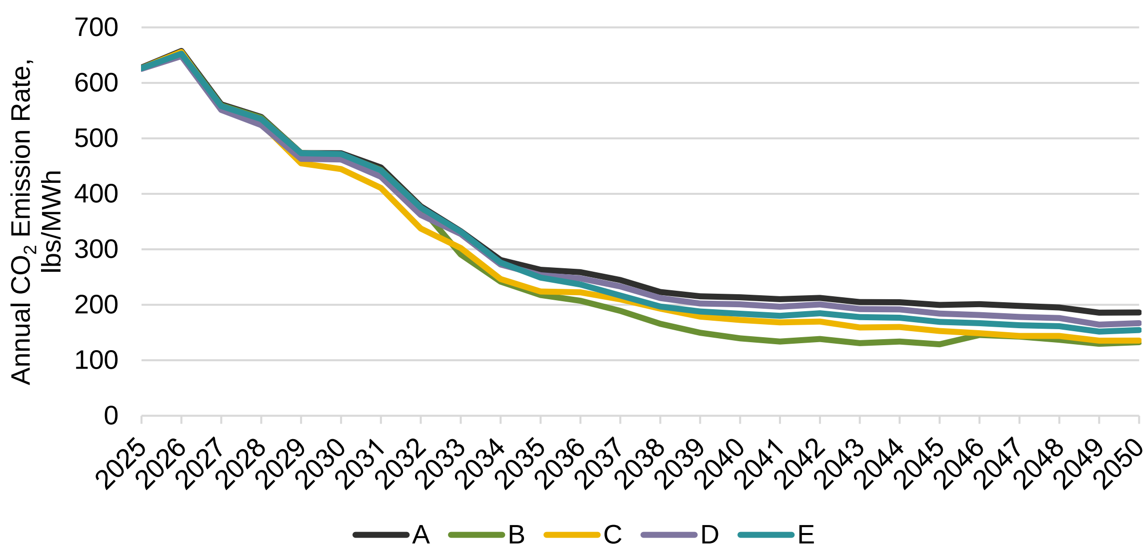
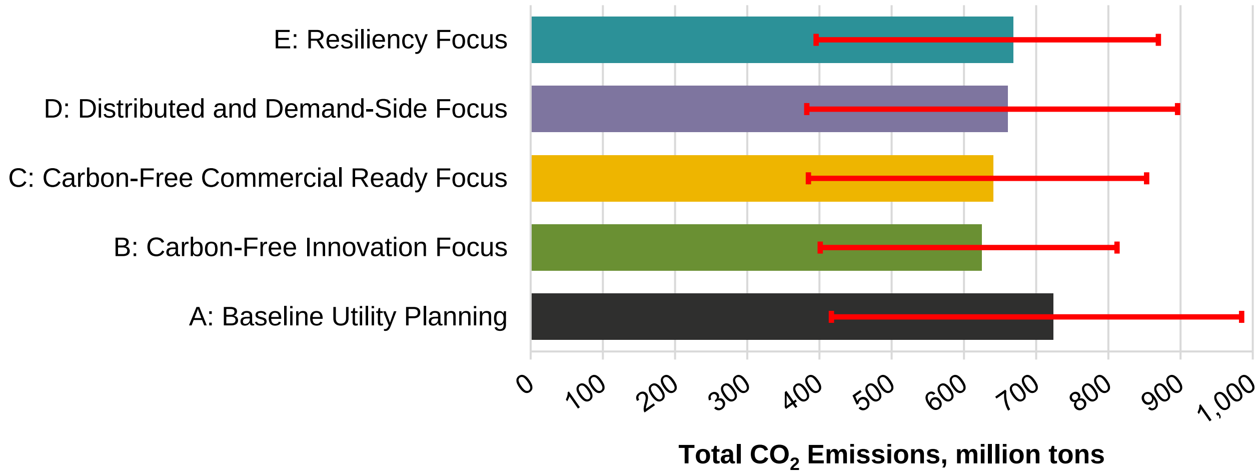
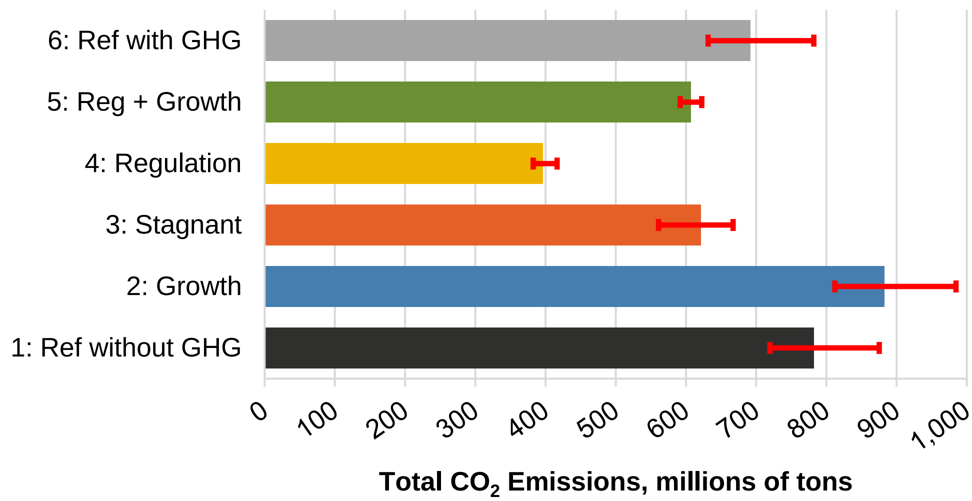


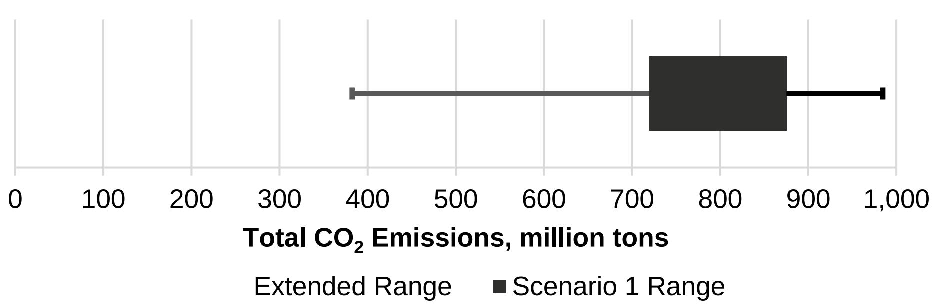
Figure 5-9: 2025-2050 Trends in CO_2 Emissions Rate by Alternative Strategy Based on Averages of the Six Scenarios



Note: The error bars in the top chart indicate the maximum and minimum values for the scenarios associated with each alternative strategy.

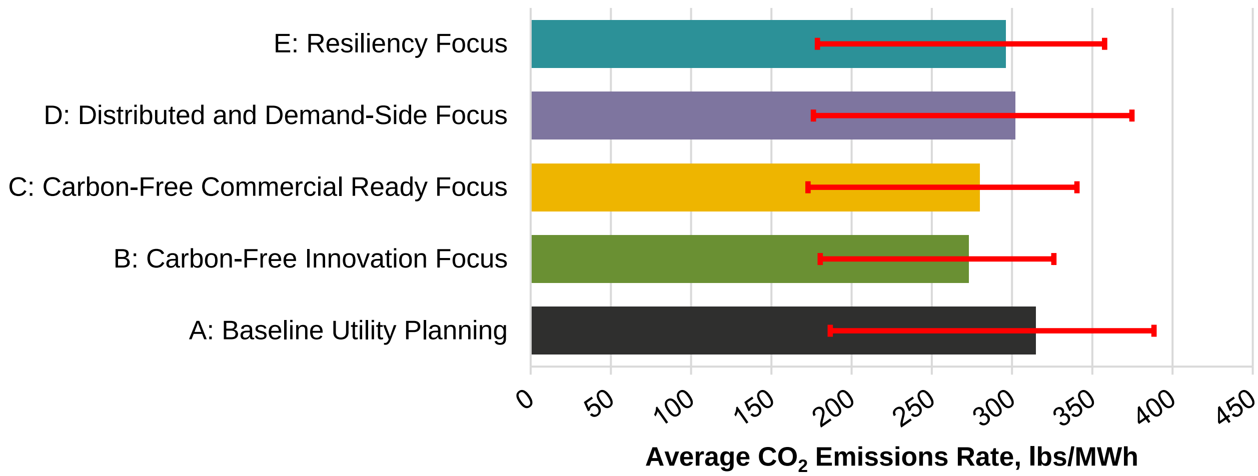


Note: The error bars in the middle chart indicate the maximum and minimum values for the alternatives associated with each scenario.

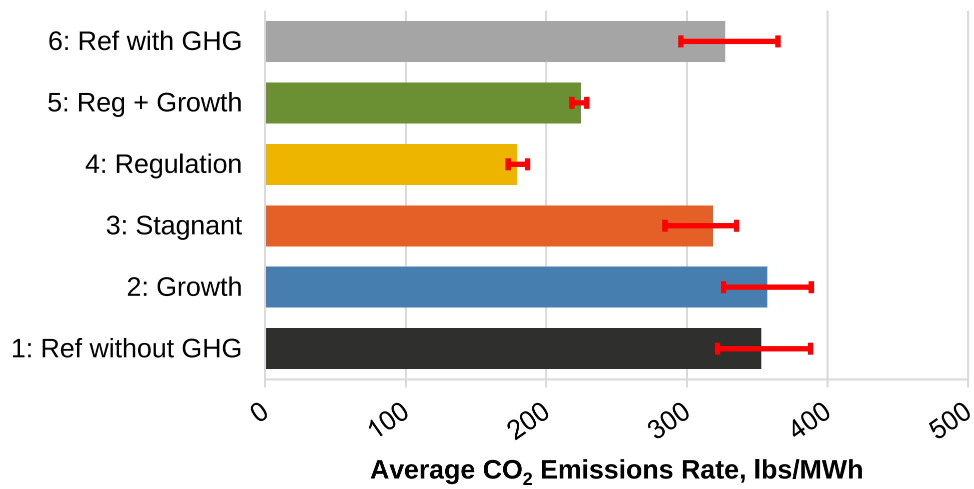


Note: The error bar in the bottom chart indicates extended range.

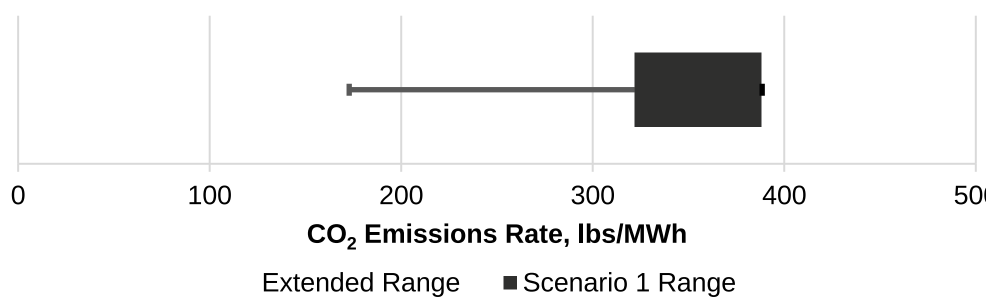
Figure 5-10: 2025-2050 Total Emissions of CO_2 by Alternative Strategy (top), Scenario (middle), and the Range for Scenario 1 as well as the Extended Range to Encompass All Scenarios and Strategies (bottom)



Note: The error bars in the top chart indicate the maximum and minimum values for the scenarios associated with each alternative strategy.



Note: The error bars in the middle chart indicate the maximum and minimum values for the alternatives associated with each scenario.



Note: The error bar in the bottom chart indicates extended range.

Figure 5-11: Average 2025-2050 CO_2 Emissions Rates by Alternative Strategy (top), Scenario (middle), and the Range for Scenario 1 as well as the Extended Range to Encompass All Scenarios and Strategies (bottom)

5.5.2.2 Direct GHG Emissions Reduction and GHG Emissions Impact on Climate Change

In addition to the forecasted reductions in direct GHG emissions from power generation, TVA has a stated aspiration to achieve net-zero carbon emissions by 2050 (TVA 2022g). 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, such as end use of electricity, steam, heating, and cooling from TVA buildings. 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 (TVA 2020f). At the end of fiscal year 2022, Scope 1 and 2 GHG emissions had been reduced by 64.1 percent, since 2008. Scope 3 emissions were reduced by 43.8 percent by the end of 2022. Additionally, energy intensity of buildings was reduced by 76.4 percent from 2003 to 2022, and renewable energy use in buildings was increased to 20.7 percent by 2022 (TVA 2022h). This falls in line with policies set forth in EO 14057, such as a 65 percent reduction in Scope 1 and Scope 2 GHG emissions by 2030, from a 2008 baseline, and net-zero emissions from federals operations by 2050 (TVA 2022h).

All alternative strategies would result in the continued, significant, long-term reductions in CO_2 emissions from the generation of power marketed by TVA. By the end of 2050, averaged across scenarios, CO_2 emissions would be reduced by approximately 60 percent (Strategy A) to 74 percent (Strategy B), compared to 2025. The climate change impacts of GHG emissions, including CO_2 emissions, have been recently described in the Fifth National Climate Assessment (USGCRP 2023). Chapter 22 of the assessment focuses on the Southeast, where there are predicted increases in climate stressors including extreme heat and precipitation events, and droughts. The Southeast frequently faces costly disasters related to weather and climate threats such as flooding, tropical storms, and hurricanes, which impact its infrastructure and agriculture. Health inequities are further exacerbated due to climate-related risks, and rising air pollution also threatens human health. Other issues include threats to the region's terrestrial and aquatic life, as land cover changes and urban development threaten unprotected biodiversity hotspots. Climate adaptation efforts also tend to be concentrated in wealthier communities, leaving under-resourced and more rural populations at a greater risk (USGCRP 2023). Other climate assessments, including the recent Intergovernmental Panel on Climate Change (IPCC) Special Report on Global Warming of 1.5 degrees Celsius (°C; 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 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 would 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.

5.5.2.3 Life Cycle GHG Emissions

In addition to the forecasted direct combustion CO_2 emissions discussed previously, TVA also developed the life cycle GHG emissions forecasts to include upstream, ongoing non-combustion, and downstream GHG emissions for each studied alternative per the 2023 CEQ NEPA guidelines on GHG and climate change analysis. Beyond direct combustion emissions, all power generating resources include additional life cycle greenhouse gas emissions associated with their construction, ongoing operations, and their decommissioning at the end of their useful life. The 2025 IRP EIS incorporates a greenhouse gas life cycle analysis (GHG LCA) in its evaluation to help quantify a full accounting of cradle-to-grave environmental impacts. For its GHG LCA, TVA partnered with the National Renewable Energy Laboratory (NREL), which has provided technical assistance, verified and generated harmonized LCA emission factors for each resource technology, and validated TVA's results by running select TVA cases through its own GHG LCA model. NREL's 2021 Los Angeles 100% Renewable Energy Study (LA100) included a GHG LCA evaluation, and TVA used this evaluation as a best practice in the development of its own GHG LCA model and approach. For more information about the scope and results of NREL's engagement with TVA, see Appendix D, which includes a summary technical report from NREL.

TVA also utilized two recently published estimates for the social cost of greenhouse gases (SC-GHG) to contextualize the results of the GHG LCA into monetary estimates. For the 2025 Draft IRP EIS, TVA utilized the 2021 White House Interim estimates for SC-GHG at a 3 percent discount rate as well as the 2023 USEPA published estimates for the SC-GHG at a 2.5 percent discount rate (USEPA 2023j; IWG 2021; NREL 2021).

5.5.2.3.1 Overview of the Greenhouse Gas Life Cycle Analysis

A GHG LCA incorporates emissions from four distinct life cycle phases: upstream, ongoing non-combustion, ongoing combustion, and downstream, as shown in Figure 5-12. Upstream emissions are primarily associated with activities required for construction and commissioning of a new power generating asset, including raw material extraction, supply chain, manufacturing, and assembly. Ongoing non-combustion emissions are the annual emissions associated with keeping a plant operational, including plant maintenance and related emissions within the supply chain and fuel cycle. In the case of natural gas and hydrogen-fired plants, the fuel cycle ongoing non-combustion emissions include upstream methane or hydrogen leakage. Ongoing combustion emissions are the annual emissions associated with direct combustion through the burning of fossil fuels at a power plant. Therefore, only power plants that burn fossil fuels or other combustible materials include direct combustion emissions. Finally, downstream emissions are associated with activities required for decommissioning at the end of a plant's useful life, including dismantling, disposal, and returning the site to a brownfield state.

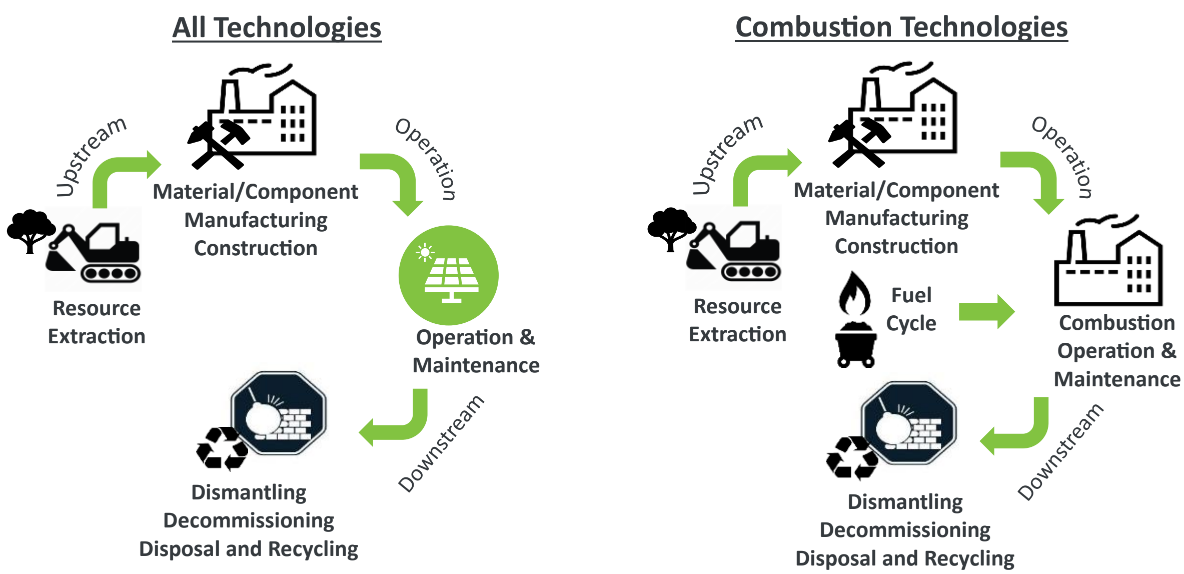


Figure 5-12: Overview of Life Cycle Phases for which Emissions are Incorporated into GHG LCA (source: NREL)

Emission factors must be used to calculate the estimated emissions associated with upstream, ongoing non-combustion, and downstream activities. Emission factors represent the quantity of emissions (in grams) emitted on a unitized basis (either per installed kW or per kWh generated). Harmonized CO_2e emission factors were sourced from NREL for all resource types included in the 2025 Draft IRP results. For upstream and downstream emissions, the emission factors are provided in terms of grams per installed capacity (g/kW). Ongoing combustion CO_2 emissions are calculated by the EnCompass model licensed through Anchor Power Solutions as a part of the development of portfolio energy plans in the IRP. For ongoing non-combustion emissions, emission factors are provided in terms of grams per unit of generation (g/kWh). The value of emissions factors for each electric power technology resource can be found in Table 5-16.

Table 5-16: CO_2e Emission Factors for all Life Cycle Phases, by Resource Type

Electric Power Technology	One-Time Upstream GHG (CO_2e), g/kW	Ongoing Annual Combustion GHG (CO_2e), g/kW-hr	Ongoing Annual Non-Combustion GHG (CO_2e), g/kW-hr	One-Time Downstream GHG (CO_2e), g/kW
Coal, Supercritical	867,240	Emissions Calculated Separately[1]	10.00	67,100
Coal, Subcritical	708,246	Emissions Calculated Separately[1]	4.90	67,100
Combined Cycle	100,000	Emissions Calculated Separately[1]	62.00	4,070
Combined Cycle with Carbon Capture	1,352,700	Emissions Calculated Separately[1]	106.75	4,086
Hydrogen CC	100,000	Emissions Calculated Separately[1]	28.90	4,070
Combustion Turbine	64,790	Emissions Calculated Separately[1]	70.00	2,600
Diesel	1,021	Emissions Calculated Separately[1]	97.17	18
Hydro	1,100	NA	1.90	-
Nuclear	483,552	NA	12.00	175,000
Nuclear SMR	483,552	NA	12.00	175,000
Pumped Hydro	310	NA	1.80	7
Solar	1,630,000	NA	9.40	37,800
Wind	619,000	NA	0.74	14,000
Landfill Gas	64,790	NA	38.00	2,600
Biomass	1,960	NA	6.02	35
Battery	527,000	NA	-	98,900
Market Purchases	NA	Emissions Calculated Separately[1]	62.00	N/A

NA – Not applicable
1 – Emissions are determined in the GHG LCA using individual plant heat rates and estimated carbon content of the fuel

Upstream emissions are assumed to occur in the year prior to the start of operations while downstream emissions are assumed to occur in the year following the final year of operations. Ongoing non-combustion emissions are calculated on an annual basis based on the amount of total generation each resource type produces in that year. Figure 5-13 shows an example of annual impacts for different resources.

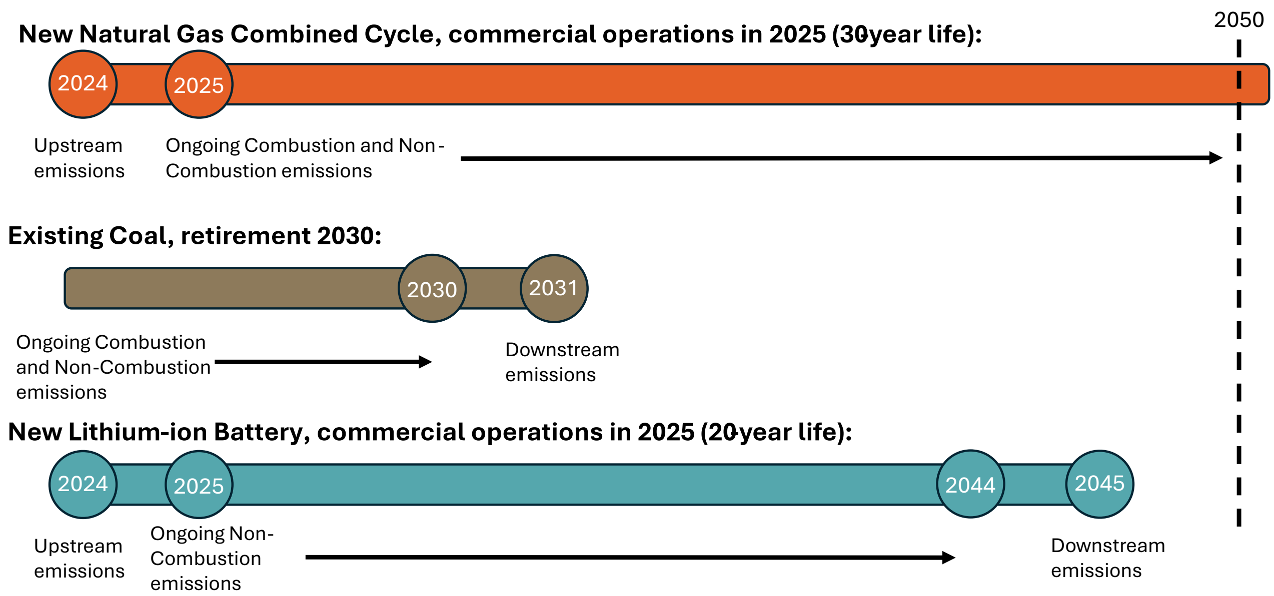


Figure 5-13: Life Cycle Phase Annual Impact Examples

5.5.2.3.2 2025 IRP Greenhouse Gas Life Cycle Analysis Approach

The results of the 30 core portfolios of resources from the 2025 draft IRP were pulled into TVA's GHG LCA model. These results included forecasted generation by unit, build and retirement schedules, and direct CO_2 emissions. The GHG LCA model utilized emission factors, provided by NREL, to calculate GHG emissions for each life cycle phase by year. GHG's included in the scope of the study included carbon dioxide (CO_2), methane (CH_4), and nitrous oxide (N_2O). Finally, TVA utilized two different estimates for the social cost of greenhouse gases (SC-GHG) to contextualize the monetary impact of emissions. For completeness, TVA also estimated upstream hydrogen (H_2) leakage for scenarios 4 and 5, although there is not an associated social cost estimate for hydrogen. An overview of the process can be found in Figure 5-14.

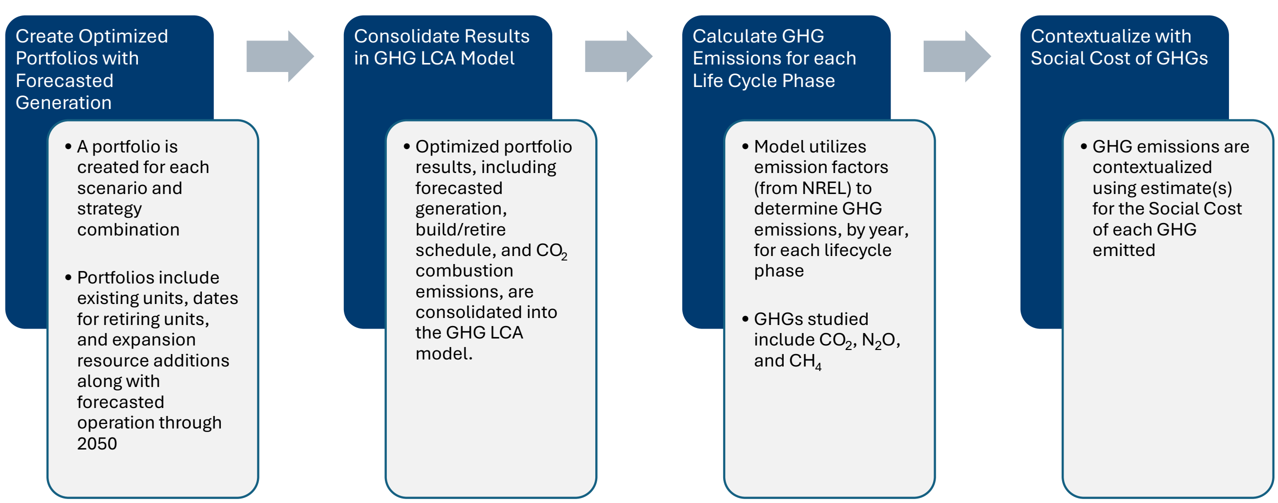


Figure 5-14: Overview of TVA's GHG LCA Approach

5.5.2.3.3 Key Assumptions

The scope of the 2025 IRP GHG LCA is calendar years 2024 through 2050. Emissions associated with activities occurring outside of this window are excluded from the study. Although many units will likely operate beyond 2050, there are too many unknown variables to account for their impacts beyond the study window of the IRP. Some of these unknown variables include changes in system load, unit generation, and other replacement assets elsewhere in the system beyond 2050.

A small number of resources included in the 2025 IRP study represent shorter-term PPAs where the asset was not built exclusively for TVA's use. An example of this could be a natural gas CC facility located outside the TVA region under a 2-year firm capacity contract. Since this facility was not built for the sole purpose of providing TVA with power and the facility is not likely to be retired at the end of the 2-year PPA, it would be incorrect for the GHG LCA to calculate and assign upstream and downstream emissions against the TVA system. As such, TVA identified and excluded these contracts from the upstream and downstream emissions calculations. However, the ongoing combustion and non-combustion emissions were calculated and assigned to the TVA system for the duration of these contracts.

To support the calculation of social costs, TVA worked with NREL to disaggregate the CO_2e emission factors, shown in a prior section, into the three primary GHGs of concern: CO_2, N_2O, and CH_4. Disaggregation percentages were provided by NREL. TVA used these percentages, along with the latest 100-year global warming potential values for N_2O (273) and CH_4 (27.9) from the IPCC 6th Assessment Report, to generate the following emission factor tables for each GHG (Table 5-17, Table 5-18, Table 5-19). Additional information regarding the disaggregation process can be found in NREL's supplied technical support documentation located in Appendix D.

Scenarios 4 and 5 incorporate the use of hydrogen-fueled CC facilities. Ongoing annual non-combustion emissions for a hydrogen CC were estimated by NREL utilizing assumptions around the mix of renewable energy sources used to generate green hydrogen (i.e., hydrogen developed via electrolysis utilizing renewable electricity). Additionally, since hydrogen leaked to the atmosphere is an indirect greenhouse gas, TVA calculated estimated upstream hydrogen leakage at 0.571 percent of total gross annual hydrogen consumption. Additional information can be found in NREL's technical appendix located in Appendix D.

Table 5-17: CO_2 Emission Factors for all Life Cycle Phases, by Resource Type

Electric Power Technology	One-Time Upstream CO_2, g/kW	Ongoing Annual Combustion CO_2, g/kW-hr	Ongoing Annual Non-Combustion CO_2, g/kW-hr	One-Time Downstream CO_2, g/kW
Coal, Supercritical	812,013	Emissions Calculated Separately[1]	5.10	65,134
Coal, Subcritical	653,782	Emissions Calculated Separately[1]	2.64	65,134
Combined Cycle	94,051	Emissions Calculated Separately[1]	31.47	3,951
Combined Cycle with Carbon Capture	1,272,227	Emissions Calculated Separately[1]	59.25	3,966
Hydrogen CC	94,051	Emissions Calculated Separately[1]	26.59	3,951
Combustion Turbine	60,038	Emissions Calculated Separately[1]	35.53	2,524
Diesel	60,038	Emissions Calculated Separately[1]	49.32	18
Hydro	1,045	NA	1.81	-
Nuclear	478,319	NA	11.04	167,065
Nuclear SMR	478,319	NA	11.04	167,065
Pumped Hydro	294	NA	1.70	7
Solar	1,455,198	NA	8.47	36,692
Wind	567,827	NA	0.71	13,590

Electric Power Technology	One-Time Upstream CO_2, g/kW	Ongoing Annual Combustion CO_2, g/kW-hr	Ongoing Annual Non-Combustion CO_2, g/kW-hr	One-Time Downstream CO_2, g/kW
Landfill Gas	59,787	NA	36.30	2,524
Biomass	1,796	NA	5.78	34
Battery	481,113	NA	0	96,002
Market Purchases	NA	Emissions Calculated Separately[1]	31.47	NA

NA – Not applicable
[1] Emissions are determined in the GHG LCA using individual plant heat rates and estimated carbon content of the fuel.

Table 5-18: CH_4 Emission Factors for all Life Cycle Phases, by Resource Type

Electric Power Technology	One-Time Upstream CH_4, g/kW	Ongoing Annual Combustion CH_4, g/kW-hr	Ongoing Annual Non-Combustion CH_4, g/kW-hr	One-Time Downstream CH_4, g/kW
Coal, Supercritical	1,794	Emissions Calculated Separately[1]	0.17	43
Coal, Subcritical	1,810	Emissions Calculated Separately[1]	0.08	43
Combined Cycle	188	Emissions Calculated Separately[1]	1.08	3
Combined Cycle with Carbon Capture	2,540	Emissions Calculated Separately[1]	1.69	3
Hydrogen CC	188	Emissions Calculated Separately[1]	0.07	3
Combustion Turbine	150	Emissions Calculated Separately[1]	1.22	2
Diesel	150	Emissions Calculated Separately[1]	1.70	0
Hydro	2	NA	0.00	-
Nuclear	60	NA	0.03	237
Nuclear SMR	60	NA	0.03	237
Pumped Hydro	1	NA	0.00	0
Solar	5,763	NA	0.02	24
Wind	1,635	NA	0.00	9
Landfill Gas	151	NA	0.05	2
Biomass	6	NA	0.01	0
Battery	1,423	NA	-	63
Market Purchases	NA	Emissions Calculated Separately[1]	1.08	NA

NA – Not applicable
[1] Emissions are determined in the GHG LCA using individual plant heat rates and estimated carbon content of the fuel.

Table 5-19: N_2O Emission Factors for all Life Cycle Phases, by Resource Type

Electric Power Technology	One-Time Upstream N_2O, g/kW	Ongoing Annual Combustion N_2O, g/kW-hr	Ongoing Annual Non-Combustion N_2O, g/kW-hr	One-Time Downstream N_2O, g/kW
Coal, Supercritical	19	Emissions Calculated Separately[1]	0.000622	3
Coal, Subcritical	15	Emissions Calculated Separately[1]	0.000287	3
Combined Cycle	3	Emissions Calculated Separately[1]	0.001199	0
Combined Cycle with Carbon Capture	35	Emissions Calculated Separately[1]	0.001308	0
Hydrogen CC	3	Emissions Calculated Separately[1]	0.001059	0
Combustion Turbine	2	Emissions Calculated Separately[1]	0.001353	0
Diesel	2	Emissions Calculated Separately[1]	0.001878	0
Hydro	0	NA	0.000038	-

Electric Power Technology	One-Time Upstream N_2O, g/kW	Ongoing Annual Combustion N_2O, g/kW-hr	Ongoing Annual Non-Combustion N_2O, g/kW-hr	One-Time Downstream N_2O, g/kW
Nuclear	13	NA	0.000755	5
Nuclear SMR	13	NA	0.000755	5
Pumped Hydro	0	NA	0.000045	0
Solar	51	NA	0.001872	2
Wind	20	NA	0.000015	1
Landfill Gas	3	NA	0.000737	0
Biomass	0	NA	0.000177	0
Battery	23	NA	-	4
Market Purchases	NA	Emissions Calculated Separately[1]	0.001199	NA

NA – Not applicable
[1] Emissions are determined in the GHG LCA using individual plant heat rates and estimated carbon content of the fuel.

5.5.2.3.4 Greenhouse Gas Life Cycle Analysis Results

Annual total GHG emissions were calculated for all four life cycle phases and all three primary greenhouse gases in each of the 30 core portfolios. Additionally, annual hydrogen leakage was calculated for Scenarios 4 and 5. A summary overview of each strategy's average performance is shown in Table 5-20. The first five columns demonstrate average strategy performance across all six scenarios. The final two columns provide the upper and lower bounds of the five Scenario 1 portfolios and the upper and lower bounds across all 30 IRP portfolios.

Table 5-20: Average Cumulative GHG Emissions (2024-2050, millions of short tons)

	Strategy A (Scenarios 1-6)	Strategy B (Scenarios 1-6)	Strategy C (Scenarios 1-6)	Strategy D (Scenarios 1-6)	Strategy E (Scenarios 1-6)		Scenario 1 Range (Strategies A-E)	All Scenarios (1-6) Range (Strategies A-E)
CO_2								
Average Cumulative Emissions, 2024-2050	921.548	818.463	834.173	852.986	864.884	Min Max	898.168 1,052.865	576.31 1,200.10
CH_4								
Average Cumulative Emissions, 2024-2050	2.442	2.268	2.138	2.326	2.299	Min Max	2.101 2.462	1.819 2.811
N_2O								
Average Cumulative Emissions, 2024-2050	0.0246	0.0226	0.0229	0.0231	0.0234	Min Max	0.0237 0.0265	0.0180 0.0309
H_2*								
Average Cumulative Leakage, 2024-2050	0.329	0.270	0.258	0.278	0.312		N/A N/A	0.126 0.473

*Hydrogen leakage only applies to Scenarios 4 and 5

Average cumulative GHG emissions are highest for Strategy A, Baseline Utility Planning. Average cumulative GHG emissions are lowest for Strategy B, Carbon-free Innovation Focus, followed closely by Strategy C, Carbon-free Commercial Ready Focus. Overall, the results from the LCA are directionally similar to combustion-only, direct emissions discussed in Section 5.5.2.1 because direct, combustion CO_2 emissions make up the largest share of overall life cycle GHG emissions for the overall TVA system in most years, for most cases.

As shown in the All Scenarios Range column of Table 5-20, the lowest cases are approximately 40 percent lower than Strategy A averaged across all scenarios, which is largely a result of portfolio evolution occurring in the net-zero regulation scenarios. Overall case 2A, Higher Growth Economy with Baseline Utility Planning, has the highest average cumulative GHG emissions, due to higher electric loads driving up the use of natural gas. Meanwhile, case 4D, Net-zero Regulation with Distributed and Demand Side Focus, has the lowest average cumulative GHG emissions, driven by carbon regulations in the scenario and increased emphasis on low-emitting demand-side and distributed generation resources.

5.5.2.3.5 Primary Life Cycle Phase Emissions by Greenhouse Gas

Of the three primary GHGs, CO_2 represents the largest volume of overall emissions. For CO_2, the highest emissions occur during the Ongoing Combustion phase, primarily due to the burning of fossil fuels. Typically, the Ongoing Non-Combustion phase releases the second largest volume of CO_2, followed by Upstream and then Downstream emissions (Figure 5-15).

CH_4 accounts for significantly less volume of overall emissions compared to CO_2, but more than N_2O. In contrast to the other two GHGs, the highest emissions for CH_4 occur during the Ongoing Non-Combustion phase. This is due primarily to methane leakage, which occurs as a part of the natural gas supply chain and fuel procurement cycle. After Ongoing Non-Combustion, the highest emissions for CH_4 are produced in this order: Upstream, Ongoing Combustion, and Downstream (Figure 5-16).

N_2O accounts for the least amount of GHG Life Cycle emissions by volume overall. Similar to CO_2, the highest emissions are produced during Ongoing Combustion, followed by Ongoing Non-Combustion, Downstream, and Upstream (Figure 5-17).

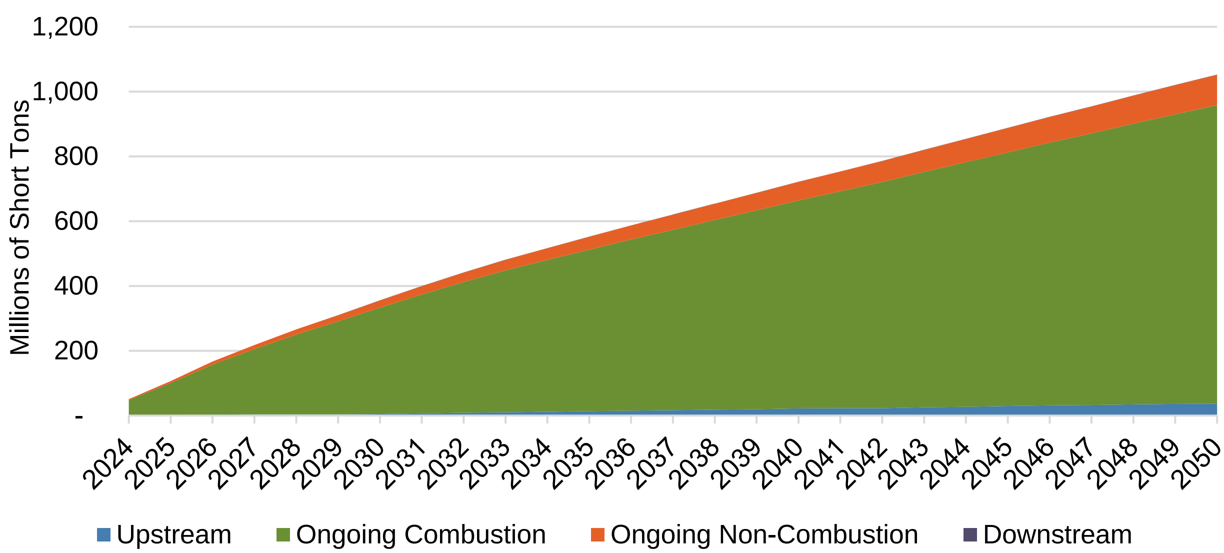


Figure 5-15: Cumulative CO_2 Emissions, Case 1A, 2024-2050

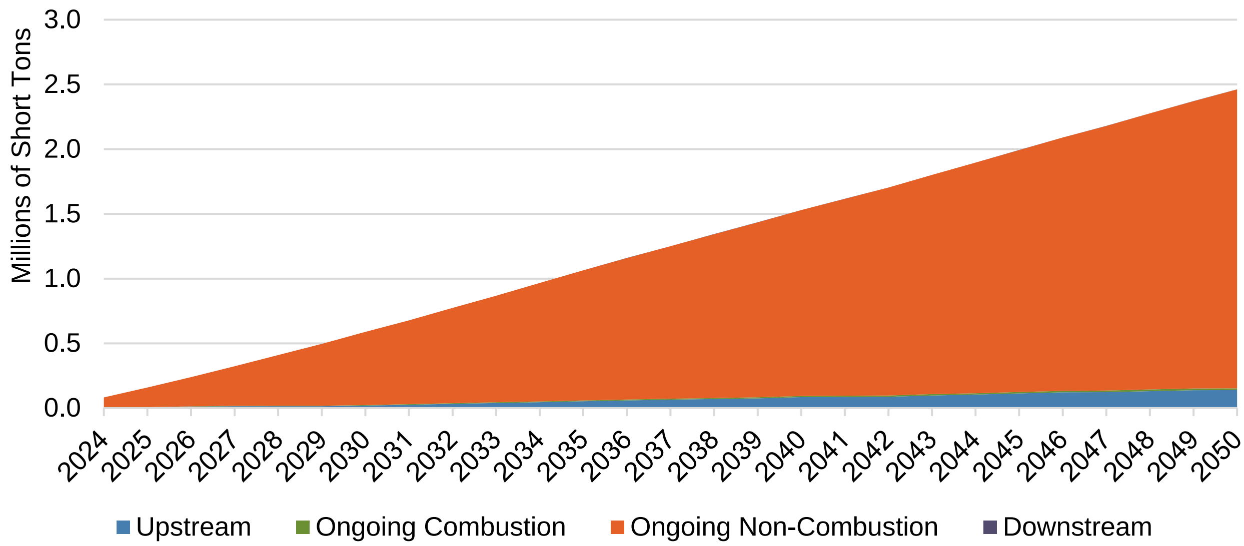


Figure 5-16: Cumulative CH_4 Emissions, Case 1A, 2024-2050

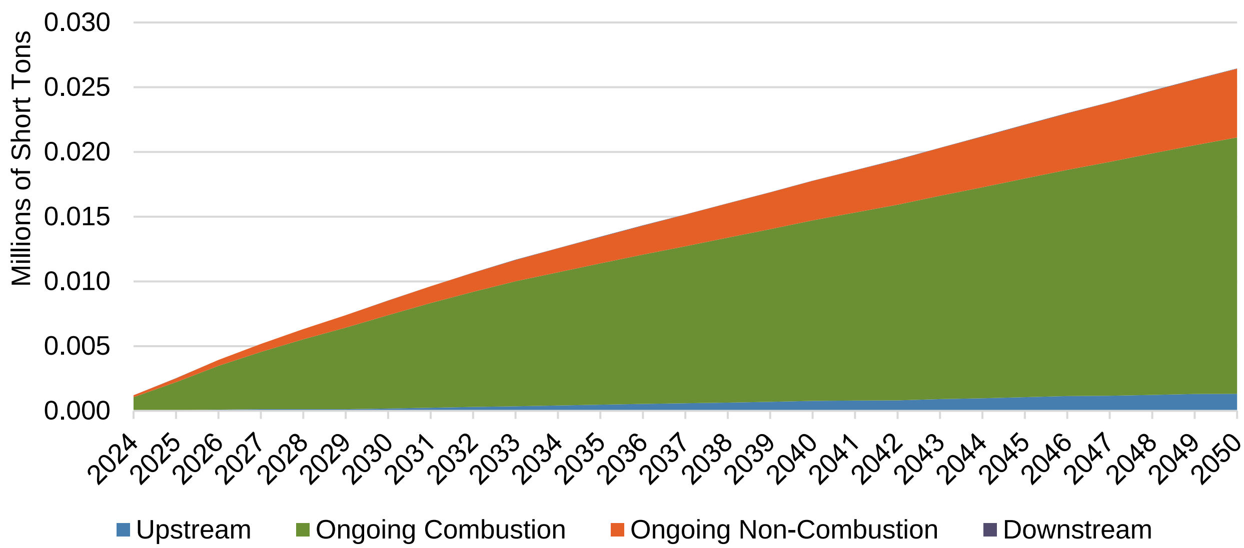


Figure 5-17: Cumulative N_2O Emissions, Case 1A, 2024-2050

5.5.2.4 Social Cost of Life Cycle GHG Emissions

Based on the forecasted life cycle GHG emissions under each alternative strategy (see Section 5.5.2.3), TVA estimated the SC-GHG, consistent with CEQ's 2023 guidance on considering GHG emissions and climate change in NEPA reviews.

The SC-GHG analysis in this EIS collectively refers to the estimated future social cost of three main greenhouse gases: CO_2, CH_4, and N_2O. Each of these GHGs has a unique social cost rate in units of dollars per metric ton of emissions. The SC-GHG is a monetary estimate of the economic damages associated with the emission of each additional ton of GHG into the atmosphere on a yearly basis, or the benefit of avoiding an emission increase. This approximation is used to assess the economic impacts of climate change and to inform decisions related to mitigation efforts based on, but not limited to, changes in net agricultural productivity, human health effects, property damage from increased flood risk and natural disasters, disruption of energy systems, risk of conflict, environmental migration, and the value of ecosystem services. The SC-GHG is used to estimate, in dollars, how much it is worth today to avoid the economic damage that is projected for the future. The SC-GHG analysis included provides a rough means of comparing alternative actions by monetizing the potential environmental impacts of their estimated future GHG emissions.

As previously stated, the 2025 Draft IRP utilizes two recently published estimates for the SC-GHG to contextualize the results of the GHG LCA into monetary estimates. In 2021, the White House released interim estimates for the social cost of CO_2, CH_4, and N_2O based on work performed by the Interagency Working Group on Social Cost of Greenhouse Gases under EO 13990 (henceforth referred to as "2021 White House estimates"). The 2021 White House estimates include social costs for CO_2, CH_4, and N_2O at an average statistic with a 5 percent, 3 percent, and 2.5 percent discount rate and at the 95th percentile with a 3 percent discount rate. The estimates calculated at an average statistic with a 3 percent discount rate were used as the first estimate for the SC-GHG in the Draft 2025 IRP. For the second estimate, TVA referenced the USEPA's 2023 supplementary material for the Regulatory Impact Analysis for the Final Rulemaking, "Standards of Performance for New Reconstructed, and Modified Sources and Emissions Guidelines for Existing Sources: Oil and Natural Gas Sector Climate Review" (henceforth referred to as "2023 USEPA estimates"). The 2023 USEPA estimates include social costs for CO_2, CH_4, and N_2O at discount rates of 2.5 percent, 2 percent, and 1.5 percent. The estimates calculated at a 2 percent discount rate were used as the second estimate for the social cost of greenhouse gases in the Draft 2025 IRP. Table 5-21 and Table 5-22 include 5-year snapshots of the social costs for each greenhouse gas under the two estimates. See Appendix D for a full listing of costs across all years.

Table 5-21: 2021 White House Estimates for the Social Cost of Greenhouse Gases, 3.0 Percent Discount Rate and Average Statistic (in 2020$ per metric ton)

Year	Social Cost of CO_2	Social Cost of CH_4	Social Cost of N_2O
2020	$51	$1,485	$18,405
2025	$56	$1,720	$20,591
2030	$62	$1,954	$22,776
2035	$67	$2,231	$25,236
2040	$73	$2,508	$27,695
2045	$79	$2,788	$30,342
2050	$85	$3,067	$32,989

Table 5-22: 2023 USEPA Estimates for the Social Cost of Greenhouse Gases, 2.0 Percent Discount Rate and Average Statistic (in 2020$ per metric ton)

Year	Social Cost of CO_2	Social Cost of CH_4	Social Cost of N_2O
2020	$193	$1,648	$54,139
2025	$212	$2,025	$60,267
2030	$230	$2,403	$66,395
2035	$248	$2,842	$72,644
2040	$267	$3,280	$78,894
2045	$287	$3,756	$85,945
2050	$308	$4,231	$92,996

The 2021 White House estimates and the 2023 USEPA estimates were converted to nominal dollars and from metric ton to short ton. As the two different estimates were reported in 2020 dollars, each year's Social Cost was multiplied by a forecasted gross domestic product (GDP) price deflator to transform each gas's Social Cost from real to nominal dollars. Then, each dollar amount was multiplied by a metric to short ton conversion factor (1.10231) to report nominal Social Cost per short ton. Annual nominal costs in short tons used for each social cost estimate are provided in Appendix D.

5.5.2.4.1 Social Cost of Greenhouse Gases Results

Annual social costs were calculated for all four life cycle phases and all three primary GHG in each of the 30 core portfolios by multiplying the annual emission amounts by the appropriate social cost for that year. The Net Present Value (NPV) of this nominal stream of annual costs was then calculated to create an overall present value cost of each portfolio, by life cycle phase and by GHG. A summary overview of each strategy's average cost under both of the social-cost estimates is shown in Table 5-23. Additional details can be found in Appendix D.

Table 5-23: Average Social Cost under each Strategy (NPV 2024-2050, millions of 2024$)

	Strategy A (Scenarios 1-5)	Strategy B (Scenarios 1-5)	Strategy C (Scenarios 1-5)	Strategy D (Scenarios 1-5)	Strategy E (Scenarios 1-5)		Reference Case Range (Scenario 1, Strategies A-E)	All Scenarios (1-5) Range (Strategies A-E)
CO_2								
Average Social Cost[1]	$41,002	$37,413	$37,885	$38,311	$38,961	Min	$39,820	$28,270
						Max	$45,200	$51,220
Average Social Cost[2]	$151,897	$138,777	$140,481	$141,991	$144,419	Min	$147,505	$105,226
						Max	$167,161	$189,374
CH_4								
Average Social Cost[1]	$3,307	$3,108	$2,945	$3,162	$3,136	Min	$2,882	$2,532
						Max	$3,311	$3,761
Average Social Cost[2]	$4,207	$3,942	$3,729	$4,018	$3,981	Min	$3,653	$3,197
						Max	$4,219	$4,800
N_2O								
Average Social Cost[1]	$399	$373	$376	$376	$383	Min	$383	$298
						Max	$420	$487
Average Social Cost[2]	$1,154	$1,079	$1,088	$1,087	$1,106	Min	$1,107	$862
						Max	$1,212	$1,405
Total								
Average Total Social Cost[1]	$44,708	$40,894	$41,207	$41,849	$42,480	Min	$43,085	$31,100
						Max	$48,931	$55,468
Average Total Social Cost[2]	$157,257	$143,799	$145,299	$147,096	$149,506	Min	$152,266	$109,286
						Max	$172,592	$195,578

[1] 2021 White House Guidance
[2] 2023 USEPA Guidance

As social costs are driven by emissions generated, strategies and cases with the highest emissions also result in the highest social costs. The average NPV of social costs is highest for Strategy A, Baseline Utility Planning. The average NPV of social costs are lowest for Strategy B, Carbon-free Innovation Focus, followed closely by Strategy C, Carbon-free Commercial Ready Focus. Compared to Strategy A, Baseline Utility Planning, the average total social cost for Strategy B is 8.53 percent and 8.56 percent lower for WH and EPA estimates respectively. Strategy C is 7.83 percent and 7.60 percent lower than Strategy A for WH and EPA estimates respectively.

Key uncertainties within each scenario have a large impact on the range of portfolio social costs, with the biggest drivers being the load forecast and potential carbon regulations. Overall, case 2A, Higher Growth

Economy with Baseline Utility Planning, has the highest NPV social cost, under both the 2021 White House estimates and 2023 USEPA estimates. This higher cost is driven by higher electric loads leading to an increase in natural gas-fired generation. Meanwhile, case 4D, Net-zero Regulation with Distributed and Demand-side Focus, has the lowest NPV social cost under both the 2021 White House estimates and the 2023 USEPA estimates. Other strategies in Scenario 4, namely Strategy C, which focus on commercial ready carbon-free technologies, are also very close to featuring the lowest overall social cost. The carbon regulations present in Scenario 4 drive the portfolio to net-zero direct emissions by 2050, which is the main driver for these lower social costs.

5.5.2.4.2 Conclusion

Overall, cases utilizing Strategy A, Baseline Utility Planning, contained the highest level of cumulative GHG emissions as well as the highest NPV of SC-GHG. Conversely, cases utilizing Strategies B and C, Carbon-free Innovation Focus and Carbon-free Commercial Ready Focus, generally saw the lowest levels of cumulative GHG emissions as well as the lowest NPV of SC-GHG.

5.5.2.5 Climate Change and Adaptation

According to its Climate Action Adaptation and Resiliency Plan (TVA 2021b), TVA identified the following climate change risks relevant to the TVA power system:

- Increased demand for cooling as the number of days over 95 degrees Fahrenheit (°F) is expected to increase.
- Decreased efficiency of thermoelectric power plants due to higher temperatures.
- Increased instances of low dissolved oxygen levels, due to warmer waters.
- Drought and stresses on the water supply are expected to increase.
- Downpours, which may lead to sewage overflows, can cause contaminated drinking water.
- Extreme weather can contribute to power outages and negatively impact energy infrastructure.
- Warmer air temperatures reduce transmission line capacity and may reduce the life expectancy of transformers.

Recent and projected trends in temperature and precipitation in the TVA region are described above in Section 4.3 and, for the larger Southeast, in the 5th USGCRP (2023). Projected trends from climate change models include increases in average temperature, the number of days over 95°F, the number of nights over 75°F, and decreases in number of days below 32°F. Predicted trends in precipitation indicate that the Southeast has received more precipitation in the fall, but drier conditions in spring and summer, and is more drought prone due to increases in evapotranspiration (USGCRP 2023).The EPRI and TVA (2009) report described the effects of the forecast climate change based on the 2007 IPCC report in the TVA region. Potential effects due to climate change include more frequent and intense heat waves, increased damage from floods and major storm events, damage from thawing permafrost and sea ice, reduced freshwater availability during dry seasons, and harm to water resources, agriculture, wildlife, and ecosystems (TVA 2023f). 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. Acidification of surface water through precipitation that deposits sulfate and nitrate aerosols can also cause adverse effects on aquatic life, especially in sensitive ecosystems (TVA 2023f). 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. For example, TVA had to reduce power generation at its Brown Ferry Nuclear Plant in 2007, 2010, and 2011 because river temperatures were too high to receive discharge water from the plant without increasing ecological risk (GAO 2022). 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 1.0°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 Reservoir Operations Study (TVA 2004) provide TVA flexibility to adapt to some climate change impacts while minimizing the effects on thermal generation. The analyses in the Reservoir Operations Study 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 (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 PSA, climate stressors could change that abundance, either locally or regionally, 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 would 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. On the other hand, intra-annual droughts, which are predicted to become more frequent and long-lasting in the Southeast, could reduce water availability for power plant operations that require water for cooling. During a drought from 2007 to 2008, coal prices doubled, forcing TVA to rely on additional natural gas to meet its needs, and even as the drought eased in 2008, hydroelectric generation was still only at 49 percent of normal operations (GAO 2022). These changes would 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 (GAO) 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 (GAO 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, which makes 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. According to a 2021 report, TVA has spent $155 million since 2009 to protect certain nuclear assets from extreme flooding. After a flooding event in 2010, where it subsequently spent $9 million to relocate a substation to higher ground, TVA then evaluated the vulnerability of all substations and switching stations (GAO 2022).

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 require little to no water to operate. Potential impacts to water resources, except for 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 CWA by meeting state water quality standards and through compliance with NPDES permit requirements. A full list of average water resource requirements (withdrawals and consumption) for each of the 30 portfolios can be found in Appendix C.

Based on the model results, the volume of water withdrawn by thermal generating facilities, (i.e., nuclear, coal, and CC facilities) would decrease between 2025 and 2050 under all alternative strategies (Figure 5-18). As illustrated in Figure 5-18, the decrease value is similar for each strategy and ranges from 45.5 to 46.1 percent. All strategies result in a decrease of water withdrawal at roughly the same amounts. This is due to the planned retirements, making all strategies similar in their water withdrawal needs as these facilities come offline and future generation sources utilize less water withdrawal.

The annual average volume of water withdrawn varies by less than 1 percent among the strategies, whereas the annual average volume of water withdrawn varies around 3.3 percent among the scenarios associated with each strategy (Figure 5-19). 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 would generally decrease in the middle of the planning period due to retirements of coal plants. In general, replacement generation has lower water use rates. Temporary spikes in water use for all strategies may occur due to projected timing of maintenance and refueling outages.

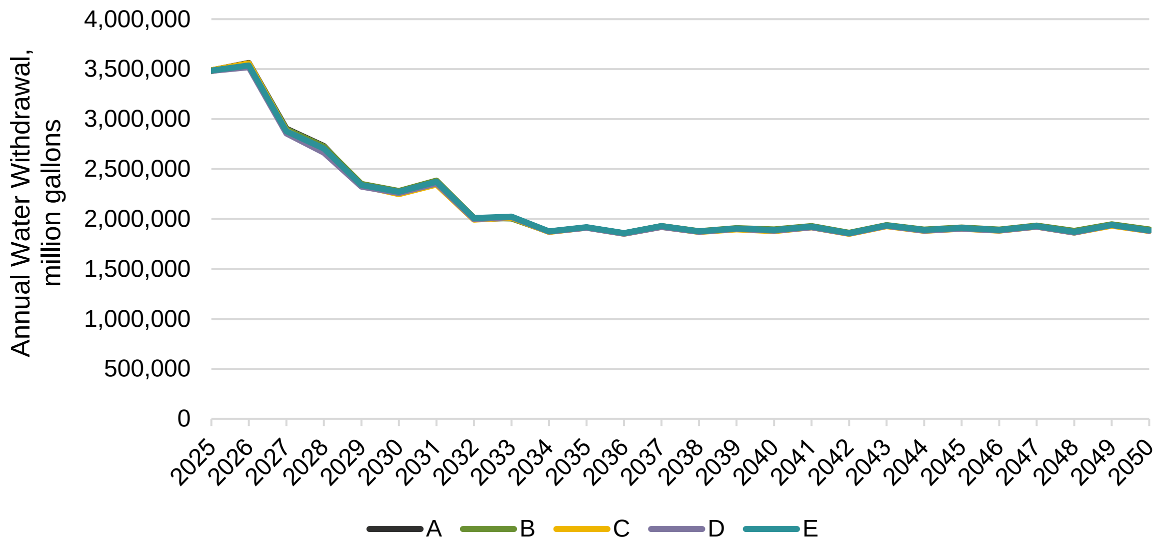
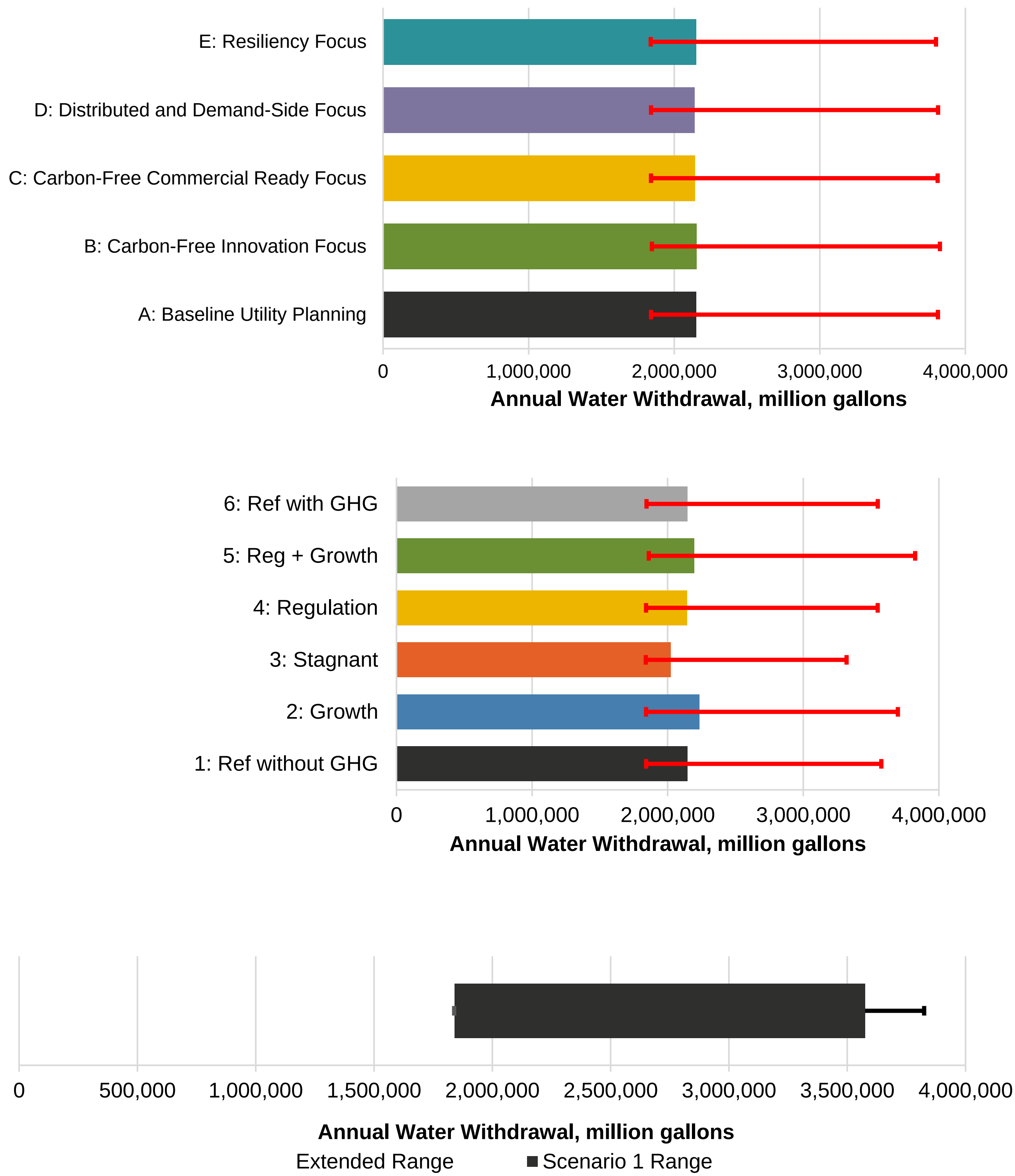


Figure 5-18: Trends in Water Withdrawal by Alternative Strategy Based on Averages of the Six Scenarios



Note: The error bars in the top chart indicate the maximum and minimum values for the scenarios associated with each alternative strategy.

Figure 5-19: Average Annual 2025-2050 Water Withdrawal by the Alternative Strategy (top), Scenario (middle), and the Range for Scenario 1 as well as the Extended Range to Encompass All Scenarios and Strategies (bottom)

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 Figure 5-18 and Figure 5-19.

Figure 5-20 and Figure 5-21 show the 2025-2050 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 4 percent of the total quantity of water used under each alternative strategy.

Water consumption decreases from 2025 to 2050 in all strategies due to planned coal retirements by 2035. Water consumption is lowest in Strategy C, which has the highest levels of renewable generation that displace thermal generation, and it is higher in Strategies B and E that include additional nuclear capacity. The reductions, averaged across scenarios associated with each alternative strategy, were least under Strategy B (21.0 percent) and greatest under Strategy C (25.1 percent). The variation in average annual water consumption (Figure 5-21) among alternative strategies is small (around 4.1 percent) and there is more variation among the scenarios (around 20.8 percent). Scenario 5 has the highest water consumption and Scenarios 4 and 3 have the lowest water consumption. 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.

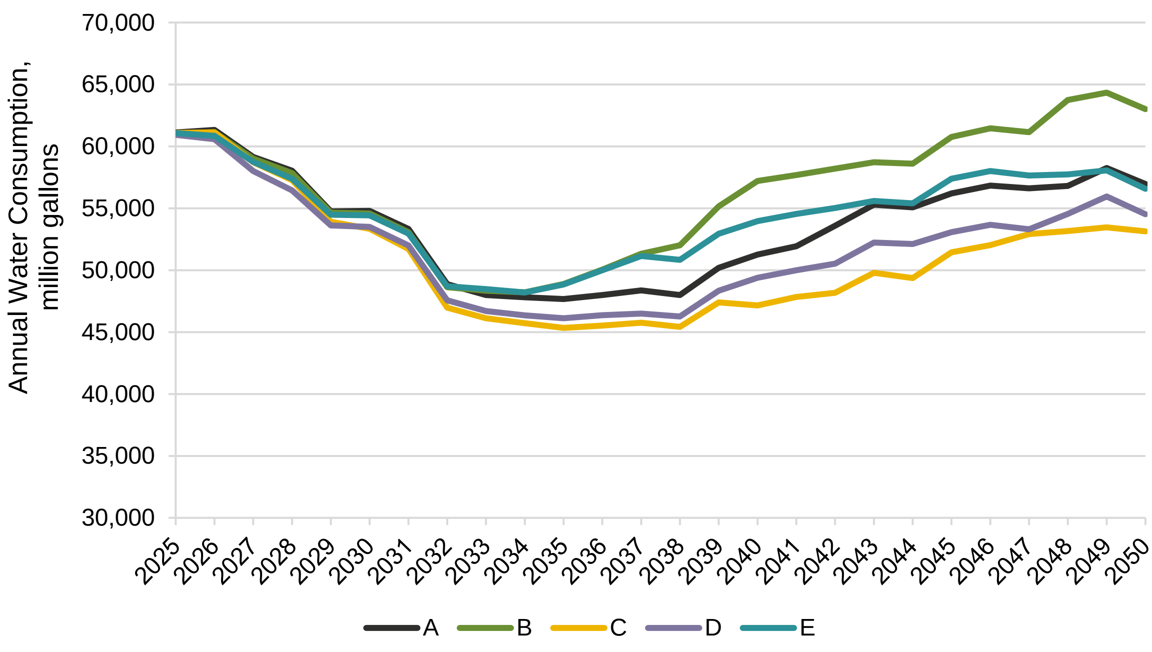
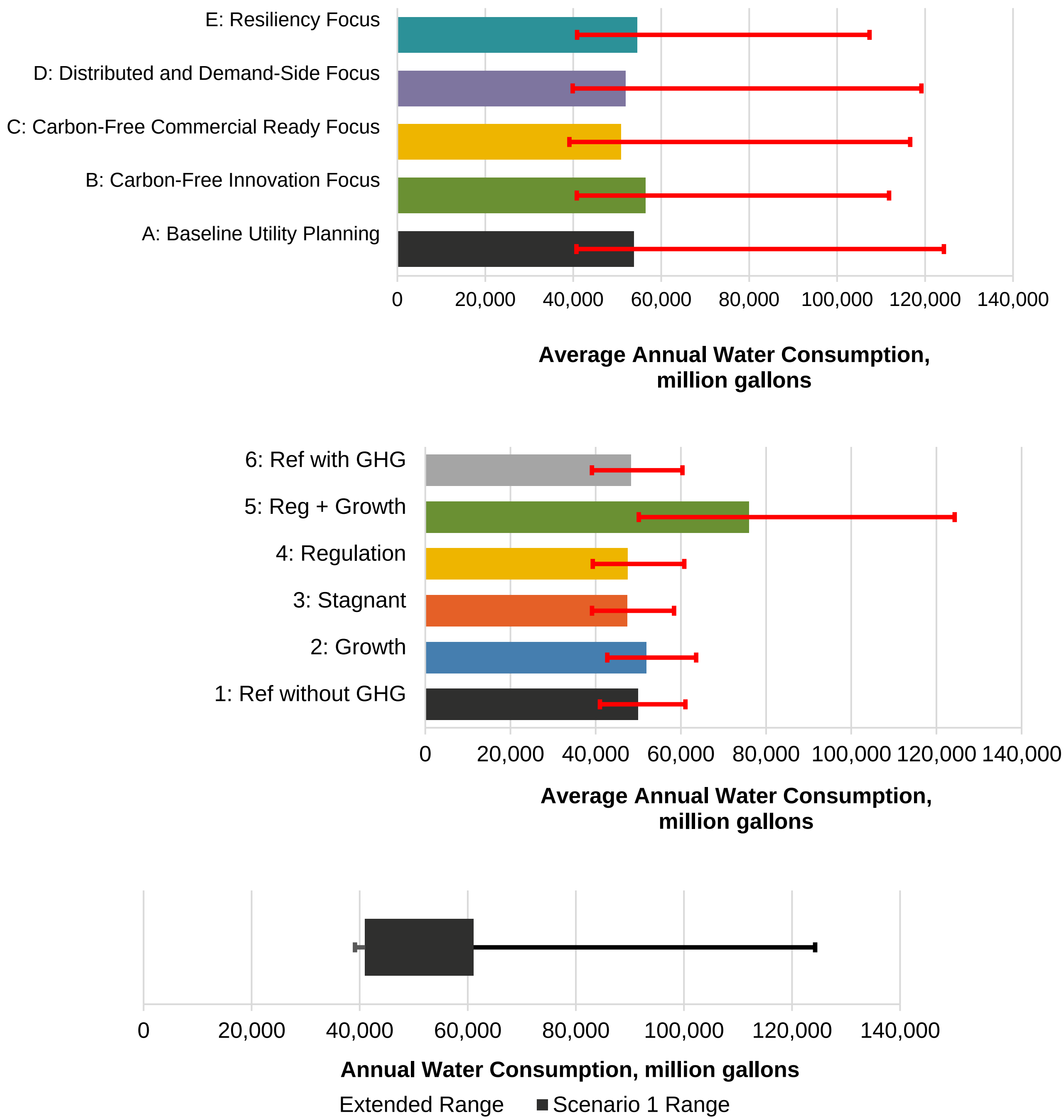


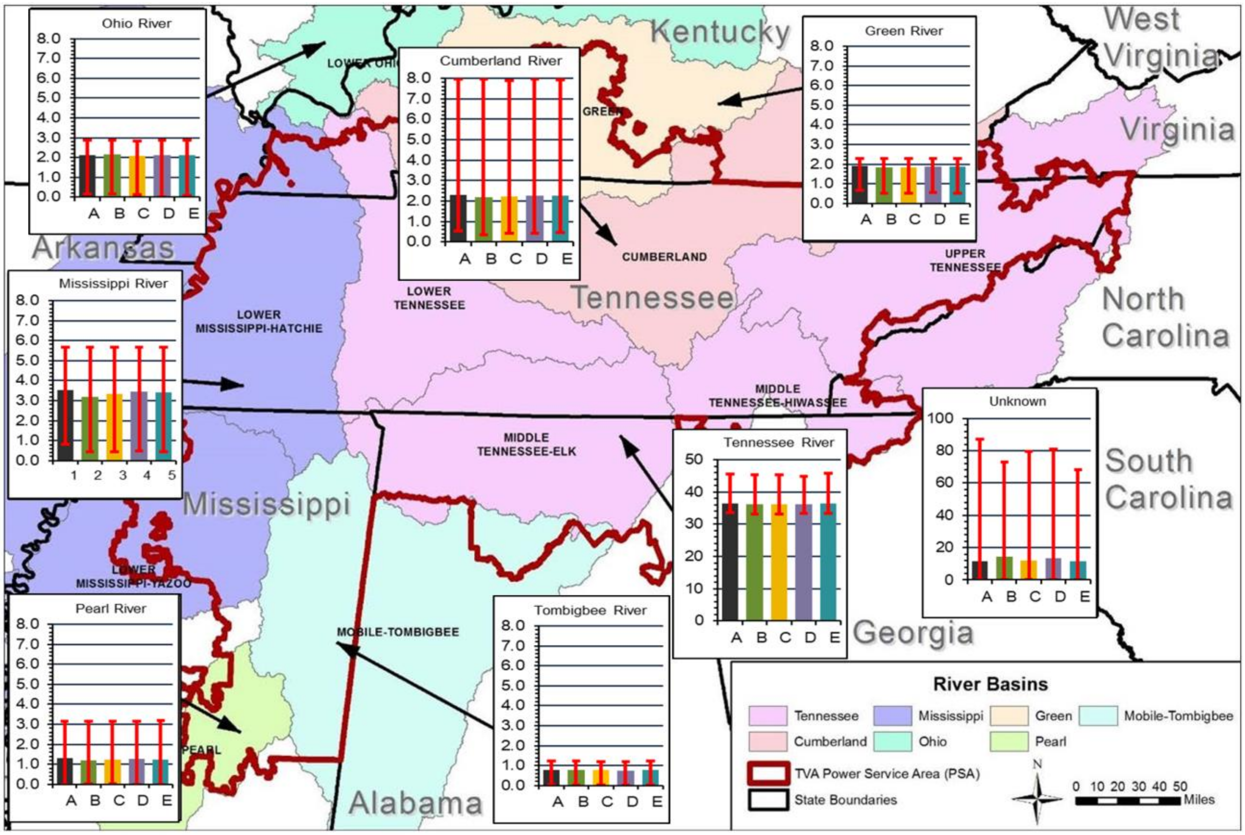
Figure 5-20: Trends in Average Annual Water Consumption by Alternative Strategy Based on Averages of the Six Scenarios



Note: The error bars in the top chart indicate the maximum and minimum values for the scenarios associated with each alternative strategy.

Figure 5-21: Average Annual 2025-2050 Water Consumption by Alternative Strategy (top), Scenario (middle), and the Range for Scenario 1 as well as the Extended Range to Encompass All Scenarios and Strategies (bottom).

Figure 5-22 shows water consumption projected for 2025-2050 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. Unknown River refers to future generating facilities whose locations are presently unknown.



Note: All basins are on the same scale except for the Tennessee River and Unknown rivers, wherein a significantly larger amount of water is taken in.

Figure 5-22: Average Annual Water Consumption by Alternative Strategy and Major River Basin (in billion gallons)

5.5.4 Land Resources

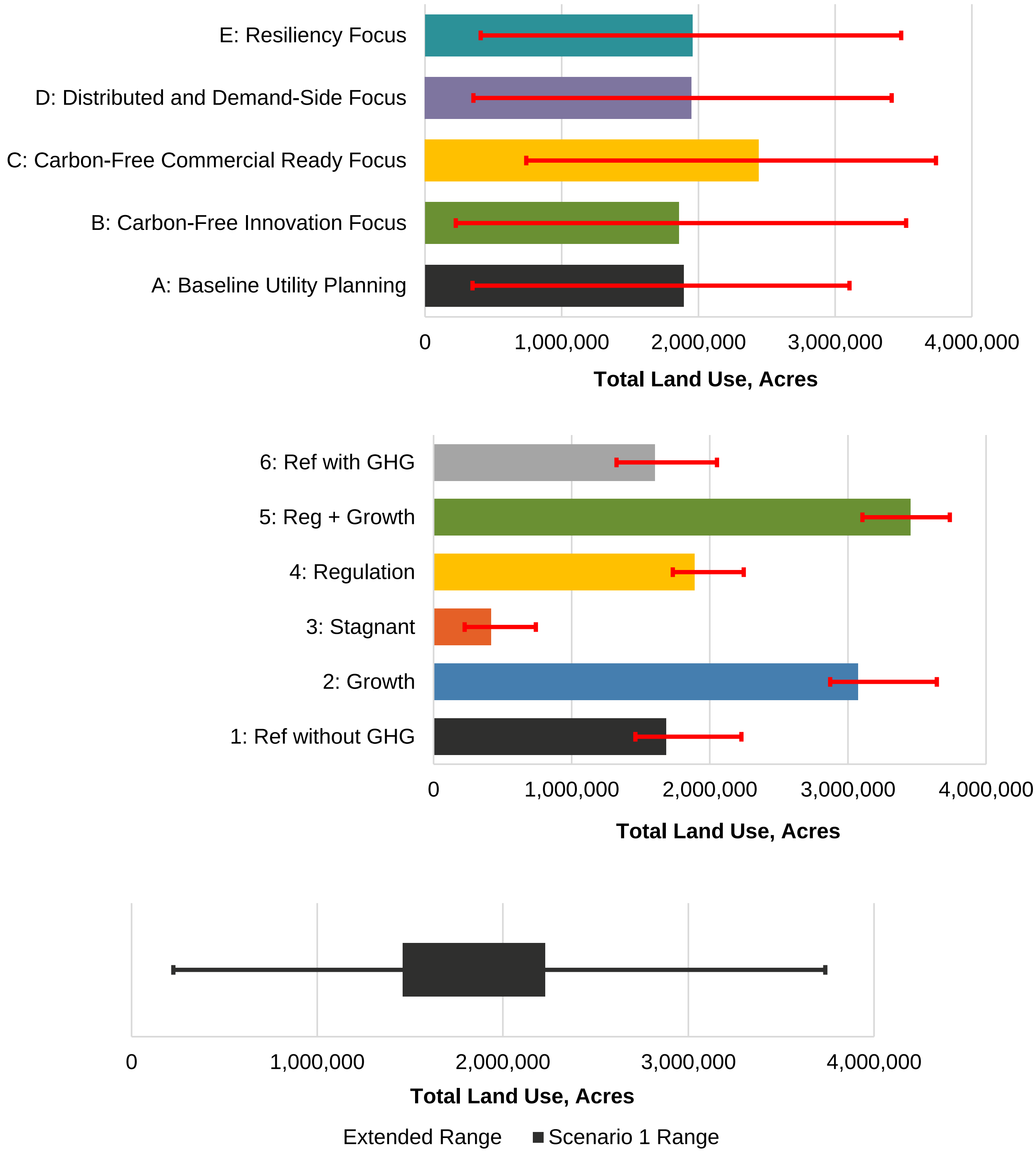
TVA's existing power plant reservations have a total area of about 25,000 acres. This total does not include conventional hydroelectric plants, most of which are closely associated with multi-purpose dams and reservoirs. Many of the power plant reservations have large, relatively undisturbed areas and 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. Since 2014, TVA has reviewed and approved 47 solar projects with facilities that occupy or will occupy a total area of over 17,200 acres (Table 5-9).

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. Where the indicated capacities translated to fractional facilities, the number of facilities was rounded up to the nearest whole number. Except for LPC flexible generation facilities, 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 full 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 2,143,996 acres for Strategy C to 1,603,169 acres for Strategy B (Figure 5-23). The land requirement for Strategy B is similar to all other strategies, except C, although all strategies have large variation across scenarios. Scenarios have less variation in land requirements across strategies, but differ greatly from each other, with the land requirement for Scenarios 2 and 5 being about 10 to 11 times the land requirement for Scenario 3 (Figure 5-24). Scenario 5 has the largest land requirements for all strategies except Strategy C, where the land requirement for Scenario 2 is slightly larger.

Averages for all portfolios (Figure 5-24) indicate about 96.1 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. A full list of average land use requirements for each of the 30 portfolios can be found in Appendix C.



Note: The error bars in the top and middle charts indicate the maximum and minimum values for the scenarios associated with each alternative strategy, or strategies associated with each scenario.

Figure 5-23: Average Total Land Area for all New Generating Facilities by Alternative Strategy (top), Scenario (middle), and the Range for Scenario 1 as well as the Extended Range to Encompass All Scenarios and Strategies (bottom)

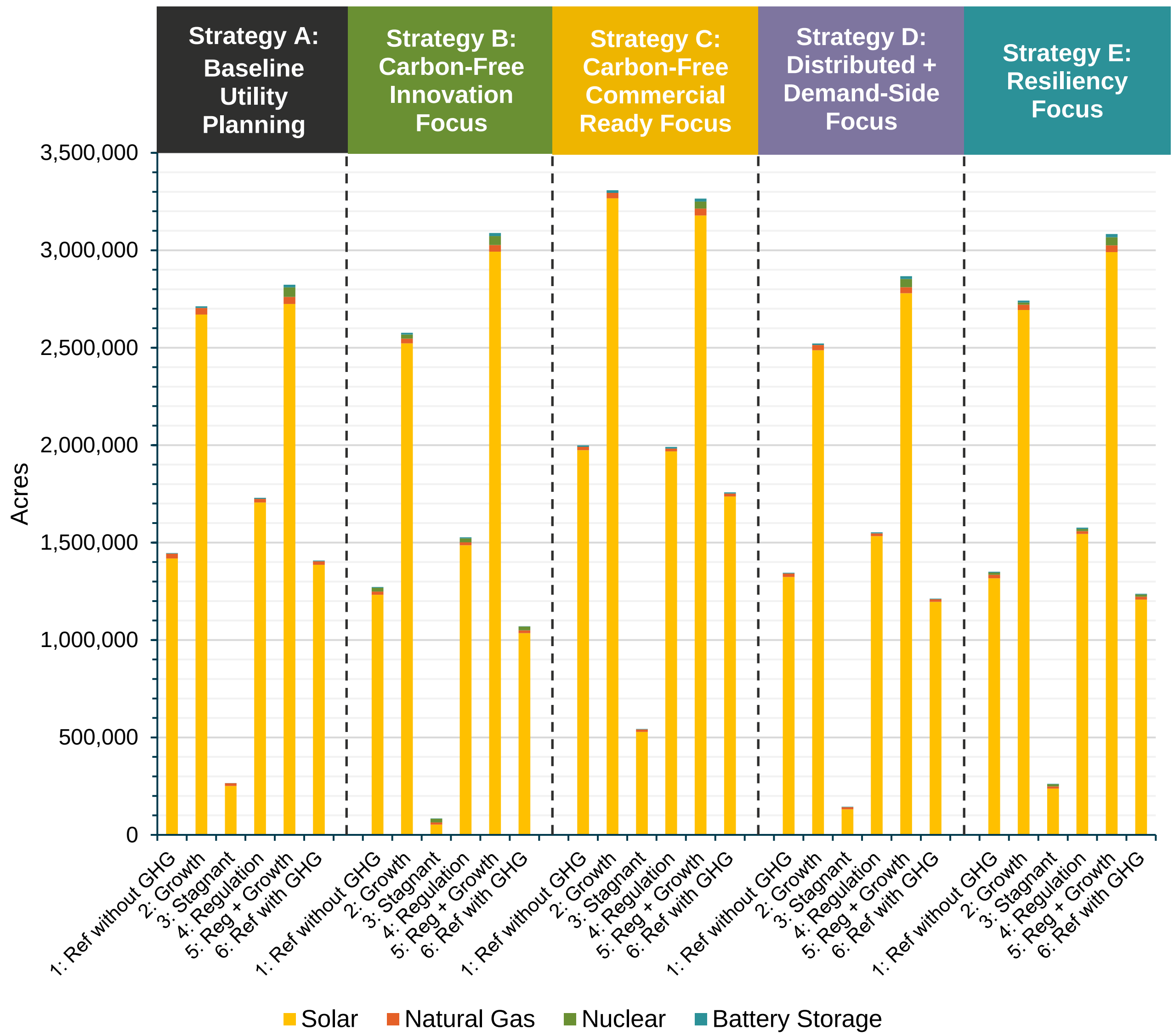


Figure 5-24: Land Requirements for New Generating Facilities by Type of Generation, Alternative Strategy, and Scenario

The majority of the land area occupied by utility-scale solar facilities constructed in the TVA PSA 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 the western portion of the TVA PSA, including western Tennessee, northern Mississippi, and northwest Alabama. There is a continued interest in developing solar facilities in these areas, primarily because of the presence of large tracts of relatively flat land in large ownerships and the region has the greatest solar generation potential in 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, footprints occupy a proportionally small amount of land in the TVA PSA and 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.

The land requirements illustrated in Figure 5-24 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.

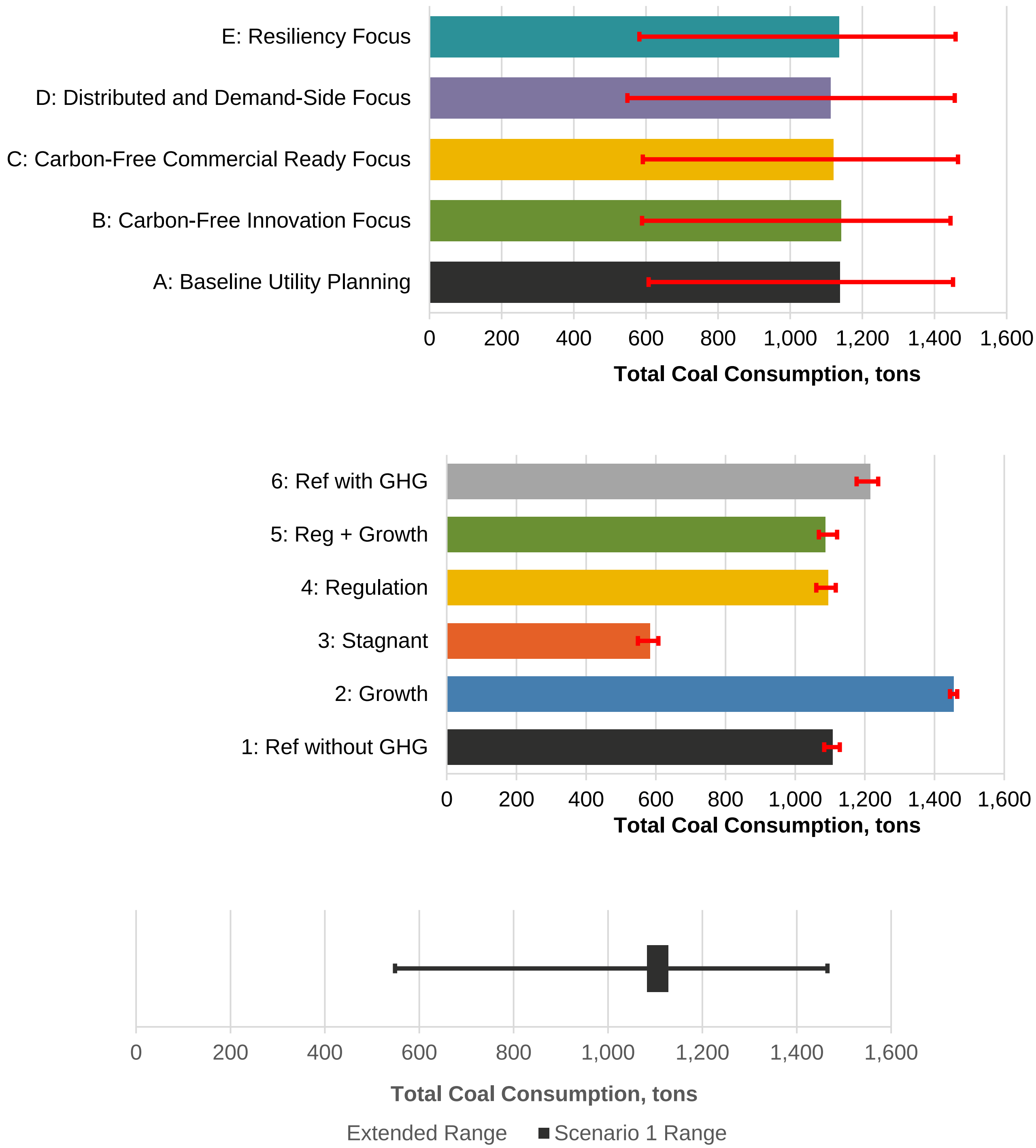
5.5.5 Fuel Consumption

The major fuels used for generating electricity would continue to be enriched uranium and natural gas in all of the alternative strategies, with coal plant retirements negating its need after 2035.

5.5.5.1 Coal Consumption

The variation in coal consumption among the alternative strategies is relatively small (Figure 5-25). 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 until 2032 when TVA’s PPA expires under all portfolios. A full list of average fuel consumption for coal in each of the 30 portfolios can be found in Appendix C.

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.



Note: The error bars in the top and middle charts indicate the maximum and minimum values for the scenarios associated with each alternative strategy, or for the strategies associated with each scenario.

Figure 5-25: Average Total 2025-2033 Coal Consumption by TVA Plants by Alternative Strategy (top), Scenario (middle), and the Range for Scenario 1 as well as the Extended Range to Encompass All Scenarios and Strategies (bottom)

5.5.5.2 Uranium Consumption

TVA presently uses about 195 tons/year of enriched uranium in its nuclear plants. Use of enriched uranium remains relatively constant throughout most of the planning period for all scenarios and strategies. Scenario 5 incorporates the highest level of enriched uranium increases, due to the selection of many new nuclear plants driven by advancements in clean energy technologies, carbon regulations, and load growth. A full list of average fuel consumption for nuclear energy in each of the 30 portfolios can be found in Appendix C.

Environmental impacts from producing 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.

5.5.5.3 Natural Gas Consumption

About 443 billion standard cubic feet (SCF) of natural gas are planned for use in 2024 by TVA gas-fueled generating facilities and by gas facilities from which TVA purchased power under PPAs. Natural gas consumption during the 2025-2050 planning period varies between the alternative strategies and scenarios (Figure 5-26 and Figure 5-27). Across the strategies, gas consumption is highest under Scenario 2 and lowest under Scenario 4, with Scenario 2 volumes roughly 1.5 times those of Scenario 4. A full list of average fuel consumption for natural gas in each of the 30 portfolios can be found in Appendix C.

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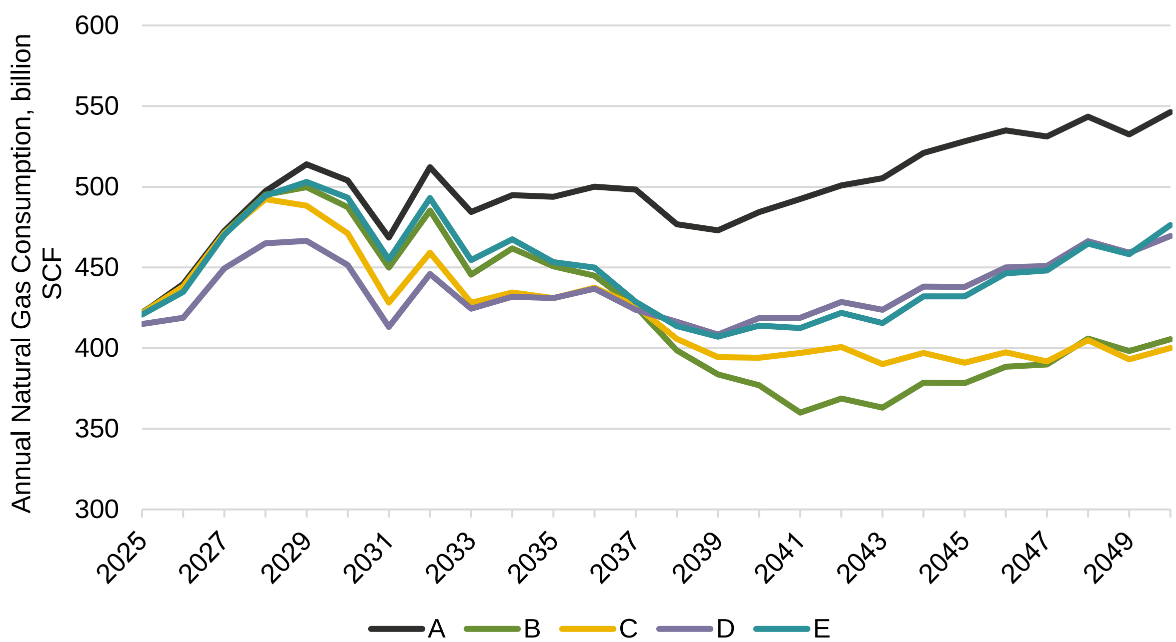
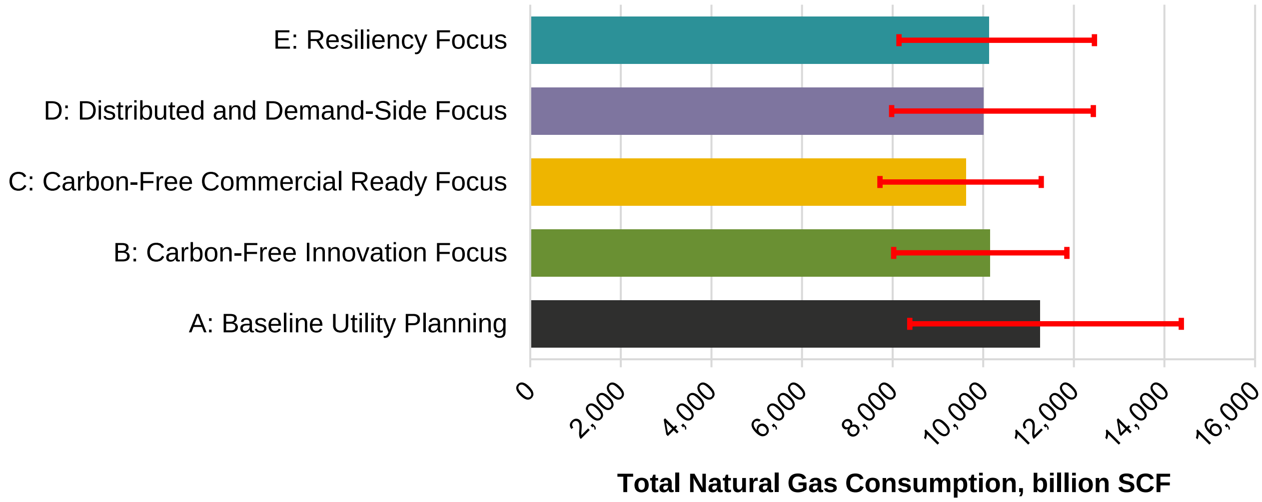
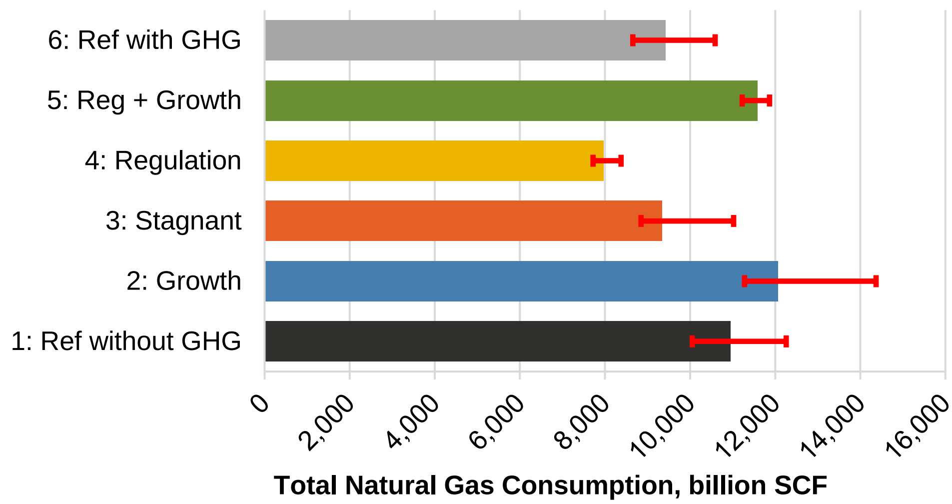
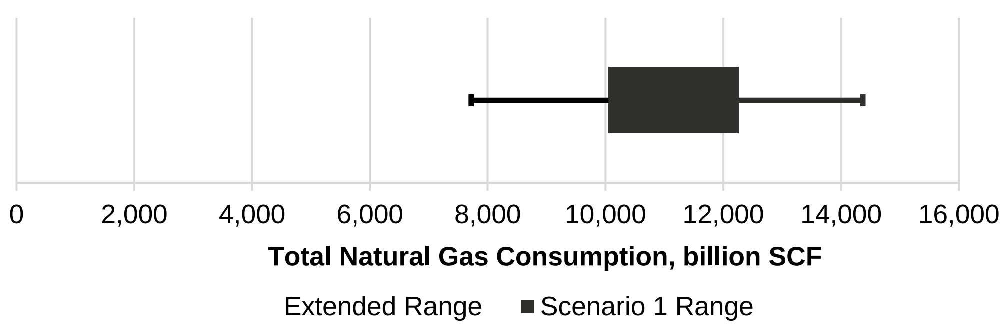


Figure 5-26: Trends in Average Annual Natural Gas Consumption by Alternative Strategy based on Averages of the Six Scenarios





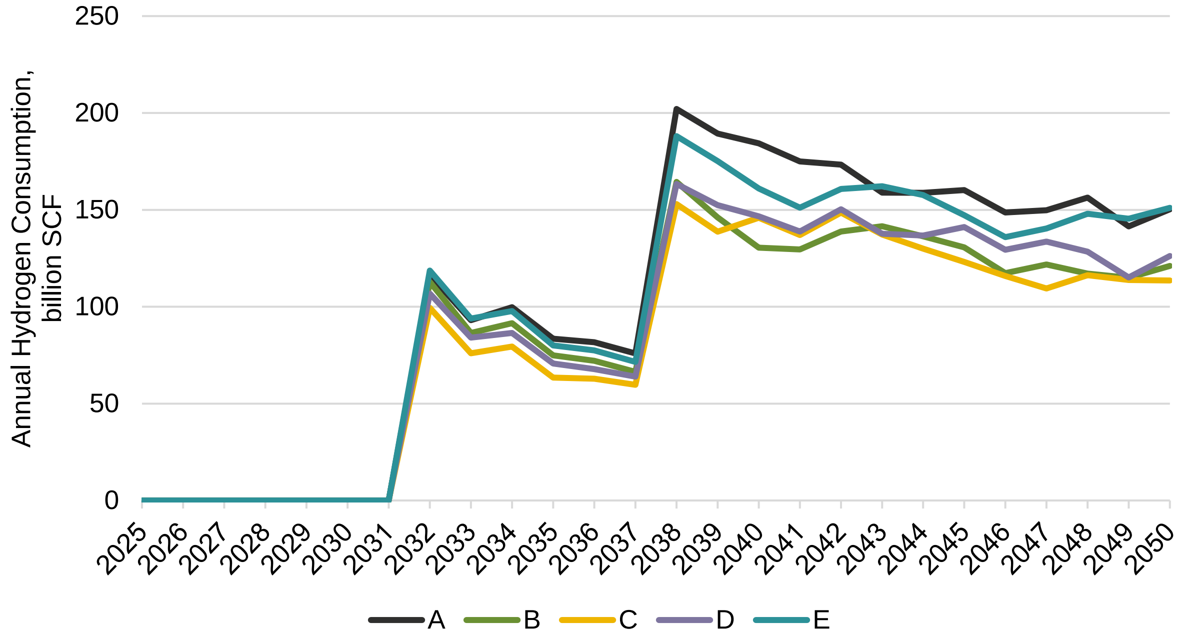


Note: The error bars in the top and middle charts indicate the maximum and minimum values for the scenarios associated with each alternative strategy, or strategies associated with each scenario.

Figure 5-27: Average Total 2025-2050 Natural Gas Consumption by Alternative Strategy (top), Scenario (middle), and the Range for Scenario 1 as well as the extended range to encompass all scenarios and strategies (bottom)

5.5.5.4 Hydrogen Consumption

Hydrogen fuel consumption was only modeled for Scenarios 4, Net-zero Regulation, and 5, Net-zero Regulation with Growth. Across strategies, consumption did not differ greatly, each increasing in consumption leading to coal facility retirements and eventually steadying over time. However, between the two scenarios, consumption was higher for Scenario 5 overall (Figure 5-28).



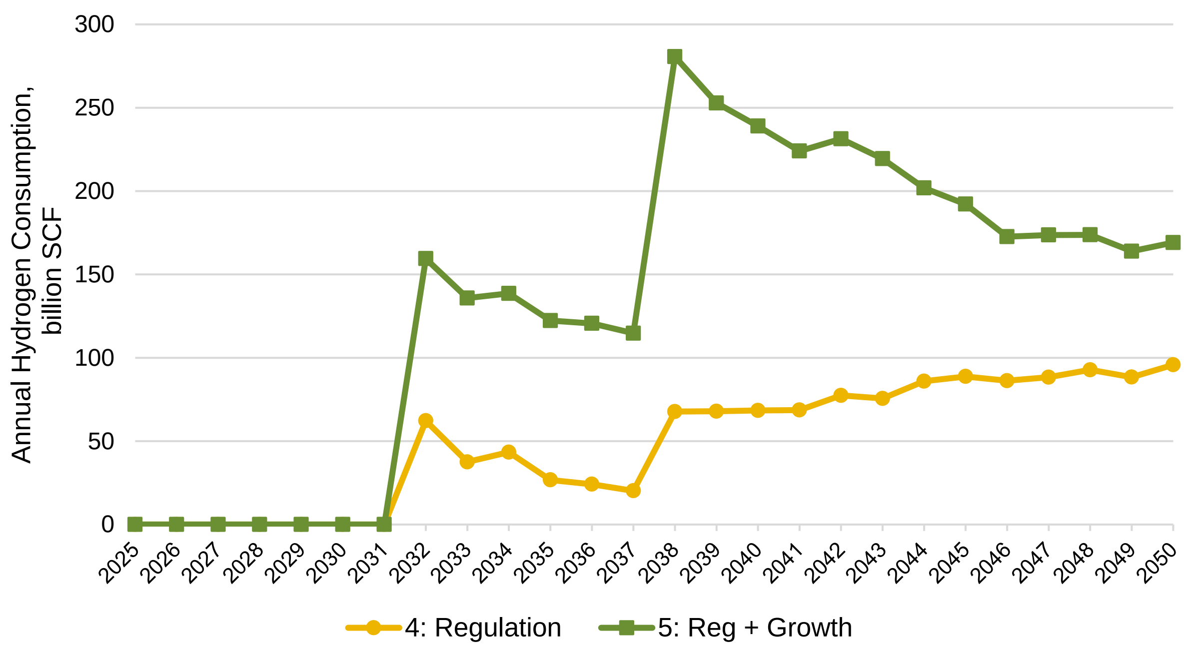


Figure 5-28: Trends in Average Annual Hydrogen Consumption by Alternative Strategy based on Averages of two Scenarios (top) and Average Annual Hydrogen Consumption by Alternative Scenario based on Averages of the Five Strategies (bottom)

5.5.6 Solid and Hazardous Waste

The following sections describe the solid and hazardous waste impacts that could occur from operational facilities and from retirement of TVA's aging facilities.

5.5.6.1 Coal Combustion Solid Wastes

Forecast production of CCR is directly correlated with forecast electricity demand and tempered by alternative energy production methods. The nation's future energy needs under normal weather conditions are directly related to forecasted economic, energy policy, and demographic conditions. As shown in Figure 5-29, all alternative strategies forecast production of CCR to increase from 2025 through 2026 before plummeting to zero CCR production by 2035. TVA's four active fossil plants, 24 active generating units with a total capacity of 5,800 MW, are planned to retire by coal fleet expected end of life in 2035. Retirement would be phased with Cumberland's two units by the end of 2026 and 2028, Kingston's 9 units by the end of 2027, Gallatin's 4 units by the end of 2031, and Shawnee's 9 units by the end of 2033. Accordingly, CCR production decreases markedly early in the planning period with an increase in retirements and slows after 2029 with fewer retirements.

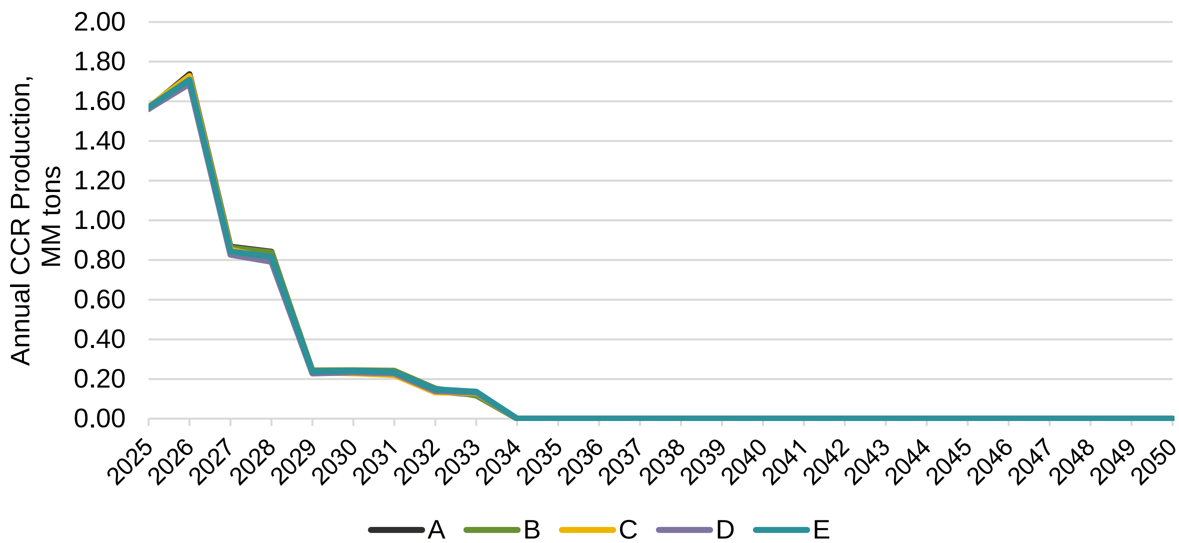
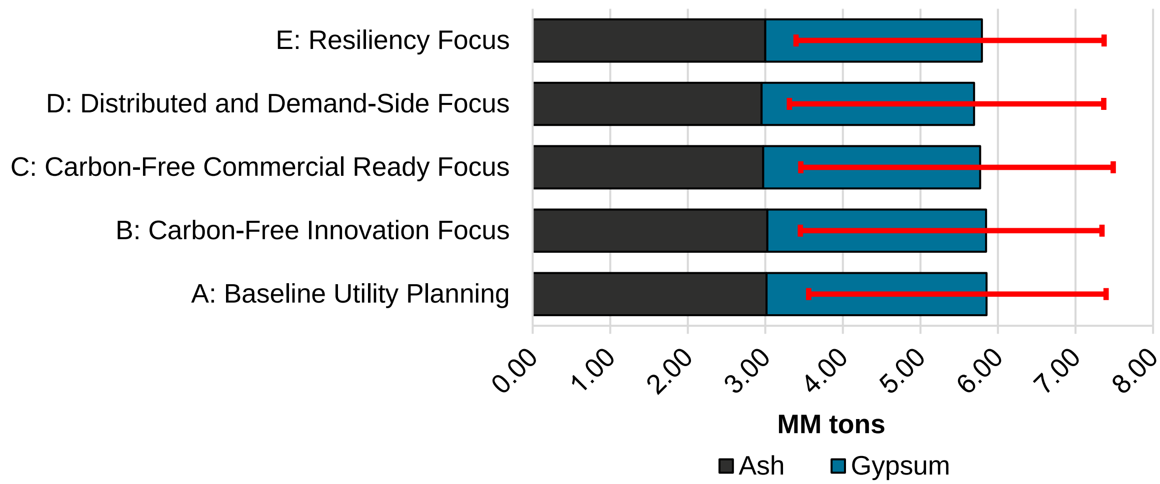
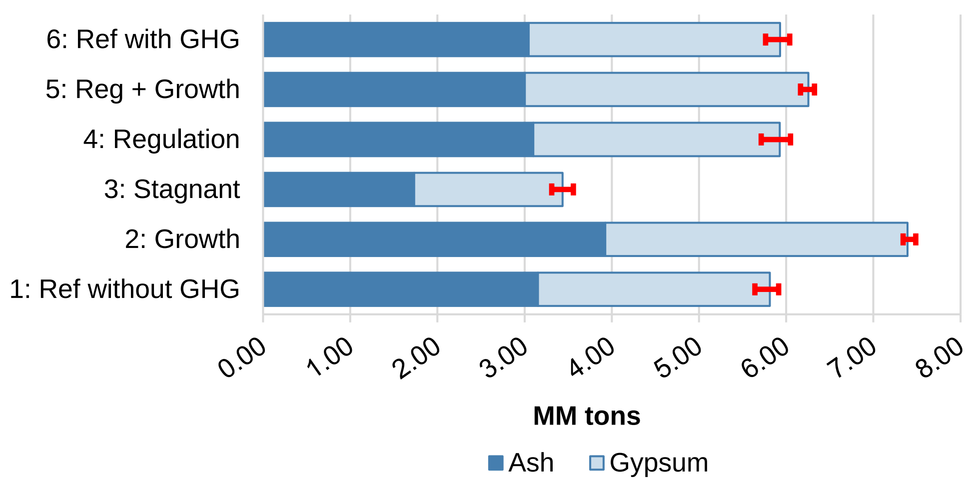
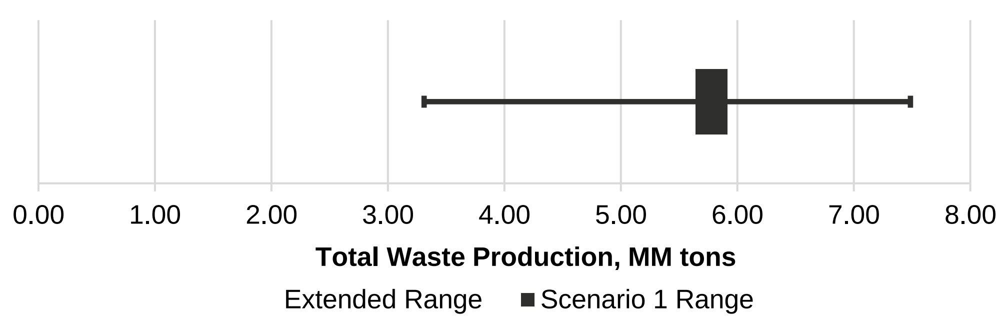


Figure 5-29: Trends in Average Annual Coal Combustion Residual (Combined Ash and Gypsum) Alternative Strategy based on Averages of the Six Scenarios

As shown in Figure 5-30, although the quantity of CCR produced during the 2025-2033 period shows little variation between alternative strategies, it varies markedly between the scenarios associated with each strategy. This variance among scenarios of different strategies is greatest with Scenario 2 and lowest with Scenario 3. Energy demand during the higher growth economy, Scenario 2, is driven by positive economic conditions and increasing electrification opportunities; thus, resulting in greater CCR production. Conversely for the stagnant economy, Scenario 3, reductions in demand relative to the current Reference Case, are reflected in less CCR production. The average CCR production, combined and split into ash and gypsum waste, for each of the 30 portfolios can be found in Appendix C.







Note: The error bars in the top and middle charts indicate the maximum and minimum values for the scenarios associated with each alternative strategy, or strategies associated with each scenario, respectively.

Figure 5-30: Total Average 2025-2050 Coal Combustion Residual Production by Alternative Strategy (top), Scenario (middle), and the Range for Scenario 1 as well as the Extended Range to Encompass All Scenarios and Strategies (bottom)

5.5.6.2 Impacts of Coal Facility Retirements

The retirement of coal plants would cease coal burning operations and no additional CCR would be produced. Residual ash and coal dust would be washed from equipment and areas and would then be managed through the ash handling system. TVA would close the CCR units at sites as required pursuant to state and federal regulations, which could include groundwater monitoring, corrective measures, and post-closure care activities.

Any lighting ballasts containing polychlorinated biphenyls (PCBs) 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 surrounding environmental resources.

5.5.6.3 Impacts of Natural Gas Facility Retirements

Natural gas plants produce very small quantities of solid waste during normal operation and therefore the potential retirement of gas units would not affect solid and hazardous wastes. Retirement of facilities would only produce waste that would be created by any construction or demolition, similar to that of coal facility retirements.

5.5.6.4 Impacts of Renewable Facility Decommissioning

While solid waste is produced during construction of solar and wind generating facilities, very little solid waste results from normal operations of these facilities. At the end of their useful life, wind and solar generating facilities are decommissioned, dismantled, and sites are restored. Typically, during decommissioning the associated infrastructure (e.g., concrete pads and foundations, equipment, and electrical connections) would be removed, compacted areas would be scarified, and soils would be stabilized. The majority of decommissioned materials and equipment would be recycled, including the solar panels and the wind turbine tower and nacelles. The recycling of PV modules is anticipated to grow over the coming decades. Similarly, although composite materials comprising nacelle covers and turbine blades are currently challenging to recycle, anticipated advances in more readily recyclable materials are anticipated to decrease waste. Alternative strategies considered by TVA that result in greater renewable generation would result in greater amounts of wastes with decommissioning.

5.5.6.5 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, with the exception of Scenario 5, are very similar for all alternative strategies. Beginning in 2038, the Carbon Free Innovation (5B) strategy shows a marked increase in nuclear consumption. By 2040, all Scenario 5 strategies show a marked increase in nuclear consumption compared with alternative scenarios, with variance in total nuclear consumption over the 2025 to 2050 period ranging from 26 percent up to 51 percent higher for Scenario 5 strategies than for other modeled scenarios. 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 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.

5.5.6.6 Building Retrofits

Building retrofits to reduce energy use, such as replacing windows and doors, produces 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 hydrochlorofluorocarbon 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.

5.5.7 Socioeconomics

The six scenarios evaluated in the IRP assume distinctly different economic conditions, as discussed in Chapter 3 and Appendix B of the IRP. Generally, the largest influence on the TVA region economy are economic trends in the U.S. overall, as economic trends in the TVA region are highly correlated to the macroeconomic trends in the U.S. However, the large manufacturing base in the region tends to create potential for greater downward moves during periods of economic slowdown or recession. Similarly, demographic trends reflect this same volatility, where significant shifts in economic conditions directly influence population growth, household formation, and employment levels.

Within each scenario, the strategies evaluated would have varying but minor impacts on the TVA region economy for the reasons noted above. Differences are primarily due to the cost of electricity and impacts to the local economy related to building and contracting for new generating resources. Often these impacts tend to be generally offsetting. As residents and businesses across the region use electricity, the difference in cost of electricity across the strategies would have the largest influence on regional income and employment. With respect to the System Average Cost metric, Strategy A is the lowest cost, Strategy C is the second lowest in cost, followed by Strategies D, E, and B (Table 5-24). However, as mentioned previously, differences across the strategies would have minor impacts on the TVA region economy as a whole.

Table 5-24: System Average Cost for each Portfolio ($/MWh)

Strategy	Scenario					
	1	2	3	4	5	6
A	$72	$81	$68	$86	$81	$76
B	$83	$91	$80	$100	$91	$88
C	$74	$82	$70	$88	$81	$78
D	$75	$83	$72	$88	$83	$79
E	$80	$88	$77	$97	$85	$85

In TVA’s 2019 IRP, the results for the Valley economics metrics (changes in real per capital income and non-farm employment) were very similar across the strategies. There were two main reasons for this lack of differentiation, which are still true today. The relationship of TVA revenues to the Valley region economy as a whole is relatively small (as noted in Section 4.8.3.1, TVA’s revenues represent about 1.8 percent of the total TVA regional GDP), and the portfolios evaluated share common elements. Given these factors and with input from the IRP Working Group, TVA did not include a similar economic metric in the 2025 IRP.

Because the IRP is programmatic and does not address the future siting and construction of generating facilities, site-specific analyses of socioeconomic impacts, including those affecting minority and low-income populations, are not possible at this time. Before implementing a specific resource option, TVA will conduct a review of its potential socioeconomic impacts. This review will, as appropriate, address resource- and/or site-specific socioeconomic issues such as impacts on employment rates, housing, health and safety, schools, emergency services, water supply, wastewater treatment capacity, and local government revenues including TVA tax equivalent payments.

The construction and/or acquisition of facilities by TVA as well as the retirement of facilities would affect employment levels within the vicinity of a project location. In addition, the construction, acquisition, and retirement of generation facilities would likely increase or decrease TVA's tax equivalent payments, also known as payments in lieu of taxes, to states where the facilities are located. These tax equivalent payments represent beneficial or adverse effects to local communities. 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.

Generally, the planned retirements of facilities resulting in the loss of local employment in the counties in which they are located, may result in direct and indirect adverse impacts to the surrounding areas. TVA would help offset this employment loss by placing some interested employees in available positions across the TVA PSA, pre-empting the need to relocate for work. Proximity to more urbanized areas such as Memphis and Nashville may help offset the need for employees and associated family members to relocate. Employees may find alternative employment in other industries due to the growth of employment opportunities in the regional economy discussed in Section 4.8.3.1.

5.5.8 Environmental Justice

The TVA PSA contains populations subject to consideration as potential communities with environmental justice concerns. Capacity expansion plans associated with alternative strategies and scenarios contemplated by the IRP include the construction and operation of new generating facilities. Because the IRP is programmatic and does not address the future siting and construction of generating facilities, site-specific analyses of environmental justice impacts resulting from socioeconomic resources or environmental effects related to the construction and operation of these facilities are not known at this time and will be determined in future environmental analyses. Before implementing a specific resource option, TVA will conduct a review of its potential impacts to communities with environmental justice concerns.

Activities associated with building retrofits and other residential, commercial, and industrial EE measures are unlikely to have disproportionate adverse impacts on communities with environmental justice concerns. Household EE efforts can result in reductions of cold-related illnesses and associated stress by making it easier for residents to heat their homes. However, reduced ventilation rates can 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.

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 implement programs to assist low-income customers as described in Section 4.9.4.

5.5.8.1 Impacts of Facility Retirements

Demographic indicators for potential environmental justice concerns were obtained using EJSCREEN for a 3-mile radius surrounding TVA power plants (see Section 4.9.5). The Allen CT facility in Tennessee and Southaven CC facility in Mississippi have significantly higher minority percentages and low-income population percentages than the state. Several plants have higher percentages of the population over the age of 64 compared to their respective states.

Minor positive indirect effects to minority and low-income populations may occur due to beneficial changes to local air quality from coal facility retirements. Beneficial impacts resulting from an increase in employment opportunities due to the short-term generation of jobs needed for deconstruction activities may benefit minority and low-income populations. This would temporarily offset direct and indirect economic impacts caused by loss of employment due to the closing of the facility. As described in Section 5.5.7, TVA would help offset employment loss by placing some interested employees in available positions across the TVA PSA.

Site-specific analyses of environmental justice impacts resulting from socioeconomic resources or environmental effects related to the construction and operation of these facilities are not known at this time and will be determined in future environmental analyses. Before implementing a specific resource option, TVA will conduct a review of its potential environmental justice impacts.

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 result in unavoidable adverse environmental impacts. The nature and potential significance of the impacts would 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 25-year planning period. The exceptions are the coal plants/units that would be retired and a few of the older natural gas units. 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 sited 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. All new facilities proposed by TVA would be subject to a site-specific NEPA review to analyze the potential adverse impacts of the proposed action.

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 would be conducted before final implementation decisions are made to use certain energy resources and would 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, and low-cost electricity is recognized as enhancing public health and welfare and will continue to sustain and increase the economic well-being of the TVA region.

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, the generation of nuclear waste that requires safe storage for an indefinite period, and the emission of any GHGs has the potential to impact the rate and intensity of climate change.

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 disturbances. 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 EE and DR 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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Integrated Resource Plan 2025

VOLUME 2 / APPENDIX

SEPTEMBER 2024

TVA

TENNESSEE
VALLEY
AUTHORITY

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Appendix A – Federally Listed Species near TVA Generation Facilities

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Appendix A - Federally Listed Species near TVA Generation Facilities

Facility	Scientific Name	Common Name	State	State Rank	State Status	Federal Status
Allen						
	Charadrius melodus	Piping Plover	TN			E, T
	Haliaeetus leucocephalus	Bald Eagle	TN		D	DL
	Sterna antillarum athalassos	Interior Least Tern	TN		E	DL
Apalachia						
	Cryptobranchus alleganiensis	Hellbender	TN	S3	E	PS
	Epioblasma florentina walkeri	Tan Riffleshell	TN	S1	E	E
	Percina tanasi	Snail Darter	TN	S2S3	T	DL
	Pityopsis ruthii	Ruth's Golden Aster	TN	S1	E	E
	Pleurobema oviforme	Tennessee Clubshell	TN	S2S3		PE
	Pleuronaia barnesiana	Tennessee Pigtoe	NC	S1	E	PE
	Pleuronaia dolabelloides	Slabside Pearlymussel	TN	S2	E	E
	Potamogeton tennesseensis	Tennessee Pondweed	TN	S2	T	UR
	Venustaconcha trabalis	Tennessee Bean	TN	S1		E
Blue Ridge Dam						
	Bombus pensylvanicus	American Bumblebee	GA	SNR		UR
	Cryptobranchus alleganiensis	Hellbender	GA	T	R	PS
	Percina tanasi	Snail Darter	TN	S2S3	T	DL
Browns Ferry						
	Campeloma decampi	Slender Campeloma	AL	S1	SP	E
	Cumberlandia monodonta	Spectaclecase	AL	S1	SP	E
	Elassoma alabamae	Spring Pygmy Sunfish	AL	S1	SP	T
	Etheostoma boschungi	Slackwater Darter	AL	S1	SP	T
	Etheostoma tuscumbia	Tuscumbia Darter	AL	S2	SP	UR
	Lampsilis abrupta	Pink Mucket	AL	S1	SP	E
	Obovaria retusa	Ring Pink	AL	SH	SP	E, XN
	Plethobasus cooperianus	Orange-foot Pimpleback	AL	SX	SP	E, XN
	Plethobasus cyphyus	Sheepnose	AL	S1	SP	E
	Pleurobema plenum	Rough Pigtoe	AL	S1	SP	E, XN
	Pleuronaia barnesiana	Tennessee Pigtoe	AL	S1	PSM	PE
Caledonia						
	Elliptio arca	Alabama Spike	MS	S1S2		UR
	Lampsilis perovalis	Orange-nacre Mucket	MS	S1	LE	T

Facility	Scientific Name	Common Name	State	State Rank	State Status	Federal Status
	Medionidus acutissimus	Alabama Moccasinshell	MS	S1	LE	T
	Obovaria unicolor	Alabama Hickorynut	MS	S1S2		UR
	Pleurobema decisum	Southern Clubshell	MS	S1		E
	Pleurobema perovatum	Ovate Clubshell	MS	S1	LE	E
Chatuge Dam						
	Fusconaia subrotunda	Longsolid	NC	S1	E	T
	Haliaeetus leucocephalus	Bald Eagle	NC	S3B,S3N	T	DL
	Moxostoma sp. 2	Sicklefin Redhorse	NC	S2	T	UR
	Pleurobema oviforme	Tennessee Clubshell	NC	S1	E	PE
	Sarracenia oreophila	Green Pitcher Plant	NC	S1	E	E
	Vermivora chrysoptera	Golden-winged Warbler	NC	S2S3B	SC	UR
Cherokee Dam						
	Acipenser fulvescens	Lake Sturgeon	TN	S1	E	UR
	Cumberlandia monodonta	Spectaclecase	TN	S2S3	E	E
	Epioblasma florentina walkeri	Tan Riffleshell	TN	S1	E	E
	Epioblasma turgidula	Turgid Blossom Pearlymussel	TN	SX	E	DL
	Haliaeetus leucocephalus	Bald Eagle	TN		D	DL
	Io fluvialis	Spiny Riversnail	TN	S2		UR
	Lampsilis abrupta	Pink Mucket	TN	S2	E	E
	Lemiox rimosus	Birdwing Pearlymussel	TN	S1	E	E, XN
	Percina tanasi	Snail Darter	TN	S2S3	T	DL
	Plethobasus cicatricosus	White Wartyback	TN	S1	E	E, XN
	Plethobasus cyphyus	Sheepnose	TN	S2S3	E	E
Chickamauga Dam						
	Acipenser fulvescens	Lake Sturgeon	TN	S1	E	UR
	Chrosomus saylori	Laurel Dace	TN	S1	E	E
	Cyprogenia stegaria	Fanshell	TN	S1	E	E, XN
	Dromus dromas	Dromedary Pearlymussel	TN	S1	E	E, XN
	Falco peregrinus	Peregrine Falcon	TN	S1B		PS:LE
	Fusconaia cor	Shiny Pigtoe Pearlymussel	TN	S1	E	E, XN
	Fusconaia subrotunda	Longsolid	TN	S3		T
	Lampsilis abrupta	Pink Mucket	TN	S2	E	E
	Percina tanasi	Snail Darter	TN	S2S3	T	DL
	Plethobasus cooperianus	Orange-foot Pimpleback	TN	S1	E	E, XN
	Plethobasus cyphyus	Sheepnose	TN	S2S3	E	E
	Pleurobema oviforme	Tennessee Clubshell	TN	S2S3		PE
	Pleurobema plenum	Rough Pigtoe	TN	S1	E	E, XN

Facility	Scientific Name	Common Name	State	State Rank	State Status	Federal Status
	Pleurobema rubrum	Pyramid Pigtoe	TN	S1S2		PT
	Scutellaria montana	Large-flowered Skullcap	TN	S4	T	T
Colbert						
	Athearnia anthonyi	Anthony's River Snail	AL	S1	SP	E, XN
	Cumberlandia monodonta	Spectaclecase	AL	S1	SP	E
	Cyprogenia stegaria	Fanshell	AL	S1	SP	E, XN
	Dromus dromas	Dromedary Pearlymussel	AL	SX	SP	E, XN
	Epioblasma brevidens	Cumberlandian Combshell	AL	S1	SP	E, XN
	Epioblasma capsaeformis	Oyster Mussel	AL	SX	SP	E, XN
	Epioblasma obliquata obliquata	Purple Catspaw	AL	SX	SP	E, XN
	Epioblasma triquetra	Snuffbox	AL	S1	PSM	E
	Fusconaia cuneolus	Fine-rayed Pigtoe	AL	S1	SP	E, XN
	Fusconaia subrotunda	Longsolid	AL	S1	PSM	T
	Hemistena lata	Cracking Pearlymussel	AL	S1	SP,P1	E, XN
	Lampsilis abrupta	Pink Mucket	AL	S1	SP	E
	Lemiox rimosus	Birdwing Pearlymussel	AL	S1	SP	E, XN
	Leptodea leptodon	Scaleshell	AL	SX	SP	E
	Medionidus conradicus	Cumberland Moccasinshell	AL	S1	SP	PE
	Obovaria retusa	Ring Pink	AL	SH	SP	E, XN
	Obovaria subrotunda	Round Hickorynut	AL	S2	PSM	T
	Palaemonias alabamae	Alabama Blind Cave Shrimp	AL	S1	SP	E
	Percina tanasi	Snail Darter	AL	S1	SP	DL
	Plethobasus cicatricosus	White Wartyback	AL	S1	SP	E, XN
	Plethobasus cooperianus	Orange-foot Pimpleback	AL	SX	SP	E, XN
	Plethobasus cyphyus	Sheepnose	AL	S1	SP	E
	Pleurobema clava	Clubshell	AL	SX	SP	E, XN
	Pleurobema oviforme	Tennessee Clubshell	AL	S1	PSM	PE
	Pleurobema plenum	Rough Pigtoe	AL	S1	SP	E, XN
	Pleurobema rubrum	Pyramid Pigtoe	AL	S1	SP	PT
	Pleurocera corpulenta	Corpulent Hornsnail	AL	S1		UR
	Pleurocera curta	Shortspire Hornsnail	AL	S1S2		UR
	Pleuronaia barnesiana	Tennessee Pigtoe	AL	S1	PSM	PE
	Pleuronaia dolabelloides	Slabside Pearlymussel	AL	S1	SP	E
	Ptychobranchus subtentum	Fluted Kidneyshell	AL	SX	SP	E
	Quadrula cylindrica cylindrica	Smooth Rabbitsfoot	AL	S1	SP	T
	Speoplatyrhinus poulsoni	Alabama Cavefish	AL	S1	SP	E
	Villosa fabalis	Rayed Bean	AL	SX		E

Facility	Scientific Name	Common Name	State	State Rank	State Status	Federal Status
Cumberland						
	Acipenser fulvescens	Lake Sturgeon	TN	S1	E	UR
	Haliaeetus leucocephalus	Bald Eagle	TN		D	DL
	Myotis septentrionalis	Northern Long-eared Bat	TN	S1S2	T	E
	Pleurobema clava	Clubshell	TN	SH	E	E, XN
	Quadrula cylindrica	Rabbitsfoot	TN			T
	Acipenser fulvescens	Lake Sturgeon	TN	S1	E	UR
	Cyprogenia stegaria	Fanshell	TN	S1	E	E, XN
	Dromus dromas	Dromedary Pearlymussel	TN	S1	E	E, XN
	Epioblasma capsaeformis	Oyster Mussel	TN	S1	E	E, XN
	Epioblasma torulosa torulosa	Tuberculed Blossom Pearlymussel	TN	SX	E	DL
	Haliaeetus leucocephalus	Bald Eagle	TN		D	DL
	Lampsilis abrupta	Pink Mucket	TN	S2	E	E
	Obovaria retusa	Ring Pink	TN	S1	E	E, XN
	Percina tanasi	Snail Darter	TN	S2S3	T	DL
	Perimyotis subflavus	Tricolored Bat	TN	S2S3	T	PE
	Plethobasus cooperianus	Orange-foot Pimpleback	TN	S1	E	E, XN
	Plethobasus cyphyus	Sheepnose	TN	S2S3	E	E
	Pleurobema plenum	Rough Pigtoe	TN	S1	E	E, XN
	Quadrula cylindrica cylindrica	Smooth Rabbitsfoot	TN	S3	T	T
	Epioblasma florentina walkeri	Tan Riffleshell	TN	S1	E	E
	Etheostoma sitikuense	Citico Darter	TN	S1	E	LE, XN
	Haliaeetus leucocephalus	Bald Eagle	NC	S3B,S3N	T	DL
	Moxostoma sp. 2	Sicklefin Redhorse	NC	S2	T	UR
	Myotis lucifugus	Little Brown Bat	NC	S3	SR	UR
	Myotis septentrionalis	Northern Long-eared Bat	NC	S2	T	E
	Myotis sodalis	Indiana Bat	NC	S1S2	E	E
	Noturus baileyi	Smoky Madtom	TN	S1	E	E, XN
	Noturus flavipinnis	Yellowfin Madtom	TN	S1	T	T, XN
	Percina tanasi	Snail Darter	TN	S2S3	T	DL
	Perimyotis subflavus	Tricolored Bat	NC	S3	SR	PE
Fort Loudoun Dam						
	Acipenser fulvescens	Lake Sturgeon	TN	S1	E	UR
	Cryptobranchus alleganiensis	Hellbender	TN	S3	E	PS
	Haliaeetus leucocephalus	Bald Eagle	TN		D	DL
	Io fluvialis	Spiny Riversnail	TN	S2		UR
	Lampsilis abrupta	Pink Mucket	TN	S2	E	E
	Percina tanasi	Snail Darter	TN	S2S3	T	DL

Facility	Scientific Name	Common Name	State	State Rank	State Status	Federal Status
	Plethobasus cooperianus	Orange-foot Pimpleback	TN	S1	E	E, XN
	Pleurobema oviforme	Tennessee Clubshell	TN	S2S3		PE
Gallatin						
	Acipenser fulvescens	Lake Sturgeon	TN	S1	E	UR
	Haliaeetus leucocephalus	Bald Eagle	TN		D	DL
	Lesquerella perforata	Spring Creek Bladderpod	TN	S1	E	E
	Myotis grisescens	Gray Bat	TN	S2	E	E
Great Falls Dam						
	Cryptobranchus alleganiensis	Hellbender	TN	S3	E	PS
	Etheostoma akatulo	Bluemask Darter	TN	S1	E	E
	Fundulus julisia	Barrens Topminnow	TN	S1	E	E
	Myotis grisescens	Gray Bat	TN	S2	E	E
	Myotis lucifugus	Little Brown Bat	TN	S3	T	UR
	Perimyotis subflavus	Tricolored Bat	TN	S2S3	T	PE
	Pleurobema gibberum	Cumberland Pigtoe	TN	S1	E	E
Guntersville Dam						
	Campeloma decampi	Slender Campeloma	AL	S1	SP	E
	Cryptobranchus alleganiensis	Hellbender	AL	S1S2	SP	PS
	Cumberlandia monodonta	Spectaclecase	AL	S1	SP	E
	Cyprogenia stegaria	Fanshell	AL	S1	SP	E, XN
	Elassoma alabamae	Spring Pygmy Sunfish	AL	S1	SP	T
	Epioblasma triquetra	Snuffbox	AL	S1	PSM	E
	Etheostoma tuscumbia	Tuscumbia Darter	AL	S2	SP	UR
	Fusconaia subrotunda	Longsolid	AL	S1	PSM	T
	Haliaeetus leucocephalus	Bald Eagle	AL	S4B	SP	DL
	Lampsilis abrupta	Pink Mucket	AL	S1	SP	E
	Myotis grisescens	Gray Bat	AL	S2	SP	E
	Percina tanasi	Snail Darter	AL	S1	SP	DL
	Perimyotis subflavus	Tricolored Bat	AL	S3		PE
	Plethobasus cooperianus	Orange-foot Pimpleback	AL	SX	SP	E, XN
	Plethobasus cyphyus	Sheepnose	AL	S1	SP	E
	Pleurobema oviforme	Tennessee Clubshell	AL	S1	PSM	PE
	Pleurobema plenum	Rough Pigtoe	AL	S1	SP	E, XN
	Pleurobema rubrum	Pyramid Pigtoe	AL	S1	SP	PT
	Pleurocera curta	Shortspire Hornsnail	AL	S1S2		UR
	Pleuronaia dolabelloides	Slabside Pearlymussel	AL	S1	SP	E
	Quadrula cylindrica cylindrica	Smooth Rabbitsfoot	AL	S1	SP	T

Facility	Scientific Name	Common Name	State	State Rank	State Status	Federal Status
Hiwassee Dam						
	Epioblasma florentina walkeri	Tan Riffleshell	TN	S1	E	E
	Fusconaia subrotunda	Longsolid	NC	S1	E	T
	Moxostoma sp. 2	Sicklefin Redhorse	NC	S2	T	UR
	Myotis septentrionalis	Northern Long-eared Bat	NC	S2	T	E
	Percina tanasi	Snail Darter	TN	S2S3	T	DL
	Platanthera integrilabia	White Fringeless Orchid	NC	SH	SC-H	T
	Pleurobema oviforme	Tennessee Clubshell	TN	S2S3		PE
	Pleuronaia barnesiana	Tennessee Pigtoe	NC	S1	E	PE
	Pleuronaia dolabelloides	Slabside Pearlymussel	TN	S2	E	E
	Venustaconcha trabalis	Tennessee Bean	TN	S1		E
John Sevier						
	Erimonax monachus	Spotfin Chub	TN	S2	T	T, XN
	Haliaeetus leucocephalus	Bald Eagle	TN		D	DL
	Io fluvialis	Spiny Riversnail	TN	S2		UR
	Myotis septentrionalis	Northern Long-eared Bat	TN	S1S2	T	E
	Venustaconcha trabalis	Tennessee Bean	TN	S1		E
Johnsonville						
	Charadrius melodus	Piping Plover	TN			E, T
	Fimbristylis perpusilla	Harper's Fimbristylis	TN	S1	E	UR
	Lampsilis abrupta	Pink Mucket	TN	S2	E	E
	Macrochelys temminckii	Alligator Snapping Turtle	TN	S2S3	T	PT
	Plethobasus cooperianus	Orange-foot Pimpleback	TN	S1	E	E, XN
Kemper County						
	Strophitus radiatus	Rayed Creekshell	MS	S2		UR
Kentucky Dam						
	Cumberlandia monodonta	Spectaclecase	KY	S1	E	E
	Cyprogenia stegaria	Fanshell	KY	S1	E	E, XN
	Falco peregrinus	Peregrine Falcon	KY	S1B	E	PS:LE
	Fusconaia subrotunda	Longsolid	KY	S3	S	T
	Haliaeetus leucocephalus	Bald Eagle	KY	S3B,S3S4N	S	DL
	Lampsilis abrupta	Pink Mucket	KY	S1	E	E
	Plethobasus cooperianus	Orange-foot Pimpleback	KY	S1	E	E, XN
	Pleurobema oviforme	Tennessee Clubshell	KY	S1	E	PE
	Pleurocera curta	Shortspire Hornsnail	KY	S2	S	UR
	Quadrula cylindrica cylindrica	Smooth Rabbitsfoot	KY	S2	T	T
	Vireo bellii	Bell's Vireo	KY	S2S3B	S	PS

Facility	Scientific Name	Common Name	State	State Rank	State Status	Federal Status
Kingston						
	Acipenser fulvescens	Lake Sturgeon	TN	S1	E	UR
	Cumberlandia monodonta	Spectaclecase	TN	S2S3	E	E
	Cyprogenia stegaria	Fanshell	TN	S1	E	E, XN
	Epioblasma capsaeformis	Oyster Mussel	TN	S1	E	E, XN
	Erimonax monachus	Spotfin Chub	TN	S2	T	T, XN
	Fusconaia cor	Shiny Pigtoe Pearlymussel	TN	S1	E	E, XN
	Fusconaia cuneolus	Fine-rayed Pigtoe	TN	S1	E	E, XN
	Io fluvialis	Spiny Riversnail	TN	S2		UR
	Lampsilis abrupta	Pink Mucket	TN	S2	E	E
	Lampsilis virescens	Alabama Lampmussel	TN	S1	E	E, XN
	Obovaria retusa	Ring Pink	TN	S1	E	E, XN
	Plethobasus cicatricosus	White Wartyback	TN	S1	E	E, XN
	Plethobasus cooperianus	Orange-foot Pimpleback	TN	S1	E	E, XN
	Plethobasus cyphyus	Sheepnose	TN	S2S3	E	E
	Pleurobema oviforme	Tennessee Clubshell	TN	S2S3		PE
	Pleurobema rubrum	Pyramid Pigtoe	TN	S1S2		PT
	Pleuronaia barnesiana	Tennessee Pigtoe	TN			PE
	Pleuronaia dolabelloides	Slabside Pearlymussel	TN	S2	E	E
	Venustaconcha trabalis	Tennessee Bean	TN	S1		E
Marshall						
	Acipenser fulvescens	Lake Sturgeon	KY	S1	E	UR
	Cyprogenia stegaria	Fanshell	KY	S1	E	E, XN
	Fusconaia subrotunda	Longsolid	KY	S3	S	T
	Lampsilis abrupta	Pink Mucket	KY	S1	E	E
	Macrochelys temminckii	Alligator Snapping Turtle	KY	S1	E	PT
	Obovaria retusa	Ring Pink	KY	S1	E	E, XN
	Plethobasus cooperianus	Orange-foot Pimpleback	KY	S1	E	E, XN
	Plethobasus cyphyus	Sheepnose	KY	S1	E	E
	Pleurobema rubrum	Pyramid Pigtoe	KY	S1	E	PT
	Pleurocera curta	Shortspire Hornsnail	KY	S2	S	UR
	Potamilus capax	Fat Pocketbook	KY	S2	T	E
	Quadrula cylindrica	Rabbitsfoot	KY	S2	E	T
	Quadrula cylindrica cylindrica	Smooth Rabbitsfoot	KY	S2	T	T
	Sterna antillarum athalassos	Interior Least Tern	KY	S1S2B	E	DL
Melton Hill Dam						
	Accipiter striatus	Sharp-shinned Hawk	TN	S3B		PS
	Acipenser fulvescens	Lake Sturgeon	TN	S1	E	UR

Facility	Scientific Name	Common Name	State	State Rank	State Status	Federal Status
	Cryptobranchus alleganiensis	Hellbender	TN	S3	E	PS
	Cumberlandia monodonta	Spectaclecase	TN	S2S3	E	E
	Cyprogenia stegaria	Fanshell	TN	S1	E	E, XN
	Fusconaia cor	Shiny Pigtoe Pearlymussel	TN	S1	E	E, XN
	Fusconaia cuneolus	Fine-rayed Pigtoe	TN	S1	E	E, XN
	Io fluvialis	Spiny Riversnail	TN	S2		UR
	Lampsilis abrupta	Pink Mucket	TN	S2	E	E
	Myotis grisescens	Gray Bat	TN	S2	E	E
	Myotis sodalis	Indiana Bat	TN	S1	E	E
	Obovaria retusa	Ring Pink	TN	S1	E	E, XN
	Perimyotis subflavus	Tricolored Bat	TN	S2S3	T	PE
	Plethobasus cicatricosus	White Wartyback	TN	S1	E	E, XN
	Plethobasus cooperianus	Orange-foot Pimpleback	TN	S1	E	E, XN
	Plethobasus cyphyus	Sheepnose	TN	S2S3	E	E
	Pleurobema oviforme	Tennessee Clubshell	TN	S2S3		PE
	Pleurobema rubrum	Pyramid Pigtoe	TN	S1S2		PT
	Pleuronaia dolabelloides	Slabside Pearlymussel	TN	S2	E	E
Nickajack Dam						
	Athearnia anthonyi	Anthony's River Snail	AL	S1	SP	E, XN
	Cyprogenia stegaria	Fanshell	TN	S1	E	E, XN
	Epioblasma triquetra	Snuffbox	AL	S1	PSM	E
	Haliaeetus leucocephalus	Bald Eagle	TN		D	DL
	Io fluvialis	Spiny Riversnail	AL	SX		UR
	Lampsilis abrupta	Pink Mucket	TN	S2	E	E
	Myotis grisescens	Gray Bat	TN	S2	E	E
	Myotis sodalis	Indiana Bat	TN	S1	E	E
	Percina tanasi	Snail Darter	TN	S2S3	T	DL
	Perimyotis subflavus	Tricolored Bat	TN	S2S3	T	PE
	Platanthera integrilabia	White Fringeless Orchid	AL	S2		T
	Plethobasus cooperianus	Orange-foot Pimpleback	AL	SX	SP	E, XN
	Pleurocera corpulenta	Corpulent Hornsnail	AL	S1		UR
	Pleuronaia dolabelloides	Slabside Pearlymussel	AL	S1	SP	E
	Quadrula cylindrica cylindrica	Smooth Rabbitsfoot	AL	S1	SP	T
Norris Dam						
	Acipenser fulvescens	Lake Sturgeon	TN	S1	E	UR
	Cryptobranchus alleganiensis	Hellbender	TN	S3	E	PS
	Cumberlandia monodonta	Spectaclecase	TN	S2S3	E	E
	Cyprogenia stegaria	Fanshell	TN	S1	E	E, XN

Facility	Scientific Name	Common Name	State	State Rank	State Status	Federal Status
	Fusconaia cor	Shiny Pigtoe Pearlymussel	TN	S1	E	E, XN
	Fusconaia cuneolus	Fine-rayed Pigtoe	TN	S1	E	E, XN
	Io fluvialis	Spiny Riversnail	TN	S2		UR
	Lampsilis abrupta	Pink Mucket	TN	S2	E	E
	Myotis grisescens	Gray Bat	TN	S2	E	E
	Myotis lucifugus	Little Brown Bat	TN	S3	T	UR
	Myotis septentrionalis	Northern Long-eared Bat	TN	S1S2	T	E
	Myotis sodalis	Indiana Bat	TN	S1	E	E
	Obovaria retusa	Ring Pink	TN	S1	E	E, XN
	Perimyotis subflavus	Tricolored Bat	TN	S2S3	T	PE
	Plethobasus cicatricosus	White Wartyback	TN	S1	E	E, XN
	Plethobasus cooperianus	Orange-foot Pimpleback	TN	S1	E	E, XN
	Plethobasus cyphyus	Sheepnose	TN	S2S3	E	E
	Pleurobema oviforme	Tennessee Clubshell	TN	S2S3		PE
	Pleurobema rubrum	Pyramid Pigtoe	TN	S1S2		PT
	Pleuronaia dolabelloides	Slabside Pearlymussel	TN	S2	E	E
North Alabama Solar						
	Elimia nassula	Round-rib Elimia	AL	S1		UR
	Etheostoma tuscumbia	Tuscumbia Darter	AL	S2	SP	UR
	Lampsilis abrupta	Pink Mucket	AL	S1	SP	E
	Leavenworthia crassa	Fleshy-fruit Gladecress	AL	S2		E
	Pleuronaia barnesiana	Tennessee Pigtoe	AL	S1	PSM	PE
Nottely Dam						
	Cryptobranchus alleganiensis alleganiensis	Eastern Hellbender	GA			PS:E,UR
	Haliaeetus leucocephalus	Bald Eagle	GA	S3	T	DL
	Moxostoma sp. 2	Sicklefin Redhorse	NC	S2	T	UR
	Myotis septentrionalis	Northern Long-eared Bat	GA	E	T	E
Paradise						
	Cyprogenia stegaria	Fanshell	KY	S1	E	E, XN
	Fusconaia subrotunda	Longsolid	KY	S3	S	T
	Gallinula galeata	Common Gallinule	KY	S1S2B	T	PS
	Haliaeetus leucocephalus	Bald Eagle	KY	S3B,S3S4N	S	DL
	Lampsilis abrupta	Pink Mucket	KY	S1	E	E
	Pleurobema plenum	Rough Pigtoe	KY	S1	E	E, XN
	Pleurobema rubrum	Pyramid Pigtoe	KY	S1	E	PT
	Vireo bellii	Bell's Vireo	KY	S2S3B	S	PS

Facility	Scientific Name	Common Name	State	State Rank	State Status	Federal Status
Pickwick Landing Dam						
	Athearnia anthonyi	Anthony's River Snail	AL	S1	SP	E, XN
	Cryptobranchus alleganiensis	Hellbender	TN	S3	E	PS
	Cumberlandia monodonta	Spectaclecase	TN	S2S3	E	E
	Cyprogenia stegaria	Fanshell	AL	S1	SP	E, XN
	Dromus dromas	Dromedary Pearlymussel	AL	SX	SP	E, XN
	Epioblasma brevidens	Cumberlandian Combshell	AL	S1	SP	E, XN
	Epioblasma capsaeformis	Oyster Mussel	AL	SX	SP	E, XN
	Epioblasma florentina florentina	Yellow-blossom Pearlymussel	AL	SX	SP	DL
	Epioblasma torulosa torulosa	Tuberculed Blossom Pearlymussel	AL	SX	SP	DL
	Fusconaia cor	Shiny Pigtoe Pearlymussel	AL	S1	SP	E, XN
	Fusconaia subrotunda	Longsolid	AL	S1	PSM	T
	Haliaeetus leucocephalus	Bald Eagle	TN		D	DL
	Hemistena lata	Cracking Pearlymussel	TN	S1	E	E, XN
	Lampsilis abrupta	Pink Mucket	TN	S2	E	E
	Lemiox rimosus	Birdwing Pearlymussel	AL	S1	SP	E, XN
	Obovaria retusa	Ring Pink	AL	SH	SP	E, XN
	Obovaria subrotunda	Round Hickorynut	AL	S2	PSM	T
	Orconectes wrighti	Hardin Crayfish	TN	S2	E	UR
	Plethobasus cicatricosus	White Wartyback	TN	S1	E	E, XN
	Plethobasus cooperianus	Orange-foot Pimpleback	TN	S1	E	E, XN
	Plethobasus cyphyus	Sheepnose	TN	S2S3	E	E
	Pleurobema clava	Clubshell	TN	SH	E	E, XN
	Pleurobema oviforme	Tennessee Clubshell	AL	S1	PSM	PE
	Pleurobema plenum	Rough Pigtoe	TN	S1	E	E, XN
	Pleurobema rubrum	Pyramid Pigtoe	AL	S1	SP	PT
	Pleurocera curta	Shortspire Hornsnail	TN	S2		UR
	Pleuronaia dolabelloides	Slabside Pearlymussel	AL	S1	SP	E
	Ptychobranchus subtentum	Fluted Kidneyshell	AL	SX	SP	E
	Quadrula cylindrica	Rabbitsfoot	TN			T
	Quadrula cylindrica cylindrica	Smooth Rabbitsfoot	AL	S1	SP	T
	Quadrula intermedia	Cumberland Monkeyface	AL	SX	SP	E, XN
	Toxolasma cylindrellus	Pale Lilliput	AL	S1	SP	E
Shawnee						
	Haliaeetus leucocephalus	Bald Eagle	KY	S3B,S3S4N	S	DL
	Lampsilis abrupta	Pink Mucket	KY	S1	E	E
	Myotis lucifugus	Little Brown Bat	KY			UR
	Myotis septentrionalis	Northern Long-eared Bat	KY	S1	E	E

Facility	Scientific Name	Common Name	State	State Rank	State Status	Federal Status
	Myotis sodalis	Indiana Bat	KY	S1S2	E	E
	Perimyotis subflavus	Tricolored Bat	KY	S2	T	PE
	Plethobasus cooperianus	Orange-foot Pimpleback	KY	S1	E	E, XN
	Plethobasus cyphyus	Sheepnose	KY	S1	E	E
	Potamilus capax	Fat Pocketbook	KY	S2	T	E
	Quadrula cylindrica	Rabbitsfoot	KY	S2	E	T
	Quadrula cylindrica cylindrica	Smooth Rabbitsfoot	KY	S2	T	T
	Sterna antillarum athalassos	Interior Least Tern	KY	S1S2B	E	DL
	Vireo bellii	Bell's Vireo	KY	S2S3B	S	PS
S Holston Dam						
	Haliaeetus leucocephalus	Bald Eagle	TN		D	DL
	Pleuronaia barnesiana	Tennessee Pigtoe	VA	S2		PE
Tellico Dam						
	Acipenser fulvescens	Lake Sturgeon	TN	S1	E	UR
	Cryptobranchus alleganiensis	Hellbender	TN	S3	E	PS
	Haliaeetus leucocephalus	Bald Eagle	TN		D	DL
	Lampsilis abrupta	Pink Mucket	TN	S2	E	E
	Percina tanasi	Snail Darter	TN	S2S3	T	DL
	Plethobasus cooperianus	Orange-foot Pimpleback	TN	S1	E	E, XN
	Pleurobema oviforme	Tennessee Clubshell	TN	S2S3		PE
Tims Ford Dam						
	Epioblasma brevidens	Cumberlandian Combshell	TN	S1	E	E, XN
	Epioblasma florentina walkeri	Tan Riffleshell	TN	S1	E	E
	Etheostoma wapiti	Boulder Darter	TN	S1	E	E, XN
	Fusconaia cor	Shiny Pigtoe Pearlymussel	TN	S1	E	E, XN
	Fusconaia cuneolus	Fine-rayed Pigtoe	TN	S1	E	E, XN
	Hemistena lata	Cracking Pearlymussel	TN	S1	E	E, XN
	Obovaria subrotunda	Round Hickorynut	TN	S2S3		T
	Pleurobema oviforme	Tennessee Clubshell	TN	S2S3		PE
	Pleuronaia dolabelloides	Slabside Pearlymussel	TN	S2	E	E
	Quadrula cylindrica cylindrica	Smooth Rabbitsfoot	TN	S3	T	T
	Quadrula intermedia	Cumberland Monkeyface	TN	S1	E	E, XN
	Villosa fabalis	Rayed Bean	TN	S1	E	E
Vonore Battery Storage						
	Acipenser fulvescens	Lake Sturgeon	TN	S1	E	UR
	Haliaeetus leucocephalus	Bald Eagle	TN		D	DL
	Percina tanasi	Snail Darter	TN	S2S3	T	DL

Facility	Scientific Name	Common Name	State	State Rank	State Status	Federal Status
Watauga Dam						
	Haliaeetus leucocephalus	Bald Eagle	TN		D	DL
	Minuartia godfreyi	Godfrey's Stitchwort	TN	S1	E	UR
	Myotis septentrionalis	Northern Long-eared Bat	TN	S1S2	T	E
	Tsuga caroliniana	Carolina Hemlock	TN	S3	T	UR
Watts Bar Nuclear						
	Acipenser fulvescens	Lake Sturgeon	TN	S1	E	UR
	Chrosomus saylori	Laurel Dace	TN	S1	E	E
	Cryptobranchus alleganiensis	Hellbender	TN	S3	E	PS
	Cyprogenia stegaria	Fanshell	TN	S1	E	E, XN
	Dromus dromas	Dromedary Pearlymussel	TN	S1	E	E, XN
	Fusconaia cor	Shiny Pigtoe Pearlymussel	TN	S1	E	E, XN
	Fusconaia subrotunda	Longsolid	TN	S3		T
	Haliaeetus leucocephalus	Bald Eagle	TN		D	DL
	Lampsilis abrupta	Pink Mucket	TN	S2	E	E
	Percina tanasi	Snail Darter	TN	S2S3	T	DL
	Plethobasus cooperianus	Orange-foot Pimpleback	TN	S1	E	E, XN
	Plethobasus cyphyus	Sheepnose	TN	S2S3	E	E
	Pleurobema oviforme	Tennessee Clubshell	TN	S2S3		PE
	Pleurobema plenum	Rough Pigtoe	TN	S1	E	E, XN
	Pleurobema rubrum	Pyramid Pigtoe	TN	S1S2		PT
Watts Bar Dam						
	Acipenser fulvescens	Lake Sturgeon	TN	S1	E	UR
	Chrosomus saylori	Laurel Dace	TN	S1	E	E
	Cryptobranchus alleganiensis	Hellbender	TN	S3	E	PS
	Cyprogenia stegaria	Fanshell	TN	S1	E	E, XN
	Dromus dromas	Dromedary Pearlymussel	TN	S1	E	E, XN
	Fusconaia cor	Shiny Pigtoe Pearlymussel	TN	S1	E	E, XN
	Fusconaia subrotunda	Longsolid	TN	S3		T
	Haliaeetus leucocephalus	Bald Eagle	TN		D	DL
	Lampsilis abrupta	Pink Mucket	TN	S2	E	E
	Percina tanasi	Snail Darter	TN	S2S3	T	DL
	Plethobasus cooperianus	Orange-foot Pimpleback	TN	S1	E	E, XN
	Plethobasus cyphyus	Sheepnose	TN	S2S3	E	E
	Pleurobema oviforme	Tennessee Clubshell	TN	S2S3		PE
	Pleurobema plenum	Rough Pigtoe	TN	S1	E	E, XN
	Pleurobema rubrum	Pyramid Pigtoe	TN	S1S2		PT

Facility	Scientific Name	Common Name	State	State Rank	State Status	Federal Status
Wheeler Dam						
	Athearnia anthonyi	Anthony's River Snail	AL	S1	SP	E, XN
	Cumberlandia monodonta	Spectaclecase	AL	S1	SP	E
	Cyprogenia stegaria	Fanshell	AL	S1	SP	E, XN
	Dromus dromas	Dromedary Pearlymussel	AL	SX	SP	E, XN
	Elimia nassula	Round-rib Elimia	AL	S1		UR
	Epioblasma brevidens	Cumberlandian Combshell	AL	S1	SP	E, XN
	Epioblasma capsaeformis	Oyster Mussel	AL	SX	SP	E, XN
	Epioblasma obliquata obliquata	Purple Catspaw	AL	SX	SP	E, XN
	Epioblasma triquetra	Snuffbox	AL	S1	PSM	E
	Etheostoma tuscumbia	Tuscumbia Darter	AL	S2	SP	UR
	Fusconaia cuneolus	Fine-rayed Pigtoe	AL	S1	SP	E, XN
	Fusconaia subrotunda	Longsolid	AL	S1	PSM	T
	Haliaeetus leucocephalus	Bald Eagle	AL	S4B	SP	DL
	Hemistena lata	Cracking Pearlymussel	AL	S1	SP,P1	E, XN
	Lampsilis abrupta	Pink Mucket	AL	S1	SP	E
	Lemiox rimosus	Birdwing Pearlymussel	AL	S1	SP	E, XN
	Leptodea leptodon	Scaleshell	AL	SX	SP	E
	Macrochelys temminckii	Alligator Snapping Turtle	AL	S3	SP	PT
	Medionidus conradicus	Cumberland Moccasinshell	AL	S1	SP	PE
	Obovaria retusa	Ring Pink	AL	SH	SP	E, XN
	Obovaria subrotunda	Round Hickorynut	AL	S2	PSM	T
	Palaemonias alabamae	Alabama Blind Cave Shrimp	AL	S1	SP	E
	Percina tanasi	Snail Darter	AL	S1	SP	DL
	Plethobasus cicatricosus	White Wartyback	AL	S1	SP	E, XN
	Plethobasus cooperianus	Orange-foot Pimpleback	AL	SX	SP	E, XN
	Plethobasus cyphyus	Sheepnose	AL	S1	SP	E
	Pleurobema clava	Clubshell	AL	SX	SP	E, XN
	Pleurobema oviforme	Tennessee Clubshell	AL	S1	PSM	PE
	Pleurobema plenum	Rough Pigtoe	AL	S1	SP	E, XN
	Pleurobema rubrum	Pyramid Pigtoe	AL	S1	SP	PT
	Pleurocera corpulenta	Corpulent Hornsnail	AL	S1		UR
	Pleurocera curta	Shortspire Hornsnail	AL	S1S2		UR
	Pleuronaia barnesiana	Tennessee Pigtoe	AL	S1	PSM	PE
	Pleuronaia dolabelloides	Slabside Pearlymussel	AL	S1	SP	E
	Ptychobranchus subtentum	Fluted Kidneyshell	AL	SX	SP	E
	Quadrula cylindrica cylindrica	Smooth Rabbitsfoot	AL	S1	SP	T

Facility	Scientific Name	Common Name	State	State Rank	State Status	Federal Status
	Speoplatyrhinus poulsoni	Alabama Cavefish	AL	S1	SP	E
	Villosa fabalis	Rayed Bean	AL	SX		E
Wilbur Dam						
	Cryptobranchus alleganiensis	Hellbender	TN	S3	E	PS
	Haliaeetus leucocephalus	Bald Eagle	TN		D	DL
	Minuartia godfreyi	Godfrey's Stitchwort	TN	S1	E	UR
	Myotis septentrionalis	Northern Long-eared Bat	TN	S1S2	T	E
	Tsuga caroliniana	Carolina Hemlock	TN	S3	T	UR
Wilson Dam						
	Athearnia anthonyi	Anthony's River Snail	AL	S1	SP	E, XN
	Cumberlandia monodonta	Spectaclecase	AL	S1	SP	E
	Cyprogenia stegaria	Fanshell	AL	S1	SP	E, XN
	Dromus dromas	Dromedary Pearlymussel	AL	SX	SP	E, XN
	Epioblasma brevidens	Cumberlandian Combshell	AL	S1	SP	E, XN
	Epioblasma capsaeformis	Oyster Mussel	AL	SX	SP	E, XN
	Epioblasma obliquata obliquata	Purple Catspaw	AL	SX	SP	E, XN
	Epioblasma triquetra	Snuffbox	AL	S1	PSM	E
	Fusconaia cuneolus	Fine-rayed Pigtoe	AL	S1	SP	E, XN
	Fusconaia subrotunda	Longsolid	AL	S1	PSM	T
	Haliaeetus leucocephalus	Bald Eagle	AL	S4B	SP	DL
	Hemistena lata	Cracking Pearlymussel	AL	S1	SP,P1	E, XN
	Lampsilis abrupta	Pink Mucket	AL	S1	SP	E
	Lemiox rimosus	Birdwing Pearlymussel	AL	S1	SP	E, XN
	Leptodea leptodon	Scaleshell	AL	SX	SP	E
	Macrochelys temminckii	Alligator Snapping Turtle	AL	S3	SP	PT
	Medionidus conradicus	Cumberland Moccasinshell	AL	S1	SP	PE
	Myotis grisescens	Gray Bat	AL	S2	SP	E
	Myotis sodalis	Indiana Bat	AL	S2	SP	E
	Obovaria retusa	Ring Pink	AL	SH	SP	E, XN
	Obovaria subrotunda	Round Hickorynut	AL	S2	PSM	T
	Palaemonias alabamae	Alabama Blind Cave Shrimp	AL	S1	SP	E
	Percina tanasi	Snail Darter	AL	S1	SP	DL
	Plethobasus cicatricosus	White Wartyback	AL	S1	SP	E, XN
	Plethobasus cooperianus	Orange-foot Pimpleback	AL	SX	SP	E, XN
	Plethobasus cyphyus	Sheepnose	AL	S1	SP	E
	Pleurobema clava	Clubshell	AL	SX	SP	E, XN
	Pleurobema oviforme	Tennessee Clubshell	AL	S1	PSM	PE
	Pleurobema plenum	Rough Pigtoe	AL	S1	SP	E, XN

Facility	Scientific Name	Common Name	State	State Rank	State Status	Federal Status
	Pleurobema rubrum	Pyramid Pigtoe	AL	S1	SP	PT
	Pleurocera corpulenta	Corpulent Hornsnail	AL	S1		UR
	Pleurocera curta	Shortspire Hornsnail	AL	S1S2		UR
	Pleuronaia barnesiana	Tennessee Pigtoe	AL	S1	PSM	PE
	Pleuronaia dolabelloides	Slabside Pearlymussel	AL	S1	SP	E
	Ptychobranchus subtentum	Fluted Kidneyshell	AL	SX	SP	E
	Quadrula cylindrica cylindrica	Smooth Rabbitsfoot	AL	S1	SP	T
	Speoplatyrhinus poulsoni	Alabama Cavefish	AL	S1	SP	E
	Villosa fabalis	Rayed Bean	AL	SX		E

B

Appendix B – Socioeconomics and Environmental Justice

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Appendix B - Socioeconomics and Environmental Justice

B.1 Counties within the TVA PSA

State	County		
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	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	

State	County		
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 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 Wayne County Weakley County White County Williamson County Wilson County
Virginia Counties and Independent Cities	Lee County Scott County	Washington County Wise County	Bristol City Norton City

B.2 Limited-Income Counties in the TVA PSA

Geography	Population 16 years and Over	Per Capita Income ($)	Poverty (%)
Lawrence County, Alabama	26,784	29,486	15.8
Colbert County, Alabama	46,692	30,724	15.9
Etowah County, Alabama	83,569	28,479	15.9
Franklin County, Alabama	24,985	24,874	16.6
Marshall County, Alabama	75,849	29,509	16.6
Winston County, Alabama	19,441	26,933	18.2
Jackson County, Alabama	43,027	27,695	18.6
DeKalb County, Alabama	56,883	24,915	20.2
Gilmer County, Georgia	26,144	34,412	14.8
Towns County, Georgia	11,180	33,443	15.3
Chattooga County, Georgia	19,821	21,576	19.9
Logan County, Kentucky	21,629	27,741	15.7
Muhlenberg County, Kentucky	25,111	31,621	16.3
Allen County, Kentucky	16,412	28,307	16.5
Christian County, Kentucky	54,414	25,973	16.7
Hickman County, Kentucky	3,724	38,895	16.7
Livingston County, Kentucky	7,432	31,024	16.8
Edmonson County, Kentucky	10,186	26,781	17.0
Warren County, Kentucky	107,619	34,201	17.2
Trigg County, Kentucky	11,426	30,172	18.2
Calloway County, Kentucky	31,421	27,850	18.7
Butler County, Kentucky	9,872	23,862	19.8
Graves County, Kentucky	28,886	28,978	19.8
Carlisle County, Kentucky	3,790	31,403	20.1
Monroe County, Kentucky	9,035	26,549	20.9
Grayson County, Kentucky	20,959	25,565	21.1
Todd County, Kentucky	9,432	30,252	21.1
Fulton County, Kentucky	5,273	19,960	27.4
Cumberland County, Kentucky	4,784	22,668	28.3
Webster County, Mississippi	7,802	27,836	15.8
Prentiss County, Mississippi	20,085	27,979	16.3
Monroe County, Mississippi	27,302	27,619	16.7
Pontotoc County, Mississippi	23,824	26,359	16.7
Tate County, Mississippi	22,445	28,306	16.7
Alcorn County, Mississippi	27,882	27,320	17.1
Benton County, Mississippi	6,299	24,690	17.6
Lowndes County, Mississippi	46,255	29,750	18.1
Calhoun County, Mississippi	10,644	24,192	18.8
Tippah County, Mississippi	17,150	27,762	18.9
Choctaw County, Mississippi	6,615	27,628	19.1
Tishomingo County, Mississippi	15,268	26,896	19.2
Marshall County, Mississippi	27,768	27,680	19.5
Lafayette County, Mississippi	46,935	32,536	19.6
Panola County, Mississippi	25,797	25,822	20.4
Yalobusha County, Mississippi	10,171	24,719	20.5

Geography	Population 16 years and Over	Per Capita Income ($)	Poverty (%)
Leake County, Mississippi	17,041	25,662	21.0
Scott County, Mississippi	21,373	23,043	21.9
Kemper County, Mississippi	7,547	22,046	22.0
Clay County, Mississippi	14,892	24,702	23.0
Noxubee County, Mississippi	7,996	19,804	23.2
Attala County, Mississippi	13,759	27,625	23.6
Tallahatchie County, Mississippi	10,281	20,348	25.7
Winston County, Mississippi	14,208	27,743	26.0
Chickasaw County, Mississippi	13,269	21,968	26.6
Neshoba County, Mississippi	22,051	23,538	28.0
Oktibbeha County, Mississippi	43,626	28,221	28.5
Cherokee County, North Carolina	24,817	28,752	16.7
Watauga County, North Carolina	48,773	30,807	24.9
Smith County, Tennessee	16,117	31,446	14.9
Cannon County, Tennessee	11,799	30,234	15.1
Sullivan County, Tennessee	132,231	33,934	15.2
Anderson County, Tennessee	62,800	32,803	15.4
Meigs County, Tennessee	10,544	26,843	15.4
Crockett County, Tennessee	10,987	30,362	15.6
Greene County, Tennessee	58,501	28,237	15.6
Marshall County, Tennessee	27,611	32,225	15.6
Rhea County, Tennessee	26,860	26,678	15.7
Washington County, Tennessee	111,727	35,562	15.7
Chester County, Tennessee	14,082	24,788	15.8
Union County, Tennessee	16,123	28,174	15.9
Monroe County, Tennessee	38,029	27,356	16.0
Hardeman County, Tennessee	21,321	22,098	16.1
Lawrence County, Tennessee	34,372	26,865	16.1
Obion County, Tennessee	24,703	28,782	16.1
Dyer County, Tennessee	28,929	37,415	16.3
Marion County, Tennessee	23,698	29,314	16.3
Putnam County, Tennessee	65,684	29,419	16.3
Carroll County, Tennessee	22,845	26,818	16.4
Macon County, Tennessee	19,914	24,979	16.5
McNairy County, Tennessee	21,082	25,004	16.7
Unicoi County, Tennessee	14,956	27,930	16.7
Warren County, Tennessee	32,671	27,059	16.8
Coffee County, Tennessee	45,845	29,277	16.9
Hawkins County, Tennessee	47,568	28,648	16.9
Van Buren County, Tennessee	5,156	24,099	17.0
Hamblen County, Tennessee	51,238	27,845	17.1
White County, Tennessee	21,993	26,213	17.1
Overton County, Tennessee	18,398	29,556	17.3
Grainger County, Tennessee	19,744	26,545	17.6
Benton County, Tennessee	13,164	27,185	18.0
Henderson County, Tennessee	22,415	25,873	18.0
Lauderdale County, Tennessee	20,161	24,358	18.0

Geography	Population 16 years and Over	Per Capita Income ($)	Poverty (%)
Carter County, Tennessee	47,403	28,321	18.1
Henry County, Tennessee	26,438	28,098	18.1
Shelby County, Tennessee	721,643	36,230	18.1
Grundy County, Tennessee	11,124	25,075	18.2
Madison County, Tennessee	79,529	31,380	18.2
Claiborne County, Tennessee	26,655	25,408	18.3
Lewis County, Tennessee	10,232	26,873	18.9
Weakley County, Tennessee	27,581	26,820	18.9
Decatur County, Tennessee	9,438	27,578	19.2
Campbell County, Tennessee	32,109	26,791	19.4
Hardin County, Tennessee	22,102	26,068	19.4
Wayne County, Tennessee	13,806	26,538	19.6
Jackson County, Tennessee	9,973	25,534	19.7
Cocke County, Tennessee	29,708	25,864	20.1
DeKalb County, Tennessee	16,416	27,684	20.2
Fentress County, Tennessee	15,403	24,595	20.2
Morgan County, Tennessee	17,542	27,320	20.9
Pickett County, Tennessee	4,201	27,259	21.0
Johnson County, Tennessee	15,396	26,627	21.6
Haywood County, Tennessee	14,396	26,031	21.9
Clay County, Tennessee	6,208	22,931	22.3
Sequatchie County, Tennessee	13,212	25,954	22.3
Scott County, Tennessee	17,387	22,273	25.7
Bledsoe County, Tennessee	12,644	24,241	26.0
Lake County, Tennessee	6,018	19,695	27.9
Hancock County, Tennessee	5,417	24,120	32.3
Bristol city, Virginia	13,904	30,419	17.0
Scott County, Virginia	18,094	26,681	17.0
Wise County, Virginia	30,055	23,702	19.9
Lee County, Virginia	18,676	23,257	26.0
Norton city, Virginia	3,138	27,666	29.1

Source: USCB 2023f

B.3 Low-Income Census Tracts in the TVA PSA

Geography	Population 16 Years and Over	Per Capita Income ($)	Poverty (%)
Census Tract 207.05; Colbert County; Alabama	913	26,663	14.8
Census Tract 9792.01; Lawrence County; Alabama	1,464	25,628	14.9
Census Tract 307.02; Marshall County; Alabama	3,175	38,894	14.9
Census Tract 9558.01; Cherokee County; Alabama	1,852	23,869	15.0
Census Tract 104.01; Etowah County; Alabama	3,232	21,477	15.0
Census Tract 9506.01; Jackson County; Alabama	3,195	23,851	15.0
Census Tract 310.01; Marshall County; Alabama	2,443	22,629	15.0
Census Tract 208.02; Colbert County; Alabama	2,850	28,554	15.1
Census Tract 9649.01; Cullman County; Alabama	3,035	37,422	15.2
Census Tract 9793; Lawrence County; Alabama	3,335	35,025	15.3
Census Tract 14.04; Madison County; Alabama	3,194	36,939	15.4
Census Tract 112.02; Madison County; Alabama	4,545	52,382	15.4
Census Tract 57.01; Morgan County; Alabama	1,697	29,545	15.4
Census Tract 57.03; Morgan County; Alabama	2,578	31,875	15.5
Census Tract 31; Madison County; Alabama	5,078	49,399	15.6
Census Tract 110.02; Etowah County; Alabama	3,855	22,382	15.7
Census Tract 505.02; Blount County; Alabama	2,911	32,678	15.8
Census Tract 304.01; Marshall County; Alabama	3,757	31,212	15.8
Census Tract 9561.02; Cherokee County; Alabama	1,918	24,271	15.9
Census Tract 9657; Winston County; Alabama	3,163	29,720	15.9
Census Tract 9729; Franklin County; Alabama	3,113	24,515	16.1
Census Tract 5.02; Madison County; Alabama	1,627	31,700	16.2
Census Tract 9642.02; Cullman County; Alabama	2,742	24,585	16.6
Census Tract 17; Etowah County; Alabama	1,124	26,497	16.8
Census Tract 111; Etowah County; Alabama	3,985	24,836	16.9
Census Tract 104.05; Madison County; Alabama	3,181	45,558	16.9
Census Tract 9558.02; Cherokee County; Alabama	2,318	31,300	17.0
Census Tract 9602; DeKalb County; Alabama	2,666	24,020	17.1
Census Tract 7.02; Madison County; Alabama	2,395	30,742	17.1
Census Tract 109.01; Lauderdale County; Alabama	3,090	30,844	17.3
Census Tract 9641; Cullman County; Alabama	5,145	28,445	17.4
Census Tract 9; Etowah County; Alabama	2,111	21,511	17.6
Census Tract 308.01; Marshall County; Alabama	3,815	31,889	17.6
Census Tract 501.07; Blount County; Alabama	2,042	23,043	17.7
Census Tract 9606.02; DeKalb County; Alabama	3,931	25,305	17.8
Census Tract 201.04; Limestone County; Alabama	2,743	27,553	17.8
Census Tract 9504; Jackson County; Alabama	1,806	38,913	17.9
Census Tract 206; Limestone County; Alabama	3,880	22,903	17.9
Census Tract 9510; Jackson County; Alabama	3,569	28,695	18.0
Census Tract 14.03; Madison County; Alabama	2,066	40,351	18.1
Census Tract 103; Etowah County; Alabama	2,326	23,128	18.2
Census Tract 6.02; Madison County; Alabama	1,798	30,976	18.5
Census Tract 9792.02; Lawrence County; Alabama	1,870	25,583	18.6
Census Tract 204.04; Limestone County; Alabama	2,513	58,030	18.6
Census Tract 25.02; Madison County; Alabama	2,852	22,233	18.7

Geography	Population 16 Years and Over	Per Capita Income ($)	Poverty (%)
Census Tract 9605; DeKalb County; Alabama	5,303	23,222	18.8
Census Tract 308.04; Marshall County; Alabama	3,793	17,610	18.8
Census Tract 53.05; Morgan County; Alabama	4,650	27,137	18.9
Census Tract 203; Limestone County; Alabama	2,675	34,130	19.2
Census Tract 501.03; Blount County; Alabama	1,614	29,396	19.3
Census Tract 9611; DeKalb County; Alabama	2,602	23,331	19.3
Census Tract 106; Lauderdale County; Alabama	2,183	25,518	19.3
Census Tract 205; Limestone County; Alabama	2,384	24,036	19.3
Census Tract 9655.02; Winston County; Alabama	2,981	31,126	19.3
Census Tract 503.02; Blount County; Alabama	2,130	24,425	19.4
Census Tract 307.01; Marshall County; Alabama	2,775	31,594	19.4
Census Tract 202; Colbert County; Alabama	1,478	22,512	19.5
Census Tract 9733; Franklin County; Alabama	2,610	24,243	19.5
Census Tract 9503.01; Jackson County; Alabama	2,132	25,326	19.7
Census Tract 15; Madison County; Alabama	5,425	20,873	20.1
Census Tract 51.09; Morgan County; Alabama	3,636	23,010	20.1
Census Tract 9730; Franklin County; Alabama	3,922	19,369	20.2
Census Tract 6.01; Madison County; Alabama	1,097	29,506	20.4
Census Tract 501.05; Blount County; Alabama	4,113	32,880	20.5
Census Tract 9; Morgan County; Alabama	4,495	22,269	20.5
Census Tract 308.03; Marshall County; Alabama	2,005	23,045	20.6
Census Tract 106.25; Madison County; Alabama	4,405	22,280	20.8
Census Tract 9655.03; Winston County; Alabama	2,451	27,346	20.9
Census Tract 9557.01; Cherokee County; Alabama	2,547	25,478	21.2
Census Tract 9607.02; DeKalb County; Alabama	1,236	25,111	21.2
Census Tract 107; Etowah County; Alabama	2,970	26,449	21.2
Census Tract 208.01; Colbert County; Alabama	3,744	33,718	21.3
Census Tract 211.01; Limestone County; Alabama	3,040	28,553	21.4
Census Tract 8; Morgan County; Alabama	2,174	23,590	21.4
Census Tract 205; Colbert County; Alabama	4,126	26,362	21.7
Census Tract 6; Etowah County; Alabama	1,785	17,336	21.7
Census Tract 9614; DeKalb County; Alabama	3,039	31,060	21.8
Census Tract 9603.03; DeKalb County; Alabama	3,604	26,475	22.1
Census Tract 302.04; Marshall County; Alabama	1,432	30,844	22.2
Census Tract 306.02; Marshall County; Alabama	3,578	28,834	22.5
Census Tract 52.02; Morgan County; Alabama	3,793	27,008	22.5
Census Tract 507.02; Blount County; Alabama	2,259	24,848	22.6
Census Tract 9653; Cullman County; Alabama	3,729	25,619	23.0
Census Tract 102; Lauderdale County; Alabama	1,777	28,096	23.0
Census Tract 9608; DeKalb County; Alabama	3,532	19,388	23.1
Census Tract 9656.02; Winston County; Alabama	2,587	22,144	23.1
Census Tract 9609; DeKalb County; Alabama	3,227	23,645	23.2
Census Tract 305.02; Marshall County; Alabama	3,911	31,618	23.2
Census Tract 110; Lauderdale County; Alabama	3,670	26,385	23.3
Census Tract 312; Marshall County; Alabama	4,262	24,146	23.3
Census Tract 9655.01; Winston County; Alabama	1,525	23,570	23.4
Census Tract 108; Lauderdale County; Alabama	2,623	18,842	23.6

Geography	Population 16 Years and Over	Per Capita Income ($)	Poverty (%)
Census Tract 311; Marshall County; Alabama	3,634	22,889	23.6
Census Tract 309.03; Marshall County; Alabama	3,684	23,337	24.1
Census Tract 9737.01; Franklin County; Alabama	1,014	22,960	24.2
Census Tract 9795.02; Lawrence County; Alabama	3,034	29,820	24.2
Census Tract 9734; Franklin County; Alabama	1,945	23,618	24.4
Census Tract 9794; Lawrence County; Alabama	3,749	24,501	24.5
Census Tract 301.01; Marshall County; Alabama	1,665	20,613	24.5
Census Tract 201; Colbert County; Alabama	2,960	30,897	24.7
Census Tract 108; Etowah County; Alabama	2,315	34,421	24.9
Census Tract 210; Colbert County; Alabama	3,059	29,298	25.3
Census Tract 9659; Winston County; Alabama	1,866	21,463	25.4
Census Tract 5.01; Madison County; Alabama	1,596	21,242	25.5
Census Tract 310.02; Marshall County; Alabama	2,601	18,983	25.7
Census Tract 1; Morgan County; Alabama	3,559	22,400	25.9
Census Tract 9507; Jackson County; Alabama	3,658	32,148	26.0
Census Tract 9508; Jackson County; Alabama	3,458	27,246	26.1
Census Tract 9502; Jackson County; Alabama	2,822	28,990	26.2
Census Tract 9606.01; DeKalb County; Alabama	996	26,988	26.3
Census Tract 9650.02; Cullman County; Alabama	3,592	29,958	26.6
Census Tract 501.06; Blount County; Alabama	2,322	22,148	27.3
Census Tract 107; Lauderdale County; Alabama	1,028	14,658	27.4
Census Tract 9607.03; DeKalb County; Alabama	3,539	22,581	27.5
Census Tract 109.02; Lauderdale County; Alabama	3,395	29,019	27.7
Census Tract 9501.01; Jackson County; Alabama	2,389	21,901	28.1
Census Tract 9654.01; Cullman County; Alabama	2,793	20,158	28.5
Census Tract 24; Madison County; Alabama	2,788	21,210	28.5
Census Tract 56.02; Morgan County; Alabama	1,804	29,076	28.6
Census Tract 3.01; Madison County; Alabama	3,069	21,318	28.9
Census Tract 12; Etowah County; Alabama	2,163	26,936	29.5
Census Tract 23; Madison County; Alabama	4,404	20,903	29.5
Census Tract 9503.02; Jackson County; Alabama	2,520	22,071	29.9
Census Tract 5; Etowah County; Alabama	1,424	20,902	31.0
Census Tract 112; Etowah County; Alabama	2,201	25,029	31.1
Census Tract 54.05; Morgan County; Alabama	4,054	27,138	31.7
Census Tract 2; Etowah County; Alabama	2,537	18,933	32.0
Census Tract 9736; Franklin County; Alabama	1,081	21,089	32.2
Census Tract 104; Lauderdale County; Alabama	2,921	24,694	32.8
Census Tract 7.01; Madison County; Alabama	2,294	23,670	33.8
Census Tract 22; Madison County; Alabama	1,588	19,803	34.1
Census Tract 9506.02; Jackson County; Alabama	1,671	24,884	34.4
Census Tract 9613; DeKalb County; Alabama	4,158	20,787	35.2
Census Tract 13.01; Madison County; Alabama	3,080	18,711	35.5
Census Tract 7; Morgan County; Alabama	2,935	16,115	35.5
Census Tract 2.03; Madison County; Alabama	5,173	10,815	35.6
Census Tract 3.02; Madison County; Alabama	3,167	14,035	35.9
Census Tract 207; Limestone County; Alabama	1,914	28,442	36.7
Census Tract 8; Etowah County; Alabama	864	15,001	36.9

Geography	Population 16 Years and Over	Per Capita Income ($)	Poverty (%)
Census Tract 9607.01; DeKalb County; Alabama	1,802	18,173	37.1
Census Tract 25.01; Madison County; Alabama	2,149	15,797	38.9
Census Tract 9601.01; DeKalb County; Alabama	1,414	22,419	39.0
Census Tract 10; Etowah County; Alabama	858	18,152	39.3
Census Tract 30; Madison County; Alabama	2,110	16,823	39.9
Census Tract 13; Etowah County; Alabama	2,312	21,427	40.1
Census Tract 203; Colbert County; Alabama	1,866	21,696	41.5
Census Tract 21; Madison County; Alabama	1,878	16,168	41.5
Census Tract 101; Lauderdale County; Alabama	2,007	12,400	41.9
Census Tract 3; Etowah County; Alabama	1,750	13,430	42.0
Census Tract 6; Morgan County; Alabama	1,987	16,191	43.4
Census Tract 12; Madison County; Alabama	2,145	13,548	43.6
Census Tract 7; Etowah County; Alabama	653	10,940	50.2
Census Tract 103; Lauderdale County; Alabama	948	15,330	60.6
Census Tract 9708.02; Gordon County; Georgia	1,632	31,506	14.8
Census Tract 803.01; Gilmer County; Georgia	1,908	30,347	15.0
Census Tract 15; Whitfield County; Georgia	5,187	26,931	15.0
Census Tract 307.02; Catoosa County; Georgia	3,755	27,878	15.1
Census Tract 11; Whitfield County; Georgia	3,693	20,343	15.2
Census Tract 401.02; Dade County; Georgia	3,072	23,792	15.5
Census Tract 2; Whitfield County; Georgia	3,783	27,020	15.5
Census Tract 9702.01; Gordon County; Georgia	2,745	35,677	15.6
Census Tract 104.01; Murray County; Georgia	2,034	20,818	15.6
Census Tract 9603.02; Towns County; Georgia	2,023	33,717	15.6
Census Tract 1.04; Union County; Georgia	2,195	32,709	16.2
Census Tract 206.02; Walker County; Georgia	3,778	22,778	16.4
Census Tract 208; Walker County; Georgia	2,347	31,192	16.5
Census Tract 101; Chattooga County; Georgia	2,069	25,825	16.6
Census Tract 9703.02; Gordon County; Georgia	4,014	25,981	16.6
Census Tract 802; Gilmer County; Georgia	5,400	35,078	17.4
Census Tract 104.02; Murray County; Georgia	2,198	23,606	17.4
Census Tract 1.01; Whitfield County; Georgia	3,048	29,350	17.4
Census Tract 9602; Towns County; Georgia	3,432	32,940	17.6
Census Tract 9706.02; Gordon County; Georgia	2,855	18,960	17.8
Census Tract 2.03; Union County; Georgia	1,833	34,257	18.1
Census Tract 203.01; Walker County; Georgia	4,279	25,834	18.3
Census Tract 9704; Gordon County; Georgia	4,922	32,643	18.4
Census Tract 101; Murray County; Georgia	2,762	28,902	18.6
Census Tract 805; Gilmer County; Georgia	3,530	29,806	18.7
Census Tract 203.02; Walker County; Georgia	4,247	24,384	20.0
Census Tract 105.01; Chattooga County; Georgia	2,332	11,259	20.1
Census Tract 1.01; Union County; Georgia	3,380	39,100	20.2
Census Tract 201.01; Walker County; Georgia	3,076	27,352	20.3
Census Tract 103; Chattooga County; Georgia	1,835	24,975	20.4
Census Tract 9707; Gordon County; Georgia	3,920	26,292	20.5
Census Tract 202; Walker County; Georgia	2,745	26,910	20.6
Census Tract 103; Murray County; Georgia	3,586	22,608	21.0

Geography	Population 16 Years and Over	Per Capita Income ($)	Poverty (%)
Census Tract 9701.02; Gordon County; Georgia	1,704	28,152	21.1
Census Tract 9705; Gordon County; Georgia	4,034	31,695	21.9
Census Tract 803.02; Gilmer County; Georgia	3,172	28,884	22.5
Census Tract 207.02; Walker County; Georgia	3,554	15,438	22.9
Census Tract 3.01; Whitfield County; Georgia	2,940	25,137	22.9
Census Tract 105.02; Chattooga County; Georgia	2,767	21,390	23.3
Census Tract 804.01; Gilmer County; Georgia	2,328	36,492	23.5
Census Tract 201.02; Walker County; Georgia	1,848	21,297	23.6
Census Tract 207.01; Walker County; Georgia	2,133	21,653	24.1
Census Tract 10; Whitfield County; Georgia	3,002	19,329	26.1
Census Tract 5.02; Whitfield County; Georgia	5,865	23,493	26.3
Census Tract 305.01; Catoosa County; Georgia	2,331	24,280	26.4
Census Tract 4.01; Whitfield County; Georgia	5,200	20,734	27.2
Census Tract 209.02; Walker County; Georgia	1,580	24,655	29.2
Census Tract 104.02; Chattooga County; Georgia	2,066	17,659	30.3
Census Tract 102.02; Chattooga County; Georgia	2,410	17,999	31.1
Census Tract 9203; Edmonson County; Kentucky	1,157	27,436	14.8
Census Tract 9602.02; Muhlenberg County; Kentucky	2,600	40,555	14.9
Census Tract 2002; Christian County; Kentucky	2,847	26,201	15.1
Census Tract 9301; Monroe County; Kentucky	1,543	31,215	15.2
Census Tract 9602; Logan County; Kentucky	2,990	28,388	15.3
Census Tract 9704.01; Simpson County; Kentucky	3,728	25,940	15.3
Census Tract 9206; Allen County; Kentucky	2,599	25,197	15.7
Census Tract 108.05; Warren County; Kentucky	2,968	37,866	16.1
Census Tract 117.02; Warren County; Kentucky	2,895	24,805	16.1
Census Tract 9702.02; Trigg County; Kentucky	2,857	31,126	16.2
Census Tract 107.01; Warren County; Kentucky	4,573	30,386	16.4
Census Tract 9304; Monroe County; Kentucky	3,837	25,915	16.5
Census Tract 9202; Edmonson County; Kentucky	3,550	24,235	16.6
Census Tract 9701; Hickman County; Kentucky	3,724	38,895	16.7
Census Tract 107.02; Warren County; Kentucky	5,868	36,279	16.7
Census Tract 2009.01; Christian County; Kentucky	2,144	50,036	16.8
Census Tract 2013.01; Christian County; Kentucky	2,725	25,592	16.8
Census Tract 9601; Logan County; Kentucky	4,155	26,918	16.8
Census Tract 9602.01; Muhlenberg County; Kentucky	3,167	23,743	17.2
Census Tract 9701; Simpson County; Kentucky	2,046	35,361	17.2
Census Tract 9703; Simpson County; Kentucky	3,661	29,145	17.4
Census Tract 113; Warren County; Kentucky	3,665	26,620	17.4
Census Tract 9506; Grayson County; Kentucky	2,816	24,599	17.5
Census Tract 9506.02; Marshall County; Kentucky	1,980	29,020	17.5
Census Tract 108; Calloway County; Kentucky	2,821	27,792	17.7
Census Tract 401; Livingston County; Kentucky	2,357	28,966	17.7
Census Tract 9604; Logan County; Kentucky	3,684	25,207	17.8
Census Tract 209; Graves County; Kentucky	2,445	26,367	17.9
Census Tract 9703.02; Trigg County; Kentucky	1,679	28,132	18.1
Census Tract 9603; Carlisle County; Kentucky	1,160	25,477	18.3
Census Tract 9204.02; Edmonson County; Kentucky	3,076	30,352	18.4

Geography	Population 16 Years and Over	Per Capita Income ($)	Poverty (%)
Census Tract 9605; Muhlenberg County; Kentucky	2,999	44,620	18.6
Census Tract 2005; Christian County; Kentucky	3,173	27,893	18.9
Census Tract 9203; Allen County; Kentucky	3,952	25,997	19.0
Census Tract 9603; Logan County; Kentucky	4,807	25,241	19.0
Census Tract 9704.02; Simpson County; Kentucky	1,787	25,710	19.2
Census Tract 402.02; Livingston County; Kentucky	2,513	27,193	19.3
Census Tract 9603; Muhlenberg County; Kentucky	3,027	25,872	19.3
Census Tract 9204; Allen County; Kentucky	3,384	31,376	19.4
Census Tract 9201; Allen County; Kentucky	2,795	29,477	19.5
Census Tract 103.04; Calloway County; Kentucky	3,069	25,409	19.5
Census Tract 202; Graves County; Kentucky	3,669	27,885	19.5
Census Tract 9304; Butler County; Kentucky	1,433	25,372	19.6
Census Tract 104; Calloway County; Kentucky	2,035	23,762	19.6
Census Tract 106.01; Calloway County; Kentucky	2,254	26,506	19.7
Census Tract 9604; Muhlenberg County; Kentucky	4,150	29,619	19.7
Census Tract 9501.01; Grayson County; Kentucky	835	31,844	20.4
Census Tract 9702.01; Trigg County; Kentucky	2,326	28,119	20.4
Census Tract 9504.02; Grayson County; Kentucky	3,918	23,947	20.8
Census Tract 9602; Fulton County; Kentucky	2,341	21,229	20.9
Census Tract 2007; Christian County; Kentucky	4,591	30,422	21.4
Census Tract 2013.04; Christian County; Kentucky	2,302	20,844	21.4
Census Tract 9504.01; Grayson County; Kentucky	1,669	31,725	21.7
Census Tract 9503; Grayson County; Kentucky	3,119	20,477	22.2
Census Tract 110.02; Warren County; Kentucky	5,786	22,663	22.3
Census Tract 9502; Cumberland County; Kentucky	1,684	24,217	22.4
Census Tract 2004; Christian County; Kentucky	2,233	20,076	22.6
Census Tract 108.01; Warren County; Kentucky	2,985	51,880	22.6
Census Tract 205; Graves County; Kentucky	3,098	25,211	22.7
Census Tract 9502; Todd County; Kentucky	4,189	30,680	22.8
Census Tract 9506.03; Marshall County; Kentucky	860	45,661	22.9
Census Tract 9501.02; Marshall County; Kentucky	1,819	28,577	23.4
Census Tract 105; Calloway County; Kentucky	2,539	26,000	23.5
Census Tract 9303; Monroe County; Kentucky	2,051	26,342	24.2
Census Tract 9607; Muhlenberg County; Kentucky	2,544	21,057	24.2
Census Tract 9302; Butler County; Kentucky	1,332	20,929	24.3
Census Tract 9502; Grayson County; Kentucky	2,454	20,023	24.8
Census Tract 9507; Grayson County; Kentucky	1,754	25,778	25.3
Census Tract 9602; Carlisle County; Kentucky	1,449	21,925	25.9
Census Tract 2001; Christian County; Kentucky	3,337	19,605	26.6
Census Tract 110.01; Warren County; Kentucky	3,305	18,365	27.3
Census Tract 109; Warren County; Kentucky	3,658	39,472	27.8
Census Tract 2008; Christian County; Kentucky	1,971	13,318	28.7
Census Tract 9505; Grayson County; Kentucky	2,472	27,906	28.8
Census Tract 203.02; Graves County; Kentucky	1,448	26,566	29.5
Census Tract 9501; Cumberland County; Kentucky	3,100	21,878	31.3
Census Tract 9601; Fulton County; Kentucky	2,932	19,065	31.3
Census Tract 203.01; Graves County; Kentucky	2,813	23,705	31.4

Geography	Population 16 Years and Over	Per Capita Income ($)	Poverty (%)
Census Tract 9503; Todd County; Kentucky	1,788	27,926	31.6
Census Tract 104; Warren County; Kentucky	4,445	6,736	31.7
Census Tract 9302; Monroe County; Kentucky	1,604	24,058	32.1
Census Tract 9505.02; Marshall County; Kentucky	2,282	23,864	32.6
Census Tract 9701; Trigg County; Kentucky	2,152	25,837	32.6
Census Tract 108.04; Warren County; Kentucky	2,982	24,484	32.8
Census Tract 112; Warren County; Kentucky	3,444	24,321	32.8
Census Tract 201; Graves County; Kentucky	3,574	27,286	33.6
Census Tract 9303.02; Butler County; Kentucky	2,443	18,902	40.0
Census Tract 102; Warren County; Kentucky	2,597	15,122	40.6
Census Tract 2003; Christian County; Kentucky	2,612	14,386	44.2
Census Tract 103.03; Calloway County; Kentucky	2,833	15,297	49.0
Census Tract 105; Warren County; Kentucky	2,654	22,747	52.1
Census Tract 103; Warren County; Kentucky	2,760	13,508	56.6
Census Tract 103.01; Calloway County; Kentucky	2,667	5,764	56.7
Census Tract 101; Warren County; Kentucky	2,885	16,636	60.6
Census Tract 9801; Edmonson County; Kentucky	157	8,568	76.2
Census Tract 9504.03; Lafayette County; Mississippi	2,827	35,469	14.9
Census Tract 9504.04; Lafayette County; Mississippi	4,756	42,930	14.9
Census Tract 9501; Tate County; Mississippi	4,162	23,090	14.9
Census Tract 9504.01; Tippah County; Mississippi	3,992	27,418	14.9
Census Tract 9504; Calhoun County; Mississippi	2,283	24,699	15.0
Census Tract 9504.02; Tishomingo County; Mississippi	3,420	25,815	15.1
Census Tract 9504; Prentiss County; Mississippi	3,663	26,883	15.2
Census Tract 9501; Tallahatchie County; Mississippi	3,279	26,881	15.3
Census Tract 9503; Union County; Mississippi	3,589	31,110	15.3
Census Tract 9509.01; Lee County; Mississippi	2,184	39,421	15.4
Census Tract 9501; Tippah County; Mississippi	3,602	40,639	15.4
Census Tract 9503; Tallahatchie County; Mississippi	3,211	15,797	15.5
Census Tract 9502.02; Panola County; Mississippi	864	24,562	15.6
Census Tract 711.22; DeSoto County; Mississippi	1,673	36,104	15.7
Census Tract 9504; Panola County; Mississippi	4,197	25,795	15.8
Census Tract 9501.02; Prentiss County; Mississippi	1,780	38,949	15.8
Census Tract 9509.02; Lee County; Mississippi	2,718	30,033	16.0
Census Tract 603; Attala County; Mississippi	2,619	24,484	16.1
Census Tract 9502; Clay County; Mississippi	1,975	25,129	16.1
Census Tract 703.25; DeSoto County; Mississippi	2,543	26,027	16.1
Census Tract 604; Attala County; Mississippi	2,146	25,921	16.2
Census Tract 9504.01; Alcorn County; Mississippi	2,158	24,102	16.3
Census Tract 401; Leake County; Mississippi	2,204	35,562	16.3
Census Tract 9502.02; Lee County; Mississippi	4,114	27,001	16.4
Census Tract 705.23; DeSoto County; Mississippi	6,161	31,751	16.6
Census Tract 9504.02; Tippah County; Mississippi	2,048	16,962	16.6
Census Tract 405; Leake County; Mississippi	2,250	26,492	16.7
Census Tract 9501; Clay County; Mississippi	3,911	21,004	16.9
Census Tract 5; Lowndes County; Mississippi	3,261	29,396	16.9
Census Tract 205; Scott County; Mississippi	4,051	20,595	16.9

Geography	Population 16 Years and Over	Per Capita Income ($)	Poverty (%)
Census Tract 9507; Alcorn County; Mississippi	3,201	22,809	17.0
Census Tract 9503.02; Lee County; Mississippi	3,366	27,255	17.0
Census Tract 703.10; DeSoto County; Mississippi	3,068	25,341	17.1
Census Tract 703.23; DeSoto County; Mississippi	3,916	23,755	17.1
Census Tract 9505.02; Panola County; Mississippi	3,240	29,646	17.2
Census Tract 9504; Union County; Mississippi	2,679	23,895	17.2
Census Tract 9501; Yalobusha County; Mississippi	2,876	26,183	17.3
Census Tract 602; Attala County; Mississippi	1,971	23,482	17.4
Census Tract 9502.01; Prentiss County; Mississippi	3,002	34,594	17.5
Census Tract 9505.02; Monroe County; Mississippi	3,245	30,945	17.6
Census Tract 9502; Webster County; Mississippi	2,843	25,010	17.6
Census Tract 705.21; DeSoto County; Mississippi	2,180	23,869	17.7
Census Tract 9505; Prentiss County; Mississippi	1,361	19,877	17.7
Census Tract 9502; Benton County; Mississippi	1,970	23,242	17.8
Census Tract 9501.01; Pontotoc County; Mississippi	2,697	32,451	18.0
Census Tract 9505; Pontotoc County; Mississippi	3,670	26,080	18.0
Census Tract 9505.07; Lafayette County; Mississippi	3,810	30,377	18.3
Census Tract 9502; Noxubee County; Mississippi	2,168	23,735	18.3
Census Tract 9503; Pontotoc County; Mississippi	4,298	26,170	18.4
Census Tract 9510.01; Lee County; Mississippi	2,828	24,394	18.6
Census Tract 9511.01; Lee County; Mississippi	2,079	25,047	18.7
Census Tract 9502.01; Monroe County; Mississippi	2,691	21,644	18.7
Census Tract 9501.02; Pontotoc County; Mississippi	4,985	23,400	18.7
Census Tract 9503.02; Prentiss County; Mississippi	2,829	34,931	19.0
Census Tract 9501; Noxubee County; Mississippi	3,574	18,633	19.3
Census Tract 9501.01; Tishomingo County; Mississippi	1,470	33,095	19.5
Census Tract 9502; Winston County; Mississippi	2,553	29,989	19.5
Census Tract 9502.02; Marshall County; Mississippi	3,467	33,020	19.9
Census Tract 206; Scott County; Mississippi	2,504	19,689	19.9
Census Tract 704.22; DeSoto County; Mississippi	2,121	20,644	20.0
Census Tract 10; Lowndes County; Mississippi	2,077	39,856	20.1
Census Tract 703.22; DeSoto County; Mississippi	3,194	25,573	20.2
Census Tract 9504.01; Chickasaw County; Mississippi	1,520	22,280	20.3
Census Tract 9506.04; Oktibbeha County; Mississippi	2,207	24,207	20.4
Census Tract 9502; Choctaw County; Mississippi	3,453	24,756	20.5
Census Tract 9502.02; Monroe County; Mississippi	2,835	24,606	20.5
Census Tract 9504.02; Chickasaw County; Mississippi	2,364	26,600	20.6
Census Tract 702.21; DeSoto County; Mississippi	2,911	28,577	20.6
Census Tract 404.02; Leake County; Mississippi	2,237	18,537	20.6
Census Tract 9503.01; Marshall County; Mississippi	3,077	32,869	20.7
Census Tract 704.21; DeSoto County; Mississippi	2,489	26,893	20.8
Census Tract 9501.02; Panola County; Mississippi	2,204	24,597	21.5
Census Tract 9501.02; Benton County; Mississippi	1,853	23,175	21.6
Census Tract 9503.01; Tate County; Mississippi	3,612	32,317	21.8
Census Tract 9504.01; Marshall County; Mississippi	2,233	26,784	22.0
Census Tract 201.01; Scott County; Mississippi	2,444	27,874	22.0
Census Tract 9503.02; Tate County; Mississippi	4,264	30,961	22.1

Geography	Population 16 Years and Over	Per Capita Income ($)	Poverty (%)
Census Tract 202; Scott County; Mississippi	3,645	24,223	22.4
Census Tract 9504; Tate County; Mississippi	5,164	21,053	22.5
Census Tract 9503; Calhoun County; Mississippi	2,466	21,959	22.6
Census Tract 704.11; DeSoto County; Mississippi	1,406	16,020	22.6
Census Tract 701.01; DeSoto County; Mississippi	2,492	29,412	22.7
Census Tract 9506.02; Lee County; Mississippi	3,035	32,568	22.8
Census Tract 9502; Yalobusha County; Mississippi	3,593	23,180	23.1
Census Tract 4.05; Lowndes County; Mississippi	4,682	22,415	23.2
Census Tract 9506; Monroe County; Mississippi	2,218	24,582	23.4
Census Tract 9502.01; Marshall County; Mississippi	2,948	22,817	23.5
Census Tract 9505; Calhoun County; Mississippi	1,981	21,227	23.6
Census Tract 9503; Alcorn County; Mississippi	2,985	34,583	23.7
Census Tract 407; Leake County; Mississippi	3,129	30,556	23.8
Census Tract 9504; Monroe County; Mississippi	2,598	21,299	24.1
Census Tract 107; Neshoba County; Mississippi	3,176	28,177	24.2
Census Tract 605; Attala County; Mississippi	2,689	47,572	24.3
Census Tract 9503.03; Lafayette County; Mississippi	1,610	27,030	24.4
Census Tract 104; Neshoba County; Mississippi	2,814	29,862	24.8
Census Tract 9507; Lee County; Mississippi	2,992	29,198	25.2
Census Tract 9505.02; Lafayette County; Mississippi	2,250	22,795	25.4
Census Tract 11; Lowndes County; Mississippi	1,221	27,113	25.8
Census Tract 9502; Tishomingo County; Mississippi	1,668	22,968	25.8
Census Tract 9503; Chickasaw County; Mississippi	4,126	21,110	26.2
Census Tract 9504; Winston County; Mississippi	2,523	31,233	26.2
Census Tract 9505.01; Marshall County; Mississippi	1,872	23,350	26.5
Census Tract 9507; Monroe County; Mississippi	1,815	29,203	26.9
Census Tract 703.24; DeSoto County; Mississippi	3,350	19,474	27.1
Census Tract 9506.01; Oktibbeha County; Mississippi	4,796	38,858	27.3
Census Tract 9502.01; Tippah County; Mississippi	3,522	23,327	27.7
Census Tract 7; Lowndes County; Mississippi	4,036	21,834	27.9
Census Tract 9503; Oktibbeha County; Mississippi	2,764	20,400	28.4
Census Tract 406; Leake County; Mississippi	4,537	21,249	28.5
Census Tract 9505.02; Alcorn County; Mississippi	2,308	17,385	28.8
Census Tract 9508; Monroe County; Mississippi	2,129	26,868	28.9
Census Tract 9501; Winston County; Mississippi	2,429	24,821	29.1
Census Tract 9502; Chickasaw County; Mississippi	2,485	18,637	29.2
Census Tract 9503; Choctaw County; Mississippi	1,285	20,780	29.2
Census Tract 9510.02; Lee County; Mississippi	2,941	20,651	29.2
Census Tract 9505.02; Marshall County; Mississippi	2,208	35,316	29.3
Census Tract 9504.01; Tishomingo County; Mississippi	2,623	26,532	29.3
Census Tract 9502.01; Oktibbeha County; Mississippi	3,212	29,639	29.4
Census Tract 201.02; Scott County; Mississippi	2,840	16,624	29.5
Census Tract 9505.04; Lafayette County; Mississippi	2,554	25,655	29.6
Census Tract 9502.02; Tippah County; Mississippi	1,711	18,965	29.6
Census Tract 106; Neshoba County; Mississippi	3,579	20,288	29.7
Census Tract 102; Neshoba County; Mississippi	2,385	20,370	29.9
Census Tract 9507.02; Oktibbeha County; Mississippi	3,012	32,456	30.8

Geography	Population 16 Years and Over	Per Capita Income ($)	Poverty (%)
Census Tract 9501.02; Oktibbeha County; Mississippi	3,294	25,800	30.9
Census Tract 9504.02; Marshall County; Mississippi	4,093	15,538	31.2
Census Tract 9503; Webster County; Mississippi	1,309	21,914	31.4
Census Tract 9506.02; Panola County; Mississippi	1,871	13,721	31.7
Census Tract 9504.02; Oktibbeha County; Mississippi	2,255	28,425	32.1
Census Tract 9506.03; Oktibbeha County; Mississippi	2,274	47,548	32.4
Census Tract 9501; Chickasaw County; Mississippi	2,774	22,240	33.1
Census Tract 9502; Calhoun County; Mississippi	980	22,167	33.2
Census Tract 9502; Tallahatchie County; Mississippi	2,085	18,044	33.3
Census Tract 301; Kemper County; Mississippi	3,970	19,140	33.6
Census Tract 9504; Clay County; Mississippi	3,514	26,669	33.7
Census Tract 9503; Noxubee County; Mississippi	2,254	18,210	33.7
Census Tract 9501.02; Tishomingo County; Mississippi	1,191	25,651	34.1
Census Tract 9502.01; Alcorn County; Mississippi	2,783	21,086	34.4
Census Tract 606; Attala County; Mississippi	2,527	18,685	34.7
Census Tract 9501.01; Oktibbeha County; Mississippi	5,298	22,082	34.9
Census Tract 601; Attala County; Mississippi	1,807	22,346	35.0
Census Tract 9503.01; Prentiss County; Mississippi	2,459	16,844	35.1
Census Tract 9503.04; Lafayette County; Mississippi	2,032	27,561	35.4
Census Tract 9501.01; Panola County; Mississippi	2,990	14,595	35.4
Census Tract 704.12; DeSoto County; Mississippi	3,245	19,577	35.7
Census Tract 9503.01; Yalobusha County; Mississippi	1,623	23,508	36.0
Census Tract 204; Scott County; Mississippi	2,358	27,193	36.2
Census Tract 9.02; Lowndes County; Mississippi	1,825	28,577	36.3
Census Tract 9505; Oktibbeha County; Mississippi	3,558	26,313	37.3
Census Tract 9401; Neshoba County; Mississippi	3,288	15,227	38.6
Census Tract 9503; Winston County; Mississippi	3,174	23,623	40.1
Census Tract 8; Lowndes County; Mississippi	2,445	13,897	41.9
Census Tract 9503; Clay County; Mississippi	2,262	17,417	42.1
Census Tract 9502.04; Lafayette County; Mississippi	2,030	42,774	43.5
Census Tract 105; Neshoba County; Mississippi	2,581	21,693	45.1
Census Tract 9502.03; Lafayette County; Mississippi	2,704	25,802	46.0
Census Tract 9503.01; Lafayette County; Mississippi	6,213	8,404	49.0
Census Tract 6; Lowndes County; Mississippi	2,476	10,871	50.9
Census Tract 9504; Tallahatchie County; Mississippi	1,706	20,334	51.4
Census Tract 9504.01; Oktibbeha County; Mississippi	4,735	13,366	53.7
Census Tract 9502.01; Panola County; Mississippi	1,385	14,569	55.6
Census Tract 9305.02; Cherokee County; North Carolina	3,169	32,767	15.9
Census Tract 9303.02; Avery County; North Carolina	2,225	30,883	17.4
Census Tract 9207.03; Watauga County; North Carolina	5,270	39,658	17.7
Census Tract 9501.01; Clay County; North Carolina	2,516	34,744	18.6
Census Tract 9502.02; Clay County; North Carolina	2,318	23,387	20.9
Census Tract 9306.04; Cherokee County; North Carolina	1,504	24,760	22.9
Census Tract 9304.02; Cherokee County; North Carolina	1,589	27,543	23.0
Census Tract 9301.01; Cherokee County; North Carolina	2,021	27,293	23.1
Census Tract 9301.02; Cherokee County; North Carolina	1,741	23,312	23.5
Census Tract 9206.02; Watauga County; North Carolina	2,315	46,666	26.7

Geography	Population 16 Years and Over	Per Capita Income ($)	Poverty (%)
Census Tract 9304.01; Cherokee County; North Carolina	3,653	27,679	30.1
Census Tract 9205; Watauga County; North Carolina	7,387	11,327	38.9
Census Tract 9204; Watauga County; North Carolina	7,526	25,205	41.6
Census Tract 9206.01; Watauga County; North Carolina	6,322	17,068	62.3
Census Tract 102.01; Bradley County; Tennessee	2,121	32,463	14.8
Census Tract 9623; Carroll County; Tennessee	3,496	28,766	14.8
Census Tract 502; Hawkins County; Tennessee	4,112	23,100	14.8
Census Tract 9607; Lawrence County; Tennessee	3,196	27,140	14.8
Census Tract 14.01; Madison County; Tennessee	1,790	26,100	14.8
Census Tract 9203; Cocke County; Tennessee	3,962	34,753	14.9
Census Tract 9710.02; Coffee County; Tennessee	4,266	34,369	14.9
Census Tract 9502.02; Hickman County; Tennessee	2,714	25,819	14.9
Census Tract 106; Maury County; Tennessee	4,295	25,628	14.9
Census Tract 1020.01; Montgomery County; Tennessee	5,211	33,244	14.9
Census Tract 201.02; Shelby County; Tennessee	2,226	34,533	14.9
Census Tract 426; Sullivan County; Tennessee	3,112	32,383	14.9
Census Tract 611; Washington County; Tennessee	4,337	37,515	14.9
Census Tract 106; Blount County; Tennessee	3,577	23,985	15.0
Census Tract 9250.02; Monroe County; Tennessee	3,169	30,593	15.0
Census Tract 201.02; Sumner County; Tennessee	4,288	27,510	15.0
Census Tract 9633; Benton County; Tennessee	2,883	27,076	15.1
Census Tract 9550.03; Decatur County; Tennessee	1,955	23,903	15.1
Census Tract 48; Knox County; Tennessee	4,130	29,481	15.1
Census Tract 9554; Marshall County; Tennessee	3,529	31,413	15.1
Census Tract 9657; Obion County; Tennessee	3,648	28,088	15.1
Census Tract 206.35; Shelby County; Tennessee	2,198	30,951	15.1
Census Tract 413; Sullivan County; Tennessee	4,047	35,891	15.1
Census Tract 802; Unicoi County; Tennessee	5,002	28,267	15.1
Census Tract 9701.02; Chester County; Tennessee	2,869	28,858	15.2
Census Tract 1007; Hamblen County; Tennessee	4,684	27,972	15.2
Census Tract 9502; Hardeman County; Tennessee	5,702	12,402	15.2
Census Tract 706; Jefferson County; Tennessee	3,833	33,034	15.2
Census Tract 39.01; Knox County; Tennessee	3,382	34,639	15.2
Census Tract 63; Shelby County; Tennessee	2,180	42,802	15.2
Census Tract 112.01; Blount County; Tennessee	4,134	31,719	15.3
Census Tract 701.03; Cheatham County; Tennessee	3,292	29,420	15.3
Census Tract 9750; Rhea County; Tennessee	3,949	32,909	15.3
Census Tract 717; Carter County; Tennessee	2,794	29,273	15.4
Census Tract 104.01; Davidson County; Tennessee	4,620	29,237	15.4
Census Tract 173; Davidson County; Tennessee	2,428	28,185	15.4
Census Tract 602.01; Dickson County; Tennessee	2,857	26,002	15.4
Census Tract 9640.01; Dyer County; Tennessee	3,828	25,211	15.4
Census Tract 9609; Lawrence County; Tennessee	1,704	22,947	15.4
Census Tract 1016; Montgomery County; Tennessee	4,747	29,928	15.4
Census Tract 9650; Obion County; Tennessee	3,427	31,491	15.4
Census Tract 401.05; Rutherford County; Tennessee	3,282	28,142	15.4
Census Tract 9703.01; Cumberland County; Tennessee	3,009	27,955	15.5

Geography	Population 16 Years and Over	Per Capita Income ($)	Poverty (%)
Census Tract 137.02; Davidson County; Tennessee	3,326	36,226	15.5
Census Tract 908; Greene County; Tennessee	3,957	25,633	15.5
Census Tract 1304; Humphreys County; Tennessee	2,059	28,540	15.5
Census Tract 23; Knox County; Tennessee	2,854	28,926	15.5
Census Tract 9555; Marshall County; Tennessee	3,968	31,081	15.5
Census Tract 133; Davidson County; Tennessee	4,315	55,214	15.6
Census Tract 608; Fayette County; Tennessee	1,784	29,463	15.6
Census Tract 18; Hamilton County; Tennessee	2,244	33,762	15.6
Census Tract 9552; Marshall County; Tennessee	5,247	36,519	15.6
Census Tract 9708.01; Coffee County; Tennessee	3,141	30,124	15.7
Census Tract 9504; Hardeman County; Tennessee	4,129	25,919	15.7
Census Tract 9505; Hardeman County; Tennessee	3,360	25,002	15.7
Census Tract 9503; Wayne County; Tennessee	2,772	24,870	15.7
Census Tract 9301; McNairy County; Tennessee	3,284	24,362	15.8
Census Tract 427.03; Sullivan County; Tennessee	2,011	22,273	15.8
Census Tract 9252; Van Buren County; Tennessee	2,690	22,989	15.8
Census Tract 183.03; Davidson County; Tennessee	3,970	48,048	15.9
Census Tract 9606; Lawrence County; Tennessee	1,721	26,865	15.9
Census Tract 9654; Obion County; Tennessee	3,571	35,593	15.9
Census Tract 9754.02; Rhea County; Tennessee	2,759	29,379	15.9
Census Tract 206.58; Shelby County; Tennessee	4,673	26,325	15.9
Census Tract 156.29; Davidson County; Tennessee	4,294	25,898	16.0
Census Tract 157; Davidson County; Tennessee	1,382	34,213	16.0
Census Tract 31; Hamilton County; Tennessee	1,918	66,209	16.0
Census Tract 110.01; Hamilton County; Tennessee	1,697	26,607	16.0
Census Tract 9753; Rhea County; Tennessee	5,232	24,987	16.0
Census Tract 418; Rutherford County; Tennessee	3,912	29,568	16.0
Census Tract 9686; Weakley County; Tennessee	3,150	26,911	16.0
Census Tract 9506; Bedford County; Tennessee	6,049	24,473	16.1
Census Tract 715; Carter County; Tennessee	1,861	37,200	16.1
Census Tract 113; Davidson County; Tennessee	4,601	35,948	16.1
Census Tract 103.02; Davidson County; Tennessee	1,334	46,533	16.2
Census Tract 9201.01; DeKalb County; Tennessee	2,547	36,348	16.2
Census Tract 21; Knox County; Tennessee	2,253	23,253	16.2
Census Tract 9756.01; Lincoln County; Tennessee	5,076	27,943	16.2
Census Tract 420; Sullivan County; Tennessee	2,965	27,240	16.2
Census Tract 505.04; Williamson County; Tennessee	3,739	34,635	16.2
Census Tract 9503; Bedford County; Tennessee	2,804	30,836	16.3
Census Tract 103.01; Blount County; Tennessee	5,233	31,082	16.3
Census Tract 9704.01; Cumberland County; Tennessee	3,944	20,878	16.3
Census Tract 422; Rutherford County; Tennessee	4,011	29,445	16.3
Census Tract 407; Sullivan County; Tennessee	2,199	37,691	16.3
Census Tract 9507.01; Campbell County; Tennessee	1,732	27,913	16.4
Census Tract 605.02; Dickson County; Tennessee	2,789	35,426	16.4
Census Tract 62.08; Knox County; Tennessee	4,072	32,812	16.4
Census Tract 9707; McMinn County; Tennessee	3,809	33,344	16.4
Census Tract 804.01; Sevier County; Tennessee	2,577	36,038	16.4

Geography	Population 16 Years and Over	Per Capita Income ($)	Poverty (%)
Census Tract 16; Shelby County; Tennessee	2,961	43,312	16.4
Census Tract 431; Sullivan County; Tennessee	2,564	27,407	16.4
Census Tract 9506; Hardeman County; Tennessee	2,052	22,177	16.5
Census Tract 501; Hawkins County; Tennessee	3,543	24,938	16.5
Census Tract 75; Shelby County; Tennessee	922	34,999	16.5
Census Tract 711; Carter County; Tennessee	1,735	28,586	16.6
Census Tract 156.19; Davidson County; Tennessee	4,294	32,914	16.6
Census Tract 9202.02; DeKalb County; Tennessee	1,566	24,612	16.6
Census Tract 503.01; Hawkins County; Tennessee	3,939	27,118	16.6
Census Tract 602.03; Loudon County; Tennessee	2,505	19,981	16.6
Census Tract 9302; McNairy County; Tennessee	2,085	27,051	16.6
Census Tract 3; Madison County; Tennessee	3,606	33,415	16.6
Census Tract 9254.02; Monroe County; Tennessee	4,234	26,200	16.6
Census Tract 210.02; Anderson County; Tennessee	2,960	24,131	16.7
Census Tract 9205.02; Cocke County; Tennessee	4,120	27,768	16.7
Census Tract 9203; Hardin County; Tennessee	3,350	25,732	16.7
Census Tract 46.08; Knox County; Tennessee	2,354	33,632	16.7
Census Tract 9255.01; Monroe County; Tennessee	2,637	25,945	16.7
Census Tract 9753; Smith County; Tennessee	1,738	24,194	16.7
Census Tract 9302.02; Warren County; Tennessee	3,147	29,316	16.7
Census Tract 9208; Giles County; Tennessee	2,588	29,027	16.8
Census Tract 606; Loudon County; Tennessee	3,926	31,168	16.8
Census Tract 210.23; Shelby County; Tennessee	6,193	54,822	16.8
Census Tract 9302.01; Warren County; Tennessee	2,610	29,971	16.8
Census Tract 112.04; Hamilton County; Tennessee	4,510	37,769	16.9
Census Tract 9201; Hardin County; Tennessee	3,263	33,482	16.9
Census Tract 32; Knox County; Tennessee	2,679	23,962	16.9
Census Tract 103; Bradley County; Tennessee	2,939	22,171	17.0
Census Tract 9706; Claiborne County; Tennessee	4,058	31,787	17.0
Census Tract 161; Davidson County; Tennessee	2,038	46,981	17.0
Census Tract 9754; Lincoln County; Tennessee	3,549	28,590	17.0
Census Tract 3.03; Putnam County; Tennessee	1,723	22,497	17.0
Census Tract 305; Roane County; Tennessee	3,919	30,860	17.0
Census Tract 9755; Henderson County; Tennessee	3,197	24,722	17.1
Census Tract 9602; Lawrence County; Tennessee	2,282	23,612	17.1
Census Tract 102.05; Maury County; Tennessee	1,196	41,314	17.1
Census Tract 404.04; Rutherford County; Tennessee	2,416	31,782	17.1
Census Tract 205.11; Shelby County; Tennessee	1,992	36,989	17.1
Census Tract 201.01; Sumner County; Tennessee	2,829	26,746	17.1
Census Tract 9681.01; Weakley County; Tennessee	2,969	27,588	17.1
Census Tract 225; Shelby County; Tennessee	3,497	23,292	17.2
Census Tract 406.01; Tipton County; Tennessee	3,887	25,545	17.2
Census Tract 9508; Campbell County; Tennessee	2,106	28,899	17.3
Census Tract 164; Davidson County; Tennessee	4,381	24,509	17.3
Census Tract 9202; Giles County; Tennessee	3,936	27,924	17.3
Census Tract 9503.02; Hickman County; Tennessee	3,587	35,818	17.3
Census Tract 418; Sullivan County; Tennessee	3,569	30,132	17.3

Geography	Population 16 Years and Over	Per Capita Income ($)	Poverty (%)
Census Tract 430; Sullivan County; Tennessee	3,806	33,077	17.3
Census Tract 9630; Benton County; Tennessee	2,735	27,761	17.4
Census Tract 101; Bradley County; Tennessee	4,091	33,113	17.4
Census Tract 101.04; Hamilton County; Tennessee	3,188	30,634	17.4
Census Tract 108; Hamilton County; Tennessee	3,441	39,260	17.4
Census Tract 404.05; Rutherford County; Tennessee	3,366	32,517	17.4
Census Tract 427.02; Sullivan County; Tennessee	1,947	35,259	17.4
Census Tract 128.02; Davidson County; Tennessee	3,435	24,695	17.5
Census Tract 35.01; Knox County; Tennessee	2,446	45,391	17.5
Census Tract 505.03; Lauderdale County; Tennessee	1,856	27,791	17.5
Census Tract 406; Rutherford County; Tennessee	4,353	29,632	17.5
Census Tract 201; Anderson County; Tennessee	2,364	25,664	17.6
Census Tract 508; Hawkins County; Tennessee	4,094	28,382	17.6
Census Tract 410; Tipton County; Tennessee	2,306	24,999	17.6
Census Tract 9685; Weakley County; Tennessee	3,548	24,136	17.6
Census Tract 9664; Gibson County; Tennessee	3,860	20,986	17.7
Census Tract 9251.01; Pickett County; Tennessee	2,405	31,904	17.7
Census Tract 211.22; Shelby County; Tennessee	4,243	25,009	17.7
Census Tract 416; Sullivan County; Tennessee	2,199	31,234	17.7
Census Tract 217.52; Shelby County; Tennessee	4,172	29,606	17.8
Census Tract 103.03; Davidson County; Tennessee	4,180	31,647	17.9
Census Tract 9551.02; Decatur County; Tennessee	2,481	27,910	17.9
Census Tract 1005; Hamblen County; Tennessee	2,658	38,428	17.9
Census Tract 113.26; Hamilton County; Tennessee	5,114	43,527	17.9
Census Tract 504; Hawkins County; Tennessee	4,872	25,364	17.9
Census Tract 9253.02; Monroe County; Tennessee	2,788	22,229	17.9
Census Tract 1102; Morgan County; Tennessee	3,232	31,662	17.9
Census Tract 72; Shelby County; Tennessee	2,586	64,075	17.9
Census Tract 217.54; Shelby County; Tennessee	3,515	29,314	17.9
Census Tract 9703; Claiborne County; Tennessee	3,904	23,031	18.0
Census Tract 9709; Claiborne County; Tennessee	3,803	25,840	18.0
Census Tract 1017.01; Montgomery County; Tennessee	2,339	32,018	18.0
Census Tract 5004.02; Grainger County; Tennessee	4,237	28,071	18.1
Census Tract 9504; Hickman County; Tennessee	1,617	26,648	18.1
Census Tract 54.02; Knox County; Tennessee	2,698	30,211	18.1
Census Tract 108.20; Shelby County; Tennessee	3,210	25,731	18.1
Census Tract 9351; White County; Tennessee	4,923	28,934	18.1
Census Tract 9551; Clay County; Tennessee	2,064	25,975	18.2
Census Tract 9307; McNairy County; Tennessee	2,578	27,300	18.3
Census Tract 9301; Perry County; Tennessee	2,700	30,633	18.3
Census Tract 9250; Van Buren County; Tennessee	2,466	25,260	18.3
Census Tract 9354; White County; Tennessee	3,044	22,046	18.3
Census Tract 9552; Grundy County; Tennessee	3,476	20,009	18.4
Census Tract 308.02; Roane County; Tennessee	2,865	24,999	18.4
Census Tract 9502; Wayne County; Tennessee	4,405	27,147	18.4
Census Tract 703; Carter County; Tennessee	4,981	25,279	18.5
Census Tract 156.37; Davidson County; Tennessee	3,174	35,813	18.5

Geography	Population 16 Years and Over	Per Capita Income ($)	Poverty (%)
Census Tract 914; Greene County; Tennessee	2,316	25,173	18.5
Census Tract 1010.01; Montgomery County; Tennessee	3,342	23,660	18.5
Census Tract 118; Shelby County; Tennessee	4,639	31,953	18.5
Census Tract 910.01; Greene County; Tennessee	3,530	26,154	18.6
Census Tract 701.02; Jefferson County; Tennessee	4,436	32,847	18.6
Census Tract 503.01; Marion County; Tennessee	4,506	26,316	18.6
Census Tract 98; Shelby County; Tennessee	1,947	24,971	18.6
Census Tract 902; Trousdale County; Tennessee	2,438	26,165	18.6
Census Tract 9625; Carroll County; Tennessee	2,160	24,347	18.7
Census Tract 9705; Claiborne County; Tennessee	2,103	24,422	18.7
Census Tract 46.09; Knox County; Tennessee	4,015	30,021	18.7
Census Tract 9504; Campbell County; Tennessee	3,631	26,323	18.8
Census Tract 606.01; Dickson County; Tennessee	2,956	28,385	18.8
Census Tract 9305.02; McNairy County; Tennessee	4,154	23,299	18.8
Census Tract 402.01; Union County; Tennessee	3,200	24,396	18.8
Census Tract 9501; Campbell County; Tennessee	2,457	19,862	18.9
Census Tract 9602.01; Cannon County; Tennessee	1,907	26,194	18.9
Census Tract 1; Knox County; Tennessee	2,492	58,958	18.9
Census Tract 1019.06; Montgomery County; Tennessee	4,638	32,020	18.9
Census Tract 811.01; Sevier County; Tennessee	1,124	30,846	18.9
Census Tract 1107; Stewart County; Tennessee	3,723	30,345	18.9
Census Tract 9667.01; Gibson County; Tennessee	1,649	21,625	19.0
Census Tract 30; Hamilton County; Tennessee	1,664	23,888	19.0
Census Tract 502; Lauderdale County; Tennessee	2,568	28,386	19.0
Census Tract 703; Jefferson County; Tennessee	6,430	27,921	19.1
Census Tract 9252; Monroe County; Tennessee	4,207	32,330	19.1
Census Tract 9253.01; Monroe County; Tennessee	3,129	20,027	19.1
Census Tract 156.23; Davidson County; Tennessee	4,342	33,836	19.2
Census Tract 114.44; Hamilton County; Tennessee	3,068	22,882	19.2
Census Tract 9503; Hardeman County; Tennessee	3,323	26,060	19.2
Census Tract 1302; Humphreys County; Tennessee	1,708	22,361	19.2
Census Tract 217.21; Shelby County; Tennessee	3,312	22,789	19.2
Census Tract 9681.02; Weakley County; Tennessee	1,463	27,439	19.2
Census Tract 9708; Claiborne County; Tennessee	3,047	25,227	19.3
Census Tract 40; Knox County; Tennessee	3,937	27,506	19.3
Census Tract 46.15; Knox County; Tennessee	3,502	29,056	19.3
Census Tract 9506; Overton County; Tennessee	2,347	32,004	19.3
Census Tract 401.06; Rutherford County; Tennessee	3,520	22,571	19.3
Census Tract 605.01; Fayette County; Tennessee	3,602	30,687	19.4
Census Tract 9601; Franklin County; Tennessee	2,958	28,534	19.4
Census Tract 5001; Grainger County; Tennessee	3,840	20,195	19.4
Census Tract 903; Greene County; Tennessee	4,966	32,230	19.4
Census Tract 30; Knox County; Tennessee	4,070	27,360	19.4
Census Tract 59.11; Knox County; Tennessee	2,352	32,929	19.4
Census Tract 428.02; Sullivan County; Tennessee	3,540	21,143	19.4
Census Tract 911; Greene County; Tennessee	2,816	32,639	19.5
Census Tract 18; Knox County; Tennessee	2,122	30,531	19.5

Geography	Population 16 Years and Over	Per Capita Income ($)	Poverty (%)
Census Tract 106.02; Davidson County; Tennessee	2,914	28,182	19.6
Census Tract 107; Maury County; Tennessee	3,919	22,950	19.6
Census Tract 32; Hamilton County; Tennessee	2,886	31,946	19.7
Census Tract 220.24; Shelby County; Tennessee	2,464	23,190	19.7
Census Tract 9305; Warren County; Tennessee	4,106	22,136	19.7
Census Tract 9352; White County; Tennessee	3,471	27,365	19.7
Census Tract 901; Greene County; Tennessee	4,999	21,761	19.8
Census Tract 9202; Hardin County; Tennessee	4,025	27,491	19.8
Census Tract 3.05; Putnam County; Tennessee	2,460	27,676	19.8
Census Tract 9754.01; Rhea County; Tennessee	5,870	20,303	19.8
Census Tract 210.20; Shelby County; Tennessee	5,007	61,188	19.8
Census Tract 212.02; Anderson County; Tennessee	4,140	25,683	19.9
Census Tract 9509; Campbell County; Tennessee	2,401	30,628	19.9
Census Tract 9550.04; Decatur County; Tennessee	1,967	33,915	19.9
Census Tract 9705; McMinn County; Tennessee	3,353	25,315	19.9
Census Tract 156.34; Davidson County; Tennessee	8,893	29,465	20.0
Census Tract 23; Hamilton County; Tennessee	1,099	18,967	20.0
Census Tract 9504; Overton County; Tennessee	1,826	25,908	20.0
Census Tract 801; Unicoi County; Tennessee	2,025	27,468	20.0
Census Tract 210.01; Anderson County; Tennessee	2,093	25,812	20.1
Census Tract 9620; Carroll County; Tennessee	3,449	26,755	20.1
Census Tract 109; Maury County; Tennessee	2,720	29,092	20.1
Census Tract 9624; Carroll County; Tennessee	2,046	23,452	20.2
Census Tract 158.04; Davidson County; Tennessee	4,005	28,653	20.2
Census Tract 28; Knox County; Tennessee	3,386	21,691	20.2
Census Tract 37; Knox County; Tennessee	2,526	44,866	20.2
Census Tract 9750; Scott County; Tennessee	3,247	24,382	20.2
Census Tract 602; Sequatchie County; Tennessee	3,876	29,818	20.2
Census Tract 206.10; Shelby County; Tennessee	3,199	25,473	20.2
Census Tract 403; Sullivan County; Tennessee	2,131	30,279	20.2
Census Tract 402.02; Union County; Tennessee	4,941	25,848	20.2
Census Tract 9602.02; Cannon County; Tennessee	3,435	30,144	20.3
Census Tract 502.03; Marion County; Tennessee	2,275	22,391	20.3
Census Tract 104.02; Maury County; Tennessee	1,990	27,543	20.3
Census Tract 9659; Obion County; Tennessee	1,149	23,850	20.3
Census Tract 303.01; Roane County; Tennessee	2,708	42,957	20.3
Census Tract 9701; Claiborne County; Tennessee	2,118	21,493	20.4
Census Tract 9707; Claiborne County; Tennessee	4,734	22,643	20.4
Census Tract 402; Tipton County; Tennessee	1,683	23,734	20.4
Census Tract 9255.04; Monroe County; Tennessee	1,606	27,982	20.5
Census Tract 223.22; Shelby County; Tennessee	3,044	24,869	20.5
Census Tract 9704; Claiborne County; Tennessee	575	20,598	20.6
Census Tract 5004.01; Grainger County; Tennessee	2,256	20,075	20.6
Census Tract 602.01; Loudon County; Tennessee	3,734	27,123	20.6
Census Tract 9614; Crockett County; Tennessee	2,910	32,501	20.7
Census Tract 205.42; Shelby County; Tennessee	4,458	18,529	20.7
Census Tract 9306; Warren County; Tennessee	2,927	27,929	20.7

Geography	Population 16 Years and Over	Per Capita Income ($)	Poverty (%)
Census Tract 109.02; Hamilton County; Tennessee	620	34,290	20.8
Census Tract 222.10; Shelby County; Tennessee	3,592	23,054	20.8
Census Tract 223.21; Shelby County; Tennessee	2,760	20,528	20.8
Census Tract 804; Unicoi County; Tennessee	3,514	26,044	20.8
Census Tract 9621.02; Carroll County; Tennessee	2,851	30,192	20.9
Census Tract 158.06; Davidson County; Tennessee	3,348	22,332	20.9
Census Tract 9550.01; Decatur County; Tennessee	1,523	29,706	20.9
Census Tract 1017.02; Montgomery County; Tennessee	4,520	30,859	20.9
Census Tract 9612; Crockett County; Tennessee	1,401	32,182	21.0
Census Tract 174.02; Davidson County; Tennessee	4,831	37,292	21.0
Census Tract 9203; DeKalb County; Tennessee	4,301	29,347	21.0
Census Tract 1004; Hamblen County; Tennessee	5,487	25,751	21.0
Census Tract 505.01; Hawkins County; Tennessee	3,300	28,792	21.0
Census Tract 9502.01; Hickman County; Tennessee	3,363	27,360	21.0
Census Tract 9505.01; Overton County; Tennessee	3,557	32,282	21.0
Census Tract 714; Carter County; Tennessee	2,592	27,901	21.1
Census Tract 9702.01; Coffee County; Tennessee	3,132	26,160	21.1
Census Tract 156.28; Davidson County; Tennessee	2,972	26,964	21.1
Census Tract 49; Knox County; Tennessee	4,712	32,086	21.1
Census Tract 16.05; Madison County; Tennessee	2,877	32,418	21.1
Census Tract 201.01; Shelby County; Tennessee	2,675	24,292	21.1
Census Tract 9682.01; Weakley County; Tennessee	3,247	32,278	21.1
Census Tract 9650; Fentress County; Tennessee	3,012	24,756	21.2
Census Tract 15; Knox County; Tennessee	2,952	33,119	21.2
Census Tract 16.07; Madison County; Tennessee	4,218	31,161	21.2
Census Tract 110.04; Maury County; Tennessee	3,178	31,567	21.2
Census Tract 1021; Montgomery County; Tennessee	3,939	32,581	21.2
Census Tract 414.01; Rutherford County; Tennessee	5,385	39,640	21.2
Census Tract 81.20; Shelby County; Tennessee	4,366	22,526	21.2
Census Tract 619.04; Washington County; Tennessee	3,163	28,068	21.2
Census Tract 9631; Benton County; Tennessee	2,684	30,759	21.3
Census Tract 9503.01; Overton County; Tennessee	4,000	27,191	21.3
Census Tract 601.04; Sequatchie County; Tennessee	3,782	22,159	21.3
Census Tract 804.02; Sevier County; Tennessee	2,835	24,637	21.3
Census Tract 9643; Dyer County; Tennessee	4,429	27,727	21.4
Census Tract 9665.02; Gibson County; Tennessee	2,582	31,681	21.4
Census Tract 1104; Morgan County; Tennessee	3,210	37,306	21.4
Census Tract 428.01; Sullivan County; Tennessee	2,071	29,795	21.4
Census Tract 5003.01; Grainger County; Tennessee	2,657	26,577	21.5
Census Tract 9702; Lewis County; Tennessee	6,227	26,903	21.5
Census Tract 13; Madison County; Tennessee	4,848	24,390	21.5
Census Tract 7; Putnam County; Tennessee	2,842	22,975	21.5
Census Tract 806.01; Sevier County; Tennessee	3,488	31,546	21.5
Census Tract 9752; Smith County; Tennessee	4,772	29,787	21.5
Census Tract 9355; White County; Tennessee	2,985	22,246	21.5
Census Tract 304.02; Wilson County; Tennessee	3,504	26,960	21.5
Census Tract 9704.02; Coffee County; Tennessee	4,362	23,781	21.6

Geography	Population 16 Years and Over	Per Capita Income ($)	Poverty (%)
Census Tract 905.02; Greene County; Tennessee	1,313	41,538	21.6
Census Tract 1003; Montgomery County; Tennessee	4,625	30,274	21.7
Census Tract 417; Sullivan County; Tennessee	2,930	33,372	21.7
Census Tract 608; Washington County; Tennessee	2,264	34,133	21.7
Census Tract 9662; Gibson County; Tennessee	2,761	22,360	21.8
Census Tract 1011.02; Montgomery County; Tennessee	6,764	22,175	21.8
Census Tract 9501; Wayne County; Tennessee	3,859	20,247	21.8
Census Tract 9703.01; Chester County; Tennessee	1,247	25,584	21.9
Census Tract 9705.01; Cumberland County; Tennessee	2,520	26,631	21.9
Census Tract 9606; Franklin County; Tennessee	3,742	24,887	21.9
Census Tract 9551; Grundy County; Tennessee	1,424	26,993	21.9
Census Tract 202.02; Anderson County; Tennessee	3,828	36,502	22.0
Census Tract 15.01; Madison County; Tennessee	4,055	28,874	22.0
Census Tract 803.02; Robertson County; Tennessee	2,532	22,171	22.0
Census Tract 79; Shelby County; Tennessee	3,841	21,454	22.0
Census Tract 9502; Campbell County; Tennessee	1,844	26,047	22.1
Census Tract 144; Davidson County; Tennessee	2,553	40,562	22.1
Census Tract 416.02; Rutherford County; Tennessee	2,333	38,853	22.1
Census Tract 93; Shelby County; Tennessee	3,312	45,132	22.1
Census Tract 217.55; Shelby County; Tennessee	1,233	30,819	22.1
Census Tract 712; Carter County; Tennessee	3,050	24,141	22.2
Census Tract 709; Carter County; Tennessee	3,313	25,527	22.3
Census Tract 158.05; Davidson County; Tennessee	2,183	25,958	22.4
Census Tract 9604.01; Lawrence County; Tennessee	4,348	35,350	22.4
Census Tract 421.02; Rutherford County; Tennessee	3,458	21,024	22.4
Census Tract 88; Shelby County; Tennessee	4,913	16,186	22.4
Census Tract 9702; Chester County; Tennessee	4,355	17,993	22.6
Census Tract 9754; Henderson County; Tennessee	3,738	23,697	22.6
Census Tract 9603; Lawrence County; Tennessee	4,200	21,667	22.6
Census Tract 602.04; Loudon County; Tennessee	4,270	25,936	22.6
Census Tract 804.01; Robertson County; Tennessee	4,228	27,105	22.6
Census Tract 9753; Scott County; Tennessee	1,940	25,511	22.6
Census Tract 15; Shelby County; Tennessee	1,553	25,337	22.6
Census Tract 804.02; Robertson County; Tennessee	3,998	26,770	22.7
Census Tract 9203.01; Giles County; Tennessee	3,830	29,079	22.8
Census Tract 1008; Hamblen County; Tennessee	2,238	25,267	22.8
Census Tract 9205.02; Hardin County; Tennessee	1,272	20,101	22.8
Census Tract 913; Greene County; Tennessee	3,746	25,016	22.9
Census Tract 166; Davidson County; Tennessee	3,395	50,299	23.0
Census Tract 73; Shelby County; Tennessee	3,817	28,706	23.0
Census Tract 205.31; Shelby County; Tennessee	3,799	18,174	23.0
Census Tract 9510; Campbell County; Tennessee	1,828	21,738	23.1
Census Tract 9707; Coffee County; Tennessee	3,853	27,568	23.1
Census Tract 9602; Jackson County; Tennessee	1,912	26,602	23.1
Census Tract 9703; McMinn County; Tennessee	3,126	27,702	23.1
Census Tract 9304; McNairy County; Tennessee	1,728	24,073	23.1
Census Tract 227; Shelby County; Tennessee	6,148	18,465	23.1

Geography	Population 16 Years and Over	Per Capita Income ($)	Poverty (%)
Census Tract 407; Tipton County; Tennessee	3,931	23,847	23.1
Census Tract 9530; Bledsoe County; Tennessee	3,664	24,107	23.2
Census Tract 9701; Coffee County; Tennessee	2,965	26,010	23.2
Census Tract 9303.01; Haywood County; Tennessee	3,415	27,168	23.3
Census Tract 9251.01; Monroe County; Tennessee	3,708	24,157	23.3
Census Tract 1012.01; Montgomery County; Tennessee	1,778	26,771	23.3
Census Tract 308; Wilson County; Tennessee	5,602	27,710	23.3
Census Tract 189.05; Davidson County; Tennessee	2,440	36,854	23.4
Census Tract 9646; Dyer County; Tennessee	2,046	29,916	23.4
Census Tract 9563; Johnson County; Tennessee	4,812	24,511	23.4
Census Tract 505.04; Lauderdale County; Tennessee	1,945	22,637	23.5
Census Tract 60; Shelby County; Tennessee	1,487	18,912	23.5
Census Tract 9309; Warren County; Tennessee	1,730	24,342	23.5
Census Tract 419; Sullivan County; Tennessee	2,959	29,519	23.6
Census Tract 605.01; Washington County; Tennessee	3,804	23,341	23.6
Census Tract 9652.02; Fentress County; Tennessee	2,503	25,374	23.7
Census Tract 217.58; Shelby County; Tennessee	2,463	22,457	23.7
Census Tract 221.21; Shelby County; Tennessee	3,648	28,223	23.7
Census Tract 127.02; Davidson County; Tennessee	2,317	29,411	23.8
Census Tract 9205.01; Hardin County; Tennessee	3,179	23,951	23.8
Census Tract 9561; Johnson County; Tennessee	3,557	20,270	23.8
Census Tract 2; Madison County; Tennessee	4,602	27,771	23.8
Census Tract 9602; Meigs County; Tennessee	4,067	23,982	23.8
Census Tract 9703.01; Macon County; Tennessee	3,352	18,446	23.9
Census Tract 221.22; Shelby County; Tennessee	3,302	25,085	23.9
Census Tract 614.04; Washington County; Tennessee	2,983	60,045	23.9
Census Tract 156.13; Davidson County; Tennessee	4,123	20,478	24.0
Census Tract 182.04; Davidson County; Tennessee	2,578	36,894	24.0
Census Tract 124; Hamilton County; Tennessee	5,937	25,835	24.0
Census Tract 503.02; Marion County; Tennessee	2,569	35,518	24.0
Census Tract 9504; Wayne County; Tennessee	2,770	36,132	24.0
Census Tract 1103; Morgan County; Tennessee	4,770	15,948	24.1
Census Tract 9506.01; Campbell County; Tennessee	1,844	20,297	24.2
Census Tract 104.03; Davidson County; Tennessee	3,223	18,791	24.2
Census Tract 502.01; Marion County; Tennessee	3,311	26,700	24.2
Census Tract 205.32; Shelby County; Tennessee	4,990	27,384	24.2
Census Tract 408; Sullivan County; Tennessee	3,050	27,525	24.2
Census Tract 9550; Clay County; Tennessee	4,144	21,440	24.3
Census Tract 143; Davidson County; Tennessee	1,353	27,164	24.3
Census Tract 9302; Haywood County; Tennessee	1,198	31,407	24.3
Census Tract 39.02; Knox County; Tennessee	2,646	18,941	24.3
Census Tract 67; Knox County; Tennessee	2,182	29,416	24.3
Census Tract 414.07; Rutherford County; Tennessee	4,583	48,250	24.3
Census Tract 11; Shelby County; Tennessee	2,067	14,947	24.3
Census Tract 211.11; Shelby County; Tennessee	2,963	21,892	24.3
Census Tract 113.02; Bradley County; Tennessee	2,012	32,392	24.4
Census Tract 9694; Henry County; Tennessee	1,539	30,518	24.4

Geography	Population 16 Years and Over	Per Capita Income ($)	Poverty (%)
Census Tract 204; Anderson County; Tennessee	3,406	31,312	24.5
Census Tract 205; Anderson County; Tennessee	3,146	24,072	24.5
Census Tract 24; Knox County; Tennessee	3,619	22,536	24.5
Census Tract 409; Sullivan County; Tennessee	2,832	44,349	24.5
Census Tract 9698; Henry County; Tennessee	1,911	22,876	24.6
Census Tract 9305.01; McNairy County; Tennessee	1,869	21,683	24.6
Census Tract 421.01; Rutherford County; Tennessee	4,248	22,893	24.6
Census Tract 195.01; Davidson County; Tennessee	2,540	73,440	24.7
Census Tract 9551.01; Decatur County; Tennessee	1,512	22,554	24.7
Census Tract 9605; Franklin County; Tennessee	3,427	31,366	24.8
Census Tract 116; Hamilton County; Tennessee	5,401	27,237	24.8
Census Tract 123; Hamilton County; Tennessee	3,142	24,547	24.8
Census Tract 221.30; Shelby County; Tennessee	4,059	26,726	24.8
Census Tract 203; Sumner County; Tennessee	4,220	25,249	24.8
Census Tract 710; Carter County; Tennessee	2,115	24,374	24.9
Census Tract 507; Hawkins County; Tennessee	2,973	24,409	25.0
Census Tract 9670.02; Gibson County; Tennessee	2,739	23,301	25.1
Census Tract 221.32; Shelby County; Tennessee	2,038	28,668	25.1
Census Tract 9667.02; Gibson County; Tennessee	2,467	19,779	25.2
Census Tract 9692; Henry County; Tennessee	1,571	23,221	25.2
Census Tract 9251.02; Pickett County; Tennessee	1,796	21,491	25.2
Census Tract 803.01; Robertson County; Tennessee	2,132	24,451	25.2
Census Tract 221.11; Shelby County; Tennessee	4,003	30,131	25.2
Census Tract 156.20; Davidson County; Tennessee	5,152	26,205	25.3
Census Tract 165; Davidson County; Tennessee	4,551	15,784	25.4
Census Tract 9550; Grundy County; Tennessee	2,070	28,734	25.4
Census Tract 107; Bradley County; Tennessee	3,801	18,045	25.5
Census Tract 807.02; Sevier County; Tennessee	4,491	20,352	25.5
Census Tract 46; Shelby County; Tennessee	1,088	22,490	25.6
Census Tract 606.01; Washington County; Tennessee	3,032	35,196	25.6
Census Tract 610; Washington County; Tennessee	1,875	22,921	25.6
Census Tract 107.02; Davidson County; Tennessee	2,689	31,152	25.7
Census Tract 9564; Johnson County; Tennessee	4,034	25,082	25.7
Census Tract 609.02; Washington County; Tennessee	2,439	18,698	25.7
Census Tract 9304; Haywood County; Tennessee	2,745	22,045	25.8
Census Tract 27; Shelby County; Tennessee	1,433	35,397	25.8
Census Tract 66; Knox County; Tennessee	2,913	50,648	25.9
Census Tract 6; Madison County; Tennessee	1,506	30,598	25.9
Census Tract 9705.02; Cumberland County; Tennessee	3,315	21,774	26.0
Census Tract 156.18; Davidson County; Tennessee	5,673	29,926	26.0
Census Tract 427.04; Sullivan County; Tennessee	1,924	23,695	26.0
Census Tract 208; Anderson County; Tennessee	3,815	28,234	26.1
Census Tract 190.08; Davidson County; Tennessee	3,891	23,136	26.2
Census Tract 109.04; Hamilton County; Tennessee	2,497	41,663	26.2
Census Tract 226; Shelby County; Tennessee	2,940	19,152	26.2
Census Tract 19; Knox County; Tennessee	1,163	21,404	26.3
Census Tract 9751; Henderson County; Tennessee	3,137	22,473	26.4

Geography	Population 16 Years and Over	Per Capita Income ($)	Poverty (%)
Census Tract 118; Davidson County; Tennessee	2,239	47,881	26.5
Census Tract 190.03; Davidson County; Tennessee	2,878	20,475	26.5
Census Tract 9605; Hancock County; Tennessee	2,083	29,388	26.5
Census Tract 102.20; Shelby County; Tennessee	5,112	20,638	26.5
Census Tract 612; Washington County; Tennessee	3,244	31,372	26.5
Census Tract 9710.01; Coffee County; Tennessee	1,018	43,787	26.6
Census Tract 509; Hawkins County; Tennessee	2,602	22,219	26.6
Census Tract 9701; Macon County; Tennessee	3,807	21,842	26.6
Census Tract 1; Putnam County; Tennessee	4,217	23,045	26.6
Census Tract 613.01; Washington County; Tennessee	2,592	30,255	26.6
Census Tract 190.04; Davidson County; Tennessee	2,990	18,934	26.8
Census Tract 9753.02; Henderson County; Tennessee	3,036	22,694	26.8
Census Tract 25; Shelby County; Tennessee	2,362	29,235	26.8
Census Tract 1001; Hamblen County; Tennessee	4,735	20,317	26.9
Census Tract 102.10; Shelby County; Tennessee	4,119	19,730	27.0
Census Tract 9205.01; Cocke County; Tennessee	5,065	24,546	27.1
Census Tract 505.05; Lauderdale County; Tennessee	2,787	22,087	27.1
Census Tract 100.02; Shelby County; Tennessee	2,312	19,656	27.1
Census Tract 9307; Warren County; Tennessee	3,810	26,388	27.1
Census Tract 9604; Jackson County; Tennessee	1,622	24,492	27.2
Census Tract 308.01; Roane County; Tennessee	1,501	25,204	27.2
Census Tract 36; Shelby County; Tennessee	1,470	42,436	27.2
Census Tract 80; Shelby County; Tennessee	3,451	22,863	27.2
Census Tract 9504.02; Bedford County; Tennessee	5,137	20,946	27.3
Census Tract 9632; Benton County; Tennessee	1,669	27,014	27.3
Census Tract 181.01; Davidson County; Tennessee	3,630	41,748	27.3
Census Tract 912; Greene County; Tennessee	2,886	23,101	27.3
Census Tract 156.32; Davidson County; Tennessee	3,250	37,911	27.5
Census Tract 9602; Lake County; Tennessee	1,799	20,249	27.6
Census Tract 9501; Polk County; Tennessee	1,244	27,744	27.6
Census Tract 20; Shelby County; Tennessee	1,136	22,107	27.6
Census Tract 217.56; Shelby County; Tennessee	1,613	31,405	27.7
Census Tract 9503; Campbell County; Tennessee	1,578	21,828	27.8
Census Tract 9644.01; Dyer County; Tennessee	2,193	24,017	27.8
Census Tract 9693; Henry County; Tennessee	2,274	23,795	27.8
Census Tract 24; Shelby County; Tennessee	1,426	23,218	28.1
Census Tract 110.10; Shelby County; Tennessee	2,427	20,913	28.1
Census Tract 213.04; Anderson County; Tennessee	2,764	25,852	28.2
Census Tract 503.02; Hawkins County; Tennessee	3,203	24,213	28.2
Census Tract 9601; Lake County; Tennessee	4,219	19,402	28.3
Census Tract 701; Carter County; Tennessee	1,745	25,405	28.4
Census Tract 119; Davidson County; Tennessee	2,264	36,753	28.6
Census Tract 506; Lauderdale County; Tennessee	1,935	18,358	28.6
Census Tract 8; Putnam County; Tennessee	5,702	14,534	28.6
Census Tract 808.01; Sevier County; Tennessee	2,166	19,888	28.6
Census Tract 9532; Bledsoe County; Tennessee	3,966	21,455	28.8
Census Tract 1; Madison County; Tennessee	3,068	31,128	28.8

Geography	Population 16 Years and Over	Per Capita Income ($)	Poverty (%)
Census Tract 19; Hamilton County; Tennessee	2,550	22,501	28.9
Census Tract 46.10; Knox County; Tennessee	3,608	27,262	28.9
Census Tract 9702.02; McMinn County; Tennessee	2,942	22,841	28.9
Census Tract 9751.02; Scott County; Tennessee	3,347	24,424	28.9
Census Tract 20; Knox County; Tennessee	2,311	19,753	29.0
Census Tract 421; Sullivan County; Tennessee	4,456	34,168	29.0
Census Tract 9695.02; Henry County; Tennessee	3,121	25,273	29.1
Census Tract 403.05; Rutherford County; Tennessee	2,039	19,313	29.1
Census Tract 97; Shelby County; Tennessee	1,796	18,210	29.1
Census Tract 107.10; Shelby County; Tennessee	3,101	20,239	29.2
Census Tract 13; Hamilton County; Tennessee	1,685	29,051	29.3
Census Tract 107.20; Shelby County; Tennessee	2,394	23,132	29.3
Census Tract 1101; Morgan County; Tennessee	2,392	24,905	29.4
Census Tract 109.04; Davidson County; Tennessee	2,363	23,270	29.5
Census Tract 419; Rutherford County; Tennessee	3,354	22,885	29.5
Census Tract 62; Shelby County; Tennessee	1,462	19,566	29.6
Census Tract 68; Shelby County; Tennessee	1,422	18,801	29.6
Census Tract 220.23; Shelby County; Tennessee	1,552	22,180	29.7
Census Tract 34; Hamilton County; Tennessee	3,309	26,368	29.8
Census Tract 10; Madison County; Tennessee	1,674	17,872	29.9
Census Tract 3; Shelby County; Tennessee	530	13,353	29.9
Census Tract 405; Sullivan County; Tennessee	3,768	20,186	30.0
Census Tract 29; Hamilton County; Tennessee	2,254	31,649	30.1
Census Tract 136; Davidson County; Tennessee	4,860	19,266	30.2
Census Tract 21; Shelby County; Tennessee	1,022	19,187	30.2
Census Tract 105; Maury County; Tennessee	3,444	23,310	30.3
Census Tract 56; Shelby County; Tennessee	3,191	19,814	30.3
Census Tract 601.03; Sequatchie County; Tennessee	3,459	22,114	30.4
Census Tract 102.02; Bradley County; Tennessee	2,130	39,023	30.5
Census Tract 1002; Hamblen County; Tennessee	4,676	19,008	30.5
Census Tract 414.06; Rutherford County; Tennessee	4,206	33,643	30.5
Census Tract 9752; Scott County; Tennessee	4,896	18,174	30.6
Census Tract 12; Shelby County; Tennessee	2,417	19,700	30.6
Census Tract 156.14; Davidson County; Tennessee	3,098	29,985	30.8
Census Tract 9680; Weakley County; Tennessee	913	24,253	30.8
Census Tract 156.15; Davidson County; Tennessee	4,268	16,747	31.0
Census Tract 108; Blount County; Tennessee	2,398	25,994	31.1
Census Tract 108; Bradley County; Tennessee	2,530	18,159	31.1
Census Tract 706; Carter County; Tennessee	2,153	25,710	31.1
Census Tract 9601; Jackson County; Tennessee	1,650	24,725	31.1
Census Tract 57; Shelby County; Tennessee	1,942	16,175	31.1
Census Tract 220.26; Shelby County; Tennessee	1,268	18,132	31.1
Census Tract 402; Sullivan County; Tennessee	1,872	25,726	31.1
Census Tract 194.01; Davidson County; Tennessee	2,772	58,752	31.2
Census Tract 67; Shelby County; Tennessee	2,794	19,059	31.2
Census Tract 191.08; Davidson County; Tennessee	2,249	19,373	31.3
Census Tract 9303.02; Haywood County; Tennessee	2,384	19,697	31.7

Geography	Population 16 Years and Over	Per Capita Income ($)	Poverty (%)
Census Tract 620; Washington County; Tennessee	3,860	24,103	31.8
Census Tract 9202.01; DeKalb County; Tennessee	4,099	19,561	31.9
Census Tract 138; Davidson County; Tennessee	1,368	23,519	32.0
Census Tract 113; Shelby County; Tennessee	1,042	29,949	32.1
Census Tract 9656; Obion County; Tennessee	2,931	19,717	32.2
Census Tract 128.01; Davidson County; Tennessee	4,099	28,048	32.3
Census Tract 9651; Fentress County; Tennessee	3,575	19,006	32.3
Census Tract 304.01; Roane County; Tennessee	2,231	23,599	32.3
Census Tract 9531.02; Bledsoe County; Tennessee	3,562	23,061	32.4
Census Tract 24; Hamilton County; Tennessee	3,224	21,650	32.4
Census Tract 9702.01; McMinn County; Tennessee	1,768	20,531	32.4
Census Tract 112; Shelby County; Tennessee	782	16,666	32.4
Census Tract 9682.03; Weakley County; Tennessee	2,689	23,562	32.4
Census Tract 103; Shelby County; Tennessee	955	15,050	32.6
Census Tract 7; Madison County; Tennessee	2,590	22,257	32.7
Census Tract 9507.02; Campbell County; Tennessee	2,205	23,340	32.8
Census Tract 704; Carter County; Tennessee	1,528	20,303	33.1
Census Tract 606.02; Washington County; Tennessee	3,680	28,106	33.3
Census Tract 11; Hamilton County; Tennessee	1,572	28,786	33.4
Census Tract 9506.02; Campbell County; Tennessee	1,724	27,882	33.8
Census Tract 1002; Montgomery County; Tennessee	1,235	22,032	33.8
Census Tract 106.20; Shelby County; Tennessee	2,365	16,387	33.8
Census Tract 14; Knox County; Tennessee	1,738	13,696	34.0
Census Tract 65; Shelby County; Tennessee	1,634	20,655	34.0
Census Tract 109.03; Davidson County; Tennessee	5,092	25,130	34.1
Census Tract 27; Knox County; Tennessee	1,640	16,796	34.1
Census Tract 810.02; Sevier County; Tennessee	2,205	25,039	34.1
Census Tract 4; Madison County; Tennessee	2,418	19,834	34.2
Census Tract 9605.01; Lawrence County; Tennessee	3,788	19,126	34.5
Census Tract 601; Washington County; Tennessee	3,359	26,482	34.5
Census Tract 191.05; Davidson County; Tennessee	3,829	24,817	34.6
Census Tract 7; Shelby County; Tennessee	3,322	22,528	34.6
Census Tract 9644.02; Dyer County; Tennessee	2,154	23,733	34.7
Census Tract 106.10; Shelby County; Tennessee	4,156	21,545	34.7
Census Tract 30; Shelby County; Tennessee	2,266	41,440	34.8
Census Tract 9204.02; Hardin County; Tennessee	2,288	19,654	35.0
Census Tract 53; Shelby County; Tennessee	2,413	15,723	35.3
Census Tract 205.21; Shelby County; Tennessee	1,912	14,595	35.3
Census Tract 205.43; Shelby County; Tennessee	2,295	20,499	35.3
Census Tract 26; Hamilton County; Tennessee	1,697	21,012	35.5
Census Tract 108.10; Shelby County; Tennessee	4,477	19,703	35.5
Census Tract 8; Knox County; Tennessee	4,268	40,799	35.8
Census Tract 13; Shelby County; Tennessee	1,810	19,440	35.9
Census Tract 406; Sullivan County; Tennessee	2,600	20,362	36.0
Census Tract 207; Anderson County; Tennessee	1,226	21,596	36.1
Census Tract 9606; Hancock County; Tennessee	3,334	20,765	36.1
Census Tract 122; Hamilton County; Tennessee	1,665	16,348	36.2

Geography	Population 16 Years and Over	Per Capita Income ($)	Poverty (%)
Census Tract 110.20; Shelby County; Tennessee	952	31,532	36.4
Census Tract 26; Knox County; Tennessee	1,927	15,852	36.5
Census Tract 89; Shelby County; Tennessee	3,023	18,128	36.6
Census Tract 205.44; Shelby County; Tennessee	1,921	22,371	37.0
Census Tract 12; Hamilton County; Tennessee	2,620	21,234	37.1
Census Tract 9; Shelby County; Tennessee	1,916	22,379	37.2
Census Tract 69; Shelby County; Tennessee	1,933	21,809	37.3
Census Tract 159; Davidson County; Tennessee	2,820	22,859	37.4
Census Tract 203.02; Shelby County; Tennessee	2,360	21,910	37.4
Census Tract 9709; Coffee County; Tennessee	3,541	21,319	37.6
Census Tract 9553; Marshall County; Tennessee	3,288	15,089	37.6
Census Tract 37; Shelby County; Tennessee	1,058	26,028	38.0
Census Tract 87; Shelby County; Tennessee	3,604	20,969	38.0
Census Tract 4; Hamilton County; Tennessee	2,409	16,234	38.1
Census Tract 127.01; Davidson County; Tennessee	4,747	21,953	38.4
Census Tract 16; Hamilton County; Tennessee	2,191	30,424	38.6
Census Tract 217.31; Shelby County; Tennessee	1,970	13,602	38.8
Census Tract 70; Knox County; Tennessee	2,152	18,930	39.0
Census Tract 9202; Cocke County; Tennessee	4,466	19,192	39.2
Census Tract 100.01; Shelby County; Tennessee	2,610	18,618	39.3
Census Tract 609.01; Washington County; Tennessee	2,369	17,765	39.3
Census Tract 307; Wilson County; Tennessee	3,082	20,455	39.6
Census Tract 9751.01; Scott County; Tennessee	1,813	25,237	39.8
Census Tract 78.21; Shelby County; Tennessee	3,995	26,214	39.8
Census Tract 208; Sumner County; Tennessee	5,417	16,542	39.8
Census Tract 38; Shelby County; Tennessee	634	21,035	39.9
Census Tract 74; Shelby County; Tennessee	2,849	21,617	39.9
Census Tract 82; Shelby County; Tennessee	3,726	12,265	40.7
Census Tract 14; Shelby County; Tennessee	1,080	17,866	40.8
Census Tract 1009; Montgomery County; Tennessee	2,214	17,108	41.2
Census Tract 217.10; Shelby County; Tennessee	1,555	18,557	41.2
Census Tract 8; Madison County; Tennessee	1,299	16,570	41.9
Census Tract 81.10; Shelby County; Tennessee	1,513	15,163	41.9
Census Tract 78.22; Shelby County; Tennessee	1,154	22,923	42.4
Census Tract 4; Shelby County; Tennessee	1,046	17,382	42.7
Census Tract 78.10; Shelby County; Tennessee	1,609	16,613	42.8
Census Tract 29; Knox County; Tennessee	2,476	17,597	42.9
Census Tract 39; Shelby County; Tennessee	1,454	26,710	43.0
Census Tract 105; Shelby County; Tennessee	1,897	14,883	43.0
Census Tract 221.31; Shelby County; Tennessee	2,087	25,483	43.1
Census Tract 223.30; Shelby County; Tennessee	3,774	18,390	43.1
Census Tract 2; Shelby County; Tennessee	880	12,578	43.5
Census Tract 99.01; Shelby County; Tennessee	2,315	16,136	43.6
Census Tract 139; Davidson County; Tennessee	1,380	24,762	44.1
Census Tract 19; Shelby County; Tennessee	1,102	17,840	44.2
Census Tract 114.01; Shelby County; Tennessee	900	14,179	44.2
Census Tract 115; Shelby County; Tennessee	1,612	12,796	44.7

Geography	Population 16 Years and Over	Per Capita Income ($)	Poverty (%)
Census Tract 91; Shelby County; Tennessee	2,173	15,531	45.3
Census Tract 70; Shelby County; Tennessee	2,420	21,286	45.5
Census Tract 1003; Hamblen County; Tennessee	2,320	13,728	46.6
Census Tract 9; Madison County; Tennessee	1,600	15,483	46.6
Census Tract 3.04; Putnam County; Tennessee	3,778	16,143	46.7
Census Tract 68; Knox County; Tennessee	3,817	18,619	46.8
Census Tract 223.10; Shelby County; Tennessee	4,086	14,373	46.8
Census Tract 106.30; Shelby County; Tennessee	2,417	13,584	46.9
Census Tract 8; Shelby County; Tennessee	1,475	21,765	47.0
Census Tract 6; Shelby County; Tennessee	1,206	15,557	47.3
Census Tract 1008; Montgomery County; Tennessee	2,399	11,901	47.9
Census Tract 101.21; Shelby County; Tennessee	1,682	17,148	48.0
Census Tract 117; Shelby County; Tennessee	813	19,803	48.0
Census Tract 104; Bradley County; Tennessee	2,264	14,230	48.2
Census Tract 160; Davidson County; Tennessee	2,018	27,708	49.4
Census Tract 101.22; Shelby County; Tennessee	2,352	14,516	49.4
Census Tract 162; Davidson County; Tennessee	2,497	45,142	49.8
Census Tract 55; Shelby County; Tennessee	1,588	13,398	49.8
Census Tract 25; Hamilton County; Tennessee	3,431	18,188	49.9
Census Tract 28; Shelby County; Tennessee	2,231	16,995	49.9
Census Tract 217.57; Shelby County; Tennessee	1,717	18,833	50.5
Census Tract 205.23; Shelby County; Tennessee	2,164	13,096	51.1
Census Tract 222.20; Shelby County; Tennessee	3,887	17,307	51.4
Census Tract 111; Shelby County; Tennessee	1,291	18,765	51.9
Census Tract 114.02; Shelby County; Tennessee	3,348	16,102	52.4
Census Tract 142; Davidson County; Tennessee	1,928	12,426	52.7
Census Tract 1001; Montgomery County; Tennessee	1,350	13,975	52.8
Census Tract 5; Madison County; Tennessee	3,061	10,536	52.9
Census Tract 58; Shelby County; Tennessee	692	10,646	54.0
Census Tract 35.02; Knox County; Tennessee	2,080	25,565	55.0
Census Tract 193; Davidson County; Tennessee	3,018	22,695	57.5
Census Tract 11; Madison County; Tennessee	832	11,081	57.5
Census Tract 101.20; Shelby County; Tennessee	2,780	12,050	57.9
Census Tract 116; Shelby County; Tennessee	1,767	12,615	58.0
Census Tract 220.25; Shelby County; Tennessee	2,393	13,136	58.6
Census Tract 99.02; Shelby County; Tennessee	1,482	15,731	59.3
Census Tract 50; Shelby County; Tennessee	659	8,737	64.4
Census Tract 59; Shelby County; Tennessee	1,418	14,355	68.8
Census Tract 45; Shelby County; Tennessee	539	11,371	69.6
Census Tract 69.01; Knox County; Tennessee	4,124	10,996	69.7
Census Tract 69.02; Knox County; Tennessee	3,034	9,266	72.4
Census Tract 148; Davidson County; Tennessee	1,037	6,434	77.9
Census Tract 69.03; Knox County; Tennessee	2,227	9,761	79.0
Census Tract 9682.02; Weakley County; Tennessee	2,069	8,229	82.6
Census Tract 9.02; Knox County; Tennessee	3,061	4,852	96.1
Census Tract 109; Washington County; Virginia	3,808	26,902	15.0
Census Tract 9310; Wise County; Virginia	1,573	26,736	15.4

Geography	Population 16 Years and Over	Per Capita Income ($)	Poverty (%)
Census Tract 306; Scott County; Virginia	3,358	25,001	15.5
Census Tract 101.01; Washington County; Virginia	2,754	32,527	15.9
Census Tract 304; Scott County; Virginia	3,038	28,322	16.2
Census Tract 9309; Wise County; Virginia	3,482	26,812	19.9
Census Tract 302; Scott County; Virginia	3,428	21,052	20.3
Census Tract 103.01; Washington County; Virginia	2,514	26,229	20.3
Census Tract 9307; Wise County; Virginia	2,712	19,897	21.9
Census Tract 9315; Wise County; Virginia	2,918	20,610	22.0
Census Tract 105.02; Washington County; Virginia	3,920	39,896	22.2
Census Tract 9504; Lee County; Virginia	2,092	25,950	22.4
Census Tract 9316; Wise County; Virginia	1,963	27,112	23.0
Census Tract 203; Bristol city; Virginia	1,938	20,437	23.9
Census Tract 9314; Wise County; Virginia	4,401	23,582	24.3
Census Tract 9503.02; Lee County; Virginia	2,579	12,921	26.2
Census Tract 201; Bristol city; Virginia	2,952	21,899	26.6
Census Tract 9501; Lee County; Virginia	2,224	19,173	27.4
Census Tract 9317; Wise County; Virginia	1,333	23,738	28.9
Census Tract 9601; Norton city; Virginia	3,138	27,666	29.1
Census Tract 303; Scott County; Virginia	2,509	23,050	30.4
Census Tract 9311; Wise County; Virginia	1,959	18,176	32.8
Census Tract 9505; Lee County; Virginia	3,878	21,393	36.0
Census Tract 202.01; Bristol city; Virginia	1,849	19,257	46.1
Census Tract 9503.01; Lee County; Virginia	1,528	19,876	50.4

Source: USCB 2023h

B.4 Minority Populations in the TVA PSA

Geography	2022 Population	% White Alone	% Minority Population	% Black or African American	% American Indian and Alaska Native	% Asian	% Native Hawaiian and Other Pacific Islander	% Some Other Race	% Two or More Races	% Hispanic or Latino
Blount County, Alabama	59,077	85.7	14.3	1.2	0.1	0.2	0.2	0.1	2.8	9.7
Cherokee County, Alabama	25,069	90.7	9.3	4.0	0.5	0.1	0.0	0.1	2.8	1.9
Colbert County, Alabama	57,270	77.7	22.3	16.0	0.3	0.4	0.1	0.1	2.2	3.2
Cullman County, Alabama	88,284	90.8	9.2	1.1	0.3	0.3	0.0	0.1	2.8	4.6
DeKalb County, Alabama	71,680	79.1	20.9	1.5	0.5	0.1	0.0	0.5	2.9	15.4
Etowah County, Alabama	103,348	77.1	22.9	15.0	0.1	0.7	0.0	0.4	2.3	4.4
Franklin County, Alabama	32,011	75.2	24.8	4.2	0.2	0.1	0.0	0.2	1.5	18.4
Jackson County, Alabama	52,618	88.8	11.2	3.2	0.8	0.4	0.0	0.1	3.5	3.2
Lauderdale County, Alabama	94,329	83.4	16.6	9.7	0.2	0.6	0.1	0.1	2.8	3.0
Lawrence County, Alabama	33,116	76.3	23.7	10.2	5.0	0.3	0.1	0.0	5.6	2.5
Limestone County, Alabama	104,199	74.7	25.3	13.0	0.4	1.8	0.1	0.1	3.6	6.3
Madison County, Alabama	389,781	63.5	36.5	24.3	0.4	2.4	0.0	0.3	3.8	5.3
Marshall County, Alabama	97,923	79.1	20.9	2.7	0.1	0.6	0.1	0.2	2.1	15.1
Morgan County, Alabama	123,102	74.3	25.7	12.9	0.2	0.5	0.0	0.3	3.0	8.8
Winston County, Alabama	23,655	92.3	7.7	1.1	0.2	0.4	0.0	0.0	2.7	3.2
Catoosa County, Georgia	68,052	89.0	11.0	2.2	0.1	1.5	0.1	0.6	3.3	3.4
Chattooga County, Georgia	24,902	82.0	18.0	9.5	0.1	0.1	0.0	0.0	2.7	5.7
Dade County, Georgia	16,239	92.2	7.8	1.0	0.0	0.8	0.0	0.3	3.1	2.6
Fannin County, Georgia	25,436	93.1	6.9	0.3	0.0	0.5	0.0	0.4	3.0	2.8
Gilmer County, Georgia	31,519	84.3	15.7	0.5	0.2	0.4	0.0	0.1	2.1	12.4
Gordon County, Georgia	57,785	76.0	24.0	3.3	0.1	1.1	0.1	0.2	2.4	16.8
Murray County, Georgia	40,063	80.2	19.8	0.4	0.1	0.8	0.0	0.4	2.2	15.9
Towns County, Georgia	12,546	93.6	6.4	1.3	0.1	0.2	0.0	0.1	1.8	2.9
Union County, Georgia	24,880	92.9	7.1	0.6	0.2	0.2	0.0	0.0	2.4	3.8
Walker County, Georgia	68,065	89.9	10.1	3.9	0.2	0.6	0.0	0.1	2.8	2.7
Whitfield County, Georgia	103,033	56.6	43.4	3.2	0.1	1.5	0.0	0.1	1.8	36.8
Allen County, Kentucky	20,773	94.1	5.9	0.8	0.0	0.0	0.0	0.3	2.3	2.4
Butler County, Kentucky	12,365	93.7	6.3	0.4	0.1	0.7	0.0	0.0	1.4	3.8
Calloway County, Kentucky	37,345	88.7	11.3	3.4	0.2	1.6	0.3	0.4	2.7	2.8
Carlisle County, Kentucky	4,782	92.3	7.7	1.2	0.3	0.5	0.1	0.1	3.0	2.5
Christian County, Kentucky	72,766	64.7	35.3	19.7	0.1	1.2	0.3	0.4	5.1	8.4
Cumberland County, Kentucky	5,974	93.0	7.0	2.7	0.3	0.8	0.0	0.0	1.5	1.8
Edmonson County, Kentucky	12,179	95.2	4.8	0.8	0.1	0.0	0.0	0.0	2.3	1.6
Fulton County, Kentucky	6,480	69.8	30.2	23.6	0.4	0.0	0.9	0.0	3.8	1.5

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Graves County, Kentucky	36,701	85.0	15.0	4.0	0.0	0.4	0.0	0.3	2.9	7.4
Grayson County, Kentucky	26,465	95.1	4.9	0.5	0.0	0.3	0.0	0.2	2.3	1.5
Hickman County, Kentucky	4,491	86.1	13.9	9.4	0.1	0.0	0.0	0.0	2.1	2.2
Livingston County, Kentucky	8,980	94.5	5.5	0.3	0.0	0.0	0.0	0.0	2.6	2.6
Logan County, Kentucky	27,498	88.1	11.9	5.8	0.0	0.4	0.0	0.2	2.3	3.1
Lyon County, Kentucky	8,721	87.9	12.1	6.5	0.5	0.7	0.1	0.3	1.6	2.5
Marshall County, Kentucky	31,706	96.0	4.0	0.6	0.3	0.2	0.0	0.0	1.0	1.8
Monroe County, Kentucky	11,331	93.2	6.8	2.6	0.1	0.2	0.0	0.0	0.8	3.2
Muhlenberg County, Kentucky	30,735	92.5	7.5	1.9	0.2	1.1	0.0	0.0	2.4	1.7
Simpson County, Kentucky	19,574	84.9	15.1	9.3	0.0	0.4	0.0	0.1	2.6	2.8
Todd County, Kentucky	12,281	85.1	14.9	8.0	0.0	0.1	0.0	0.4	1.6	4.8
Trigg County, Kentucky	14,154	87.1	12.9	6.3	0.0	0.3	0.0	0.4	3.3	2.5
Warren County, Kentucky	135,307	76.6	23.4	8.6	0.1	4.9	0.5	0.1	3.5	5.7
Avery County, North Carolina	17,679	87.5	12.5	3.6	0.8	0.5	0.0	0.0	2.4	5.1
Cherokee County, North Carolina	28,868	90.1	9.9	1.5	1.6	0.5	0.0	0.1	2.5	3.7
Clay County, North Carolina	11,186	91.7	8.3	1.0	1.1	1.1	0.1	0.0	1.1	3.9
Watauga County, North Carolina	54,540	91.1	8.9	1.7	0.3	1.4	0.0	0.1	1.5	4.0
Lee County, Virginia	22,287	92.1	7.9	4.0	0.1	0.3	0.0	0.0	1.4	2.1
Scott County, Virginia	21,536	96.1	3.9	1.2	0.1	0.1	0.2	0.1	0.8	1.5
Washington County, Virginia	53,985	94.8	5.2	1.7	0.1	0.5	0.0	0.1	1.3	1.6
Wise County, Virginia	36,105	90.8	9.2	4.6	0.1	1.1	0.0	0.2	1.9	1.3
Bristol city, Virginia	17,036	86.6	13.4	6.3	0.0	0.3	0.0	0.7	3.6	2.6
Norton city, Virginia	3,668	94.4	5.6	2.0	0.0	0.1	0.0	0.0	3.5	0.0
Alcorn County, Mississippi	34,717	80.8	19.2	9.4	0.1	0.4	0.1	0.1	5.6	3.5
Attala County, Mississippi	17,842	52.6	47.4	42.2	0.1	0.3	0.0	0.0	2.6	2.2
Benton County, Mississippi	7,637	60.1	39.9	32.9	0.0	0.4	0.1	0.0	3.3	3.1
Calhoun County, Mississippi	13,193	63.8	36.2	28.4	0.0	0.0	0.0	0.1	1.3	6.5
Chickasaw County, Mississippi	17,024	49.1	50.9	43.7	0.0	0.2	0.0	0.0	1.9	5.1
Choctaw County, Mississippi	8,208	67.0	33.0	29.2	0.1	0.4	0.0	0.2	1.3	1.8
Clay County, Mississippi	18,598	38.0	62.0	60.0	0.0	0.0	0.0	0.0	1.8	0.2
DeSoto County, Mississippi	186,214	59.8	40.2	30.8	0.1	1.3	0.0	0.2	2.7	5.2
Itawamba County, Mississippi	23,888	88.8	11.2	6.0	0.4	0.2	0.0	0.2	2.6	1.8
Kemper County, Mississippi	8,980	33.4	66.6	61.8	3.8	0.0	0.0	0.0	0.2	0.8
Lafayette County, Mississippi	56,172	69.9	30.1	23.3	0.1	2.3	0.0	0.1	1.6	2.6
Leake County, Mississippi	21,335	47.7	52.3	39.8	5.7	0.4	0.0	0.0	1.4	5.1
Lee County, Mississippi	83,343	63.7	36.3	29.7	0.1	1.0	0.2	0.5	1.8	3.0

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Lowndes County, Mississippi	58,547	50.0	50.0	44.5	0.1	1.1	0.0	0.4	1.5	2.4
Marshall County, Mississippi	33,980	47.1	52.9	45.5	0.0	0.1	0.0	0.5	2.4	4.3
Monroe County, Mississippi	34,168	66.7	33.3	30.2	0.0	0.3	0.0	0.0	1.3	1.5
Neshoba County, Mississippi	28,970	57.7	42.3	22.8	16.0	0.6	0.1	0.7	1.9	0.2
Noxubee County, Mississippi	10,261	25.6	74.4	73.6	0.4	0.0	0.0	0.0	0.2	0.3
Oktibbeha County, Mississippi	51,388	56.0	44.0	36.6	0.1	3.1	0.1	0.1	2.3	1.8
Panola County, Mississippi	33,157	46.9	53.1	49.6	0.1	0.3	0.4	0.1	1.9	0.6
Pontotoc County, Mississippi	31,202	75.1	24.9	14.4	0.2	0.0	0.0	0.1	2.8	7.5
Prentiss County, Mississippi	24,945	79.9	20.1	10.7	0.1	2.5	0.0	1.0	4.3	1.5
Scott County, Mississippi	27,943	48.7	51.3	35.6	0.1	0.1	0.0	0.2	3.5	11.8
Tallahatchie County, Mississippi	12,621	34.9	65.1	61.4	0.0	0.1	0.0	0.2	1.5	1.9
Tate County, Mississippi	28,094	64.2	35.8	30.4	0.0	0.0	0.1	0.0	1.8	3.4
Tippah County, Mississippi	21,769	77.1	22.9	14.5	0.0	0.0	0.0	0.4	3.2	4.7
Tishomingo County, Mississippi	18,837	91.0	9.0	1.3	0.4	0.6	0.0	0.4	2.7	3.5
Union County, Mississippi	27,880	77.2	22.8	15.7	0.2	0.2	0.0	0.6	1.6	4.6
Webster County, Mississippi	9,942	78.2	21.8	18.5	0.1	0.8	0.0	0.1	0.8	1.6
Winston County, Mississippi	17,741	49.6	50.4	46.7	0.5	0.1	0.0	0.0	1.6	1.5
Yalobusha County, Mississippi	12,499	57.8	42.2	38.3	0.2	0.1	0.0	0.0	1.0	2.6
Anderson County, Tennessee	77,337	87.6	12.4	3.2	0.3	1.3	0.1	0.6	3.6	3.4
Bedford County, Tennessee	50,533	75.2	24.8	6.5	0.3	0.3	0.0	0.5	3.7	13.6
Benton County, Tennessee	15,933	91.4	8.6	1.9	0.1	1.1	0.8	0.0	2.9	1.8
Bledsoe County, Tennessee	14,816	87.3	12.7	5.7	0.3	0.1	0.0	0.2	3.3	3.0
Blount County, Tennessee	135,951	89.9	10.1	2.6	0.1	0.7	0.0	0.2	2.6	3.8
Bradley County, Tennessee	108,859	83.9	16.1	4.6	0.2	1.0	0.0	1.0	2.5	6.9
Campbell County, Tennessee	39,397	95.9	4.1	0.3	0.0	0.4	0.0	0.0	1.6	1.7
Cannon County, Tennessee	14,481	92.9	7.1	2.5	0.1	0.0	0.0	0.0	1.7	2.7
Carroll County, Tennessee	28,381	84.0	16.0	8.8	0.1	0.3	0.0	0.0	3.6	3.1
Carter County, Tennessee	56,315	92.9	7.1	2.2	0.1	0.5	0.0	0.0	1.6	2.7
Cheatham County, Tennessee	41,184	90.2	9.8	1.9	0.2	0.5	0.0	0.7	2.5	3.8
Chester County, Tennessee	17,392	84.6	15.4	10.3	0.0	0.2	0.0	0.6	1.4	2.9
Claiborne County, Tennessee	32,092	94.7	5.3	0.8	0.1	0.8	0.0	0.0	2.1	1.5
Clay County, Tennessee	7,592	93.9	6.1	0.7	0.4	0.6	0.0	0.0	1.7	2.8
Cocke County, Tennessee	36,186	92.5	7.5	1.2	0.5	0.5	0.1	0.0	2.4	2.8
Coffee County, Tennessee	58,080	86.7	13.3	3.8	0.0	1.3	0.2	0.4	2.3	5.2
Crockett County, Tennessee	13,955	72.0	28.0	11.0	0.6	0.5	0.1	0.0	4.3	11.5
Cumberland County, Tennessee	61,552	93.8	6.2	0.8	0.2	0.3	0.0	0.1	1.7	3.2

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Davidson County, Tennessee	709,786	55.6	44.4	26.0	0.1	3.6	0.1	0.5	3.6	10.6
Decatur County, Tennessee	11,483	91.0	9.0	2.4	0.0	0.1	0.0	0.0	2.9	3.6
DeKalb County, Tennessee	20,209	87.0	13.0	1.6	0.3	0.4	0.0	0.1	2.1	8.4
Dickson County, Tennessee	54,563	88.2	11.8	3.6	0.2	0.1	0.0	0.4	3.3	4.2
Dyer County, Tennessee	36,818	78.3	21.7	13.3	0.1	0.5	0.0	0.0	4.1	3.8
Fayette County, Tennessee	42,228	66.7	33.3	26.9	0.0	0.7	0.0	0.2	2.2	3.2
Fentress County, Tennessee	18,642	95.3	4.7	0.3	0.0	0.3	0.1	0.0	2.1	1.8
Franklin County, Tennessee	42,980	87.7	12.3	4.8	0.0	0.6	0.1	0.2	2.8	3.8
Gibson County, Tennessee	50,455	75.9	24.1	16.0	0.2	0.3	0.0	0.1	4.5	3.0
Giles County, Tennessee	30,317	82.7	17.3	8.8	0.1	0.1	0.0	0.4	4.6	3.3
Grainger County, Tennessee	23,648	93.0	7.0	0.9	0.2	0.1	0.3	0.1	1.7	3.6
Greene County, Tennessee	70,399	92.0	8.0	1.7	0.1	0.5	0.0	0.2	2.3	3.3
Grundy County, Tennessee	13,550	94.8	5.2	0.4	0.2	0.3	0.0	0.0	2.7	1.6
Hamblen County, Tennessee	64,531	80.3	19.7	3.1	0.2	0.9	0.4	0.3	2.6	12.3
Hamilton County, Tennessee	367,193	70.1	29.9	17.7	0.1	1.9	0.0	0.4	3.6	6.2
Hancock County, Tennessee	6,726	96.2	3.8	0.6	0.0	0.5	0.0	0.1	1.9	0.7
Hardeman County, Tennessee	25,519	53.9	46.1	39.4	0.6	0.4	0.0	0.1	3.6	2.0
Hardin County, Tennessee	26,824	90.9	9.1	3.4	0.3	0.1	0.0	0.1	2.7	2.6
Hawkins County, Tennessee	57,107	94.1	5.9	1.0	0.1	0.5	0.1	0.1	2.3	1.8
Haywood County, Tennessee	17,806	43.7	56.3	50.0	0.0	0.1	0.0	0.4	1.4	4.3
Henderson County, Tennessee	27,845	86.5	13.5	8.2	0.1	0.1	0.1	0.1	2.2	2.7
Henry County, Tennessee	32,305	86.4	13.6	7.4	0.5	0.4	0.0	0.0	2.5	2.8
Hickman County, Tennessee	24,996	89.6	10.4	3.4	0.5	0.9	0.0	0.2	2.5	2.9
Houston County, Tennessee	8,253	91.0	9.0	3.4	0.3	0.3	0.2	0.0	1.9	2.8
Humphreys County, Tennessee	19,032	90.4	9.6	1.2	0.2	0.8	0.0	0.9	3.7	2.7
Jackson County, Tennessee	11,730	93.3	6.7	0.7	0.1	0.0	0.1	0.0	3.4	2.4
Jefferson County, Tennessee	55,017	91.0	9.0	1.7	0.1	0.6	0.0	0.4	2.4	3.9
Johnson County, Tennessee	17,982	90.4	9.6	3.6	0.6	0.2	0.0	0.3	2.7	2.3
Knox County, Tennessee	481,406	81.1	18.9	8.2	0.1	2.3	0.1	0.4	3.2	4.8
Lake County, Tennessee	6,898	65.8	34.2	25.5	0.7	0.2	0.1	0.0	4.7	2.9
Lauderdale County, Tennessee	25,171	58.8	41.2	34.4	0.4	0.2	0.0	0.3	3.2	2.9
Lawrence County, Tennessee	44,377	92.2	7.8	1.4	0.0	0.4	0.1	0.4	2.9	2.5
Lewis County, Tennessee	12,637	92.1	7.9	1.2	0.0	1.1	0.0	0.0	3.0	2.6
Lincoln County, Tennessee	35,365	85.4	14.6	6.2	0.1	0.7	0.0	0.1	3.6	3.9
Loudon County, Tennessee	55,507	86.3	13.7	1.2	0.1	1.0	0.0	0.4	1.4	9.6
McMinn County, Tennessee	53,532	87.1	12.9	3.4	0.1	0.8	0.0	0.1	4.1	4.5

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McNairy County, Tennessee	25,895	89.1	10.9	5.9	0.3	0.6	0.0	0.1	1.7	2.4
Macon County, Tennessee	25,365	90.3	9.7	0.6	0.1	0.4	0.0	0.0	3.3	5.3
Madison County, Tennessee	98,644	54.5	45.5	37.1	0.1	1.0	0.1	0.5	2.5	4.3
Marion County, Tennessee	28,852	90.9	9.1	2.9	0.1	0.5	0.0	0.1	3.5	2.1
Marshall County, Tennessee	34,567	84.4	15.6	4.7	0.3	0.6	0.0	0.6	3.4	6.0
Maury County, Tennessee	102,002	78.0	22.0	10.8	0.2	0.9	0.0	0.1	3.3	6.6
Meigs County, Tennessee	12,839	90.4	9.6	2.4	0.0	0.5	0.0	0.4	5.1	1.2
Monroe County, Tennessee	46,489	88.0	12.0	1.8	0.1	0.4	0.0	0.2	4.9	4.6
Montgomery County, Tennessee	222,305	60.9	39.1	19.6	0.2	2.3	0.3	0.6	5.3	10.7
Moore County, Tennessee	6,558	92.3	7.7	3.7	0.5	0.9	0.0	0.0	2.1	0.5
Morgan County, Tennessee	21,124	90.5	9.5	4.7	0.3	0.2	0.0	0.0	2.7	1.6
Obion County, Tennessee	30,670	80.1	19.9	10.5	0.1	0.2	0.1	0.2	3.7	5.1
Overton County, Tennessee	22,576	95.5	4.5	1.3	0.1	0.3	0.0	0.0	1.0	1.9
Perry County, Tennessee	8,432	90.9	9.1	0.4	0.5	2.2	0.0	0.0	5.0	1.0
Pickett County, Tennessee	5,042	95.2	4.8	0.3	0.0	0.0	0.0	0.0	2.3	2.2
Polk County, Tennessee	17,620	90.6	9.4	0.4	0.3	0.2	0.0	0.2	6.0	2.2
Putnam County, Tennessee	80,157	87.2	12.8	2.1	0.1	1.0	0.0	0.0	2.8	6.7
Rhea County, Tennessee	33,031	88.0	12.0	1.7	0.1	0.5	0.0	0.3	3.9	5.5
Roane County, Tennessee	53,777	91.2	8.8	2.7	0.2	0.6	0.0	0.1	2.8	2.2
Robertson County, Tennessee	73,297	81.4	18.6	7.1	0.1	0.7	0.0	0.6	2.5	7.7
Rutherford County, Tennessee	343,727	67.5	32.5	15.0	0.1	3.6	0.0	0.3	4.3	9.1
Scott County, Tennessee	21,917	96.8	3.2	0.3	0.2	0.4	0.0	0.3	1.8	0.2
Sequatchie County, Tennessee	16,065	92.3	7.7	0.5	0.4	0.3	0.1	0.3	2.2	4.0
Sevier County, Tennessee	98,455	88.4	11.6	0.9	0.2	1.2	0.0	0.3	2.1	6.9
Shelby County, Tennessee	926,440	34.5	65.5	53.6	0.1	2.9	0.0	0.3	1.9	6.8
Smith County, Tennessee	20,034	90.5	9.5	1.7	0.1	0.4	0.0	0.3	3.8	3.2
Stewart County, Tennessee	13,724	90.1	9.9	0.7	0.1	0.5	0.8	0.0	4.2	3.6
Sullivan County, Tennessee	158,722	92.4	7.6	1.9	0.1	0.8	0.0	0.3	2.3	2.2
Sumner County, Tennessee	196,845	81.1	18.9	8.2	0.1	1.6	0.0	0.3	2.9	5.7
Tipton County, Tennessee	61,116	74.5	25.5	18.5	0.1	0.6	0.0	0.7	2.7	2.9
Trousdale County, Tennessee	11,596	81.9	18.1	11.8	0.4	0.2	0.0	0.0	2.8	2.9
Unicoi County, Tennessee	17,845	91.3	8.7	0.3	0.4	0.2	0.0	0.0	2.0	5.9
Union County, Tennessee	19,860	95.1	4.9	0.5	0.0	0.0	0.0	0.1	2.3	2.0
Van Buren County, Tennessee	6,182	95.1	4.9	0.1	0.4	0.2	0.0	0.0	3.2	0.9
Warren County, Tennessee	41,163	84.1	15.9	2.6	0.2	0.4	0.1	0.0	3.0	9.5
Washington County, Tennessee	133,282	87.4	12.6	3.7	0.1	1.5	0.0	0.1	3.4	3.9

Geography	2022 Population	% White Alone	% Minority Population	% Black or African American	% American Indian and Alaska Native	% Asian	% Native Hawaiian and Other Pacific Islander	% Some Other Race	% Two or More Races	% Hispanic or Latino
Wayne County, Tennessee	16,325	88.9	11.1	4.8	0.1	0.1	0.1	0.1	3.5	2.4
Weakley County, Tennessee	32,946	85.5	14.5	7.9	0.2	1.2	0.1	0.3	1.9	3.0
White County, Tennessee	27,420	92.7	7.3	1.8	0.1	0.3	0.2	0.0	2.0	2.9
Williamson County, Tennessee	248,897	82.7	17.3	3.9	0.0	5.1	0.0	0.4	2.8	5.1
Wilson County, Tennessee	149,096	82.1	17.9	6.9	0.1	1.9	0.0	1.0	3.1	5.0

Source: USCB 2022b

County has a minority population greater than the TVA PSA average of 26.7%

County has a minority population greater than 50%

C

Appendix C – Environmental Parameters of the 30 Capacity Expansion Plans

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Appendix C - Environmental Parameters of the 30 Capacity Expansion Plans

Total 2025 – 2033 SO_2 Emissions, tons

Strategy	Scenario					
	1	2	3	4	5	6
A	165,114	204,818	82,553	155,553	132,252	150,594
B	165,953	204,992	80,271	154,613	141,355	150,541
C	159,557	204,977	80,331	152,866	134,625	143,278
D	161,944	207,150	72,985	150,449	136,904	146,573
E	166,807	206,822	79,644	154,077	131,737	152,192

Total 2025 – 2050 NOx Emissions, tons

Strategy	Scenario					
	1	2	3	4	5	6
A	198,886	226,533	143,578	174,795	208,145	183,798
B	185,817	212,799	123,939	165,400	215,462	163,937
C	179,562	213,838	126,695	160,946	204,352	157,134
D	185,576	217,600	122,455	162,967	205,856	163,147
E	186,580	213,593	128,339	166,061	208,744	169,141

Total 2025 – 2033 Mercury Emissions, pounds

Strategy	Scenario					
	1	2	3	4	5	6
A	463	630	244	468	464	478
B	463	625	236	464	492	475
C	443	639	238	457	473	446
D	445	630	219	440	476	454
E	466	634	233	458	467	477

Total 2025 – 2050 CO_2 Emissions, thousand tons

Strategy	Scenario					
	1	2	3	4	5	6
A	875,240	984,601	667,124	416,484	616,140	782,075
B	719,633	812,050	560,926	401,006	622,482	631,524
C	741,934	853,052	620,154	384,623	591,776	653,409
D	783,602	895,888	622,226	382,386	593,374	685,122
E	792,030	869,296	635,130	395,302	612,911	705,381

Average Annual CO_2 Emission Rate, pounds/MWh

Strategy	Scenario					
	1	2	3	4	5	6
A	388	388	335	187	226	365
B	322	326	284	180	229	296
C	330	340	312	173	218	305
D	366	375	334	176	223	337
E	358	355	325	179	226	334

Average Annual Water Withdrawal, million gallons

Strategy	Scenario					
	1	2	3	4	5	6
A	2,148,412	2,233,083	2,029,075	2,149,361	2,196,965	2,150,059
B	2,154,995	2,237,533	2,028,626	2,153,126	2,200,081	2,157,683
C	2,136,468	2,232,546	2,022,289	2,139,966	2,190,698	2,134,585
D	2,134,902	2,230,042	2,013,459	2,131,935	2,196,343	2,139,227
E	2,151,525	2,235,153	2,023,523	2,147,216	2,191,289	2,154,047

Average Annual Water Consumption, million gallons

Strategy	Scenario					
	1	2	3	4	5	6
A	49,614	51,808	47,197	46,694	79,947	47,403
B	53,596	56,160	50,880	51,145	75,073	52,102
C	47,105	48,936	45,275	45,200	73,178	45,817
D	47,910	50,036	45,360	45,629	75,895	46,385
E	51,483	52,755	48,657	48,987	75,746	49,822

Total 2025 – 2033 Coal Consumption, million tons

Strategy	Scenario					
	1	2	3	4	5	6
A	1,121	1,451	607	1,116	1,070	1,235
B	1,126	1,444	589	1,109	1,120	1,236
C	1,083	1,465	591	1,093	1,084	1,176
D	1,083	1,456	549	1,060	1,093	1,196
E	1,128	1,458	582	1,097	1,068	1,238

Total 2025 – 2050 Natural Gas Consumption, billion standard cubic feet

Strategy	Scenario					
	1	2	3	4	5	6
A	12,259	14,372	11,023	8,378	11,814	10,589
B	10,883	11,846	9,036	8,023	11,784	9,373
C	10,051	11,279	8,847	7,720	11,224	8,654
D	10,744	12,429	9,147	7,978	11,311	9,119
E	10,844	12,454	9,338	8,139	11,867	9,390

Total 2025 – 2050 Nuclear Consumption, billion standard cubic feet

Strategy	Scenario					
	1	2	3	4	5	6
A	17,889	17,884	17,890	17,881	26,994	17,875
B	20,660	20,992	20,649	20,771	26,062	20,661
C	17,888	17,873	17,887	17,876	24,948	17,884
D	17,875	17,878	17,887	17,875	25,803	17,888
E	19,485	19,489	19,481	19,491	25,505	19,482

Total 2025-2033 Waste (Coal Combustion Residuals) Production, MM tons

Strategy	Scenario					
	1	2	3	4	5	6
A	5.87	7.39	3.56	6.05	6.24	6.00
B	5.91	7.34	3.45	6.01	6.32	6.04
C	5.75	7.49	3.46	5.92	6.25	5.76
D	5.64	7.36	3.31	5.71	6.29	5.84
E	5.89	7.37	3.40	5.93	6.16	6.01

Total 2025 – 2033 Ash Production, MM tons

Strategy	Scenario					
	1	2	3	4	5	6
A	3.18	3.92	1.80	3.15	2.98	3.07
B	3.20	3.91	1.75	3.13	3.06	3.09
C	3.10	3.94	1.75	3.09	2.99	2.96
D	3.08	3.94	1.65	3.01	3.03	3.01
E	3.20	3.93	1.72	3.11	2.94	3.09

Total 2025 – 2033 Gypsum Production, MM tons

Strategy	Scenario					
	1	2	3	4	5	6
A	2.70	3.48	1.76	2.90	3.26	2.93
B	2.71	3.43	1.70	2.88	3.26	2.95
C	2.65	3.55	1.71	2.83	3.26	2.80
D	2.56	3.43	1.66	2.70	3.26	2.83
E	2.69	3.44	1.67	2.83	3.22	2.91

Land Use, total acres

Strategy	Scenario					
	1	2	3	4	5	6
A	1,567,715	2,906,960	347,652	1,848,951	3,104,843	1,575,218
B	1,461,037	2,871,302	225,045	1,731,928	3,519,204	1,324,489
C	2,228,600	3,643,472	740,476	2,245,489	3,737,513	2,051,786
D	1,620,909	2,901,646	354,117	1,841,186	3,413,527	1,561,250
E	1,542,815	3,034,887	407,199	1,782,708	3,482,967	1,493,413

D

Appendix D – Life Cycle Greenhouse Gas Emissions

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Appendix D - Life Cycle Greenhouse Gas Emissions

D.1 National Renewable Energy Laboratory Partnership

TVA partnered with the National Renewable Energy Laboratory (NREL) to evaluate and inform the greenhouse gas life cycle analysis (GHG LCA) process. The model used for the 2025 IRP was developed in tandem with NREL's methods and guidance. Included below is a technical report provided by NREL which explains the scope of NREL's work with TVA for the GHG LCA and documents values used in TVA's LCA study.

Documentation of Support by the National Renewable Energy Laboratory

Garvin Heath, Chris Skangos, Noah Frey, Lauren Sittler, and Tapajyoti Ghosh

National Renewable Energy Laboratory

Technical Report
September 2024

NREL is a national laboratory of the U.S. Department of Energy
Office of Energy Efficiency & Renewable Energy
Operated by the Alliance for Sustainable Energy, LLC

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Garvin Heath, Christopher Skangos, Noah Frey, Lauren Sittler, and Tapajyoti Ghosh

National Renewable Energy Laboratory

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List of Acronyms

CCS	carbon capture and storage
CH_4	methane
CO_2	carbon dioxide
DOE	U.S. Department of Energy
GHG	greenhouse gas
H_2	hydrogen
IPCC	Intergovernmental Panel on Climate Change
IRP	Integrated Resource Plan
ISO	International Organization for Standardization
LA100	Los Angeles 100% Renewable Energy Study
LCA	life cycle assessment
LCI	life cycle inventory
LiAISON	Life-cycle Assessment Integration into Scalable Open-source Numerical models
N_2O	nitrous oxide
NREL	National Renewable Energy Laboratory
OSTI	Office of Scientific and Technical Information
premise	PRospective EvironMental Impact AsSEssment
SMR	small modular reactor
TVA	Tennessee Valley Authority

Table of Contents

List of Tables

1 Introduction

The National Renewable Energy Laboratory (NREL) was contracted by the Tennessee Valley Authority (TVA) to support TVA's independent estimation of life cycle GHG emissions associated with their portfolios evaluated in their 2025 Integrated Resource Plan (IRP). TVA desires to follow an approach developed and used by NREL for more than a decade, most recently in the Los Angeles 100% Renewable Energy Study (LA100) (Cochran and Denholm 2021; Nicholson et al. 2021).[1] NREL's approach quantifies all greenhouse gas (GHG) emissions attributable to a choice in electricity generation technology, which is well suited to the goal of an IRP in supporting decisions regarding which resources to use for electrical capacity and generation. This appendix describes the motivation for using NREL's approach, which differs from traditional GHG emissions accounting; the scope of NREL's support of TVA; the verification of TVA's replication of NREL's approach; the methods developed specifically for the TVA IRP that differ from those previously documented for LA100; and NREL's independent validation of results achieved by TVA for select IRP cases.

1.1 Why Estimate Life Cycle GHG Emissions?

Estimating carbon dioxide (CO_2) emissions from combustion based on the product of generation per technology category and/or unit and a CO_2 emissions factor (EF) for that category/unit (i.e., g CO_2/kWh) is the traditional approach to accounting for GHG emissions in the power sector; however, such an estimation scheme does not consider several other components of GHG emissions attributable to electricity generation. In the traditional approach:

- Only emissions from the combustion of fossil fuel energy are counted, whereas emissions from upstream fossil fuel extraction and processing are disregarded.
- Only CO_2 emissions are considered, whereas other GHG emissions (e.g., methane [CH_4], nitrous oxide [N_2O]) are ignored. This omission might be particularly important for CH_4 released in coal mining, oil production, and natural gas production and transport, as well as any emissions of non-CO_2 GHG emissions released through combustion processes.
- A focus on combustion-only emissions does not consider the implications of GHG emissions from equipment manufacturing and construction, operations and maintenance activities, and plant decommissioning, which can be usefully categorized into four life cycle stages:
    - Plant construction (called "upstream" in life cycle assessment [LCA] literature)
    - Plant operating emissions, which are further disaggregated into:
        - Emissions associated with fuel combustion for electricity generation
        - All other emissions during plant operation, e.g., maintenance activities, including those associated with obtaining the fuel (called the "fuel cycle")
    - Plant decommissioning (or "downstream").

[1] For the full report, see https://maps.nrel.gov/la100/#home-1. For the chapter on GHG emissions, see https://www.nrel.gov/docs/fy21osti/79444-8.pdf.

As a result, although most renewable electricity technologies have no or limited operational GHG emissions (with the exception of biopower[2]), a more comprehensive evaluation of the impact of capacity expansion scenarios requires evaluating GHG emissions across the full life cycle of each technology by intentionally employing accepted procedures from the field of LCA (e.g., International Organization for Standardization [ISO] 14040). NREL's LCA-based approach is tailored to enabling fair comparisons of GHG emissions attributable to choices being made today among various combinations of electricity generation technologies that will be used decades into the future.

1.2 NREL's Expertise in This Area

To support the assessment of non-combustion emissions, for more than a decade, NREL conducted a comprehensive and systematic review of the LCA literature to create a database of GHG emissions factors disaggregated by the four life cycle stages noted on page 1. These estimates were compiled under NREL's seminal LCA Harmonization project (NREL 2024).[3] The results of the LCA Harmonization study were first featured in the Intergovernmental Panel on Climate Change (IPCC) *Special Report of the Intergovernmental Panel on Climate Change* (Sathaye et al. 2012) and in a special issue of the *Journal of Industrial Ecology* on the meta-analysis of LCAs that centered on the results of this study.[4] Note that the LCA Harmonization study did not focus only on renewable technologies; seminal reviews of fossil fuel-based generation technologies (Whitaker et al. 2012; Heath et al. 2014) as well as nuclear technologies (Warner and Heath 2012) have also been completed.

Results from the IPCC special report and the *Journal of Industrial Ecology* special issue articles (e.g., Whitaker et al. 2012; Warner and Heath 2012) were then used to analyze capacity expansion scenarios in a series of flagship reports for the U.S. Department of Energy (DOE), starting with the *Renewable Electricity Futures Study* (NREL 2012) and later including updates for most renewable technologies, such as the Wind Vision (DOE 2015a; 2015b), Hydropower Vision (DOE 2016a; 2016b), and GeoVision (DOE 2019a; 2019b). As mentioned, LA100 (Nicholson et al. 2021) was the most recent application of the results of the LCA Harmonization study, which added two storage technologies (lithium-ion batteries and hydrogen fuel cells).

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[2] The combustion of biomass emits CO_2 and other GHGs; however, because the carbon emitted during combustion is absorbed during photosynthesis in feedstock production, these emissions cancel when summed over the life cycle. The impacts of combustion-only CO_2 emissions reported in this chapter assume no net emissions from biopower facilities, consistent with a recent U.S. Environmental Protection Agency policy decision on the programmatic treatment of biomass and the forest products industry (Pruitt 2018), which treats biogenic CO_2 emissions resulting from the combustion of biomass from managed forests at stationary sources for energy production as carbon neutral. Nevertheless, there are non-cancelling GHG emissions from biopower systems outside of the biomass production and combustion processes associated with component manufacturing and construction, operations and maintenance, and, often, feedstock production. All these GHG emissions were accounted for here in the life cycle estimates; however, unaccounted for altogether in NREL's prior LCA Harmonization studies are potential GHG emissions associated with changes in land use directly or indirectly induced by the cultivation of a biomass feedstock.

[3] See https://www.nrel.gov/analysis/life-cycle-assessment.html.

[4] See https://onlinelibrary.wiley.com/toc/15309290/2012/16/s1

1.3 Approach

The approach to estimating changes in attributable GHG emissions from the future utilization of electricity generation technologies combines three key outputs of a capacity expansion model (fuel combustion CO_2 emissions, electricity generation, and capacity additions/decommissions) with literature-based estimates of life cycle GHG emissions for TVA assets. The collected literature went through several rounds of strict screening to be considered in the analytical phases of the LCA Harmonization project. NREL's most recent application of this systematic literature review approach supports TVA's IRP and is described in Sections 3.3 and 3.4 of this paper. (Additional information about the screening process for the LCA Harmonization project is detailed in the *Renewable Electricity Futures Study*, Appendix C [NREL 2012].) Of approximately 3,000 references screened throughout the history of the LCA Harmonization project, about 300 have been used as the basis to compute life cycle GHG emissions factors.

The references passing the LCA Harmonization project's systematic review were then further analyzed to develop GHG emissions factors for each life cycle phase. Following are descriptions of the definitions of each phase and our analytical approaches:

- *One-time upstream emissions* include emissions resulting from raw materials extraction, materials manufacturing, component manufacturing, transportation from the manufacturing facility to the construction site, and on-site construction. These emissions occur once during the lifetime of a generation unit. Emissions factors used in the analysis of this life cycle stage are median estimates taken from the results of the LCA Harmonization project.
- *Ongoing non-combustion operational emissions* occur during the operating phase and include fuel cycle emissions (where applicable) and emissions resulting from non-combustion-related operations and maintenance activities. These emissions occur each year the plant operates. Emissions factors used in the analysis of this life cycle stage are median estimates taken from the results of the LCA Harmonization project.
- *Ongoing combustion emissions* result from combustion at the power plant (where applicable) for the purpose of electricity generation. These emissions occur each year the plant operates. TVA's capacity expansion model directly calculates CO_2 emissions from combustion. In this work, emissions of non-CO_2 GHG emissions from combustion are also considered (differing from prior, analogous NREL research like LA100).
- *One-time downstream emissions* include emissions resulting from facility decommissioning, disassembly, transportation to the waste site, and the ultimate disposal and/or recycling of the generation assets and other site materials. These emissions occur once during the lifetime of a generation unit. Emissions factors used in the analysis of this life cycle stage are median estimates taken from the results of the LCA Harmonization project.

One-time emissions (upstream and downstream) are related to the embodied emissions of a generation unit, which are largely determined by the unit's size (capacity). Capacity additions and subtractions of all technologies are tracked by TVA's capacity expansion model. Multiplying literature-estimated, technology-specific, one-time upstream (downstream) GHG emissions normalized per kilowatt of installed (retired) capacity by the capacity changes reported by TVA's capacity expansion model yields an estimate of GHG emissions associated with the addition (retirement) of that technology's capacity.

Ongoing, non-combustion GHG emissions factors are assigned by technology type. Estimates of GHG emissions associated with the fuel cycle and other ongoing, non-combustion-related activities are derived by multiplying literature-estimated, ongoing, non-combustion-related GHG emissions normalized per kilowatt-hour by the TVA model-estimated generation.

Summing GHG emissions over all years, life cycle phases, technologies, and generators yield estimates of cumulative life cycle GHG emissions for each TVA IRP case.

1.4 NREL's Tasks Performed to Support TVA's IRP

TVA's results reported in the main body of this report are considered the IRP's results, not those reported in this appendix. NREL was contracted to help TVA ensure that their methods and their model is consistent with that of NREL's, as outlined in Section 1.3. This appendix summarizes NREL's limited role in supporting TVA's estimates of life cycle GHG emissions for the IRP cases.

NREL was contracted to support TVA's independent estimation of life cycle GHG emissions in the following ways:

1. Verify that TVA's life cycle GHG estimation model follows the approach developed by NREL, including verification that:
    - A. All emissions factors for the three non-combustion life cycle phases are the same as those developed by NREL.
    - B. The structure of the mathematical approach to estimating life cycle GHG emissions is consistent with that developed by NREL.
2. Add four additional capabilities to NREL's life cycle GHG emissions modeling approach in support of TVA's IRP. These capabilities have been added to both the NREL and TVA life cycle GHG emissions models to:
    - A. Disaggregate the CO_2-equivalent GHG emissions calculated using NREL's life cycle emissions factors into individual mass emissions estimates for each of the three major GHGs (CO_2, CH_4 and N_2O). This was done to support the economic valuation of the emissions of each GHG.
    - B. Account for hydrogen generated through electrolysis powered solely by renewable energy (aka green hydrogen) for its use in combined cycle plants blended with natural gas.
    - C. Add a new technology featured in TVA's IRP—nuclear small modular reactors (SMRs). The review of all extant SMR literature was not completed in time for use in the draft IRP; a placeholder estimate is used in the draft IRP. The literature review will be completed for the final IRP.
    - D. Update the review of published life cycle GHG emissions estimates for a technology potentially important within the context of TVA's IRP: natural gas with carbon capture and storage (CCS).
3. Validate the estimates of life cycle GHG emissions from TVA's model by independently estimating life cycle GHG emissions using NREL's model. This was done for two

selected cases chosen to represent the range of technology options within the overall IRP framework.

The remainder of this appendix follows NREL's scope as outlined here.

2 Verification of TVA Model

2.1 Syncing the Models

NREL verified the outputs of TVA's LCA model by matching and entering TVA's capacity expansion model inputs into NREL's model for each technology type and for each life cycle phase—construction, operation, and decommissioning. TVA's capacity expansion model expresses the capacity that was built, operating, and retired per year from 2024–2050. It covers the following technologies:

- Coal supercritical: higher-efficiency coal power plant
- Coal subcritical: traditional coal power plant
- Combined cycle: natural gas-fueled power plant
- Combined cycle with CCS: natural gas-fueled power plant with low carbon emissions
- Hydrogen combined cycle: power plant burning a blend of natural gas and hydrogen
- Combustion turbine: natural gas-fueled power plant to quickly meet peak demand
- Diesel: diesel engine power plant
- Hydro: utility-scale hydroelectric dam
- Nuclear: conventional utility-scale nuclear power plant
- Nuclear SMR: SMR technology, smaller capacity than conventional utility-scale nuclear
- Pumped hydro: hydroelectric energy storage technology
- Solar: utility-scale solar power plant
- Wind: utility-scale wind power plant
- Landfill gas: biogas used from landfill off-gas
- Biomass: biomass waste combusted to generate electricity
- Battery: utility-scale battery energy storage technology
- Market: purchased electricity to meet demand

NREL converted the upstream (installations) and downstream (decommissioning) life cycle emissions for each technology from megawatts to grams of GHG emissions, which were summed for installations and decommissioned capacity per technology within a given year. The emissions from installations were placed in the year before a facility was commissioned, whereas the emissions for decommissioning were assigned to the year following the plant's final year of operation. Combustion and non-combustion emissions during each plant's operating years were tabulated using the TVA-generated CO_2 emissions and the monthly generation per technology per year, respectively.

NREL calculated the emissions of each plant per phase (upstream, downstream, and non-combustion) using the emissions factors shown in Table 1. Combustion emissions are output directly from the capacity expansion model and are appropriately added for each year per technology. NREL converted each phase's emissions into its CO_2 equivalent.

Table 1. Emissions Factors for Each Phase and Technology

Data from Nicholson et al. (2021) with updates for NGCC-CCS, Hydrogen, and SMR

Electric Power Technology	One-Time Upstream GHG (CO_2 equivalent), g/kW	Ongoing Annual Non-Combustion GHG (CO_2 equivalent), g/kW-hr		One-Time Downstream GHG (CO_2 equivalent), g/kW
Coal supercritical	867,240	10		67,100
Coal subcritical	708,246	4.9		67,100
Natural Gas combined cycle	100,000	62		4,070
Natural Gas combined cycle with CCS	1,352,700	107		4,090
Natural Gas combustion turbine	64,790	70		2,600
Hydrogen combined cycle	100,000	Fuel Cycle: 28.5[a]	O&M: 0.4	4,070
NG/H_2 fuel blend combined cycle	100,000	Fuel Cycle: $28.5(X_{H2})^a + 92(X_{NG})^b$	O&M: 0.4	4,070
Diesel	1,021	97		18
Hydro	1,100	1.9		0
Nuclear	483,552	12		175,000
Nuclear SMR[c]	460,000	7.8		180,000
Pumped hydro	310	1.8		7
Solar	1,630,000	9.4		37,800
Wind	619,000	0.74		14,000
Landfill gas	64,790	38		2,600
Biomass	1,960	6		35
Battery	527,000	0		98,900
Market	NA	62		NA

[a] Pipeline hydrogen leakage is assumed to be 1.59% by energy content and calculated separately

[b]. Where "X" is the percentage of mmBtus supplied

[c] Updated nuclear SMR emission factors were not available in time for the calculation of life cycle GHG emissions in the Draft IRP and NREL's subsequent verification; as such, conventional nuclear numbers were assumed.

2.2 Verification of Results

NREL successfully aligned TVA's model inputs for emissions factors across all included technologies and LCA phases with NREL's methods, which are exemplified in the LA100 study (Nicholson et al. 2021). Further, TVA's methods and calculations (formulas) were verified to align with NREL's; thus, the TVA model was verified.

3 Additional NREL Model Capabilities

To align with the technologies being considered within TVA's IRP, NREL's LCA model had to be expanded in several ways. To support the use of social cost calculations, we required mass emissions of each GHG. Previously, NREL's LCA model reported results only as CO_2-equivalents, so a method was developed to disaggregate to the constituent GHGs (CO_2, CH_4, N_2O).

In another model expansion, we added technologies not previously considered by NREL's LCA model. First, NREL added accounting for the production of hydrogen used for combustion. Second, NREL added nuclear SMR technology. Third, NREL updated the life cycle GHG emissions estimates for natural gas combined cycle with CCS.

3.1 GHG Disaggregation Method and Results for Each Technology

To support the analysis of social costs stemming from the emissions of individual GHGs, it was necessary to disaggregate the LCA Harmonization study's CO_2-equivalent emissions factors (in gram CO_2e per kWh or per kW, depending on the phase) into the three primary constituent pollutants: CO_2, CH_4, and N_2O. NREL disregarded other pollutants that negligibly contributed to GHG emissions.

It would require too much effort in the context of the TVA IRP to go back to the original studies underlying the median estimates of the per-phase life cycle GHG emissions and extract their per-GHG emissions factors; therefore, we developed an alternative method. The premise of this alternative approach was to use a single, reputable source of life cycle inventory (LCI) data for electricity generation technologies to estimate the proportional contribution (to CO_2e) of each of the three main GHGs and then apply the proportion to the LCA Harmonization study median per-phase GHG emissions factors to obtain the per-GHG emissions factors. A single data source was desired so that the underlying LCA methods were common for all technologies. NREL sought proportional contributions because even if one LCA might differ in its estimate of magnitude of life cycle GHG emissions, the proportional contribution of each GHG is likely to be more stable.

Experts in LCA at NREL examined potential data sources offering detailed GHG emissions factors for each of the four phases of electricity generation technologies. NREL prioritized sources that could provide such detailed breakdowns with a high level of confidence. Our ideal solution was to identify a single source of LCI data; in the end, a few exceptions were made, described in the following. Given its extensive technological detail and coverage of a wide range of technologies, Ecoinvent 3.8 (Wernet et al. 2016) was chosen as the foundational dataset for the analysis.

NREL expanded the Ecoinvent dataset using premise (PRospective EvironMental Impact AsSEssment) (Sacchi et al. 2022), an open-source tool for prospective LCA, supplementing the original database with LCI data for several new power generation technologies. Due to its significance and the absence of data in Ecoinvent, LCI information for nuclear power plant decommissioning was sourced from the literature (Gibon & Menacho, 2023). The updated database was exported using the code-based LCA framework Life-cycle Assessment Integration into Scalable Open-source Numerical models (LiAISON) (Ghosh & Lamers, 2023) and imported into Activity Browser (Steubing et al. 2020), a graphical user interface employing Brightway2 (Mutel, 2017) for conducting emissions analysis. The sequential steps for disaggregating GHG emissions factors are outlined as follows.

First, for each power generation technology, the LCI dataset was separated into four phases: construction, non-combustion operations, combustion processes (where applicable), and the end of life of the power plant. Second, an LCA was performed for each phase with a functional unit of 1 kWh of generated electricity. (Note that the estimate of the proportion of CO_2e emissions contributed by each emitted GHG is not dependent on the choice of functional unit—kWh or kW—because the parameters required to convert between the two [i.e., capacity, capacity factor, and lifetime] themselves do not depend on emissions ratios of different GHGs). Using the emissions inventory explorer, we obtained the total CO_2, CH_4, and N_2O emissions quantities. Using global warming potentials for these emissions, the ratio for emissions factor disaggregation was obtained as follows:

$$R_i = \frac{Q_i . W_i}{\sum_j Q_j . W_j}$$

where R_i is the disaggregation ratio for the i^{th} emission, Q_i is the quantity of the i^{th} emission, W_i is the midpoint indicator weight (global warming potential) for the GHG footprint for the i^{th} emissions, and i and j belong to the set of three pollutants: CO_2, CH_4, and N_2O. Once these ratios were obtained, the aggregated GHG emissions factor (E) from the LCA Harmonization study was multiplied by the R_i value to estimate the disaggregated emissions factor (E_i) for the respective pollutants.

$$E_i = E . R_i$$

Table 2 lists the estimated proportions for each of the three considered GHGs for each technology and phase.

Data were not available to disaggregate GHGs for each of the TVA-analyzed technologies; therefore, assumptions were made to fill in missing values using those for other technologies that were deemed close proxies, as noted in the table.

Table 2. Disaggregation Percentages for Emissions Factors by Technology

	One-Time Upstream			Combustion			Non-Combustion			One-Time Downstream[a]		
Electric Power Technology	CO_2	CH_4	N_2O	CO_2	CH_4	N_2O	CO_2	CH_4	N_2O	CO_2	CH_4	N_2O
Coal supercritical	94%	6%	1%	100%	0%	0%	51%	47%	2%	97%	2%	1%
Coal subcritical	92%	7%	1%	99%	0%	1%	54%	45%	2%	97%	2%	1%
Combustion turbine	93%	6%	1%	99%	0%	1%	51%	49%	1%	97%	2%	1%
Combined cycle	94%	5%	1%	99%	0%	1%	51%	49%	1%	97%	2%	1%
Combined cycle with CCS	97%	2%	1%	95%	0%	5%	56%	44%	0%	97%	2%	1%
Solar	89%	10%	1%	0%	0%	0%	90%	5%	5%	97%	2%	1%
Hydro	95%	4%	1%	0%	0%	0%	95%	4%	1%	97%	2%	1%
Pumped hydro	95%	5%	1%	0%	0%	0%	95%	5%	1%	97%	2%	1%
Battery	91%	8%	1%	0%	0%	0%	0%[g]	0%[g]	0%[g]	97%	2%	1%
Wind	92%	7%	1%	0%	0%	0%	95%	4%	1%	97%	2%	1%
Nuclear	99%	0%	1%	0%	0%	0%	92%	6%	2%	95%[d]	4%[d]	1%[d]
Nuclear SMR	99%[b]	0%[b]	1%[b]	0%	0%	0%	92%	6%[b]	2%[b]	95%[b]	4%[b]	1%[b]
Biomass	92%	8%	0%	0%[e]	0%[e]	0%[e]	96%	3%	1%	98%	1%	1%
Landfill gas	92%	6%	1%	0%[e]	0%[e]	0%[e]	96%	4%	1%	97%	2%	1%
Hydrogen Combined cycle[h]	93%[c]	6%[c]	1%[c]	0%[f]	0%[f]	0%[f]	92%	7%	1%	97%	2%	1%

[a] The only technology with an Ecoinvent unit process for the downstream life cycle phase was "hard coal IGCC." Biomass and all other technologies are assumed to have the same proportional contribution by GHG as the coal IGCC, except for nuclear, which we obtained from a source as noted in table note d.

[b] Nuclear SMR is assumed to have the same proportional GHG emissions as "nuclear."

[c] A hydrogen combustion turbine is assumed to have the same proportional GHG emissions as a natural gas-fired "combustion turbine" for this life cycle phase.

[d] From Gibon and Menacho (2023)

[e] As per US EPA (Pruitt, 2018), the combustion of biomass is assumed to be net carbon neutral, i.e., the amount of carbon sequestered in the biomass is the same as that which is released to the atmosphere from combustion.

[f] Only NOx emissions are emitted in the combustion of H_2, which were not considered as a GHG in this analysis. NOx is defined as oxides of nitrogen, which includes nitrogen monoxide (NO) and nitrogen dioxide (NO_2). NO_2 should not be confused with N_2O, nitrous oxide, which is a GHG.

[g] There were no operation phase non-combustion emissions present in the Ecoinvent unit process.

[h] Due to the green hydrogen production assumptions, hydrogen co-fired combined cycle utilizes a total life cycle disaggregation percentage for both H_2 and NG ongoing non-combustion phase. Values used for the NG portion were 91%, 8%, and 1% for CO_2, CH_4, and N_2O, respectively.

The Ecoinvent unit processes assumed for each of the analyzed technologies reported in Table 2 are noted in Table 3. The cell entries are the exact names defined in Ecoinvent (Wernet et al. 2016).

Table 3. Ecoinvent Unit Process Correspondence

Technology	Upstream and Downstream	Combustion and Non-Combustion
Coal supercritical	Construction, hard coal IGCC power plant 450 MW[a]	Electricity production, hard coal, ultra-supercritical
Coal supercritical	Hard coal power plant construction, 500 MW	Electricity production, hard coal, subcritical
Combustion turbine	Market for gas power plant, 300 MW electrical	Electricity production, natural gas, conventional power plant
Combined cycle	Market for gas power plant, combined cycle, 400 MW electrical	Electricity production, natural gas, combined cycle power plant
Combined cycle with CCS	Market for gas power plant, combined cycle, 400 MW electrical + CCS construction	Electricity production, at natural gas-fired combined-cycle power plant, post, pipeline 200 km, storage 1,000 m
Solar	Market for photovoltaic plant, 570 kWp, multi-Si, on open ground	Electricity production, photovoltaic, 570 kWp, open ground installation, multi-Si
Hydro	Market for hydropower plant, reservoir	Electricity production, hydro, reservoir, alpine region
Pumped hydro	Market for hydropower plant, reservoir + 5 22-KW pumps	Electricity production, hydro, pumped storage
Battery	Market for battery, Li-ion, rechargeable, prismatic	Note: b
Wind	Market for wind turbine, 2 MW, land-based	Electricity production, wind, 1–3-MW turbine, land-based
Nuclear	Nuclear power plant construction, boiling water reactor 1,000 MW	Electricity production, nuclear, boiling water reactor
Nuclear SMR	Note: c	Note: c
Biomass	Market for heat and power co-generation unit, organic Rankine cycle, 1,000 kW electrical[d]	Heat and power co-generation, wood chips, 6,667 kW, state of the art
Landfill gas	Heat and power co-generation unit construction, 160 kW electrical, components for electricity only	Electricity production, at biomass-fired IGCC power plant
Hydrogen combustion turbine	Note: e	Heat and power co-generation, biogas, gas engine

[a] This is one of two technologies where the downstream Ecoinvent unit process differs from the upstream. In this case, the downstream unit process is "dismantling, hard coal IGCC power plant 450 MW."

[b] There were no operation phase non-combustion emissions present in the Ecoinvent unit process.

[c] Nuclear SMR is assumed to have the same proportional GHG emissions as "nuclear."

[d] The downstream unit process for biomass differed from the upstream, and it is "dismantling, BIGCC power plant 450 MW."

[e] A hydrogen combustion turbine is assumed to have the same proportional GHG emissions as a natural gas-fired "combustion turbine" for this life cycle phase.

3.2 Hydrogen Life Cycle Emission Factor Development

When hydrogen (H_2) is combusted, no greenhouse gas is emitted.[5] However, the production of H_2 always has some embodied GHG emissions. There are many pathways to produce hydrogen; in TVA's IRP, hydrogen usage is assumed to be only "green" H_2, i.e., hydrogen produced through electrolysis powered by 100% renewable energy sources. Thus, there are no GHGs directly emitted in the H_2 production process; yet there are GHGs emitted in the life cycle of the renewable technologies used to produce green H_2.

For H_2 that is combusted to generate electricity, NREL developed an emission factor for the ongoing, non-combustion phase of a combined cycle plant[6] based on the embodied GHG emissions proportional to the mix of renewable technologies that would be expected to produce the green H_2 purchased by TVA. This method also considers leakage of hydrogen once produced. NREL's approach also accounts for different ratios of blending H_2 with natural gas that evolve over time within certain IRP cases.

The below subsections describe the approach NREL developed to account for embodied H_2 emissions.

3.2.1 Proportional Contribution to Green H_2 Production from Renewable Technologies

Leveraging NREL's hydrogen production expertise and in consultation with TVA, NREL selected solar photovoltaic (PV), land-based wind, and short-duration batteries (e.g., 2-hour and 4-hour lithium-ion batteries) as candidate technologies that could be combined to produce green hydrogen within the TVA region.[7] NREL then used a robust least-cost optimization approach, based on cost and performance characteristics for each technology specific to the TVA region, to determine a typical mixture of these three technologies to produce green hydrogen at the scale of future TVA demand.

NREL's approach for estimating the typical generation mix of PV, wind and batteries relies on the Regional Energy Deployment Systems (ReEDS) model (Ho et al. 2020). The ReEDS capacity expansion model simulates the evolution of the U.S. electricity system at a regional scale through 2050. ReEDS is a linear optimization model that identifies the least-cost mix of resources that meet regional electricity demand and policy requirements across the contiguous United States. In each simulated future year, ReEDS co-optimizes the investment, retirement, and operation of all electricity generation, storage, and transmission technologies. To properly

[5] Combustion of H_2 does not emit the three main GHGs – CO_2, CH_4 and N_2O. Combustion of H_2 does emit NO_2, which is an indirect GHG, but this effect is not considered in NREL's LCAs.

[6] Note that at present, no IRP case utilizes hydrogen in combustion turbines. Thus, the discussion will focus explicitly only on combined cycle plants, though analogous methods and results are directly applicable to combustion turbine use of hydrogen.

[7] TVA assumes the green hydrogen will be produced using a similar mixture of renewable resources that are available within its region, coupled with battery storage.

bound the ReEDS model for this analysis on green hydrogen production, several decisions were made:

- Hydrogen production strictly originated from the technologies that were pre-defined as investment options (PV, land-based wind, and short-duration batteries),
- Hydrogen was produced via proton exchange membrane (PEM) water electrolysis,
- All hydrogen produced is behind-the-meter (i.e., not grid connected), and
- Hydrogen was not transported outside of the demand area where it was produced.

TVA forecasted hydrogen demand profiles from 2025-2050 were integrated along with TVA's utility boundaries to calculate the optimal, least-cost mix of electricity supply for hydrogen production via electrolysis. Based on 30 ReEDS simulations, NREL found a representative proportional generation mix of 45% PV, 45% wind, and 10% lithium-ion battery. For reference, the levelized cost of hydrogen (LCOH) leading up to the 2032 target of 30% hydrogen blending (see section 3.3.4 below), LCOH values within the TVA region range from \$4.10 per kg to \$7.60 per kg. When accounting for the 45V incentive, this value would be reduced to \$1.10 to \$4.60 per kg in 2032. The large variation reflects regional differences in the cost of hydrogen production, primarily due to differences in the wind and solar resource, including the strength (capacity factor) and timing (hourly generation profile) of electricity production.

3.2.2 Green H_2 Ongoing, Non-combustion Emissions

The ongoing, non-combustion phase for green hydrogen is composed of three components:

1. Green H_2 fuel cycle (production of the fuel by renewables)
2. Operation and maintenance of the plants burning the green H_2
3. Leakage of H_2 once produced and prior to combustion

The estimation of emission factors for each of these components is presented below.

3.2.2.1 Green H_2 Fuel Cycle Emission Factor

To build in flexibility to the LCA model's capability to accommodate differing generation ratios of PV, wind and lithium-ion batteries, a generic formula was developed for the green H_2 fuel cycle emission factor:

$$\begin{aligned} &H2\ Fuel\ Cycle\ Emission\ Factor \\ &\quad = (Total\ Life\ Cycle\ PV\ EF * PV\ Generation\ \%) \\ &\quad + (Total\ Life\ Cycle\ Wind\ EF * Wind\ Generation\ \%) \\ &\quad + (Total\ Life\ Cycle\ Li\_ion\ Battery\ EF * Li\_ion\ Battery\ Generation\ \%) \end{aligned}$$

In this formula, the total life cycle GHG emission factor of each of the three renewable resources is used instead of per phase emission factors. This is a simplifying assumption, justified for two reasons. First, NREL assumes that an analyst would not know when a PV, wind or battery resource used to produce the green H_2 sold on an open market was constructed or decommissioned. Second, because the life cycle GHG emissions from renewables is small (relative to fossil sources), NREL asserts such differentiation is not influential to accurate accounting of life cycle GHG emissions of the TVA system under IRP cases.

The renewable technology production mix determined applicable for the TVA region was used to quantify embodied emissions from the hydrogen fuel cycle: per above, 45%, 45%, and 10% of solar PV, wind, and lithium-ion batteries, respectively. These percentages were then applied against the total life cycle emission factor values, of 43 g CO_2e/kWh, 13 g CO_2e/kWh, and 33 g CO_2e/kWh, respectively, which were developed in the LCA Harmonization study and most recently documented in the LA100 study (Nicholson et al. 2021). The TVA region-specific mixture of PV, wind and batteries yields a weighted average emission factor of 28.5 g CO_2e/kWh.

3.2.2.2 H_2 Operation and Maintenance Emission Factor

The ongoing non-combustion emission factor for hydrogen combustion requires quantification of GHG emissions associated with plant operation and maintenance (O&M). For this analysis, NREL made the simplifying assumption that O&M for a hydrogen-fueled CC plant would be approximately the same as for a similar plant burning natural gas as their fuel, and that likewise, a plant burning blended H_2 and natural gas would also be approximately the same.[8] These assumptions are adopted also because there is no published LCA that has reported a detailed analysis of O&M for plants using similar combustion technology on different fuels.

Most natural gas LCAs don't separately report O&M GHG emissions; it is usually reported grouped with other activities. NREL identified one study – Cutshaw et.al (2023) – that separately reported O&M GHG emissions from a combined cycle plant, estimating GHG emissions of 0.4 g CO_2e/kWh which is assumed applicable for both H_2 and natural gas-fired (and blended) CCs.

3.2.2.3 H_2 Leakage Rate

An emission concern for hydrogen fuel production and utilization is hydrogen leakage. Part of NREL's method for quantifying hydrogen fuel's ongoing, non-combustion emission factor involved estimating the hydrogen leakage rate during green H_2 production, pipeline transport, storage and local distribution. The state of knowledge of these emission rates is still evolving, without a strong empirical basis currently. Referencing best available literature (Cooper et al., 2022; Esquivel-Elizondo et al., 2023; Fan et al., 2022; Mills, 2022) NREL identified all that disaggregated H_2 leakage for different supply chain stages and assessed the range of estimated hydrogen leakage rates. Table 4 summarizes the central tendency for upper and lower bounds for hydrogen leakage rates found in current literature.

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[8] As an aside, note that NREL makes the same assumption for H_2 combusted in a Combustion Turbine.

Table 4. Range of Hydrogen Mass Leakage Rates along Supply Chain Stages Relevant for Combustion of Hydrogen for Electricity Generation

Supply Chain Stage	Upper Bound Leakage (Mass %)	Lower Bound Leakage (Mass %)	Source(s)
Green Hydrogen Production	4%	2%	Fan et al., 2022
Pipeline Transport & Storage	2%	1%	Fan et al., 2022; Cooper et al., 2022
Local Distribution	0.44%	0.17%	Fan et al., 2022; Cooper et al., 2022

To develop a best (point) estimate for H_2 leakage applicable to TVA's IRP cases, NREL reviewed TVA's assumptions regarding H_2 production. TVA's set of *Net-zero Regulation* and *Net-zero Regulation Plus Growth* IRP cases adopt the Department of Energy's H_2 Earthshot (*Hydrogen Shot*) goals and milestones to determine hydrogen pricing. DOE assumes that strict policies and regulations have been enacted to support hydrogen fuel's integration into the energy sector. NREL extended the pricing assumptions regarding policies and regulations to leakage regulation and mitigation strategies to develop a point estimate of hydrogen leakage from each of the above supply chain stages. Below in Table 5 are the values used to calculate a total life cycle leakage rate for the production of green hydrogen within TVA's *Net-Zero Regulation* and *Net-Zero Regulations Plus Growth* cases.

Table 5. Point Estimate Hydrogen Mass Leakage Rates along TVA IRP-Relevant Supply Chain Stages

Supply Chain Stage	Hydrogen Leakage (Mass %)
Green Hydrogen Production	3%
Pipeline Transport & Storage	1.5%
Local Distribution	0.26%
Total:	4.76%

Note that the leakage percentage is on a mass basis; conversion to energy content or volume basis can be accomplished using the following constants (Table 6):

Table 6. Hydrogen Properties

Property	**Value**	**Source**
Energy Density of Hydrogen	120 MJ/kg	*Hydrogen Storage*. (n.d.).
Hydrogen Density	0.08376 kg/m^3	Lanz, 2001
Hydrogen Energy Density in MMBTU	0.1137 MMBTU/kg	

NREL then converted the selected leakage rate from a percent by mass, 4.76%, to a percent by energy. Using hydrogen's energy density in MMBTU of 0.1137 MMBTU/kg, the converted leakage contribution was found to equal 0.571% by energy.

3.2.3 Final Emission Factors for H_2-Fueled Combined Cycle Plants

Prior to considering blends of H_2 and natural gas, life cycle emission factors for the three applicable life cycle phases must be developed (recalling that combustion of H_2 emits none of the three major GHGs) for Combined Cycle plants fueled solely by hydrogen: upstream, ongoing non-combustion, and downstream phases.

3.2.3.1 Upstream/Downstream

The onetime upstream and downstream emission factors for a H_2 Combined Cycle are assumed to be essentially equivalent to their natural gas counterparts, as reported in the LA100 study (Nicholson et al. 2021).[9] These values, in grams CO_2e/kW, are listed in Table 7.

Table 7. Upstream and Downstream Life Cycle GHG Emissions for Hydrogen-powered Combined Cycle Plants

Electric Power Technology	**One-Time Upstream GHG (CO_2 equivalent), g/kW**	**One-Time Downstream GHG (CO_2 equivalent), g/kW**
Hydrogen Combined Cycle	100,000	4,070

3.2.3.2 Ongoing Non-Combustion

For determining the ongoing non-combustion emission factor for hydrogen-fueled combined cycle plants, NREL developed the following equation to incorporate the three components of GHG emissions detailed in section 3.3.3.

[9] As an aside, note that NREL assumes the same equivalence is true for Combustion Turbines.

$$H_2\ Ongoing\ Non\text{-}Combustion\ EF\ (\frac{g\ CO2e}{kWh}) = (H_2\ Fuel\ Cycle\ EF + H_2\ O\&M\ EF) * (1 + H_2\ Leakage\ Rate)$$

First, the renewable technology production mix determined applicable for the TVA region was used to quantify embodied emissions from the hydrogen fuel cycle. Refer to section 3.2.2.1 for full description and calculation.

Next, the emissions contribution of hydrogen combustion plant O&M was assumed to be identical to that of O&M for natural gas fuel systems. Thus, the value from Cutshaw et.al (2023) of 0.4 g CO_2e/kWh was applied.

Third, for the hydrogen leakage rate, the determined average leakage rate percent across the total hydrogen life cycle for the given TVA scenarios was referenced: 4.76% by mass, and 1.58% by energy. Refer to section 3.2.2.3 for full description and derivation.

Using the equation above the total ongoing non-combustion hydrogen emission factor was found to be 29 g CO_2e/kWh.

3.2.4 H_2/NG Blended Fuel Cycle Emission Factors

TVA's Net-zero Regulation IRP cases have assumed a phased shift from natural gas to hydrogen-blended fuel for the combined cycle fleet, based on regulatory requirements. Given forecasted hydrogen demand in H_2-relevant IRP cases, and the determined volumetric fuel blend of H_2/NG per year from 2024-2050, NREL developed the below equation for the ongoing fuel cycle emission factor.

$$Blended\ Fuel\ Cycle\ EF = (H_2\ Fuel\ Cycle\ EF * H_2\ Blend\ \%) + (NG\ Fuel\ Cycle\ EF * NG\ Blend\ \%)$$

where:

$$1 = (H_2\ Blend\ \%) + (NG\ Blend\ \%)$$

First, the associated hydrogen fuel cycle value was determined by the weighted average of renewable energy technology generation associated with producing green hydrogen; 28.5 g CO_2e/kWh. For the natural gas fuel cycle emission factor, the latest LCA study reporting the natural gas fuel cycle disaggregated from other components of ongoing, non-combustion -- Cutshaw et.al (2023) – was referenced to determine the value associated with natural gas extraction, processing, and transport for a combined cycle system with no carbon capture and sequestration: 92 g CO_2e/kWh.

Finally, the volumetric blending percentages for the H2/NG fuel cycle were determined by TVA's scenario assumptions. The blending percentage profile from 2024-2050 can be seen in Table 8.

Table 8. TVA IRP H_2 Blending Assumptions, 2024-2050

Year	Volumetric Percent NG In blend	Volumetric Percent H_2 in Blend
2024	100%	0%
2025	100%	0%
2026	100%	0%
2027	100%	0%
2028	100%	0%
2029	100%	0%
2030	100%	0%
2031	100%	0%
2032	70%	30%
2033	70%	30%
2034	70%	30%
2035	70%	30%
2036	70%	30%
2037	70%	30%
2038	4%	96%
2039	4%	96%
2040	4%	96%
2041	4%	96%
2042	4%	96%
2043	4%	96%
2044	4%	96%
2045	4%	96%
2046	4%	96%
2047	4%	96%
2048	4%	96%
2049	4%	96%
2050	4%	96%

3.3 SMR Life Cycle GHG Emissions

The approach to adding a new technology to NREL's LCA model follows that first developed in the LCA Harmonization study (NREL 2024). The methods are summarized here; they have been described in prior publications, such as those previously noted (Brandao, Heath, and Cooper 2012; Warner and Heath 2012), which focused on a systematic review of conventional nuclear LCAs and were thus a model for this review of SMR LCAs.

Since the first LCA Harmonization studies, methods for conducting systematic literature reviews have become further developed and codified in global guidance (The Cochrane Collaboration 2022; Page et al. 2021). The present analysis improved methods for systematic reviews using these and another more recent study (Heath et al. 2022). The goal of a systematic review is to identify all published sources within the scope of the study, which here is SMR. This requires identifying and then screening the literature from bibliographic databases to ensure that only those relevant to the study scope are retained.

3.3.1 Literature Identification

To identify potentially relevant literature, we established keywords in synonym clusters, centering on (1) LCA and (2) SMR. The number of publications identified from these keywords defines the "universe" of publications then subjected to screening.

Prospective literature was obtained by searching Scopus, an abstract and citation database. For the final IRP, NREL will also search a database of DOE-funded literature, including reports from DOE national laboratories.

NREL performed several iterations of searches using the following terms as potential indicators that the paper contained a lifecycle assessment:

> lifecycle, life cycle, life-cycle, lifecycle assessment(s), lifecycle analysis/analyses, life-cycle assessment(s), lifecycle analysis/analyses, life cycle assessment(s), life cycle analysis/analyses, footprint analysis, carbon footprint, carbon foot print, carbon footprinting, carbon accounting, carbon emissions, cradle W/3 cradle, cradle W/3 grave, environmental impact, environmental impacts, total cycle, fuel cycle, externalities, embodied carbon, embedded carbon.

The following terms were used as potential synonyms, acronyms, and trade names of *small modular reactor*:

> small modular reactor, small modular reactors, smr, smrs, small modular W/5 reactor, small W/5 modular reactor, mpower, voyger, smr-300, klt-40s, ap1000, smmsr, hwmsr, abv-6m, ritm-200, sm-tmsr, sm-msr, advanced nuclear, small W/5 reactor, small W/5 reactors, mPower, voyger, SMR-300, KLT-40S, AP-1000, SMMSR, HWMSR, ABV-6M, RITM-200, SM-TMSR, SM-MSR.

These keywords were combined into a complex query string to collect literature from the Scopus publication database:

> TITLE ((lifecycle) OR (life AND cycle) OR (life-cycle) OR (lifecycle AND assessment) OR (lifecycle AND assessments) OR (lifecycle AND analysis) OR (lifecycle AND analyses) OR (life-cycle AND assessment) OR (life-cycle AND assessments) OR (lifecycle AND analysis) OR (lifecycle AND analyses) OR (life AND cycle AND assessment) OR (life AND cycle AND assessments) OR (life AND cycle AND analysis) OR (life AND cycle AND analyses) OR (footprint AND analysis) OR (carbon AND footprint) OR (carbon AND foot AND print) OR (carbon AND footprinting) OR (carbon AND accounting) OR (carbon AND emissions) OR (cradle W/3 cradle) OR (cradle W/3 grave) OR (environmental AND impact) OR (environmental AND impacts) OR (total AND cycle) OR (fuel AND cycle) OR (externalities) OR (embodied AND carbon) OR (embedded AND carbon)) AND TITLE ((small AND modular AND reactor) OR (small AND modular AND reactors) OR (smr) OR (smrs)

> OR (small AND modular W/5 reactor) OR (small W/5 modular AND reactor) OR (mpower) OR (voyger) OR (smr-300) OR (klt-40s) OR (ap1000) OR (smmsr) OR (hwmsr) OR (abv-6m) OR (ritm-200) OR (sm-tmsr) OR (sm-msr) OR (advanced AND nuclear) OR (small W/5 reactor) OR (small W/5 reactors))

A total of 90 publications were identified using this query, which defines the universe subjected to screening.

3.3.2 Literature Screening

Following the successive screening approach of Warner and Heath (2012), a series of quantitative and qualitative objective screens were established. The process was iterative to ensure accuracy and completeness. The philosophy of the series of screens is to move from easier and faster identification of failing characteristics to ones that are more complex and take longer to judge.

The identified SMR LCAs were processed through three screening stages to establish quality, relevance, transparency, and recency. The criteria used in each screening step are outlined here.

Screen 1

The first screen was performed using bibliographic data contained in Scopus via the Scopus interface. It was used to filter literature that:

- Was shorter than five pages
- Was written in a language other than English
- Was published prior to 1980
- Was an abstract, poster, or PowerPoint presentation.

Screen 2

In the second screen, a preliminary review of the full texts was conducted to filter literature that:

- Was not an LCA (i.e., considered all life cycle phases and reported results normalized to a functional unit, per kWh)
- Did not evaluate SMR(s).

Screen 3

The third screen employed several groups of screening criteria to identify literature that met requirements for quality, transparency, and relevance.

Quality Criteria

- Used a currently accepted LCA protocol as defined by ISO 14040:1997, ISO 14044:2006, and ISO 14067:2018 (ISO 1997; ISO 2006; ISO 2018). Literature that used the average economic intensity method (a highly aggregated form of the economic input-output LCA method) were excluded, per Warner and Heath (2012).
- Reported emissions from all three life cycle phases: upstream, operations, and downstream
- At a minimum, reported CO_2 emissions. Could also include emissions of other GHGs.

Transparency Criteria

- Documented all assumptions and methods, and described the system boundaries for each stage
- Cited data sources
- Named the LCA model used to calculate emissions (e.g., SimaPro, GaBi)
- Represented original work (not only a citation of a prior published LCA)
- Reported results numerically, in units that can be converted to g CO_2-eq/kW for upstream and downstream stages and to g CO_2-eq/kWh for the operational stage.

Relevance

- Evaluated SMRs for electricity production
- Electricity was a reported product (even if it was later converted into another product, such as hydrogen).

Of the 90 publications that formed the universe of publications identified in the Scopus database, only one paper met all criteria from the three screening stages: Carless et al. (2016). Most of the literature was eliminated during Screen 2 because it was either not an LCA or did not evaluate SMR technology. Many papers that did evaluate SMRs were on the topic of SMR performance. One paper, Godsey (2019), eliminated in Screen 3, was an LCA for SMR technology, but it did not report results numerically, only graphically as percentages in a chart in which the results could not be accurately estimated.

3.3.3 Life Cycle GHG Emissions per Phase for SMR

Table 9 summarizes the findings for GHG emissions for each life cycle stage from the publication that passed all literature screens: Carless et al. (2016).

Table 9. Findings for GHG Emissions for Each Life Cycle Stage from Carless et al. (2016)

Author (Year)	Upstream (g CO_2-eq/kW)	Operational (g CO_2 eq/kWh)	Downstream (g CO_2-eq/kW)
Carless et al. (2016)	460,000	7.8	180,000

Upstream and downstream emissions were originally reported in units of g CO_2-eq/kWh. They were translated into units of g CO_2-eq/kW by multiplying by the total operational hours of the reactor (reported in Carless et al. [2016]).

In support of the final IRP, NREL will complete a literature search of the Office of Scientific and Technical Information (OSTI) database of DOE-funded literature, including reports from DOE national laboratories. Any potential publications identified through a search using the same keywords detailed here (adjusted for OSTI syntax) will be subjected to the same screening process reported here.

3.4 NGCC-CCS Life Cycle GHG Emissions

NREL performed a literature review of LCAs focused on natural gas combined cycle with carbon capture and storage (NGCC-CCS) systems with the goal of developing updated GHG emissions factors for each life cycle phase. The literature review was completed in two steps:

first, NREL searched bibliographic databases and performed snowball sampling (defined below) to identify relevant publications; second, NREL screened the identified publications to eliminate nonapplicable studies. These steps were performed in accordance with global guidance on conducting and reporting systematic literature reviews (Page et al., 2021).

This literature review built on the foundation provided by O'Donoughue et al. (2014), who performed a systematic review and harmonization of the natural gas electricity generation LCA literature published between 1980 and 2012. Their work identified twelve results (from nine publications) in which per phase GHG emissions were reported for NGCC-CCS systems. This work also built upon a more recent systematic literature review performed within the National Petroleum Council's (NPC) Charting the Course: Reducing GHG Emission from the U.S, Natural Gas Supply Chain study (NPC, 2024). The NPC's review searched for natural gas supply chain LCAs published 2016-2022, inclusive of those that used the natural gas for electricity generation with CCS. However, there were no usable results for NGCC-CCS systems identified within the NPC's review. Updating the results of both of the prior literature reviews added eight results (from four publications) to their tally.

3.4.1 Literature Identification

NREL generated a series of keywords related to LCAs focused on NGCC-CCS, starting from those used in O'Donoughue et al. (2014) but tailored to NGCC with CCS (Table 10). NREL grouped these keywords into four categories: emissions, LCA, natural gas, and power. Note that natural gas combustion turbines-associated keywords were included in our search criteria because some of those studies would also have investigated NGCC, however, all results relevant to NGCT were later screened out.

Table 10. Keywords used to identify published LCAs focused on NGCC-CCS

Emissions	LCA	Natural Gas	Power
Carbon footprint*	LCA*	Natural gas	Power
Carbon foot print*	Life cycle assessment*	Shale gas	Electric*
Greenhouse gas analys*	Life cycle analys*	Fossil gas	Carbon capture
Greenhouse gas emission*	Lifecycle assessment*	Natural gaz	Carbon dioxide capture
GHG analys*	Lifecycle analys*	Shale gaz	CO_2 capture
GHG emission*	Life-cycle assessment*	Fossil gaz	CCS
	Life-cycle analys*	NG	CCUS
	LCIA*	NGCC	
	Life cycle impact assessment*	NG-CC	
	Life cycle impact analys*	NGCT	
	Lifecycle impact assessment*	NG-CT	
	Lifecycle impact analys*	NGSC	
	Life-cycle impact assessment*	NG-SC	
	Life-cycle impact analys*	NGT	
		LNG	
		Methane	
		CH4	

	Peaker Plant*
	Peaker*

Notes: LCIA - Life Cycle Impact Assessment, NGCC – Natural Gas Combined Cycle, NGCT – Natural Gas Combustion Turbine, NGSC – Natural Gas Single Cycle, NGT – Natural Gas Turbine, LNG - Liquefied Natural Gas, CCUS - Carbon Capture, Utilization and Storage. An asterisk (*) acts as a truncation symbol, meaning that the search term will pick up alternate word endings. For example, the keyword “carbon footprint*” will pick up “carbon footprint,” “carbon footprints,” and “carbon footprinting.”

Using Boolean operators, NREL then generated two search strings to obtain our “universe” of studies (Table 11). The first string was formatted to search SCOPUS, a large abstract and citation database. The second search string was formatted to search the Office of Scientific and Technical Information (OSTI) database, the Department of Energy’s primary search tool.

Table 11. Search strings used to identify literature in the SCOPUS and OSTI databases

SCOPUS Search String	OSTI Search String
TITLE-ABS-KEY (("LCA*" OR "life cycle assessment*" OR "life cycle analys*" OR "lifecycle assessment*" OR "lifecycle analys*" OR "life-cycle assessment*" OR "life-cycle analys*" OR "LCIA*" OR "life cycle impact assessment*" OR "life cycle impact analys*" OR "lifecycle impact assessment*" OR "lifecycle impact analys*" OR "life-cycle impact assessment*" OR "life-cycle impact analys*") AND ("natural gas" OR "shale gas" OR "fossil gas" OR "natural gaz" OR "shale gaz" OR "fossil gaz" OR "NG" OR "NGCC" OR "NG-CC" OR "NGCT" OR "NG-CT" OR "NGSC" OR "NG-SC" OR "NGT" OR "LNG" OR "methane" OR "CH4" OR "peaker plant*" OR "peaker*") AND ("power" OR "electric*" OR "carbon capture" OR "carbon dioxide capture" OR "CO2 capture" OR "CCS" OR "CCUS") AND ("carbon footprint*" OR "carbon foot print*" OR "greenhouse gas analys*" OR "greenhouse gas emission*" OR "GHG analys*" OR "GHG emission*"))	("LCA*" OR "life cycle assessment*" OR "life cycle analys*" OR "lifecycle assessment*" OR "lifecycle analys*" OR "life-cycle assessment*" OR "life-cycle analys*" OR "LCIA*" OR "life cycle impact assessment*" OR "life cycle impact analys*" OR "lifecycle impact assessment*" OR "lifecycle impact analys*" OR "life-cycle impact assessment*" OR "life-cycle impact analys*") AND ("natural gas" OR "shale gas" OR "fossil gas" OR "natural gaz" OR "shale gaz" OR "fossil gaz" OR "NG" OR "NGCC" OR "NG-CC" OR "NGCT" OR "NG-CT" OR "NGSC" OR "NG-SC" OR "NGT" OR "LNG" OR "methane" OR "CH4" OR "peaker plant*" OR "peaker*") AND ("power" OR "electric*" OR "carbon capture" OR "carbon dioxide capture" OR "CO2 capture" OR "CCS" OR "CCUS") AND ("carbon footprint*" OR "carbon foot print*" OR "greenhouse gas analys*" OR "greenhouse gas emission*" OR "GHG analys*" OR "GHG emission*")

NREL performed both searches on March 6, 2024, and received 867 publications from the SCOPUS search and 2,206 publications from the OSTI search. Combining the results from these searches, this brought our total universe of identified publications to 3,073.

In addition to searching the bibliographic databases NREL performed snowball sampling using a smaller number of publications initially identified as meeting our screening criteria and preliminarily judged of high quality to find any publications that may had been missed in the searches. Snowballing refers to mining reference lists of highly relevant studies to identify those missed using the standard keyword search of bibliographic databases approach. To include publications that may have been missed in this or previous literature searches, NREL relaxed the criteria for publication date (Criteria 1.3 described in Table 12) for publications obtained via snowball sampling. The publications used for snowball sampling (Cutshaw et al., 2023; Navajas et al., 2019; O’Donoughue et al., 2014; Wang et al., 2022) were chosen due to their quality and relevance to the topic, and produced an additional 40 publications. The addition of these publications resulted in a final universe of 3,113 publications.

3.4.2 Literature Screening

NREL subjected our universe of publications to a series of rigorous quantitative and qualitative screens to eliminate nonapplicable studies (Table 12). These screens were iteratively refined to be as objective as possible, where all marginal studies were discussed with a second researcher to confirm objective and consistent application of the criteria. The first screen targets common bibliographic information such as language, date, page count, and publication type. NREL implemented this screen through the search tools available in OSTI and SCOPUS, respectively. Then, using the title and abstract of the publications, NREL screened out those analyses that were not complete LCAs (Screen 2A and 2B) and those that were not high quality, relevant, original, or transparent (Screen 3). Finally, using the full text of the publications, NREL screened out the LCAs that did not focus on CCS (Screen 4) or did not focus on GHG emissions (Screen 5).

Table 12. Criteria used for screening the identified universe of publications

Screen (Information Used to Screen)	Criteria
Screen 1 (Search)	**1 Search criteria** 1.1 Remove duplicated publications 1.2 Remove publications not written in English 1.3 Remove publications published before 2022 1.4 Remove publications that are less than five pages 1.5 Remove publications that are not articles, books, book chapters, theses, dissertations, or technical reports
Screen 2A (Title and Abstract)	**2 Complete LCA on natural gas electricity generation** 2A.1 Remove publications that are comments on prior publications 2A.2 Remove publications that are not LCAs (defined here as not containing more than one life cycle phase) 2A.3 Remove publications that are not focused on natural gas 2A.4 Remove publications that do not include information on both CO_2 and methane
Screen 2B (Title and Abstract)	2B.1 Remove publications that are not on technologies whose primary purpose is to generate electricity by combusting natural gas
Screen 3 (Full Text)	**3 High quality, relevant, original, and transparent LCA** 3.1 Remove publications that do not mention ISO standard (14040 series standards; 14067 series standards) or a peer reviewed LCA model (such as SimaPRO, GaBi, Brightway, OpenLCA, NETL, GREET, Cheniere, or Saudi-ARAMCO) 3.2 Remove publications that do not report results in terms of a functional unit for their LCA 3.3 Remove publications that do not refer to tracking methane emissions from the fuel cycle 3.4 Remove publications that do not contain independent results (e.g., merely citing another publication's results) 3.5 Remove publications that do not provide transparent reporting of methods, assumptions, and technology descriptions
Screen 4 (Full Text)	**4 Focus on carbon capture and storage**

	4.1 Remove publications that do not focus on natural gas power generation technologies with carbon capture and storage
Screen 5 (Full Text)	**5 Focus on emissions** 5.1 Remove publications that do not report GHG emissions quantitatively in mass units 5.2 Remove publications that do not report results by life cycle phase (quantitatively)

Notes: ISO - International Organization for Standardization, NETL - National Energy Technology Laboratory, GREET - Greenhouse Gases, Regulated Emissions, and Energy Use in Transportation Model

Of the 3,113 publications in our universe, four publications passed all screens and supplied usable results to update the GHG emissions factors for NGCC-CCS systems.

3.4.3 Life Cycle GHG Emissions per Phase for NGCC-CCS

Our screening process identified eight results from four different publications. System characteristics of each result such as capture rate, capacity, lifespan, capacity factor, and location are reported in Table 13. The system characteristics previously reported in O'Donoughue et al. (2014) and NPC (2024) are also included in Table 13.

Table 13. System characteristics of each published scenario

Author (Year)	Capture Rate (%)	System Capacity (MW)	System Lifespan (Years)	Capacity Factor (%)	Location
Cutshaw et al. (2023)	90	470	30	85	N.R.
Cutshaw et al. (2023)	95	470	30	85	N.R.
Cutshaw et al. (2023)	97	470	30	85	N.R.
Gibon et al. (2017)	90	470	30	85	N.R.
Gibon et al. (2017)	90	470	30	85	N.R.
Gibon et al. (2017)	90	470	30	85	N.R.
Lacy et al. (2015)	87	450	30	80	Mexico
Singh et al. (2011)	90	400	25	91	Norway
Audus & Saroff (1995)*	86	N.R.	N.R.	N.R.	Norway
Bernier et al. (2010)*	96	360	30	86	N.R.
Bernier et al. (2010)*	90	360	30	86	N.R.
Bergerson & Lave (2007)*	90	N.R.	30	N.R.	N.R.
Jaramillo et al. (2007)*	90	N.R.	N.R.	N.R.	N.R.
Lombardi (2003)*	85	240	15	N.R.	N.R.
James III & Skone (2012)*	N.R.	470	30	85	N.R.
Skone (2012)*	N.R.	470	30	85	N.R.
Skone (2012)*	N.R.	470	30	85	N.R.
Skone (2012)*	N.R.	470	30	85	N.R.
Odeh & Cockerill (2008)*	90	430	30	75	United Kingdom
Spath & Mann (2004)*	N.R.	510	30	80	N.R.

Notes: N.R. – Not Reported. Asterisk (*) signifies that this result was previously reported in O’Donoughue et al. (2014). Values are rounded to two significant figures. Some values previously reported in O’Donoughue et al. (2014) have been revised to correct transcription errors.

Of these system characteristics, the carbon capture rate of an NGCC-CCS system heavily influences its total life cycle GHG emissions. Specifically, the capture rate directly modulates the most important life cycle phase for NGCC-CCS systems: the ongoing combustion phase. The capture rates reported in the published scenarios ranged from 85 percent to 97 percent.

The per phase GHG emissions results from the publications that passed our screens, and the results previously reported in O’Donoughue et al. (2014) and NPC (2024), are compiled in Table 14.

Table 14. Published, per phase GHG emissions for NGCC-CCS

Author (Year)	Upstream GHG Emissions (g CO_2e / kWh)	Ongoing Combustion GHG Emissions (g CO_2e / kWh)	Ongoing Non-Combustion GHG Emissions (g CO_2e / kWh)	Downstream GHG Emissions (g CO_2e / kWh)	Total Life Cycle GHG Emissions (g CO_2e / kWh)
Cutshaw et al. (2023)	8.7×10^{-5}	38	110	N.R.	N.R.
Cutshaw et al. (2023)	8.7×10^{-5}	19	110	N.R.	N.R.
Cutshaw et al. (2023)	8.7×10^{-5}	11	110	N.R.	N.R.
Gibon et al. (2017)	12	51	73	0.019	N.R.
Gibon et al. (2017)	13	52	180	0.019	N.R.
Gibon et al. (2017)	15	54	480	0.020	N.R.
Lacy et al. (2015)	N.R.	66	110	N.R.	170
Singh et al. (2011)	20	47	99	N.R.	170
Audus & Saroff (1995)*	N.R.	N.R.	N.R.	N.R.	82
Bernier et al. (2010)*	N.R.	N.R.	N.R.	N.R.	88
Bernier et al. (2010)*	N.R.	N.R.	N.R.	N.R.	110
Bergerson & Lave (2007)*	N.R.	43	75	N.R.	120
Jaramillo et al. (2007)*	N.R.	43	59	N.R.	10
Lombardi (2003)*	0.64	65	N.R.	N.R.	65
James III & Skone (2012)*	N.R.	51	86	N.R.	140
Skone (2012)*	N.R.	47	64	N.R.	110
Skone (2012)*	N.R.	47	51	N.R.	98
Skone (2012)*	N.R.	47	110	N.R.	160
Odeh & Cockerill (2008)*	N.R.	75	130	N.R.	200
Spath & Mann (2004)*	N.R.	98	150	N.R.	250

Notes: N.R. – Not Reported. Asterisk (*) signifies that this result was previously reported in O’Donoughue et al. (2014). Values are rounded to two significant figures.

NREL then summarized these results in Table 15. The median total life cycle GHG emissions for NGCC-CCS systems is 120 g CO2e per kWh. Median is the summary statistic that the LCA

Harmonization project uses to represent the central tendency from the literature. This value is 9 g CO2e per kWh greater than the median total life cycle GHG emissions for NGCC-CCS systems that was previously reported by O'Donoughue et al. (2014). The phase that contributes the most emissions, on average, is the ongoing non-combustion phase, with a median value of 110 g CO2e per kWh. This is due to the emissions related to the natural gas fuel cycle and storage of CO2.

Table 15. Summary statistics of life cycle GHG emissions per phase for NGCC-CCS

Summary Statistic	Upstream GHG Emissions (g CO_2e / kWh)	Ongoing Combustion GHG Emissions (g CO_2e / kWh)	Ongoing Non-Combustion GHG Emissions (g CO_2e / kWh)	Downstream GHG Emissions (g CO_2e / kWh)	Total Life Cycle GHG Emissions (g CO_2e / kWh)
Minimum	8.7×10^{-5}	11	51	0.019	65
First Quartile	8.7×10^{-5}	43	75	NA	99
Median	6.4	47	110	0.019	120
Third Quartile	14	54	120	NA	160
Maximum	20	98	480	0.020	250
Count	8	17	16	3	14

Note: Values are rounded to two significant figures. NA = this distributional statistic was not applicable given the count of estimates.

The results pulled from the publications were all reported in terms of electricity generation (g CO2e per kWh); however, NREL is interested in the upstream and downstream emissions factors in power capacity units (g CO2e per kW) to align with the other technologies used in this study (Table 16). To convert to power capacity units, NREL assumed a system lifespan of 30 years and a capacity factor of 85 percent. Many of the publications did not report system lifespan and capacity factor, so NREL made these assumptions to ensure the conversion to power capacity units was consistent across all studies. These specific assumptions were chosen using the modal value of the system lifespans and the capacity factors that were reported in O'Donoughue et al. (2014) and the publications screened in this study.

Table 16. Summary statistics of life cycle GHG emissions per phase for NGCC-CCS (with the units of upstream and downstream phases per kW)

Summary Statistic	Upstream GHG Emissions (g CO_2e / kW)	Ongoing Combustion GHG Emissions (g CO_2e / kWh)	Ongoing Non-Combustion GHG Emissions (g CO_2e / kWh)	Downstream GHG Emissions (g CO_2e / kW)	Total Life Cycle GHG Emissions (g CO_2e / kWh)
Minimum	20	11	51	4200	65
First Quartile	20	43	75	NA	99
Median	1.4×10^{6}	47	110	4300	120
Third Quartile	3.1×10^{6}	54	120	NA	160
Maximum	4.5×10^{6}	98	480	4500	250
Count	8	17	16	3	14

Note: Values are rounded to two significant figures. NA = this distributional statistic was not applicable given the count of estimates.

An NGCC-CCS system that has a plant lifespan of 30 years and a capacity factor of 85 percent would run for 223,533 hours. The summary statistics reported per energy capacity for the upstream and downstream phases (shown in Table 15) were multiplied by 223,533 to achieve the summary statistics in power capacity units (shown in Table 16).

3.4.4 Limitation

Our study focused on identifying publications published starting in 2022 because prior literature would be largely captured by the National Petroleum Council (NPC, 2024) and the O'Donoughue et al. (2014) literature reviews. This resulted in a literature gap between the years of 2012 and 2016 that is not accounted for in these GHG emissions factors given the cutoff date for O'Donoghue and start date of the NPC review, respectively. NREL employed snowball sampling to fill this literature gap; however, that process is not fully systematic when used alone, and it is unlikely that NREL identified all relevant publications from 2012 to 2016. Thus, there is a possibility that some NGCC-CCS LCAs published between 2012 and 2016 are missing, and that the results reported here could differ were they to be included. Given the small change in median values for each phase of the life cycle between those reported here as compared to those reported in O'Donoughue et al. (2014), NREL believes that any omission due to the literature search gap would likely not substantially change the estimates reported here and not be biased directionally.

4 Results From Two TVA IRP Cases

Following are the results of the NREL independent validation of the TVA capacity expansion model. The NREL validation covered two distinct IRP capacity expansion scenarios: Case 1A and Case 5B. This validation was done for two select cases chosen to represent the range of technology options within the overall IRP framework.

4.1 TVA Case Descriptions

Case 1A is a reference case scenario that reflects business-as-usual expansion with traditional technologies, least-cost planning, existing programs, no carbon regulations, increasing efficiencies, and increasing electric vehicles. (See Chapter 3 and Chapter 4 of the 2025 IRP, Volume I, for further description.) In this case, electricity demand increases at approximately 0.8% annually, and this growth in demand is largely served through the deployment of solar photovoltaics, battery, and natural gas-fired combined-cycle and combustion turbines.

Case 5B is TVA's highest load growth case and additionally assumes significant carbon regulation, load growth driven by electrification, and advancements in clean energy technologies.

This scenario implements the May 2023 proposed U.S. Environmental Protection Agency GHG rules under the Clean Air Act to reduce the emissions of coal plants and operate natural gas plants with installed CCS or hydrogen fuel blends, a carbon tax initiated at $86/ton beginning in 2034 (pushing the national electric sector to net zero by 2050), and load growth at approximately 2.5% annually through 2050. This capacity expansion largely relies on battery, solar, combined cycle with carbon capture, the use of green hydrogen as a fuel, and both conventional and SMR nuclear.

4.2 TVA Case Results

The following tables report the results for TVA cases 1A and 5B using NREL's LCA model. The results are the aggregate annual total for each GHG, summed across all technologies commissioned, operating, or decommissioned in that year and across all four phases.

Table 17. NREL Validation of CO_2, CH_4, and N_2O Life Cycle Annual Emissions Resulting From TVA Case 1A in Short Tons

Year	CO_2	CH_4	N_2O
2024	50,638,026	82,359	1,198
2025	56,050,596	76,092	1,310
2026	59,903,041	80,678	1,403
2027	50,966,000	84,927	1,233
2028	48,535,249	85,831	1,149
2029	43,847,660	86,992	1,069
2030	45,789,582	92,497	1,127
2031	43,953,036	89,117	1,098
2032	42,047,132	96,746	1,045
2033	39,568,006	94,769	987
2034	35,873,404	98,834	890
2035	35,206,239	97,243	879
2036	34,902,075	96,322	877
2037	33,179,938	91,362	840
2038	34,018,738	93,074	863
2039	33,261,550	91,504	851
2040	34,140,612	95,081	884
2041	31,872,930	87,010	813
2042	32,198,542	87,652	816
2043	34,660,643	97,177	908
2044	33,819,791	95,634	880
2045	33,948,251	96,956	893
2046	33,825,499	96,580	893
2047	32,216,265	90,136	841
2048	33,597,185	97,272	887
2049	32,580,637	94,347	869
2050	32,098,546	91,082	841

Table 18. NREL Validation of CO_2, CH_4, and N_2O Life Cycle Annual Emissions Resulting From TVA Case 5B in Short Tons

Year	CO_2	CH_4	N_2O
2024	50,627,441	86,758	1,202
2025	60,774,699	83,423	1,419
2026	70,252,508	100,457	1,658
2027	65,184,506	112,937	1,584
2028	67,916,741	130,096	1,650
2029	60,750,725	135,739	1,500
2030	62,784,094	139,374	1,556
2031	64,020,137	138,435	1,604
2032	54,862,591	83,003	1,377
2033	48,408,772	95,278	1,270
2034	41,062,610	101,526	1,143
2035	34,502,759	111,125	1,024
2036	33,905,555	110,664	1,020
2037	32,845,701	109,859	1,015
2038	17,792,289	106,466	723
2039	14,216,155	96,163	647
2040	12,744,021	95,072	626
2041	12,527,301	92,888	622
2042	11,655,811	89,261	594
2043	12,148,823	90,186	615
2044	12,244,131	89,697	619
2045	12,549,060	90,844	649
2046	10,338,809	80,736	585
2047	9,073,393	73,400	538
2048	10,723,395	80,021	603
2049	10,369,764	77,181	599
2050	8,189,884	69,758	526

4.3 TVA Results Comparison

These results were compared to TVA's model results. The two independent models nearly perfectly agree. The magnitude of difference found between the NREL and TVA models for Case 1A's CO_2e emissions was found to be 0.020%. Moreover, when disaggregated into their component emissions contributions, CO_2, CH_4, and N_2O emissions in Case 1A were 0.023%, 0.20%, and 0.39% respectively, showing somewhat greater discrepancy for non-CO_2 gases yet still less than 1%.

For Case 5B, the magnitude of difference was found to be 0.06% in terms of CO_2e. The ranges of difference for individual GHGs were 0.05%, 0.41%, and 0.96% for CO_2, CH_4, and N_2O, respectively.

NREL will continue working with TVA to close these gaps; however, the differences in the NREL- and TVA-calculated values can be considered minor.

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D.2 Detailed Total Emissions

The following tables include detailed annual emissions for three select IRP cases. These three cases represent a baseline portfolio (Table D-1), the portfolio with the highest total GHG emissions (Table D-2), and the portfolio with the lowest total GHG emissions (Table D-3). Scenarios 4 and 5 include hydrogen blending for fuel, so Table D-4 outlines forecasted hydrogen leakage associated with the same portfolio as Table D-3.

Table D-1: Detailed Total Emissions, by Year (millions of short tons), Life Cycle Phase, and per GHG, for Portfolio 1A, Reference Case with Baseline Utility Planning (Representing a Baseline Portfolio)

1A Phase	GHG	2024	2025	2026	2027	2028	2029
Upstream	CO_2	834,824	496,302	1,426,006	896,936	210,961	-
	CH_4	3,236	1,965	5,356	3,272	750	-
	N_2O	30	18	49	32	7	-
Ongoing Combustion	CO_2	46,721,886	52,579,661	55,491,716	46,783,642	44,932,749	40,394,548
	CH_4	574	618	645	590	585	556
	N_2O	1,023	1,147	1,206	1,042	976	903
Ongoing Non-Combustion	CO_2	3,081,328	2,972,123	2,985,390	3,208,283	3,307,595	3,375,947
	CH_4	78,356	73,338	74,510	80,808	84,228	86,155
	N_2O	150	151	153	162	167	168
Downstream	CO_2	-	2,603	-	77,182	84,075	77,183
	CH_4	-	2	-	50	55	50
	N_2O	-	0	-	3	4	3

1A Phase	GHG	2030	2031	2032	2033	2034	2035
Upstream	CO_2	1,122,856	1,759,551	1,747,603	1,662,583	1,662,583	1,724,385
	CH_4	4,447	6,677	6,724	6,499	6,499	6,829
	N_2O	40	61	62	59	59	61
Ongoing Combustion	CO_2	41,268,073	38,906,294	36,732,727	34,387,269	30,527,316	29,906,015
	CH_4	565	529	533	511	503	493
	N_2O	924	873	805	748	641	628
Ongoing Non-Combustion	CO_2	3,398,671	3,285,713	3,488,916	3,478,325	3,606,607	3,572,517
	CH_4	87,252	81,695	89,199	87,501	91,552	89,694
	N_2O	169	169	179	183	191	194
Downstream	CO_2	0	1,513	77,881	39,825	76,895	3,318
	CH_4	0	1	51	26	50	2
	N_2O	0	0	3	2	3	0

1A Phase	GHG	2036	2037	2038	2039	2040	2041
Upstream	CO_2	1,657,113	1,423,620	1,388,023	1,468,227	2,311,171	587,291
	CH_4	6,509	5,638	5,231	5,549	8,887	2,219
	N_2O	59	50	52	55	85	22
Ongoing Combustion	CO_2	29,672,764	28,259,158	29,088,762	28,257,459	28,288,777	27,766,467
	CH_4	489	466	480	466	466	457
	N_2O	623	593	611	593	594	583
Ongoing Non-Combustion	CO_2	3,572,154	3,494,123	3,541,949	3,520,697	3,539,158	3,514,933
	CH_4	89,100	85,043	87,146	85,265	85,513	84,120
	N_2O	197	199	203	205	209	211
Downstream	CO_2	40	3,033	-	15,162	1,502	4,236
	CH_4	0	2	-	10	1	3
	N_2O	0	0	-	1	0	0

1A Phase	GHG	2042	2043	2044	2045	2046	2047
Upstream	CO_2	186,271	2,810,165	1,707,739	2,290,134	2,198,479	734,237
	CH_4	631	10,524	6,477	8,800	8,420	2,351
	N_2O	8	102	64	84	81	28
Ongoing Combustion	CO_2	28,423,737	28,256,961	28,450,370	27,992,693	27,972,590	27,835,366
	CH_4	468	466	470	462	461	459
	N_2O	597	593	598	588	587	585
Ongoing Non-Combustion	CO_2	3,577,388	3,587,290	3,655,627	3,649,339	3,666,388	3,673,333
	CH_4	86,331	85,971	88,473	87,510	87,593	87,236
	N_2O	214	215	221	223	227	231
Downstream	CO_2	11,143	6,224	7,225	30,424	23,401	10,552
	CH_4	7	4	5	20	15	7
	N_2O	0	0	0	1	1	0

1A Phase	GHG	2048	2049	2050	Cumulative (2024-2050)
Upstream	CO_2	1,869,247	1,869,247	323,671	36,369,227
	CH_4	7,137	7,137	931	138,692
	N_2O	69	69	14	1,317
Ongoing Combustion	CO_2	28,003,542	27,025,871	28,035,896	921,962,307
	CH_4	461	444	461	13,676
	N_2O	587	566	588	19,802
Ongoing Non-Combustion	CO_2	3,742,385	3,695,075	3,767,106	93,958,359
	CH_4	89,544	86,611	89,565	2,309,307
	N_2O	234	236	242	5,306
Downstream	CO_2	10,717	10,582	-	574,720
	CH_4	7	7	-	376
	N_2O	0	0	-	25

Table D-2: Detailed Total Emissions (millions of short tons), by Year, Life Cycle Phase, and per GHG, for Portfolio 2A, Higher Growth Economy with Baseline Utility Planning (Representing the Highest Total GHG Portfolio Studied)

2A Phase	GHG	2024	2025	2026	2027	2028	2029
Upstream	CO_2	834,824	496,302	2,228,045	1,939,588	2,823,837	2,531,303
	CH_4	3,236	1,965	8,532	7,400	10,721	9,889
	N_2O	30	18	78	68	98	89
Ongoing Combustion	CO_2	48,283,482	55,251,758	59,421,446	53,618,192	53,766,108	46,233,547
	CH_4	593	652	696	655	656	602
	N_2O	1,059	1,205	1,290	1,194	1,183	1,051
Ongoing Non-Combustion	CO_2	3,160,411	3,106,515	3,190,993	3,355,621	3,408,636	3,563,330
	CH_4	81,026	77,853	81,464	85,299	86,530	90,442
	N_2O	153	157	162	172	179	188
Downstream	CO_2	-	2,603	-	77,182	84,075	77,183
	CH_4	-	2	-	50	55	50
	N_2O	-	0	-	3	4	3
2A Phase	**GHG**	**2030**	**2031**	**2032**	**2033**	**2034**	**2035**
Upstream	CO_2	2,464,623	1,945,168	2,686,956	2,729,791	2,729,791	2,765,076
	CH_4	9,675	7,226	10,217	10,459	10,459	10,711
	N_2O	87	70	95	99	99	100
Ongoing Combustion	CO_2	45,671,654	43,046,750	40,447,592	37,927,635	32,522,624	32,329,140
	CH_4	594	556	572	544	534	531
	N_2O	1,038	981	895	834	680	676
Ongoing Non-Combustion	CO_2	3,550,329	3,446,291	3,764,039	3,770,970	3,994,491	3,997,625
	CH_4	89,290	83,466	94,844	93,498	100,462	99,704
	N_2O	193	197	211	217	230	235
Downstream	CO_2	0	1,513	77,881	39,825	76,895	3,318
	CH_4	0	1	51	26	50	2
	N_2O	0	0	3	2	3	0
2A Phase	**GHG**	**2036**	**2037**	**2038**	**2039**	**2040**	**2041**
Upstream	CO_2	2,351,662	2,651,236	885,099	1,789,043	2,211,649	505,780
	CH_4	9,045	10,233	3,154	6,819	8,404	1,737
	N_2O	86	97	34	66	81	21
Ongoing Combustion	CO_2	32,545,151	31,552,694	32,266,709	32,238,767	32,533,053	32,889,309
	CH_4	535	518	530	530	534	540
	N_2O	681	660	675	675	681	689
Ongoing Non-Combustion	CO_2	4,032,192	3,992,167	4,040,075	4,066,667	4,109,160	4,145,002
	CH_4	100,005	97,203	98,914	98,969	99,902	100,672
	N_2O	242	246	251	254	260	264
Downstream	CO_2	40	3,033	-	15,162	1,502	4,236
	CH_4	0	2	-	10	1	3
	N_2O	0	0	-	1	0	0
2A Phase	**GHG**	**2042**	**2043**	**2044**	**2045**	**2046**	**2047**
Upstream	CO_2	2,669,980	4,272,042	1,604,644	3,266,971	3,198,623	3,495,695
	CH_4	10,148	15,613	5,985	12,391	12,189	12,686
	N_2O	99	155	60	119	118	130
Ongoing Combustion	CO_2	33,999,353	33,156,048	32,473,815	32,819,015	32,356,340	32,239,098
	CH_4	559	545	534	540	532	531
	N_2O	712	694	681	688	678	676
Ongoing Non-Combustion	CO_2	4,242,427	4,219,600	4,212,699	4,263,150	4,249,758	4,261,653
	CH_4	104,105	101,689	101,281	102,403	101,095	100,607
	N_2O	268	273	277	280	285	291
Downstream	CO_2	11,143	6,224	7,225	30,424	23,401	10,552
	CH_4	7	4	5	20	15	7
	N_2O	0	0	0	1	1	0

2A Phase	GHG	2048	2049	2050	Cumulative (2024-2050)
Upstream	CO_2	2,830,388	3,437,192	509,289	61,854,596
	CH_4	10,784	12,540	1,480	233,700
	N_2O	105	128	23	2,255
Ongoing Combustion	CO_2	31,936,362	30,932,508	30,426,827	1,032,884,976
	CH_4	527	510	501	15,151
	N_2O	671	650	639	22,235
Ongoing Non-Combustion	CO_2	4,256,666	4,211,795	4,174,679	104,786,942
	CH_4	99,591	96,583	95,356	2,562,254
	N_2O	295	299	302	6,382
Downstream	CO_2	10,717	10,582	-	574,720
	CH_4	7	7	-	376
	N_2O	0	0	-	25

Table D-3: Detailed Total Emissions (millions of short tons), by Year, Life Cycle Phase, and per GHG, for Portfolio 4D, Net-zero Regulation with Distributed and Demand Side Focus (Representing the Lowest Total GHG Portfolio Studied)

4D Phase	GHG	2024	2025	2026	2027	2028	2029
Upstream	CO_2	834,824	496,302	2,067,637	1,939,588	1,809,571	1,657,113
	CH_4	3,236	1,965	7,897	7,400	7,112	6,509
	N_2O	30	18	72	68	65	59
Ongoing Combustion	CO_2	44,272,343	51,629,165	53,811,506	45,916,219	43,590,172	38,472,579
	CH_4	545	606	627	566	549	505
	N_2O	973	1,128	1,172	1,022	954	873
Ongoing Non-Combustion	CO_2	3,112,890	2,979,514	3,039,306	3,187,990	3,254,502	3,267,078
	CH_4	79,439	73,361	76,206	79,607	81,394	80,789
	N_2O	151	152	156	164	171	174
Downstream	CO_2	-	2,603	-	77,182	84,075	77,183
	CH_4	-	2	-	50	55	50
	N_2O	-	0	-	3	4	3
4D Phase	**GHG**	**2030**	**2031**	**2032**	**2033**	**2034**	**2035**
Upstream	CO_2	1,948,798	2,139,704	3,609,495	3,954,213	3,954,213	1,830,453
	CH_4	7,372	7,908	10,356	11,376	11,376	7,142
	N_2O	73	80	112	128	128	66
Ongoing Combustion	CO_2	37,183,588	33,781,839	20,613,131	15,818,841	8,043,289	5,129,693
	CH_4	486	434	339	301	195	174
	N_2O	845	772	449	383	247	221
Ongoing Non-Combustion	CO_2	3,221,658	3,076,709	4,754,045	4,597,393	4,916,936	4,875,950
	CH_4	78,923	72,086	53,184	68,422	69,283	80,376
	N_2O	176	175	206	204	207	207
Downstream	CO_2	0	1,513	154,776	39,825	-	13,313
	CH_4	0	1	101	26	-	9
	N_2O	0	0	7	2	-	1
4D Phase	**GHG**	**2036**	**2037**	**2038**	**2039**	**2040**	**2041**
Upstream	CO_2	-	380,969	-	-	441,924	299,115
	CH_4	-	1,509	-	-	1,750	1,099
	N_2O	-	13	-	-	16	10
Ongoing Combustion	CO_2	4,503,275	3,990,411	1,510,703	1,447,973	1,478,861	1,465,217
	CH_4	162	152	112	112	113	112
	N_2O	206	193	143	142	143	142
Ongoing Non-Combustion	CO_2	4,761,570	4,644,658	4,124,454	4,140,267	4,188,354	4,203,861
	CH_4	78,881	77,526	78,130	77,435	78,820	79,306
	N_2O	210	210	203	204	206	206
Downstream	CO_2	2,514	3,033	-	15,162	1,502	4,236
	CH_4	2	2	-	10	1	3
	N_2O	0	0	-	1	0	0
4D Phase	**GHG**	**2042**	**2043**	**2044**	**2045**	**2046**	**2047**
Upstream	CO_2	79,550	1,004,799	858,252	2,022,584	2,210,966	2,007,301
	CH_4	235	3,719	3,295	8,009	8,463	7,519
	N_2O	4	39	30	71	81	75
Ongoing Combustion	CO_2	1,506,370	1,525,012	1,576,674	1,549,037	1,583,288	1,560,545
	CH_4	114	114	116	116	108	107
	N_2O	144	144	147	147	137	136
Ongoing Non-Combustion	CO_2	4,269,866	4,271,772	4,383,386	4,392,414	4,290,161	4,290,758
	CH_4	80,135	79,926	82,520	81,787	79,007	78,102
	N_2O	208	209	212	213	216	220
Downstream	CO_2	11,143	6,224	-	30,424	23,401	10,552
	CH_4	7	4	-	20	15	7
	N_2O	0	0	-	1	1	0

4D Phase	GHG	2048	2049	2050	Cumulative (2024-2050)
Upstream	CO_2	1,948,798	1,992,675	403,222	39,892,064
	CH_4	7,372	7,482	1,166	141,270
	N_2O	73	74	18	1,403
Ongoing Combustion	CO_2	1,616,527	1,503,210	1,578,711	426,658,180
	CH_4	108	105	107	7,083
	N_2O	137	134	135	11,269
Ongoing Non-Combustion	CO_2	4,325,699	4,270,150	4,337,508	109,178,849
	CH_4	78,049	75,835	76,746	2,075,274
	N_2O	224	227	232	5,341
Downstream	CO_2	7,948	10,582	-	577,194
	CH_4	5	7	-	378
	N_2O	0	0	-	25

Table D-4: Detailed Hydrogen Leakage Emissions (millions of short tons), by Year, Life Cycle Phase, for Portfolio 4D, Net-Zero Regulation with Distributed and Demand Side Focus (Representing the Lowest Total GHG Portfolio Studied)

4D Phase	GHG	2024	2025	2026	2027	2028	2029
Ongoing Non-Combustion	H_2	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
4D Phase	**GHG**	**2030**	**2031**	**2032**	**2033**	**2034**	**2035**
Ongoing Non-Combustion	H_2	0.0000	0.0000	0.0072	0.0044	0.0048	0.0030
4D Phase	**GHG**	**2036**	**2037**	**2038**	**2039**	**2040**	**2041**
Ongoing Non-Combustion	H_2	0.0027	0.0023	0.0078	0.0082	0.0084	0.0085
4D Phase	**GHG**	**2042**	**2043**	**2044**	**2045**	**2046**	**2047**
Ongoing Non-Combustion	H_2	0.0097	0.0094	0.0108	0.0112	0.0111	0.0114
4D Phase	**GHG**	**2048**	**2049**	**2050**	**Cumulative (2024-2050)**		
Ongoing Non-Combustion	H_2	0.0119	0.0113	0.0127	0.1567		

D.3 Social Cost of Greenhouse Gases Assumptions

Table D-5: 2021 White House estimates for the Social Cost of Greenhouse Gases, 3.0% discount rate and average statistic (nominal dollars per short ton)

2021 White House Estimates			
Year	Social Cost of CO_2	Social Cost of CH_4	Social Cost of N_2O
2020	$46.34	$1,347.24	$16,697.03
2021	$49.43	$1,452.25	$17,861.35
2022	$53.98	$1,601.60	$19,555.95
2023	$57.16	$1,712.00	$20,760.77
2024	$59.70	$1,804.12	$21,735.34
2025	$62.06	$1,891.62	$22,648.34
2026	$64.46	$1,980.76	$23,575.55
2027	$66.88	$2,071.37	$24,515.17
2028	$69.40	$2,165.43	$25,490.55
2029	$72.00	$2,262.87	$26,500.62
2030	$74.66	$2,362.59	$27,532.30
2031	$77.48	$2,475.48	$28,658.98
2032	$80.37	$2,591.30	$29,812.71
2033	$83.33	$2,710.49	$30,998.40
2034	$86.45	$2,835.62	$32,245.23
2035	$89.69	$2,965.40	$33,537.96
2036	$93.03	$3,099.74	$34,875.17
2037	$96.48	$3,238.63	$36,256.50
2038	$100.04	$3,382.16	$37,682.73
2039	$103.74	$3,531.15	$39,162.69
2040	$107.56	$3,685.36	$40,693.38
2041	$111.47	$3,844.09	$42,314.19
2042	$115.49	$4,007.86	$43,985.20
2043	$119.64	$4,177.23	$45,712.56
2044	$123.95	$4,353.03	$47,504.95
2045	$128.38	$4,534.07	$49,349.30
2046	$132.90	$4,719.31	$51,233.99
2047	$137.53	$4,909.70	$53,169.56
2048	$142.32	$5,106.48	$55,169.02
2049	$147.24	$5,309.28	$57,228.36
2050	$152.31	$5,518.27	$59,349.23

Table D-6: 2023 EPA estimates for the Social Cost of Greenhouse Gases, 2.0% discount rate and average statistic (nominal dollars per short ton)

2023 EPA Estimates			
Year	Social Cost of CO_2	Social Cost of CH_4	Social Cost of N_2O
2020	$175.09	$1,495.04	$49,114.13
2021	$186.74	$1,633.29	$52,481.48
2022	$202.87	$1,824.80	$57,401.57
2023	$214.80	$1,973.25	$60,878.05
2024	$224.32	$2,103.04	$63,674.72
2025	$233.19	$2,227.36	$66,289.49
2026	$241.05	$2,355.56	$68,942.49
2027	$250.12	$2,485.22	$71,630.64
2028	$259.54	$2,620.99	$74,421.14
2029	$268.10	$2,760.50	$77,309.48
2030	$278.03	$2,904.80	$80,259.85
2031	$288.22	$3,066.91	$83,317.66
2032	$297.38	$3,234.74	$86,445.82
2033	$308.04	$3,407.65	$89,658.48
2034	$319.28	$3,588.92	$93,038.28
2035	$329.59	$3,776.99	$96,543.21
2036	$341.60	$3,970.42	$100,167.49
2037	$354.00	$4,171.93	$103,909.71
2038	$365.38	$4,380.34	$107,771.83
2039	$378.62	$4,596.74	$111,778.67
2040	$392.31	$4,819.40	$115,921.28
2041	$406.28	$5,059.79	$120,391.42
2042	$420.67	$5,309.62	$124,998.56
2043	$435.53	$5,566.67	$129,760.01
2044	$450.94	$5,833.60	$134,701.72
2045	$466.78	$6,108.86	$139,783.27
2046	$482.94	$6,391.07	$144,973.15
2047	$501.20	$6,681.56	$150,301.13
2048	$518.34	$6,982.02	$155,805.57
2049	$535.97	$7,292.01	$161,471.45
2050	$554.11	$7,611.80	$167,304.99

D.4 Detailed Social Cost of Greenhouse Gasses

Table D-7: White House Social Cost for Portfolio 1A (NPV 2024-2050, millions of 2024$), Reference Case with Baseline Utility Planning (Representing the Baseline Portfolio)

1A WH Phase	GHG	2024	2025	2026	2027	2028	2029
Upstream	CO_2	$49.84	$30.80	$91.92	$59.99	$14.64	$0.00
	CH_4	$5.84	$3.72	$10.61	$6.78	$1.62	$0.00
	N_2O	$0.64	$0.40	$1.16	$0.78	$0.19	$0.00
Ongoing Combustion	CO_2	$2,789.27	$3,263.17	$3,576.81	$3,128.97	$3,118.24	$2,908.54
	CH_4	$1.04	$1.17	$1.28	$1.22	$1.27	$1.26
	N_2O	$22.24	$25.97	$28.43	$25.53	$24.88	$23.92
Ongoing Non-Combustion	CO_2	$183.95	$184.45	$192.43	$214.58	$229.54	$243.08
	CH_4	$141.36	$138.73	$147.59	$167.38	$182.39	$194.96
	N_2O	$3.26	$3.43	$3.61	$3.98	$4.27	$4.46
Downstream	CO_2	$0.00	$0.16	$0.00	$5.16	$5.83	$5.56
	CH_4	$0.00	$0.00	$0.00	$0.10	$0.12	$0.11
	N_2O	$0.00	$0.00	$0.00	$0.08	$0.09	$0.09
1A WH Phase	**GHG**	**2030**	**2031**	**2032**	**2033**	**2034**	**2035**
Upstream	CO_2	$83.83	$136.34	$140.45	$138.55	$143.73	$154.65
	CH_4	$10.51	$16.53	$17.42	$17.61	$18.43	$20.25
	N_2O	$1.09	$1.75	$1.84	$1.82	$1.89	$2.04
Ongoing Combustion	CO_2	$3,081.15	$3,014.58	$2,952.18	$2,865.58	$2,639.15	$2,682.14
	CH_4	$1.34	$1.31	$1.38	$1.39	$1.43	$1.46
	N_2O	$25.43	$25.03	$24.01	$23.19	$20.67	$21.07
Ongoing Non-Combustion	CO_2	$253.75	$254.59	$280.40	$289.86	$311.80	$320.40
	CH_4	$206.14	$202.23	$231.14	$237.17	$259.61	$265.98
	N_2O	$4.66	$4.84	$5.34	$5.68	$6.15	$6.49
Downstream	CO_2	$0.00	$0.12	$6.26	$3.32	$6.65	$0.30
	CH_4	$0.00	$0.00	$0.13	$0.07	$0.14	$0.01
	N_2O	$0.00	$0.00	$0.10	$0.05	$0.11	$0.00
1A WH Phase	**GHG**	**2036**	**2037**	**2038**	**2039**	**2040**	**2041**
Upstream	CO_2	$154.16	$137.35	$138.86	$152.31	$248.59	$65.46
	CH_4	$20.18	$18.26	$17.69	$19.59	$32.75	$8.53
	N_2O	$2.06	$1.82	$1.96	$2.15	$3.45	$0.93
Ongoing Combustion	CO_2	$2,760.43	$2,726.48	$2,910.15	$2,931.42	$3,042.76	$3,095.00
	CH_4	$1.52	$1.51	$1.62	$1.64	$1.72	$1.76
	N_2O	$21.73	$21.51	$23.04	$23.23	$24.16	$24.66
Ongoing Non-Combustion	CO_2	$332.31	$337.12	$354.35	$365.24	$380.67	$391.79
	CH_4	$276.19	$275.42	$294.74	$301.08	$315.15	$323.36
	N_2O	$6.89	$7.22	$7.63	$8.04	$8.50	$8.95
Downstream	CO_2	$0.00	$0.29	$0.00	$1.57	$0.16	$0.47
	CH_4	$0.00	$0.01	$0.00	$0.04	$0.00	$0.01
	N_2O	$0.00	$0.00	$0.00	$0.03	$0.00	$0.01

1A WH Phase	GHG	2042	2043	2044	2045	2046	2047
Upstream	CO_2	$21.51	$336.21	$211.68	$294.00	$292.17	$100.98
	CH_4	$2.53	$43.96	$28.19	$39.90	$39.74	$11.54
	N_2O	$0.34	$4.65	$3.02	$4.14	$4.13	$1.48
Ongoing Combustion	CO_2	$3,282.57	$3,380.70	$3,526.45	$3,593.67	$3,717.50	$3,828.31
	CH_4	$1.88	$1.95	$2.04	$2.09	$2.18	$2.25
	N_2O	$26.25	$27.12	$28.42	$29.02	$30.09	$31.08
Ongoing Non-Combustion	CO_2	$413.14	$429.19	$453.12	$468.50	$487.26	$505.21
	CH_4	$346.00	$359.12	$385.13	$396.78	$413.38	$428.30
	N_2O	$9.42	$9.85	$10.51	$10.99	$11.63	$12.28
Downstream	CO_2	$1.29	$0.74	$0.90	$3.91	$3.11	$1.45
	CH_4	$0.03	$0.02	$0.02	$0.09	$0.07	$0.03
	N_2O	$0.02	$0.01	$0.01	$0.07	$0.05	$0.02

1A WH Phase	GHG	2048	2049	2050	NPV (2024-2050, millions of 2024$)
Upstream	CO_2	$266.03	$275.23	$49.30	$1,426.83
	CH_4	$36.44	$37.89	$5.14	$181.93
	N_2O	$3.81	$3.95	$0.86	$19.33
Ongoing Combustion	CO_2	$3,985.47	$3,979.39	$4,270.19	$39,937.80
	CH_4	$2.35	$2.36	$2.54	$18.88
	N_2O	$32.37	$32.39	$34.87	$321.11
Ongoing Non-Combustion	CO_2	$532.62	$544.08	$573.77	$3,809.19
	CH_4	$457.25	$459.84	$494.24	$3,109.99
	N_2O	$12.92	$13.53	$14.36	$79.07
Downstream	CO_2	$1.53	$1.56	$0.00	$26.07
	CH_4	$0.04	$0.04	$0.00	$0.55
	N_2O	$0.03	$0.03	$0.00	$0.42

Table D-8: EPA Social Cost for Portfolio 1A (NPV 2024-2050, millions of 2024$), Reference Case with Baseline Utility Planning (Representing the Baseline Portfolio)

1A EPA Phase	GHG	2024	2025	2026	2027	2028	2029
Upstream	CO_2	$187.27	$115.73	$343.74	$224.34	$54.75	$0.00
	CH_4	$6.81	$4.38	$12.62	$8.13	$1.97	$0.00
	N_2O	$1.89	$1.16	$3.39	$2.27	$0.55	$0.00
Ongoing Combustion	CO_2	$10,480.86	$12,260.80	$13,376.27	$11,701.59	$11,661.77	$10,829.86
	CH_4	$1.21	$1.38	$1.52	$1.47	$1.53	$1.53
	N_2O	$65.17	$76.01	$83.15	$74.61	$72.65	$69.78
Ongoing Non-Combustion	CO_2	$691.22	$693.06	$719.63	$802.46	$858.45	$905.10
	CH_4	$164.79	$163.35	$175.51	$200.83	$220.76	$237.83
	N_2O	$9.55	$10.03	$10.56	$11.62	$12.46	$13.01
Downstream	CO_2	$0.00	$0.61	$0.00	$19.30	$21.82	$20.69
	CH_4	$0.00	$0.00	$0.00	$0.13	$0.14	$0.14
	N_2O	$0.00	$0.01	$0.00	$0.24	$0.27	$0.26
1A EPA Phase	**GHG**	**2030**	**2031**	**2032**	**2033**	**2034**	**2035**
Upstream	CO_2	$312.19	$507.13	$519.69	$512.15	$530.82	$568.34
	CH_4	$12.92	$20.48	$21.75	$22.15	$23.32	$25.79
	N_2O	$3.18	$5.08	$5.35	$5.26	$5.45	$5.88
Ongoing Combustion	CO_2	$11,473.74	$11,213.39	$10,923.40	$10,592.77	$9,746.63	$9,856.72
	CH_4	$1.64	$1.62	$1.72	$1.74	$1.81	$1.86
	N_2O	$74.13	$72.77	$69.62	$67.07	$59.64	$60.64
Ongoing Non-Combustion	CO_2	$944.93	$946.99	$1,037.52	$1,071.47	$1,151.50	$1,177.46
	CH_4	$253.45	$250.55	$288.54	$298.17	$328.57	$338.77
	N_2O	$13.58	$14.08	$15.48	$16.41	$17.75	$18.68
Downstream	CO_2	$0.00	$0.44	$23.16	$12.27	$24.55	$1.09
	CH_4	$0.00	$0.00	$0.16	$0.09	$0.18	$0.01
	N_2O	$0.00	$0.01	$0.29	$0.16	$0.31	$0.01
1A EPA Phase	**GHG**	**2036**	**2037**	**2038**	**2039**	**2040**	**2041**
Upstream	CO_2	$566.07	$503.96	$507.16	$555.90	$906.70	$238.61
	CH_4	$25.84	$23.52	$22.91	$25.51	$42.83	$11.23
	N_2O	$5.92	$5.22	$5.62	$6.14	$9.82	$2.65
Ongoing Combustion	CO_2	$10,136.22	$10,003.71	$10,628.48	$10,698.92	$11,098.00	$11,281.02
	CH_4	$1.94	$1.94	$2.10	$2.14	$2.25	$2.31
	N_2O	$62.42	$61.65	$65.88	$66.30	$68.84	$70.16
Ongoing Non-Combustion	CO_2	$1,220.25	$1,236.92	$1,294.16	$1,333.02	$1,388.45	$1,428.05
	CH_4	$353.77	$354.79	$381.73	$391.94	$412.12	$425.63
	N_2O	$19.78	$20.69	$21.83	$22.94	$24.20	$25.46
Downstream	CO_2	$0.01	$1.07	$0.00	$5.74	$0.59	$1.72
	CH_4	$0.00	$0.01	$0.00	$0.05	$0.00	$0.01
	N_2O	$0.00	$0.01	$0.00	$0.07	$0.01	$0.02

1A EPA Phase	GHG	2042	2043	2044	2045	2046	2047
Upstream	CO_2	$78.36	$1,223.91	$770.10	$1,069.00	$1,061.73	$368.00
	CH_4	$3.35	$58.58	$37.78	$53.76	$53.81	$15.71
	N_2O	$0.98	$13.20	$8.57	$11.73	$11.70	$4.19
Ongoing Combustion	CO_2	$11,957.01	$12,306.77	$12,829.54	$13,066.56	$13,509.07	$13,951.12
	CH_4	$2.49	$2.59	$2.74	$2.82	$2.95	$3.07
	N_2O	$74.59	$76.99	$80.60	$82.19	$85.15	$87.86
Ongoing Non-Combustion	CO_2	$1,504.90	$1,562.37	$1,648.48	$1,703.46	$1,770.64	$1,841.08
	CH_4	$458.38	$478.57	$516.12	$534.59	$559.81	$582.87
	N_2O	$26.78	$27.96	$29.79	$31.14	$32.91	$34.72
Downstream	CO_2	$4.69	$2.71	$3.26	$14.20	$11.30	$5.29
	CH_4	$0.04	$0.02	$0.03	$0.12	$0.10	$0.05
	N_2O	$0.06	$0.04	$0.04	$0.19	$0.15	$0.07

1A EPA Phase	GHG	2048	2049	2050	NPV (2024-2050, millions of 2024$)
Upstream	CO_2	$968.90	$1,001.86	$179.35	$5,249.16
	CH_4	$49.83	$52.04	$7.09	$233.68
	N_2O	$10.76	$11.16	$2.42	$55.49
Ongoing Combustion	CO_2	$14,515.31	$14,485.05	$15,534.95	$147,769.95
	CH_4	$3.22	$3.24	$3.51	$23.88
	N_2O	$91.42	$91.40	$98.30	$927.73
Ongoing Non-Combustion	CO_2	$1,939.82	$1,980.45	$2,087.39	$14,045.55
	CH_4	$625.19	$631.56	$681.75	$3,961.18
	N_2O	$36.48	$38.18	$40.48	$227.28
Downstream	CO_2	$5.56	$5.67	$0.00	$96.64
	CH_4	$0.05	$0.05	$0.00	$0.69
	N_2O	$0.07	$0.07	$0.00	$1.23

Table D-9: White House Social Cost for Portfolio 2A (NPV 2024-2050, millions of 2024$), Higher Growth Economy with Baseline Utility Planning (Representing the Highest Total GHG Portfolio Studied)

2A WH Phase	GHG	2024	2025	2026	2027	2028	2029
Upstream	CO_2	$49.84	$30.80	$143.61	$129.72	$195.97	$182.26
	CH_4	$5.84	$3.72	$16.90	$15.33	$23.21	$22.38
	N_2O	$0.64	$0.40	$1.83	$1.68	$2.51	$2.37
Ongoing Combustion	CO_2	$2,882.50	$3,429.00	$3,830.11	$3,586.08	$3,731.26	$3,328.96
	CH_4	$1.07	$1.23	$1.38	$1.36	$1.42	$1.36
	N_2O	$23.01	$27.29	$30.41	$29.26	$30.16	$27.84
Ongoing Non-Combustion	CO_2	$188.67	$192.79	$205.68	$224.43	$236.55	$256.57
	CH_4	$146.18	$147.27	$161.36	$176.69	$187.37	$204.66
	N_2O	$3.33	$3.55	$3.82	$4.22	$4.57	$4.99
Downstream	CO_2	$0.00	$0.16	$0.00	$5.16	$5.83	$5.56
	CH_4	$0.00	$0.00	$0.00	$0.10	$0.12	$0.11
	N_2O	$0.00	$0.00	$0.00	$0.08	$0.09	$0.09
2A WH Phase	**GHG**	**2030**	**2031**	**2032**	**2033**	**2034**	**2035**
Upstream	CO_2	$184.01	$150.72	$215.95	$227.48	$236.00	$247.99
	CH_4	$22.86	$17.89	$26.47	$28.35	$29.66	$31.76
	N_2O	$2.39	$2.00	$2.84	$3.08	$3.20	$3.37
Ongoing Combustion	CO_2	$3,409.93	$3,335.40	$3,250.74	$3,160.61	$2,811.65	$2,899.46
	CH_4	$1.40	$1.38	$1.48	$1.47	$1.51	$1.57
	N_2O	$28.58	$28.12	$26.67	$25.86	$21.94	$22.69
Ongoing Non-Combustion	CO_2	$265.07	$267.03	$302.51	$314.25	$345.33	$358.53
	CH_4	$210.96	$206.62	$245.77	$253.43	$284.87	$295.66
	N_2O	$5.32	$5.64	$6.29	$6.73	$7.41	$7.89
Downstream	CO_2	$0.00	$0.12	$6.26	$3.32	$6.65	$0.30
	CH_4	$0.00	$0.00	$0.13	$0.07	$0.14	$0.01
	N_2O	$0.00	$0.00	$0.10	$0.05	$0.11	$0.00
2A WH Phase	**GHG**	**2036**	**2037**	**2038**	**2039**	**2040**	**2041**
Upstream	CO_2	$218.77	$255.79	$88.55	$185.60	$237.89	$56.38
	CH_4	$28.04	$33.14	$10.67	$24.08	$30.97	$6.68
	N_2O	$3.00	$3.51	$1.29	$2.59	$3.30	$0.89
Ongoing Combustion	CO_2	$3,027.65	$3,044.24	$3,228.08	$3,344.44	$3,499.28	$3,666.01
	CH_4	$1.66	$1.68	$1.79	$1.87	$1.97	$2.08
	N_2O	$23.76	$23.93	$25.45	$26.43	$27.71	$29.14
Ongoing Non-Combustion	CO_2	$375.11	$385.17	$404.18	$421.88	$441.98	$462.02
	CH_4	$309.99	$314.80	$334.54	$349.47	$368.18	$386.99
	N_2O	$8.44	$8.91	$9.46	$9.97	$10.56	$11.18
Downstream	CO_2	$0.00	$0.29	$0.00	$1.57	$0.16	$0.47
	CH_4	$0.00	$0.01	$0.00	$0.04	$0.00	$0.01
	N_2O	$0.00	$0.00	$0.00	$0.03	$0.00	$0.01

2A WH Phase	GHG	2042	2043	2044	2045	2046	2047
Upstream	CO_2	$308.35	$511.11	$198.90	$419.41	$425.09	$480.78
	CH_4	$40.67	$65.22	$26.05	$56.18	$57.52	$62.29
	N_2O	$4.36	$7.11	$2.84	$5.85	$6.07	$6.90
Ongoing Combustion	CO_2	$3,926.48	$3,966.83	$4,025.15	$4,213.26	$4,300.09	$4,433.97
	CH_4	$2.24	$2.28	$2.33	$2.45	$2.51	$2.60
	N_2O	$31.32	$31.74	$32.34	$33.96	$34.75	$35.94
Ongoing Non-Combustion	CO_2	$489.94	$504.84	$522.17	$547.30	$564.78	$586.12
	CH_4	$417.24	$424.78	$440.88	$464.30	$477.10	$493.95
	N_2O	$11.79	$12.47	$13.17	$13.84	$14.60	$15.47
Downstream	CO_2	$1.29	$0.74	$0.90	$3.91	$3.11	$1.45
	CH_4	$0.03	$0.02	$0.02	$0.09	$0.07	$0.03
	N_2O	$0.02	$0.01	$0.01	$0.07	$0.05	$0.02

2A WH Phase	GHG	2048	2049	2050	NPV (2024-2050, millions of 2024$)
Upstream	CO_2	$402.82	$506.10	$77.57	$2,465.04
	CH_4	$55.07	$66.58	$8.17	$310.31
	N_2O	$5.79	$7.31	$1.38	$33.56
Ongoing Combustion	CO_2	$4,545.19	$4,554.61	$4,634.36	$44,520.17
	CH_4	$2.69	$2.71	$2.77	$20.80
	N_2O	$37.01	$37.17	$37.90	$359.13
Ongoing Non-Combustion	CO_2	$605.81	$620.16	$635.85	$4,208.90
	CH_4	$508.56	$512.79	$526.20	$3,429.36
	N_2O	$16.29	$17.12	$17.93	$93.90
Downstream	CO_2	$1.53	$1.56	$0.00	$26.07
	CH_4	$0.04	$0.04	$0.00	$0.55
	N_2O	$0.03	$0.03	$0.00	$0.42

Table D-10: EPA Social Cost for Portfolio 2A (NPV 2024-2050, millions of 2024$), Higher Growth Economy with Baseline Utility Planning (Representing the Highest Total GHG Portfolio Studied)

2A EPA Phase	GHG	2024	2025	2026	2027	2028	2029
Upstream	CO_2	$187.27	$115.73	$537.07	$485.13	$732.89	$678.65
	CH_4	$6.81	$4.38	$20.10	$18.39	$28.10	$27.30
	N_2O	$1.89	$1.16	$5.34	$4.90	$7.32	$6.91
Ongoing Combustion	CO_2	$10,831.17	$12,883.89	$14,323.53	$13,411.05	$13,954.36	$12,395.31
	CH_4	$1.25	$1.45	$1.64	$1.63	$1.72	$1.66
	N_2O	$67.41	$79.88	$88.94	$85.49	$88.04	$81.22
Ongoing Non-Combustion	CO_2	$708.96	$724.39	$769.19	$839.31	$884.67	$955.34
	CH_4	$170.40	$173.41	$191.89	$211.99	$226.79	$249.66
	N_2O	$9.76	$10.40	$11.16	$12.32	$13.34	$14.54
Downstream	CO_2	$0.00	$0.61	$0.00	$19.30	$21.82	$20.69
	CH_4	$0.00	$0.00	$0.00	$0.13	$0.14	$0.14
	N_2O	$0.00	$0.01	$0.00	$0.24	$0.27	$0.26

2A EPA Phase	GHG	2030	2031	2032	2033	2034	2035
Upstream	CO_2	$685.24	$560.63	$799.03	$840.89	$871.56	$911.34
	CH_4	$28.10	$22.16	$33.05	$35.64	$37.54	$40.45
	N_2O	$6.98	$5.81	$8.24	$8.91	$9.25	$9.69
Ongoing Combustion	CO_2	$12,698.06	$12,406.74	$12,028.11	$11,683.35	$10,383.69	$10,655.35
	CH_4	$1.73	$1.71	$1.85	$1.85	$1.92	$2.00
	N_2O	$83.31	$81.75	$77.35	$74.78	$63.30	$65.30
Ongoing Non-Combustion	CO_2	$987.10	$993.27	$1,119.33	$1,161.62	$1,275.34	$1,317.58
	CH_4	$259.37	$255.98	$306.80	$318.61	$360.55	$376.58
	N_2O	$15.52	$16.38	$18.23	$19.47	$21.37	$22.72
Downstream	CO_2	$0.00	$0.44	$23.16	$12.27	$24.55	$1.09
	CH_4	$0.00	$0.00	$0.16	$0.09	$0.18	$0.01
	N_2O	$0.00	$0.01	$0.29	$0.16	$0.31	$0.01

2A EPA Phase	GHG	2036	2037	2038	2039	2040	2041
Upstream	CO_2	$803.33	$938.53	$323.40	$677.37	$867.65	$205.49
	CH_4	$35.91	$42.69	$13.82	$31.35	$40.50	$8.79
	N_2O	$8.63	$10.05	$3.69	$7.41	$9.40	$2.52
Ongoing Combustion	CO_2	$11,117.43	$11,169.62	$11,789.64	$12,206.33	$12,763.07	$13,362.34
	CH_4	$2.12	$2.16	$2.32	$2.43	$2.58	$2.73
	N_2O	$68.25	$68.59	$72.78	$75.43	$78.94	$82.89
Ongoing Non-Combustion	CO_2	$1,377.40	$1,413.22	$1,476.17	$1,539.73	$1,612.07	$1,684.04
	CH_4	$397.06	$405.52	$433.28	$454.93	$481.47	$509.38
	N_2O	$24.25	$25.53	$27.07	$28.45	$30.09	$31.80
Downstream	CO_2	$0.01	$1.07	$0.00	$5.74	$0.59	$1.72
	CH_4	$0.00	$0.01	$0.00	$0.05	$0.00	$0.01
	N_2O	$0.00	$0.01	$0.00	$0.07	$0.01	$0.02

2A EPA Phase	GHG	2042	2043	2044	2045	2046	2047
Upstream	CO_2	$1,123.18	$1,860.60	$723.61	$1,524.97	$1,544.74	$1,752.05
	CH_4	$53.88	$86.91	$34.92	$75.70	$77.90	$84.76
	N_2O	$12.40	$20.17	$8.07	$16.57	$17.18	$19.50
Ongoing Combustion	CO_2	$14,302.50	$14,440.47	$14,643.89	$15,319.41	$15,626.16	$16,158.28
	CH_4	$2.97	$3.03	$3.12	$3.30	$3.40	$3.54
	N_2O	$89.00	$90.09	$91.69	$96.18	$98.32	$101.59
Ongoing Non-Combustion	CO_2	$1,784.66	$1,837.76	$1,899.69	$1,989.97	$2,052.38	$2,135.95
	CH_4	$552.76	$566.07	$590.83	$625.56	$646.10	$672.21
	N_2O	$33.49	$35.40	$37.36	$39.20	$41.31	$43.72
Downstream	CO_2	$4.69	$2.71	$3.26	$14.20	$11.30	$5.29
	CH_4	$0.04	$0.02	$0.03	$0.12	$0.10	$0.05
	N_2O	$0.06	$0.04	$0.04	$0.19	$0.15	$0.07

2A EPA Phase	GHG	2048	2049	2050	NPV (2024-2050, millions of 2024$)
Upstream	CO_2	$1,467.10	$1,842.23	$282.20	$9,081.35
	CH_4	$75.29	$91.44	$11.27	$397.07
	N_2O	$16.34	$20.63	$3.88	$96.49
Ongoing Combustion	CO_2	$16,553.84	$16,578.89	$16,859.78	$164,684.16
	CH_4	$3.68	$3.72	$3.82	$26.35
	N_2O	$104.51	$104.88	$106.83	$1,037.35
Ongoing Non-Combustion	CO_2	$2,206.39	$2,257.39	$2,313.23	$15,511.39
	CH_4	$695.34	$704.29	$725.83	$4,375.59
	N_2O	$46.01	$48.30	$50.53	$269.70
Downstream	CO_2	$5.56	$5.67	$0.00	$96.64
	CH_4	$0.05	$0.05	$0.00	$0.69
	N_2O	$0.07	$0.07	$0.00	$1.23

Table D-11: White House Social Cost for Portfolio 4D (NPV 2024-2050, millions of 2024$), Net-zero Regulation with Distributed and Demand Side Focus (Representing the Lowest Total GHG Portfolio Studied)

4D WH Phase	GHG	2024	2025	2026	2027	2028	2029
Upstream	CO2	$49.84	$30.80	$133.27	$129.72	$125.58	$119.32
	CH4	$5.84	$3.72	$15.64	$15.33	$15.40	$14.73
	N2O	$0.64	$0.40	$1.69	$1.68	$1.64	$1.57
Ongoing Combustion	CO2	$2,643.03	$3,204.18	$3,468.51	$3,070.96	$3,025.07	$2,770.15
	CH4	$0.98	$1.15	$1.24	$1.17	$1.19	$1.14
	N2O	$21.15	$25.55	$27.62	$25.05	$24.31	$23.15
Ongoing Non-Combustion	CO2	$185.84	$184.91	$195.90	$213.22	$225.86	$235.24
	CH4	$143.32	$138.77	$150.95	$164.89	$176.25	$182.82
	N2O	$3.28	$3.45	$3.67	$4.03	$4.37	$4.60
Downstream	CO2	$0.00	$0.16	$0.00	$5.16	$5.83	$5.56
	CH4	$0.00	$0.00	$0.00	$0.10	$0.12	$0.11
	N2O	$0.00	$0.00	$0.00	$0.08	$0.09	$0.09
4D WH Phase	**GHG**	**2030**	**2031**	**2032**	**2033**	**2034**	**2035**
Upstream	CO2	$145.50	$165.79	$290.09	$329.52	$341.85	$164.17
	CH4	$17.42	$19.58	$26.84	$30.83	$32.26	$21.18
	N2O	$2.01	$2.28	$3.34	$3.98	$4.14	$2.21
Ongoing Combustion	CO2	$2,776.19	$2,617.52	$1,656.66	$1,318.23	$695.36	$460.06
	CH4	$1.15	$1.07	$0.88	$0.82	$0.55	$0.52
	N2O	$23.27	$22.13	$13.39	$11.86	$7.97	$7.41
Ongoing Non-Combustion	CO2	$240.53	$238.39	$382.08	$383.11	$425.08	$437.30
	CH4	$186.46	$178.45	$137.82	$185.46	$196.46	$238.35
	N2O	$4.84	$5.02	$6.13	$6.31	$6.67	$6.95
Downstream	CO2	$0.00	$0.12	$12.44	$3.32	$0.00	$1.19
	CH4	$0.00	$0.00	$0.26	$0.07	$0.00	$0.03
	N2O	$0.00	$0.00	$0.20	$0.05	$0.00	$0.02
4D WH Phase	**GHG**	**2036**	**2037**	**2038**	**2039**	**2040**	**2041**
Upstream	CO2	$0.00	$36.76	$0.00	$0.00	$47.53	$33.34
	CH4	$0.00	$4.89	$0.00	$0.00	$6.45	$4.23
	N2O	$0.00	$0.49	$0.00	$0.00	$0.63	$0.44
Ongoing Combustion	CO2	$418.94	$385.00	$151.14	$150.21	$159.07	$163.32
	CH4	$0.50	$0.49	$0.38	$0.39	$0.42	$0.43
	N2O	$7.17	$7.01	$5.37	$5.55	$5.83	$6.02
Ongoing Non-Combustion	CO2	$442.96	$448.12	$412.63	$429.51	$450.50	$468.58
	CH4	$244.51	$251.08	$264.25	$273.44	$290.48	$304.86
	N2O	$7.33	$7.61	$7.64	$7.99	$8.36	$8.72
Downstream	CO2	$0.23	$0.29	$0.00	$1.57	$0.16	$0.47
	CH4	$0.01	$0.01	$0.00	$0.04	$0.00	$0.01
	N2O	$0.00	$0.00	$0.00	$0.03	$0.00	$0.01

4D WH Phase	GHG	2042	2043	2044	2045	2046	2047
Upstream	CO2	$9.19	$120.22	$106.38	$259.66	$293.83	$276.07
	CH4	$0.94	$15.53	$14.34	$36.32	$39.94	$36.91
	N2O	$0.16	$1.76	$1.45	$3.52	$4.17	$3.98
Ongoing Combustion	CO2	$173.97	$182.45	$195.43	$198.86	$210.42	$214.63
	CH4	$0.46	$0.48	$0.50	$0.52	$0.51	$0.53
	N2O	$6.35	$6.60	$6.97	$7.24	$7.00	$7.23
Ongoing Non-Combustion	CO2	$493.11	$511.08	$543.32	$563.89	$570.15	$590.13
	CH4	$321.17	$333.87	$359.21	$370.83	$372.86	$383.46
	N2O	$9.15	$9.54	$10.07	$10.49	$11.06	$11.67
Downstream	CO2	$1.29	$0.74	$0.00	$3.91	$3.11	$1.45
	CH4	$0.03	$0.02	$0.00	$0.09	$0.07	$0.03
	N2O	$0.02	$0.01	$0.00	$0.07	$0.05	$0.02

4D WH Phase	GHG	2048	2049	2050	NPV (2024-2050, millions of 2024$)
Upstream	CO2	$277.35	$293.41	$61.42	$1,693.79
	CH4	$37.65	$39.72	$6.44	$195.64
	N2O	$4.02	$4.25	$1.08	$22.11
Ongoing Combustion	CO2	$230.06	$221.34	$240.46	$22,175.24
	CH4	$0.55	$0.56	$0.59	$10.79
	N2O	$7.58	$7.65	$8.03	$204.46
Ongoing Non-Combustion	CO2	$615.63	$628.75	$660.65	$4,374.42
	CH4	$398.55	$402.63	$423.50	$2,803.54
	N2O	$12.37	$12.97	$13.77	$80.16
Downstream	CO2	$1.13	$1.56	$0.00	$26.51
	CH4	$0.03	$0.04	$0.00	$0.56
	N2O	$0.02	$0.03	$0.00	$0.43

Table D-12: EPA Social Cost for Portfolio 4D (NPV 2024-2050, millions of 2024$), Net-zero Regulation with Distributed and Demand Side Focus (Representing the Lowest Total GHG Portfolio Studied)

4D EPA Phase	GHG	2024	2025	2026	2027	2028	2029
Upstream	CO_2	$187.27	$115.73	$498.40	$485.13	$469.65	$444.28
	CH_4	$6.81	$4.38	$18.60	$18.39	$18.64	$17.97
	N_2O	$1.89	$1.16	$4.95	$4.90	$4.80	$4.57
Ongoing Combustion	CO_2	$9,931.37	$12,039.16	$12,971.25	$11,484.63	$11,313.32	$10,314.58
	CH_4	$1.15	$1.35	$1.48	$1.41	$1.44	$1.39
	N_2O	$61.96	$74.77	$80.78	$73.19	$70.96	$67.52
Ongoing Non-Combustion	CO_2	$698.30	$694.78	$732.62	$797.38	$844.67	$875.91
	CH_4	$167.06	$163.40	$179.51	$197.84	$213.33	$223.02
	N_2O	$9.60	$10.10	$10.74	$11.78	$12.75	$13.43
Downstream	CO_2	$0.00	$0.61	$0.00	$19.30	$21.82	$20.69
	CH_4	$0.00	$0.00	$0.00	$0.13	$0.14	$0.14
	N_2O	$0.00	$0.01	$0.00	$0.24	$0.27	$0.26
4D EPA Phase	**GHG**	**2030**	**2031**	**2032**	**2033**	**2034**	**2035**
Upstream	CO_2	$541.82	$616.70	$1,073.37	$1,218.07	$1,262.48	$603.30
	CH_4	$21.41	$24.25	$33.50	$38.77	$40.83	$26.98
	N_2O	$5.85	$6.63	$9.69	$11.50	$11.94	$6.36
Ongoing Combustion	CO_2	$10,338.13	$9,736.45	$6,129.83	$4,872.89	$2,568.03	$1,690.69
	CH_4	$1.41	$1.33	$1.10	$1.03	$0.70	$0.66
	N_2O	$67.83	$64.33	$38.82	$34.31	$23.00	$21.33
Ongoing Non-Combustion	CO_2	$895.72	$886.76	$1,413.73	$1,416.20	$1,569.86	$1,607.06
	CH_4	$229.26	$221.08	$172.04	$233.16	$248.65	$303.58
	N_2O	$14.11	$14.59	$17.78	$18.25	$19.24	$20.00
Downstream	CO_2	$0.00	$0.44	$46.03	$12.27	$0.00	$4.39
	CH_4	$0.00	$0.00	$0.33	$0.09	$0.00	$0.03
	N_2O	$0.00	$0.01	$0.59	$0.16	$0.00	$0.06
4D EPA Phase	**GHG**	**2036**	**2037**	**2038**	**2039**	**2040**	**2041**
Upstream	CO_2	$0.00	$134.86	$0.00	$0.00	$173.37	$121.53
	CH_4	$0.00	$6.29	$0.00	$0.00	$8.43	$5.56
	N_2O	$0.00	$1.40	$0.00	$0.00	$1.81	$1.26
Ongoing Combustion	CO_2	$1,538.32	$1,412.60	$551.98	$548.24	$580.17	$595.29
	CH_4	$0.64	$0.64	$0.49	$0.51	$0.54	$0.57
	N_2O	$20.60	$20.10	$15.37	$15.83	$16.60	$17.14
Ongoing Non-Combustion	CO_2	$1,626.55	$1,644.20	$1,507.00	$1,567.60	$1,643.14	$1,707.95
	CH_4	$313.19	$323.43	$342.23	$355.95	$379.87	$401.27
	N_2O	$21.07	$21.80	$21.85	$22.80	$23.83	$24.81
Downstream	CO_2	$0.86	$1.07	$0.00	$5.74	$0.59	$1.72
	CH_4	$0.01	$0.01	$0.00	$0.05	$0.00	$0.01
	N_2O	$0.01	$0.01	$0.00	$0.07	$0.01	$0.02

4D EPA Phase	GHG	2042	2043	2044	2045	2046	2047
Upstream	CO_2	$33.46	$437.62	$387.02	$944.11	$1,067.76	$1,006.06
	CH_4	$1.25	$20.70	$19.22	$48.93	$54.09	$50.24
	N_2O	$0.47	$5.00	$4.10	$9.98	$11.81	$11.24
Ongoing Combustion	CO_2	$633.68	$664.19	$710.99	$723.07	$764.63	$782.15
	CH_4	$0.60	$0.63	$0.67	$0.71	$0.69	$0.72
	N_2O	$18.04	$18.75	$19.75	$20.51	$19.82	$20.45
Ongoing Non-Combustion	CO_2	$1,796.20	$1,860.49	$1,976.66	$2,050.31	$2,071.89	$2,150.53
	CH_4	$425.49	$444.92	$481.39	$499.62	$504.94	$521.84
	N_2O	$26.00	$27.09	$28.55	$29.72	$31.29	$33.00
Downstream	CO_2	$4.69	$2.71	$0.00	$14.20	$11.30	$5.29
	CH_4	$0.04	$0.02	$0.00	$0.12	$0.10	$0.05
	N_2O	$0.06	$0.04	$0.00	$0.19	$0.15	$0.07

4D EPA Phase	GHG	2048	2049	2050	NPV (2024-2050, millions of 2024$)
Upstream	CO_2	$1,010.14	$1,068.01	$223.43	$6,262.31
	CH_4	$51.47	$54.56	$8.88	$247.36
	N_2O	$11.35	$12.00	$3.04	$63.82
Ongoing Combustion	CO_2	$837.91	$805.67	$874.78	$82,749.67
	CH_4	$0.76	$0.77	$0.81	$13.29
	N_2O	$21.41	$21.60	$22.65	$594.45
Ongoing Non-Combustion	CO_2	$2,242.18	$2,288.67	$2,403.45	$16,116.21
	CH_4	$544.94	$552.99	$584.17	$3,566.50
	N_2O	$34.93	$36.61	$38.82	$230.53
Downstream	CO_2	$4.12	$5.67	$0.00	$98.29
	CH_4	$0.04	$0.05	$0.00	$0.70
	N_2O	$0.05	$0.07	$0.00	$1.25

TVA

E

Appendix E – NEPA Documents Reviewed for Chapter 5 Generic Effects Tables

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Appendix E - NEPA Documents Reviewed for Chapter 5 Generic Effects Tables

The following five NEPA documents (available at www.tva.gov/nepa) were reviewed by TVA in compiling information presented in *Table 5-2 (Generic Construction Effects of Natural Gas Generation Plants (TVA Projects 2010-2022)*:

- Allen Fossil Plant Emission Control Project Environmental Assessment, August 2014
- Paradise and Colbert Combustion Turbine Plants Environmental Assessment, June 2021
- Cumberland Fossil Plant Retirement Final Environmental Impact Statement, December 2022
- John Sevier Fossil Plant Addition of Gas-Fired Combustion Turbine/Combined-Cycle Generating Capacity and Associated Gas Pipeline Environmental Assessment, March 2010
- Johnsonville Aeroderivative Combustion Turbine Project Environmental Assessment, July 2022

To compile information for *Table 5-4 (Generic Construction Effects of Solar Generation Facilities (TVA Projects 2014-2023),* TVA reviewed the following 44 environmental documents that analyzed impacts at 47 solar projects (available at www.tva.gov/nepa):

- Bellefonte Solar Energy Center Project Environmental Assessment, April 2020
- Cumberland Solar Farm Environmental Assessment, January 2018
- Elora Solar Energy Center Project Environmental Assessment, February 2020
- Five Western North Carolina Solar Farms Environmental Assessments (5 documents), March and April 2014
- Golden Triangle I Solar and Battery Energy Storage (BESS) Project Draft Environmental Assessment, December 2020
- Golden Triangle II Solar Facility and BESS Project Environmental Assessment, May 2022
- Haywood Solar Farm Environmental Assessment, March 2017
- Horus Kentucky 1 Solar Project Environmental Assessment, December 2021
- Houston, Mississippi Solar Farms Environmental Assessment, June 2016
- Jackson Solar Project Environmental Assessment, March 2019
- JEA Industrial Community Solar Environmental Assessment, March 2019
- Jonesborough Solar Site Environmental Assessment, October 2017
- Knoxville Utilities Board Solar Project Environmental Assessment, October 2020
- Latitude Solar Center Environmental Assessment, August 2016
- Logan County Solar Environmental Assessment, January 2023
- Marshall Properties Solar Farm Environmental Assessment, March 2014
- Memphis Solar Project Environmental Assessment, December 2018
- Millington Solar Farm Environmental Assessment, December 2017
- Moore County Solar Project Final Environmental Impact Assessment, December 2022
- Muscle Shoals Solar Project Environmental Assessment, November 2019
- Naval Air Station Meridian Solar Farm Environmental Assessment, April 2017 (U.S. Department of the Navy)
- North Alabama Utility-Scale Solar Project Final Environmental Impact Statement, May 2022
- Optimist Solar and BESS Project Environmental Assessment, September 2022
- Purchase of Power Generated at Brownsville, Tennessee Solar Facility, March 2017
- Providence Solar Center Environmental Assessment, March 2016
- Pulaski Energy Park Expansion Environmental Assessment, April 2014
- Ridgely Energy Farm Environmental Assessment, April 2021
- River Bend Solar Project Environmental Assessment, November 2015
- Selmer North I Solar Project Environmental Assessments, October 2016

- Selmer North II Solar Project Environmental Assessments, August 2016
- Skyhawk Solar Project Environmental Assessment, January 2021
- Silicon Ranch (SR) Bell Buckle Solar Project Environmental Assessment, November 2021
- SR Canadaville Solar Environmental Assessment, July 2022
- SR McKellar Solar Project Environmental Assessment, May 2021
- SR Millingston II Solar Project Environmental Assessment, August 2022
- Starkville Solar Facilities Environmental Assessment (3 locations were analyzed separately), February 2014
- Volunteer Electric Cooperative – Gaynor Solar Project, July 2023
- Wildberry Solar Center Environmental Assessment, June 2016
- WR Graceland Solar Project Environmental Assessment, September 2022
- Yum Yum Solar Project Environmental Assessment, December 2019

To compile information for Table 5-5 (Generic Effects of Transmission System Construction and Maintenance Activities (TVA Projects 2005-2023), TVA reviewed records of the following 470 transmission-related projects:

Environmental Impact Statements	Completion Date
500-kV Transmission Line in Middle Tennessee	1-Oct-2005
Rutherford-Williamson-Davidson Power Supply Improvement Project	1-Apr-2008

Environmental Assessments	Completion Date
Algood 161-KV Transmission Line	1-May-2008
Anderson 500-kV Substation and Associated System Modifications	9-Dec-2020
Artesia-West Columbus Power System Improvements	31-Aug-2020
Ashland, Mississippi 161-kV Delivery Point	1-Jun-2016
Biggersville, MS	1-Jan-2010
Bradley 500-KV Substation and Transmission Line - Southeast Area Power Improvement Project	1-Jun-2005
Bridgeport Alabama Power Supply Upgrade	1-Feb-2008
Burkesville, KY 161-kV Transmission Line	9-Mar-2012
Burlison 161-kV Transmission Line	May-27-2011
Calhoun, Georgia – Area Powere Sysem Improvements	1-Apr-2016
Calpine's Morgan Energy Center Transmission Line	1-Sep-2005
Center Point to Moss Lake Substation, N. Georgia	1-Aug-2007
Columbus Air Force Base 161-kV Substation and Transmission Line	1-Sep-2005
Eagle Creek 161-kV Transmission Line	8-Oct-2020
East Franklin-Triune 161-KV Transmission Line Tap to Clovercroft 161-KV Substation	1-Nov-2006
Etowah Power Supply Improvement Project	1-Mar-2005
Five Points-Homewood 161-kV Transmission Line	1-Mar-2006
Florence-South Jackson 115-kV Transmission Line - Mississippi	1-Nov-2010
Gallatin Fossil Plant-Angeltown 161-kV Transmission Line and Switching Station	Oct-8-2010
Helicon, Alabama Power Supply Improvement Project	Apr-7-2011
Hillsboro 161-kV Transmission Line	Dec-17-2012
Holly Springs-Miller 161-KV Transmission Line Tap to Coldwater Substation	1-Aug-2007
Kelsey Road-Byrdstown 161-kV Transmission Line and Switching Station	Jan-31-11
Kirkmansville-Clifty City Power Improvement Project	1-Feb-2005
Madison-Charity Lane 161-kV Transmission Line	Jul-9-2013
Memphis Regional Megasite Power Supply	1-Feb-2016
Memphis Regional Megasite Power Supply SEA	1-Jun-2022

Environmental Assessments	Completion Date
Monroe, TN-Provide 161-KV Delivery Point	1-Dec-2008
Montgomery-Oakwood Transmission Line	1-Feb-2007
Montpelier, Mississippi 161-kV Transmission Line	1-Feb-2017
Moscow-Miller Power System Improvements	16-Oct-2019
Murfreesboro-East Franklin and Pinhook-Radnor 161-KV Transmission Lines	1-Mar-2007
New Transmission Line to Bolivar Substation	1-Nov-2006
North Dayton Power System Improvements	30-Oct-2020
ORNL Primary 161-kV Substation and Transmission Line Connection	1-May-2005
Oxford-Coffeeville, Mississippi 161 kV Transmission Line	28-Feb-2019
Putnam-Cumberland, Tennessee Improve Power Supply Project	Nov-13-2013
Ranger North Carolina Substation 161-kV Delivery Point	1-Apr-2005
RedHills-Kosciusko 161-kV Transmission Line	1-Jan-2017
Replacement Ocoee Transmission Line	1-Nov-2006
Replacement of Structure 7 - Kentucky Hydroelectric Plant-Gilbertsville 69-kV Transmission Line, KY Dam Reservation	Jun-15-2010
Rugby-Sunbright Power Supply Improvements	1-Feb-2017
Selmer-West Adamsville 161-kV Transmission Line and Swiching Station	1-Jan-2015
SeverCorr 2-Catalpa Crk-Lowndes County Power Supply Improvement Project	1-Jan-2008
South Pittsburg 161-kV Delivery Point	20-Aug-2014
Starksville and Columbus, Mississippi - Power Supply Improvements	Jul-9-2010
Supplement to the Wacker Chemi Poly 11 Request for TVA Land Use and Section 26a Approval	Jul-21-2011
Transmission Line Tap to New BGMU Substation	1-Dec-2006
TVA System Operations Center and Power System Supply	19-Feb-2020
Union-Rally Hill 161-kV Transmission System Improvements	Aug-8-2010
Union-Tupelo No. 3 161-kV Transmission Line	1-Oct-2014
Volunteer-East Knox Bulk Transmission Project	Dec-03-2012
Watts Bar Hydro Plant-Great Falls Hydro Plant 161-kV Transmission Line Tap to Spencer & Great Falls Hydro Plant-Spencer 46-kV Transmission Line Retirement and Removal	1-Feb-2016
Weir 161-kV Transmission Line	1-Jan-2006
West Batesville-North Oakland, Mississippi 161-kV Transmission Line	27-Oct-2017
West Pleasant Hill 161-KV Transmission Line	1-May-2006
West Point-SeverCorr 161-KV Transmission Line	1-Mar-2006

Categorical Exclusion Checklist (CEC) Reviews	Completion Date	CEC #
Wrigley-Dickson District- Retire 12.1 miles of TL	19-Mar-2001	32051
Polk Tennessee Delivery Point	10-Mar-2008	17616
Improve Power Supply in Huntsville, TN Area	25-Mar-2008	17898
Park City 161-kV Substation-Provide Delivery Point	8-Oct-2008	19175
Resaca North and Resaca South-Construct Tap Line	4-Nov-2008	19510
Locust Fork-Ketona Transmission Line-Relocation for Alawest	22-Dec-2008	19727
Revision-Gallatin-Murfressboro 161-kV Uprate	1-Jan-2009	17348
Campbelltown 161-kV Delivery Point	22-Jan-2009	18085
Parsons, TN 161-kV Substation-Provide Delivery Point	6-Feb-2009	19104
Milligan College 161-kV Substation-Provide Delivery Point	15-Apr-2009	20291
Jena, TN 161-kV Substation-Provide Delivery Point	21-Apr-2009	20251
Fanin 161-kV Delivery Point	23-Apr-2009	20326

Categorical Exclusion Checklist (CEC) Reviews	Completion Date	CEC #
Revision-Marshall-C33 161-kV TL-Reconductor	21-May-2009	18236
Wheeler-Maury 161-kV TL-Uprate/Reconductor Project	7-Jul-2009	20704
North Cowan-161-kV Substation and Connections	31-Jul-2009	19691
Moccasin 161-kV Substation-Install Capacitor Bank	29-Sep-2009	21154
Revision 2-Johnsonville-South Jackson 161-kV TL Uprate	7-Jan-2010	20346
Volkswagen Chattanooga-Provide 161-kV Delivery Point	15-Jan-2010	20430
Revision 1-Alvaton 161-kV Delivery Point	11-Feb-2010	20719
Elysian Fields - Craighead 161-kV TL - Reconductor Section	25-Mar-2010	21986
Revision 1-Taylor-McFerrin 161-kV Delivery Point	8-Apr-2010	18084
Cloudland Canyon, GA. 230-kV SS - Provide 230-kV Deliver Point - Project No. 203515	27-Apr-2010	22236
Owl Hollow, TN-Provide 161-kV Delivery Point	9-Jun-2010	20709
Rainsville 161-kV Substation-Provide Delivery Point - Project 201470	28-Jun-2010	22511
County Line Rd., AL. 161-kV SS - Provide Delivery Point - PN 201326	8-Jul-2010	22640
Madison Farley #1 & #2 161-kV TL Uprate - Project 104432	19-Aug-2010	22884
Cordova - Freeport 500-kV TL - Relocation for Memphis BFI Landfill - Project No. 203551	24-Aug-2010	22939
East Batesville, MS 161-kV SS - Provide Delivery Point & Breakers - Project No. 200417	23-Sep-2010	23121
Hemlock Semiconductor, TN 161-kV Substation-Provide Delivery Point	6-Oct-2010	21876
Kingston 161-kV Substation-Provide Delivery Point	9-Oct-2010	21215
Wheeler Mountain, TN. 161-kV - Provide Delivery Point - PN.104032	18-Oct-2010	23209
Byrd Springs, AL SS - Provide 161-kv Delivery Point - PN 200527	18-Oct-2010	23243
Widows Creek Fossil Plant - Install Capacitor Banks - PN 203604	20-Oct-2010	23192
Morris 161-kV Delivery Point	21-Oct-2010	23012
Gibbs Lane, TN. 161-kV SS - Provide Delivery Point – PN 203592	17-Nov-2010	23398
Chapel Hill, TN. 161-kv SS - Provide 161-kV Deliver Point - 202366	24-Jan-2011	23661
New Albany - Ripley 161-kV TL - Relocate for MDOT - PN 203914	9-Feb-2011	23756
Rockvale, TN Provide Delivery Point Project Number 107008,	28-Mar-2011	23634
201460 - Niles Ferry, TN. SS - Provide Delivery Point - PN 201460	8-Apr-2011	23283
Tiptonville-Ridgley 161kV Reconductor Project Number 205943	15-Apr-2011	24209
S. Philadelphia MS, Provide 161-KV Delivery Point Project Number: 103581	18-Apr-2011	23671
Southwest Bruce 161-kV Delivery Point - Project No. 102907,	9-May-2011	24200
Shelby-Cordova # 2 500-KV TL	27-Jul-2011	24367
North Knoxville – Eagle Bend 161-kV TL – Relocate for Chestnut Ridge Landfill - Project No. 204353	15-Aug-2011	24860
Niota, TN. 161-kV SS - Provide Delivery Point - Project No. 107345	24-Aug-2011	24950
Mt. Vernon Road Provide Delivery Point Project Number: 200588	31-Aug-2011	24966
Goodlettsville, Tn 161kV Substation - Improve Power Supply	26-Sep-2011	25105
Widows Creek - Rock Springs 230kV T.L. Relocate for GADOT Project 400459	17-Oct-2011	25292
Redstone Arsenal No. 1 161-kV SS – Relocate Substation - 205768	20-Oct-2011	25321
Ripley, TN. 161-kV SS - Supply Loop Feed and Install Breakers - 202363	27-Oct-2011	25355
Greeneville, TN. 161-kV SS - Install 161-kV Capacitor Banks - 400180	6-Dec-2011	25512
Bells 161-kV Delivery Point - Project 202094 - line and substation expansion	5-Jan-2012	25466
Occidental, TN. 161-kV SS - Provide Delivery Point - 205922/205946	17-Jan-2012	25696
Revision - Lake Lowndes 161-kV Delivery Point - Project 104651	19-Jan-2012	25166
Guntersville - Goosepond 161-kV TL - Up-rate/Reconductor - 203607	30-Jan-2012	23736
Shipps Bend, Tn. 161-kV SS - Provide Delivery Point - 204641	8-Feb-2012	25819

Categorical Exclusion Checklist (CEC) Reviews	Completion Date	CEC #
Rarity Pointe, TN 161kV Substation Provide 161kV Delivery Point (Fort Loudoun EC)	9-Apr-2012	26122
East Simpson Ky 161-KV Provide Delivery Point - Project 106988	2-May-2012	23329
Calvert-South Calvert 161-kV TL - Reconductor - Project 402465	15-May-2012	25549
Holly Springs - Miller 161-kV TL - Relocate for MDOT - 203883	18-May-2012	26434
Revision - Beulah Grove 161-kV Delivery Point - Project 204615	31-May-2012	26143
East Point - Fairview 161-kV TL - Uprate - 204098 - W.O. 4497A - reconductor and select pole modifications	13-Jun-2012	26592
Guntersville - Decatur 161kV Transmission Line Reconductor Decatur - Priceville Section	13-Jul-2012	26722
Bridgeport, Al SS Slack Span Delivery Point Project Number 200587	13-Jul-2012	26773
Paradise - Wilson - New Hardinsburg 161-kV TL - Modify Protection and Associated Equipment for 3-Terminal TL(BREC) - 403390	14-Aug-2012	26893
Revision - Marshall-Calvert #1 and #2 161-kV TL Reconductor - Project 204542	5-Sep-2012	23266
HCA, TN 161kV Substation Provide Delivery Point	14-Sep-2012	27032
Wilson HP - Shoals 161kV TL Reconductor Line	23-Oct-2012	27314
Finley SS - Amoco 161-kV TL - Up-Rate - 206051	24-Oct-2012	27312
Montgomery-Clarksville #1 / Montgomery-Savage 161kV TL CIP Relocation	25-Oct-2012	27334
Waverly, MS161 kV Substation Provide Delivery Point (4 County EPA)	30-Oct-2012	27381
Wilson HP - Reynolds 161kV TL Reconductor Line	31-Oct-2012	27344
Lexington 161-kV SS - Convert to 161-kV Operation - 102383 - 44K87 & 43Q84.	26-Nov-2012	27471
Widows Creek - East Point 500-kV TL - Relocate for Duck River Reservoir - 400139	3-Dec-2012	26220
South Limestone, AL. 161-kV SS - Provide Delivery Point - 404798	10-Dec-2012	27518
Jackson Avenue, Alabama 161 kv Substation Provide Delivery Point	20-Dec-2012	27591
Replacement of two spans of OPGW on the Murfreesboro-Smyrna 161kV TL	23-Jan-2013	27758
Wilson-Shoals 161-KV TL – Reconductor, Material Laydown Yard	25-Jan-2013	27792
Construction Laydown Yard - Chesterfield - Montgomery 161-kV SS - Convert to 161-kV Operation	25-Jan-2013	27800
Volunteer-East Knox Bulk Transmission Project - Construction Laydown Yard - Project 102350	12-Feb-2013	27905
C33-Marshall 161-kV TL Uprate and Reconductor - Project 206074	1-Mar-2013	26892
Montgomery, TN. 161-kV SS - Convert To 161-kV Operation - 202006	1-Mar-2013	27329
Trinity - Browns Ferry NP 161 & 500-kV TL - Uprate & Install OPGW - 206087	12-Mar-2013	28027
Toray, AL. 161-kV SS - Provide Delivery Point (JWEMC) - 407271	29-Apr-2013	28284
Ardmore - Fayetteville 161kV TL Reconductor Ardmore-Park City Line Section	30-Apr-2013	27299
Marshall-Golo-Mayfield 161-kV TL - Uprate and Reconductor - Project 402468	29-May-2013	28469
Centerville, TN. 161-kV SS - Relocate Substation - Project No. 205814	10-Jun-2013	28547
Colbert Fossil Plant - Install Capacitor Bank	11-Jul-2013	28681
Mecca Pike 161-kV Delivery Point - Project 205908	22-Jul-2013	28347
Oak Level, KY. 161-kV SS - Provide Delivery Point (West Kentucky RECC) - Project No. 403949	22-Jul-2013	28755
Johnsonville – McEwen 69-kV TL – Retire, Acquire, and Relocate Sections of TL - Project No. 406030	22-Jul-2013	28767
John Sevier-White Pine #2 161-kV TL Uprate - Project 400456, W.O. 310CT (conductor replacement)	31-Jul-2013	28787
Bethel Valley, TN. 161-kV SS - Construct SS and TL Feeds for ORNL - 406588	5-Aug-2013	28515
Revision - Hartselle-Cullman 161-kV TL Uprate - Project 400209	13-Aug-2013	27894
Georgetown, TN. 161-kV Substation - Provide Delivery Point (VEC) - Project No. 107018	19-Aug-2013	28909
Trinity -Caddo 161-kV Transmission Line Uprate - reconductoring	3-Sep-2013	28967

Categorical Exclusion Checklist (CEC) Reviews	Completion Date	CEC #
Cordova-Benton 500kV Uprate	5-Sep-2013	28108
Athens-Ardmore 161kV TL Rebuild - Project 206089 - reconductor entire line and replace many structures	11-Sep-2013	28134
Revision - Browns Ferry-Athens 161-kV TL Rebuild - Project 206083	2-Oct-2013	27943
Lake Kathy, Ga - Provide Delivery Point	23-Oct-2013	29248
Geraldine 161 kV Substation	24-Oct-2013	27276
Colbert Shoals 161-kV TL - Reconductor Shoals - Tuscumbia - Woodmont TL Section - Project No. 400207	4-Nov-2013	29336
Barkley Hydro Plant - Oakwood Switching Station 161kV TL Uprate	6-Nov-2013	29377
GAF Scrubber - TL Feeds and associated Relay and Yard Work	13-Nov-2013	28940
Trinity Hills, TN. 161-kV SS - Provide Delivery Point - 407583	14-Nov-2013	29446
161-kV Delivery Point at Flex Drive	19-Nov-2013	29411
Colbert FP-Oakland 161kV TL Reconductor and Uprate	2-Dec-2013	29419
Triathlon 161-kV Delivery Point - Project 409174	4-Dec-2013	29360
Northwest Area Fiber Project - Install Fiber Optic Equipment - Project: 206093	9-Jan-2014	29687
Volunteer-North Knoxville 161kV TL Reconductor	10-Jan-2014	29695
Construction Laydown Yard - Trinity - Decatur - Guntersville 161-kV TL- Reconductor	15-Jan-2014	28554
Construction Laydown Yard - Apalachia - East Cleveland No. 1 & No. 2 161-kV TL - Uprate	16-Jan-2014	29738
Guntersville - Farley 161-kV TL - Uprate - Project No. 203609	17-Jan-2014	23640
Apalachia - East Cleveland No. 1 161-kV TL - Reconductor/Uprate & Install Fiber Optic Cable - Project No. 205213 & 406589.	22-Jan-2014	29188
Westbourne-Jellico 69-kV Transmission Line (L3874) Retirement	14-Feb-2014	29903
Cornersville 161-kV Delivery Point - Project 400251	21-Feb-2014	29835
Waynesboro, TN 161 kV Substation - Provide Delivery Point	25-Feb-2014	28270
East Calvert, South Calvert, and Calvert Substations - Calvert Area Improvements - Project No. 406878,406901,& 406907.	25-Feb-2014	28662
Marshall Area Projects - Construction Laydown Yard	6-Mar-2014	30067
Martintown-Enterprise 46-kV Transmission Line (L2712) - Install 46-kV Sectionalizing Switch - Project: 103446	4-Apr-2014	30192
Center Hill-Str. 117 (Baxter) 46-kV Transmission Line - Transmission Line Retirement - Project: 402666	4-Apr-2014	30221
Cross Plains Capacitor Bank Addition	1-May-2014	30141
Paradise-Peabody 69-kV Transmission Line (L3857) - Transmission Line Retirement - Project: 402660	6-May-2014	30385
Center Point - Moss Lake 115/230-kV TL - GADOT Replace Structure - Project No. 413028	12-May-2014	30406
Pickwick HP - Kimberly Clark 161-kV Transmission Line (L5877) - Partial Reconductor - Project: 409552	21-May-2014	30349
Mississippi Silicon, MS 161-kV Substation (Direct Serve) - Provide Delivery Point - Project: 410270	23-Jul-2014	30813
Wolf Creek - Huntsville 161-kV TL - Uprate - Project No. 205216	28-Jul-2014	30866
Widow's Creek - Reese Ferry 161-kV TL - Reconductor & Widow's Creek - Nickajack 161-kV TL - Uprate - Projects 403986 & 403989	19-Aug-2014	30235
Roane-Harriman 161kV NERC Alert	24-Sep-2014	31243
Lafayette-Str. 4 (L3050) and Lafayette-Str. 172 (Scottsville) (L3355) 69-kV Transmission Lines Retirement - Project: 402660	25-Sep-2014	31211
Transpark, Kentucky 161KV delivery point	29-Sep-2014	31251
Winchester-Hillsboro 46-kV Transmission Line - Transmission Line Retirement - Project 202139	16-Oct-2014	31345

Categorical Exclusion Checklist (CEC) Reviews	Completion Date	CEC #
Project No. 400210 - Spring Creek-Nance 161kV Transmission Line Uprate	20-Nov-2014	31580
Belfast-Cornersville 46-kV Transmission Line - TL Retirement - Project 400251	15-Jan-2015	31882
Hankook, TN. 161-kV Substation - Provide Delivery Point - Project No. 412721	20-Jan-2015	31244
Union-Tupelo #3 161-kV Transmission Line - Construction Laydown Yard - Project 400236	2-Feb-2015	31961
Laydown Area associated with East Bowling Green - Summershade 161kV Project	2-Feb-2015	31973
Colbert - Stateline No. 1 161-kV TL - Uprate - 206039	10-Feb-2015	32012
East Bowling Green - Summer Shade 161-kV Uprate	19-Feb-2015	31680
TL Retirement- Rockwood Dist-Spring City TL- Retire 18.878 miles of TL	19-Mar-2015	32050
Great Falls-Sparta TL2437 Retirement	14-Apr-2015	31960
Temporary Construction Laydown Area - Wilson - Oakland 161-kV TL Uprate	15-Apr-2015	32393
Wilson HP-Oakland 161-kV TL - Reconductor - Project 400215	1-May-2015	32105
Vesta Road, TN - Provide 161-kV Delivery Point	5-Jun-2015	32245
John Sevier - Volunteer 161-kV TL - Uprate - Project No. 205211	22-Jun-2015	30392
Dover-Erin 69kV Transmission Line - TL Retirement-Retire approximately 10 miles of TL - Project 402667	13-Jul-2015	32708
Hopkinsville-Casky-Edgoten 161-kV Transmission Line Uprate	17-Jul-2015	32988
Fontana-Peppertree 13-kV TL Relocation/Rebuild - Project 418958	24-Jul-2015	32974
Widows Creek-Bryant-Oglethorpe #1 161-kV Transmission Line - Uprate - 206037-31A5H	21-Aug-2015	33161
Plateau 500-kV Substation - Borrow Area	14-Sep-2015	33268
Athens-Etowah Power Supply Improvement - Project 409013	23-Sep-2015	33321
Covington-Dyersburg 161-kV TL Uprate - Project 406725	5-Oct-2015	32399
Lynnville, TN. 161-kV Substation - Provide Delivery Point - 409288	7-Dec-2015	33768
Paradise CC Plant, KY. - Provide 161-kV Interconnection - 412718	22-Dec-2015	32008
Center Hill-Smithville 46kV Transmission Line Retirement	17-Feb-2016	33171
Cullman - Moulton 161-kV TL - Medium NERC Alert - Project 406572	24-Feb-2016	34199
Selmer West Adamsville Access Road Alterations	25-Feb-2016	34268
Battery Hill Access Road Improvement - Project: 422462	7-Mar-2016	34308
Construction Laydown Yard - Lynnville 161-kV TL - Provide Delivery Point	9-Mar-2016	34303
Kingston-Rockwood-Roane Brookfield Smokey Mountain Hydro 161kV TL Uprate	10-Mar-2016	34306
Wilson - Trinity OHGW Replacement - Project 107319	15-Mar-2016	34320
Morgan, AL 161-kV Delivery Point - Project 418783	21-Mar-2016	34425
Smithville, TN 161kV Transmission Line Delivery Point for Smithville Electric System (SES) PN: 420637	28-Mar-2016	34348
Franklin, KY 161-kV Substation- Project: 420182	8-Apr-2016	34114
Cordova - Haywood 500kV Uprate - Project 202879	21-Apr-2016	34662
Deerbrook 161-kV Delivery Point - Project 413337	26-Apr-2016	34598
Allen CC Plant Interconnection - 414013	28-Apr-2016	34310
John Sevier FP - Phipps Bend No 3 161kV Uprate	9-May-2016	32760
L3803-2 Gallatin-Hartsville-Westmoreland (69 Kv) 7.78 miles Line Retirement.	12-May-2016	33990
L3808 Rogersville-Fitts Gap (69 Kv) 15.197 miles Transmission Line Retirement	12-May-2016	34009
Johnsonville-Lawrenceburg 161kV TL - Lightning Mitigation - 404668	16-May-2016	34718
L3351-1 N.E. Johnson City-Erwin No. 2 (1.19 miles) Transmission Line Retirement.	19-May-2016	34003
Transmission Line Laydown Yard-Spencer,TN area projects	8-Jun-2016	34963
Wheeler - Ardmore OHGW Replacement - 107319	15-Jun-2016	34967
Oxford-CR 300 46-kV TL - Construct 161-kV TL - Project 422806	15-Jun-2016	35004
421225 Davis Ferry 161kV Delivery Point for Loudon Utilities	17-Jun-2016	35018

Categorical Exclusion Checklist (CEC) Reviews	Completion Date	CEC #
Calhoun,GA area Projects-Construction Laydown Yard	30-Jun-2016	35031
Loopers Farm – Alpha 230 KV 31GP1	5-Jul-2016	35105
Selmer West Adamsville 161-kV TL Segment Reroute	7-Jul-2016	35130
Starkville - Sturgis 161kV TL NERC Alert Remediation - Medium Priority - Project: 421234	11-Jul-2016	34265
Sequoyah - Watts Bar HP 161-kV TL	2-Aug-2016	35290
TL Retirement-L2447 Huntsville-Scottsboro (Str 125-Str 167 & Str 200-S) 46 Kv TL (5.858 miles).	8-Aug-2016	34055
Nolensville-Elysian Fields TL Reconductor - Project 202004	15-Aug-2016	35337
Murfreesboro-Smyrna 161-kV TL Reconductor - Project 202004	15-Aug-2016	35339
Murfreesboro Road-Airport 161-kV TL Reconductor - Project 202004	15-Aug-2016	35340
Relocation of Dover-Erin 69-kV TL Easement for Cumberland Landfill	12-Sep-2016	35475
Cox Road Delivery Point - 421830	26-Sep-2016	35463
Clay - Aberdeen 161-kV Uprate - Project 420116	3-Oct-2016	35140
Center Hill-Smithville 46kV Transmission Line Demolition	21-Oct-2016	35093
Bluefield, MS. 161-kV Substation - Provide Delivery Point – 417652	21-Oct-2016	35669
Westbourne-Jellico 69-kV Transmission Line (L3874) Retirement Phase 1 - Emergency Work PN: 402659	8-Nov-2016	35595
Temporary Construction Laydown Yard : Deerbrook 161-kV Delivery Point - Project 413337	21-Nov-2016	35864
Weyerhaeuser-S. Macon NERC MP L5316 31IPT	22-Nov-2016	35858
Southeast Huntsville, AL. 161-kV Substation - Provide Delivery Point (Huntsville Utilities) - 409812	22-Nov-2016	35862
Buck Island Delivery Point - Project No. 414719	28-Nov-2016	35813
Clay-Starkville (West Point) 161-KV T.L. NERC Medium Priority Remediation L5675 31K1P	28-Nov-2016	35880
Colbert-Pickwick	5-Dec-2016	35856
Broadview, TN 161kV DP for DREMC	8-Dec-2016	34477
Weakley-Dyersburg 1 161 KV TL 415149	21-Dec-2016	35282
Pine Ridge, TN. 161-kV Switching Station - Provide Delivery Point (Y12-UPF) - 422917	4-Jan-2017	36047
Guntown-Turner Park 46kV Transmission Line (L2470), Structures 570D, 571, 572, and 578 - Line Retirement	23-Jan-2017	35982
Demolition of the Englewood-Madisonville 69 KV transmission line (L3056).	23-Feb-2017	34987
Oakland, Alabama OPGW Fiber line ROW Clearing	23-Feb-2017	36125
North Huntsville-Limestone L5836 TL Medium Priority NERC Alert - Project Number 421234	24-Feb-2017	36120
Guthrie Kentucky Purchase R.O.W - 418551	2-Mar-2017	36361
Indorama 161-kV – Provide Temporary 161-kV Feed to Indorama - 427179	8-Mar-2017	36421
Gallatin Industrial 161kV Delivery Point for Gallatin Electric Department PN: 413061	9-Mar-2017	36392
North Wilkey, KY 161kV Delivery Point for WRECC 422432	10-Mar-2017	36377
Ider, AL 161-kV Substation - Provide Delivery Point - 414720	14-Mar-2017	35930
Widows Creek FP - Provide Temporary Power Feed (NAEC) - 403988	27-Mar-2017	33975
Battery Hill TL Work - Install Moccasin Loop, Nickajack HP Loop, and OPGW - Widows Creek - Battery Hill NO.1 and NO.2 Reconductor - Project: 422462/422119	28-Mar-2017	34659
Pulaski-Fayetteville 161kV Medium NERC Alert - L5904 PN: 421234	16-Apr-2017	36643
Tupelo - Turner Park 161kV Transmission Line - 415148	18-Apr-2017	36539
Retire Portions of the Kingston - Rockwood - Roane 161kV TL - Project: 419583	26-Apr-2017	36656
Summer Shade - Summer Shade Tap 161kV Upgrade Tap Section Capacity PN: 415148, 425422, 421558	12-May-2017	36788

Categorical Exclusion Checklist (CEC) Reviews	Completion Date	CEC #
East Chickamauga, GA. 161-kV Substation - Provide Delivery Point - 407532	15-Jun-2017	36976
Jackson - Bud Crockett 161-kV TL - Medium Priority NERC Alert - 31J70 - 415148	27-Jun-2017	37031
Kittrell, TN 161-KV Delivery Point PN: 421320	2-Jul-2017	36980
Dalton B Smith 161kV Provide Transmission Line Delivery Point PN: 417829	2-Jul-2017	37030
Widows Creek - Rock Springs OPGW Installation - 426396	5-Jul-2017	36616
Sturgis - Louisville 161kV TL - OPGW Replacement - 417191	6-Jul-2017	37037
Northeast College 161-kV Substation Provide Slack Span Delivery Point Project Number: 424945	18-Jul-2017	37149
North Dayton, TN 161kV Delivery Point PN: 403139	15-Aug-2017	37261
Wildberry Solar Center Interconnection - Project: 428114	21-Aug-2017	37313
Temporary Construction Laydown Yard : Bluefield 161-kV Delivery Point - Project 417652	22-Aug-2017	37314
Bolivar-Bolivar Dist #2 46kV Transmission Line (L2659), Structures 4-17 - Line Retirement	23-Aug-2017	36039
Project 419888 - Replace Microwave System	23-Aug-2017	36255
John Sevier-Cherokee No.1 NERC Medium Priority PN: 415148	24-Aug-2017	37130
Cordova - Shelby L6089 500-kV Capacity Increase	30-Aug-2017	37234
Pinewood, TN. 161-kV Substation - Provide Delivery Point - 407530	30-Aug-2017	37359
Martintown - Enterprise 46kV TL - L2712 - Lightning Mitigation - 404668	30-Aug-2017	37399
Singleton to Kosciusko Transmission Line Rebuild	1-Sep-2017	36877
Watts Bar HP - Great Falls HP 161kV Transmission Line Relocation Section PN: 428834	5-Sep-2017	37430
Mountain Home Road Delivery Point - 409294	11-Sep-2017	34964
Longtown 161-kV Delivery Point - Project 414684	14-Sep-2017	37478
Alcoa Substation - TPS Material Storage Laydown Yard	20-Sep-2017	37511
Widows Creek - Rock Springs NAMP - Project 421234	26-Sep-2017	36620
Beckwith Connector Project - South Nashville-Green River 161-kV TL (L5029) - 425987	2-Oct-2017	37554
Nickajack Hydro Plant Reservation - TPS Material Storage Laydown Yard.	4-Oct-2017	36682
Van Vleet, MS Microwave - Replace Unlicensed MW CKT 8613 - Project: 413168	4-Oct-2017	37536
Waynesboro-Howenwald 69kV Transmission Line (L3882), Structures 1-25 and 175-244 - Line Retirement	6-Oct-2017	36040
Columbia Dist-Str 234 Lewisburg #2 46kV Transmission Line (L2468) - Line Retirement	6-Oct-2017	36178
Montgomery-Clarksville #3 161-kV TL - Construct - 202004	12-Oct-2017	36526
Newtown, TN 161kV Substation Provide Delivery Point-Metering & UFLS, 429471	16-Oct-2017	37604
Colbert - Pickwick 161-kV TL(Pickwick - Str. 74) - Install Fiber - 429445	16-Oct-2017	37606
Gallatin - Lebanon No. 1 Tap to Lebanon Idustrial Park Replace Switch PN: 421558 L5781	16-Oct-2017	37628
Moscow Microwave Repeater Station - 413168	17-Oct-2017	36988
Coosa River - Centre Rebuild River Crossing - 425124	8-Nov-2017	36843
Spring Creek, TN. 161-kV Substation - Provide Delivery Point - 425096 - 31MMD, 33MQD, & 33MQI.	13-Nov-2017	36736
Colbert - Oakland 161-kV TL (Str. 74 - Str. 66) - Install Fiber - 429445	29-Nov-2017	37827
Westbourne - Jellico 69kV Transmission Line Retirement PN: 430042	7-Dec-2017	36730
Construction Laydown Yard – Ashland, MS 161-kV TL 405784	11-Dec-2017	37920
Project Flash Switching Station and 161-kV TL Connection Project Number 432262,	21-Dec-2017	37400
SNS - ORNL 161kV Reconductor PN: 424633 & Bethel Valley 161kV Loop Kingston FP - Ft Loudon PN: 426017	3-Jan-2018	36762

Categorical Exclusion Checklist (CEC) Reviews	Completion Date	CEC #
House 161-kV Delivery Point - Project 409942	5-Jan-2018	35050
House 161-kV Delivery Point - Project 409942	15-Jan-2018	35050
Shawnee Area Reconfiguration - Project 409329, 421127, 421229	20-Jan-2018	34272
Removing 2.93 miles of L2420 segment 3 of Columbia-Jongo 46 Kv Transmission Line.	23-Jan-2018	36373
Johnsonville -Monsanto 161kV TL Replace Structure 98 - 31OUX - 431609	1-Feb-2018	37665
Sequoyah NP - Chickamauga Hydro 161-kV TL (L5043) - Install OPGW Project Number: 432352	15-Feb-2018	38236
Colbert - Wilson 161-kV TL - Install Fiber - 429445	27-Feb-2018	38289
Harriman, TN 161kV Switching Station - Install Breakers - Project: 419583	13-Mar-2018	35932
Counce - Hickory Valley L5216 MP NERC - Project Number 415148	13-Mar-2018	37190
Colbert - Reynolds #2 L5793 MP NERC - 415148	13-Mar-2018	38136
Construction Laydown Yard - Montpelier, MS. 161-kV SS - Provide Delivery Point	16-Mar-2018	37369
Union City - Samburg 69kV Transmission Line (L3860) Retirement	20-Mar-2018	36185
Latitude Solar Interconnection - Project: 430779	22-Mar-2018	38469
Gallatin-West Cookeville 161kV OPGW Installation PN; 432352	22-Mar-2018	38532
Sequoyah NP- Watts Bar HP 161-kV TL (L-5047) – Install OPGW Project Number 432352	23-Mar-2018	38165
Limestone-Jetport 161-kV TL (L5922) Install OPGW Project Number: 429445	27-Mar-2018	38581
Artesia 161-kV Delivery Point and Switching Station Construction	28-Mar-2018	37268
Johnsonville FP - Lawrenceburg 161-kV TL - Medium Priority NERC Alert	9-Apr-2018	37659
Wilson-Wheeler 161-kV TL (l5123) - Install OPGW Project Number: 429445	12-Apr-2018	38566
Wheeler-Nance (L5669) & Nance-Trinity (L5832) 161-kV TL Install Fiber Project Number: 429445	16-Apr-2018	38578
Superior Graphite #2 Provide Delivery Point PN: 432937	30-Apr-2018	38649
Science Hill, TN 161-kV Switching Station Install Capacitor Banks	3-May-2018	37127
Redstone Gateway, AL 161-kV Delivery Point - Project number 423388	3-May-2018	38764
Gallatin - Center Hill-West Cookeville, Gallatin - Cordell Hull, Cordell Hull - West Cookeville MPNA	8-May-2018	37083
Huntsville-Jetport 161-kV TL (L5146) Install OPGW Project Number: 429445	14-May-2018	38838
N. Nash.-Str.24 to Str.24A-W. Nash.(NES Whites Creek)161-kV TL-Install OPGW-PN: 432352	22-May-2018	38936
Cordova - Benton OPGW L6125 - Project Number 417191	29-May-2018	38925
Tusculum - Jonesborough 161kV Transmission Line Reconductor PN: 431164	29-May-2018	38937
Construction of 0.86-Acre LayDown Yard Within the Existing Jackson 500-kV Substation Reservation	21-Jun-2018	39076
West Greene, TN 161kV Transmission Line Delivery Point PN: 425432	12-Jul-2018	39063
Winton, AL 161-kV Switching Station & TL Loop - Project: 409268	10-Aug-2018	36793
Paradise - Montgomery 500kV Capacity Increase PN: 406884	21-Sep-2018	37464
Sullivan - NE Johnson City 161kV TL L5005 MPNA PN: 421234	21-Sep-2018	39623
Construction Laydown Yard : West Batesville - North Oakland Project : Project Number 413286	10-Oct-2018	39090
Jackson - Haywood 161-kV TL - LPC fix span 349-350 & 355-356 - 425997	12-Oct-2018	38823
Woodland Mills 161-kV Delivery Point	18-Nov-2018	31559
West Centerville-Monsanto 161kV TL MPNA L5101 PN: 415148	27-Nov-2018	37908
West Trousdale, TN 161kV Delivery Point PN: 431057	27-Nov-2018	38905
Racer, KY. 161-kV Substation - Provide Delivery Point - PN: 410513	30-Nov-2018	39250
Oakland Laydown Yard - 413286	10-Dec-2018	39468

Categorical Exclusion Checklist (CEC) Reviews	Completion Date	CEC #
Counce, TN 161-kV Switching Station - Convert to Double Breaker & Add Two Lines - Project: 424553	17-Dec-2018	36873
Russellville Industrial Park, AL. 161-kV Substation - Provide Delivery Point.	18-Dec-2018	38308
Horn Lake-Allen 161-kV TL Rebuild	10-Jan-2019	39769
Town Creek, AL 161-kV substation - Provide delivery point. Project: 435304	10-Jan-2019	39789
Bud Crockett, TN 161-kV Switching Station - Provide Slack Span Delivery Point - Project: 416952	16-Jan-2019	40146
Dumplin Valley - Pigeon Forge WO: 31PBQ PN: 407277	29-Jan-2019	40287
New Johnsonville, TN. 161-kV Substation - Provide Delivery Point - 430383 - 31ODT.	4-Feb-2019	38755
Clay Ms 500-kV Laydown Yard	14-Feb-2019	39826
Sandtown 161-kV Delivery Point : 426571	25-Feb-2019	36956
Construction Laydown Yard - Alcoa Substation	25-Feb-2019	39042
Guthrie, KY. 161-kV Substation - Provide Delivery Point to Pennyrile RECC - 435580	27-Feb-2019	38223
North Starkville Delivery Point - Project Number 432320	11-Mar-2019	39362
Provide 161-kV Delivery Point - Paducah Gaseous Diffusion Plant (PGDP) - Project: 434276	13-Mar-2019	38380
Oxford-Coffeeville 161-kV TL - Construction Laydown Yard - Project 420142	19-Mar-2019	40658
West Ringgold - Alpha 115/230-kV TL - GA DOT Relocation - PN: 433434	26-Mar-2019	39680
Wolf Creek HP - Summer Shade No. 1 MPNA L5700 PN: 415148	18-Apr-2019	38671
Douglas HP-Pigeon Forge 161kV TL L5693 MPNA PN: 415148	24-Apr-2019	39696
Sedalia, KY. 161-kV Delivery Point - PN: 430142	20-May-2019	39253
Sewell, AL 161-kV Substation and Transmission Line Project Number 435704	29-May-2019	39541
Springfield-Logan Aluminum 161kV MPNA L5310 PN: 415148	29-May-2019	40373
Singleton-Leake Laydown Yard Project Number 409032	17-Jun-2019	41122
Construction Laydown Yard - Counce Area Projects	20-Jun-2019	41143
Piperton, TN 161-kV substation: Provide delivery point. Project: 441422 - WO: 33U9W; Project: 441576	21-Jun-2019	40829
Vonore, TN 161kV Substation Construct and 161kV Transmission Line PN: 429909	2-Jul-2019	37841
Blackjack, MS 161-kV SS- Provide Delivery Point - 429943	12-Jul-2019	37403
Miser, TN 161kV Transmission Line Delivery Point PN: 435339	17-Jul-2019	40141
Mayfield 161-kV Substation Laydown	23-Jul-2019	41267
Longino 161 kV Delivery Point : 426568	24-Jul-2019	36955
SW Starkville Delivery Point - 430440	3-Sep-2019	37926
Construction Laydown Yard -Philadelphia Area Projects	28-Oct-2019	41810
McMinnville-Manchester 161kV MPNA L5696 PN: 430018	4-Nov-2019	40374
West Lewisburg, TN. 161-kV Substation - Provide Delivery Point for LES - 434970	8-Nov-2019	38711
Ryan Creek, AL 161-kV Delivery Point - Project Number 490093	30-Jan-2020	39361
Flowood, MS 161 kV Delivery Point - Project Number 429122 -	2-Apr-2020	39359
South Medina, TN. 161-kV Delivery Point - PN: 441019	28-May-2020	40874
Flowood Temporary Transmission Laydown Yard	29-Jul-2020	42832
Fontana Area System Improvements- PWR REPLACE L1914 PN: 532634	15-Sep-2020	43344
Shelby - Dell 500-kV Transmission Line Relocation - 442893	2-Oct-2020	39672
Shady Grove 161-kV Delivery Point - PN: 438332	20-Oct-2020	42181
Mineral Wells - West Pleasant Hill - 436014 - W.O. 64A01	28-Oct-2020	41670
Madisonville - Vonore Construct 161kV TL - Project: 409409	4-Dec-2020	41812
North Gallatin, TN 161-kV Switching Station and Loop Line. Project: 439098 - Work Orders: Multiple	17-Dec-2020	42028
Sweet Home , AL 161-kV Transmission Line : 440238	10-Feb-2021	42018

Categorical Exclusion Checklist (CEC) Reviews	Completion Date	CEC #
Construction Laydown Yard - Shady Grove 161-kV TL Project.	22-Feb-2021	44794
W Oktibbeha 161-kV DP : 441647	1-Mar-2021	42014
Sweet Home Laydown Yard WO:31S5V	10-Mar-2021	44984
Kenlake, KY. 161-kV Substation - Provide Delivery Point - PN: 410521	16-Mar-2021	41584
Davis Gap 161-kV Transmission Line DP : 441235	16-Mar-2021	42015
Pond Creek 161- KV Delivery Point - 615175	16-Mar-2021	42430
Allen - Horn Lake TL and Re-conductor : 500370	17-Mar-2021	42013
Madison-Flash #2 161-kV Transmission Line. Funding Project: FP614903 - Work Orders: Multiple	18-Mar-2021	42267
Hwy 412 Re-conductor Laydown Yard	23-Mar-2021	45108
Temporary Laydown Yard: Madison-Flash TL Project. Project: 443762	13-Jul-2021	45253
South West Point 161-kV Delivery Point - 442746	16-Jul-2021	42286
North Desoto 161 - KV Delivery Point - 440387	5-Aug-2021	42429
Santa Fe TN161kV Slack Span Delivery Point Project: 430220 WO: 31OOX	1-Sep-2021	42591
North Lawrenceburg, TN 161-kV Substation - Provide Delivery Point to LUS- Project: 200922	3-Sep-2021	44425
Construction Laydown Yard - Murray, KY.	16-Sep-2021	44024
Fox Hollow Tie Line and Substation PN: 433070	20-Sep-2021	39943
Mary Haughton Delivery Point PN:531115	3-Nov-2021	43669
Construction Laydown Yard - Decatur, AL.	10-Nov-2021	46831
Fontana Phase 2 Transmission Work - 533962	16-Nov-2021	43910
ransmission Line (L5190) Upgrades for Yum Yum Solar	18-Nov-2021	44484
Horus, KY Laydown Yard Q388 WO:2T113 PN:535290	3-Dec-2021	46725
Alcoa-Nixon Road 161-kV TL. Project: 443430	6-Jan-2022	44826
Strategic Fiber Benefit-Haywood/Brownsville, Jackson, and S. Jackson switching stations. Project: 531962	24-Jan-2022	47340
Construction Laydown Yard - TVA Lagoon Creek	25-Feb-2022	47611
Pilot Oak KY 161kV Delivery Point	11-Apr-2022	43357
Temporary Construction Laydown Yard - Fayette County, TN	19-Apr-2022	47990
Gladstone, AL 161-kV Switching Station and Loop Line. Project: 533772	22-Apr-2022	45858
Temporary Construction Laydown Yard - Marshall County, MS	10-May-2022	48112
Construction Laydown Yard - Memphis Regional Megasite Power Supply	27-May-2022	48195
Tupelo Area Fiber Work : PN: 533698, 533699, 533706, 533707, 533708, 533709	16-Jun-2022	48273
FP629008 Strategic Fiber Benefit Implementation Albertville, AL and Geraldine, AL – Install Fiber Optic Equipment (539625)	29-Jun-2022	48392
Trade, AL 161-kV Substation - Provide Delivery Point. Project: 438921	8-Aug-2022	46028
Project Night Sky - TVA Ultium, TN 161kV Switching Station and Loop Line. Project: 539168	11-Aug-2022	47184
Limestone-Harding Spring 161-kV Transmission Line: Install OPGW. Project: 533773	11-Aug-2022	48540
AP 40 Line Relocation L3305 (E. Cleveland - McDonald 161kV TL) WO: 2T02M, Project: 532602	18-Aug-2022	43940
Temporary Laydown Yard - Mercer, TN. Project: 534347 - Work Order: 31SEY	23-Aug-2022	48727
Tiptonville-Hwy 412 TL (L5931) Upgrades. Project: 535291	29-Aug-2022	46210
Provide Cantrell Flats, TN 161-kV slack span delivery point. Project: 438641	30-Aug-2022	42262
South Okolona, MS 161-kV substation - Provide delivery point. Project: 542351	1-Sep-2022	48794
Temporary Construction Lay Down Yard - Knoxville Area Projects	19-Sep-2022	48943
Elizabethton - Cranberry #2 161-KV TL - 437516	29-Sep-2022	41831
Morristown Laydown yard expansion	21-Oct-2022	48506

Categorical Exclusion Checklist (CEC) Reviews	Completion Date	CEC #
Guntersville - Goose Pond L5683 Str 433 to Dam Emergency Fiber Replacement	25-Oct-2022	49120
Burnsville - Tri-State Commerce 443434	8-Nov-2022	47395
Colbert - Cherokee MPNERC L5668 - PN:443187	8-Nov-2022	48046
License Agreement: 2.3-acre Preliminary Site (Cullman County, AL). Project: 438921	14-Nov-2022	49235
Braytown - Wartburg 537493	17-Nov-2022	47392
Gallatin-Cairo Bend Reconductor 2T06C 532033	21-Nov-2022	47200
Construction laydown yard - Hanceville, AL. Project: 438921	11-Jan-2023	49125
Browns Ferry River Crossing Assessment on L6074 Structures 23-26 and L6078 Structures 25-28	26-Jan-2023	49433
North Madisonville, TN 161-kV Delivery Point. Project: 540361	26-Jan-2023	49527
Flat Fork 69-KV Expansion	31-Jan-2023	47975
Powell Chapel Road, TN 46-kV Substation - Metering & Delivery Point - FP: 629843 - PN: 537573	6-Feb-2023	47972
Mountain City, TN 161-kV Delivery Point. Project: 541594 -	15-Feb-2023	48384
Ludlow, MS PN: 530475	21-Mar-2023	45946
Sanford Road Delivery Point - PN: 541285-FP630045	29-Mar-2023	49949
Northeast New Albany, MS 161kV Delivery Point - FP: 629734 - PN: 537013	10-Apr-2023	47779
Wheeler - Maury 161-kV TL - Reconductor Str. 1-232A - PN: 532588	12-Apr-2023	46355
Tiptonville-New Madrid 161-kV TL - Reconductor & Build Second Line - PN: 529154	12-Apr-2023	48399
Hertz 161kV Delivery Point to Microvast	17-Apr-2023	48307
North Green Street, MS 161-kV Delivery Point - FP: 628675	2-May-2023	47964
Gallatin-Portland 161-kV TL Loop into North Gallatin. Project: 533421	11-May-2023	47568
Thacker, MS 161-kV Delivery Point	15-May-2023	48050
Hardin Valley, TN 161-kV Delivery Point. Project: 441716	24-May-2023	47201
Berlin, AL DP PN:543434, 544883,539329	25-May-2023	49339
NAEC Fiber Request at Widow's Creek – Dark Fiber Lease/Splicing	1-Jun-2023	50303
Lawrenceburg-Anderson-Pulaski 161-kV (L5021, L5117) MPNA OPGW - PN: 500500, 537971, 537992, 540829, 540926, 540927, 540928	2-Jun-2023	47712
Tiny Town Provide 161kV Delivery Point	5-Jun-2023	48005
Lawrenceburg Area Temporary Construction Laydown Area	12-Jun-2023	50363
Claysville, AL 161-kV Delivery Point - 539720, 542083, 542089	26-Jun-2023	48035
Winstead, TN 161-kV Delivery Point - FP: 629992 - PN: 540583, 541439, 541760	28-Jun-2023	49434
VZW L5292 OPGW Replacement	3-Jul-2023	49792
East Cleveland - NE Benton TL OPGW Repair	6-Jul-2023	50592
Tower Installation - Beech Grove, TN Microwave - PN: 536993	3-Aug-2023	49622

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Appendix F – Literature Cited

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Appendix F - Literature Cited

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Appendix G – List of Preparers

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Appendix G - List of Preparers

Anneliesa Barta (AECOM)
Education: M.B.A., Finance, B.S., Psychology
Experience: 13 years of experience in environmental and sustainability planning, 5 years of experience in NEPA compliance
Role: Socioeconomics and Environmental Justice

Kelly Baxter (TVA)
Education: M.S., Plant Science and Landscape Systems; B.S., Botany
Experience: 11 years in NEPA compliance and 10 years in TVA land management and planning
Role: NEPA Compliance and EIS Document Preparation

Crystal Bishop (TVA)
Education: M.S., Biology, B.S., Wildlife and Fisheries Science
Experience: 18 years in surface water and NPDES permitting, monitoring and compliance
Role: Water Quality and Surface Water

Suama Bolden (TVA)
Education: M.S., Geology
Experience: 15 years in groundwater investigation
Role: Groundwater and Wastewater

Alex Britt (TVA)
Education: M.B.A., Accounting; M.S. Industrial-Organizational Psychology
Experience: 4 years' experience in strategic business and resource planning
Role: IRP Document Preparation

Jane-Coleman Cottone (AECOM)
Education: M.A., History, M.S., Information Science, and B.A., History
Experience: 10 years in historic preservation and 1 year in NEPA compliance
Role: Cultural Resources

Amy Dalton (AECOM)
Education: M.S., Forestry, B.S./B.A., Biology
Experience: 25 years in wetland delineation and permitting and 6 years in NEPA compliance
Role: Wetlands and Floodplains

Michael Deacon (AECOM)
Education: B.S., Environmental Studies; B.S., Environmental Health
Experience: Over 30 years of experience in NEPA compliance
Role: EIS Document Preparation

Shane Downey (TVA)
Education: B.S., Finance
Experience: 15 years of experience in resource planning, financial planning, commodity forecasting, and accounting
Role: Production cost, financial modeling, and stochastic and risk analysis

Jane Elliott (TVA)
Education: B.B.A., Finance
Experience: 18 years in strategic and long-range planning
Project Role: Senior Consultant, 2025 Integrated Resource Plan; IRP Document Preparation

Regina Greer (AECOM)
Education: B.S., Computer Science
Experience: 28 years in project administration and 19 years of experience in NEPA document preparation
Role: EIS Technical Editor and Document Preparation

Hallie Hearnes (TVA)
Education: M.A., History; B.S., Historic Preservation
Experience: 15 years in cultural resource management
Role: Cultural Resources

Matthew Higdon (TVA)
Education: M.S., Environmental Planning; B.A., History
Experience: 21 years in natural resource planning and NEPA compliance
Role: NEPA Compliance and Document Preparation

Susan Innis (AECOM)
Education: Master of Public Administration, B.S. Biology
Experience: 25 years' experience in public affairs and project management
Role: Deputy Project Manager and Technical Reviewer

Scott C. Jones, P.E. (TVA)
Education: B.S., Electrical Engineering; Professional Engineer in Tennessee
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

Candy Kelly (TVA)
Education: M.B.A., B.S., Chemistry
Experience: 19 years of TVA experience in environmental planning, strategic planning, and long-range resource planning and forecasting.
Role: TVA Senior Manager, Resource Strategy, Integrated Resource Planning Modeling

Russell Kiesling (AECOM)
Education: M.A., Public Administration, M.S., Zoology, B.S., Biology
Experience: 35 years of directing siting and permitting experience and 19 years of experience in NEPA compliance
Role: Project Manager

Trystan Knowles (TVA)
Education: B.A., Economics; B.A., French
Experience: 2 years in data analytics, 1 year in government programs and financial modeling
Role: Capacity Planning and Data Analytics

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

Amy Lin (AECOM)
Education: B.A., Earth and Space Sciences
Experience: 1 year in environmental laboratory testing, and 1 year in NEPA compliance
Role: Air Quality and Climate Change

John Majsztrik (AECOM)
Education: Ph.D., Plant Science and Landscape Architecture; M.S., Forest Biotechnology; B.S., Biology
Experience: Over 8 years in specialty crop production, experimental design and analysis, and survey methodology; and 2 years in NEPA compliance
Role: Air Quality and Climate Change

David K. Mitchell (TVA)
Education: M.S., Soil and Water Science, B.S., Horticulture
Experience: 16 years of botany and ecological restoration, 6 years of environmental research management.
Role: Botany

Kate Melanson (AECOM)
Education: Ph.D., Ecology and Evolutionary Biology, M.A., Ecology and Evolutionary Biology; B.A, Biology
Experience: 9 years in research, 3 years in government, and 1 year in NEPA compliance
Role: Biological Resources

Laura Owens (AECOM)
Education: B.S., Physics and Geology
Experience: 27 years in environmental services and 10 years in NEPA compliance
Role: Geology, Solid and Hazardous Wastes

Fallon Parker Hutcheon (TVA)
Education: M.S., Environmental Studies, B.S., Biology
Experience: 5 years in wetland delineation, wetland impact analysis, and NEPA and CWA compliance
Role: Wetlands

Roger Pierce (TVA)
Education: M.B.A.; B.S.M.E., Mechanical Engineering
Experience: 15 years TVA experience in resource planning.
Role: Expansion and production cost modeling

M. Hunter Reed (TVA)
Education: M.B.A; B.S.B.A., Finance and Management of Information Systems
Experience: 12 years TVA experience in resource planning and IT systems engineering
Role: Project Management, strategy and scenario development, IRP and EIS document preparation

Bob Roth (TVA)
Education: M.S. and B.S., Economics
Experience: 39 years of energy industry experience, with 22 years of utility industry experience in economic and load forecasting, marketing, and rates
Role: Economic forecasting, Socioeconomics, Environmental Justice

Marylee Sauder (TVA contractor)
Education: B.A., English and Journalism
Experience: 29 years in corporate communications
Role: IRP project communications

Gary Springston (TVA)
Education: M.S. and B.S., Civil Engineering
Experience: 38 years in water resource analyses and management
Role: Water Supply

Preeth Srinivasaraghavan (TVA)
Education: M.E.M., Environmental Management; B.A., Environmental Studies and Political Science
Experience: 8 years experience in wholesale power markets, environmental policy, and resource planning
Role: IRP document preparation

Chloe Sweda (TVA)
Education: B.S., Earth and Environmental Sciences
Experience: 6 years in natural resource management
Role: Managed and Natural Areas

James Hunter Terrell (TVA)
Education: M.S., Geography; B.S., Environmental Studies
Experience: 20 years in natural resource management and species data management
Role: TVA Regional Natural Heritage data (wildlife and vegetation)

Jesse Troxler (TVA)
Education: B.S. and M.S., Wildlife and Fisheries Science
Experience: 20 years in wildlife monitoring/research, 8 years NEPA/Endangered Species Act compliance
Role: Terrestrial Wildlife, Threatened and Endangered Species

Jennifer Sharkey, P.E. (TVA)
Education: M.S. and B.S., Civil and Environmental Engineering
Experience: 8 years in River Forecasting; 1 year in Floodplains and Flood Risk; 1 year in Water Supply
Role: Water Supply

Carrie C. Williamson, P.E., CFM (TVA)
Education: M.S., Civil Engineering; B.S., Civil Engineering
Experience: 11 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: 20 years of experience in financial and risk analysis and modeling, resource planning
Role: Scenario, strategy, and metrics design, IRP document preparation

Amy Vargas (AECOM)
Education: M.S., Biology; B.S., Botany
Experience: 18 years experience in environmental consulting and 16 years in NEPA compliance
Role: Project Reviewer, QA/QC

Fang Yang (AECOM)
Education: M.S., Atmospheric Science; B.S., Physics
Experience: Over 35 years of experience in air quality and noise studies and 29 years in NEPA compliance
Role: Greenhouse gas and climate change analysis