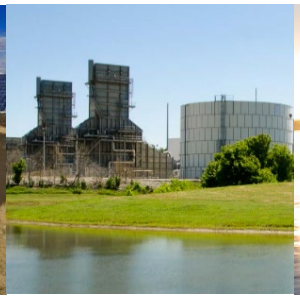
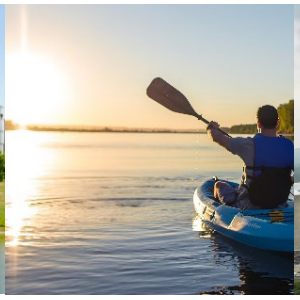
2019 Draft Integrated Resource Plan

EXECUTIVE SUMMARY





TENNESSEE VALLEY AUTHORITY

Introduction

PURPOSE AND NEED

The 2019 Integrated Resource Plan (IRP) is a long-term plan that provides direction on how TVA can best meet future demand for power. It shapes how TVA provides low-cost, reliable electricity; supports environmental stewardship; and fosters economic development in the Tennessee Valley for the next 20 years. The utility marketplace is changing rapidly. Long-range planning with innovative thinking is necessary to guide TVA's decisions about power generation. The IRP will enhance TVA's ability to create a more flexible power-generation system that can successfully integrate increasing amounts of renewable energy sources and distributed energy resources (DER). It also will inform TVA's next Long-Range Financial Plan.

In developing this draft IRP, TVA specialists—with significant input from stakeholders and the public—considered a wide range of future scenarios, various business strategies and a diverse mix of power generation resources. The final IRP will serve as a compass that provides broad direction, rather than as a GPS that provides a specific route. Per the National Environmental Policy Act (NEPA), TVA has also prepared a draft Environmental Impact Statement (EIS) to analyze the 2019 IRP's potential impacts on the environment, economy and population in the Tennessee Valley.

A FOCUS ON FLEXIBILITY

The 2019 draft IRP emphasizes the importance of flexibility in response to the changing energy marketplace. TVA evaluated a wide range of possible futures and how flexible the power system needs to be to ensure reliable power at the lowest system cost. These possible futures include increasing renewables and DER, driven by technology advancements as well as the improving economics and accessibility of those technologies. The IRP is focused on flexibility because TVA needs a diverse power-generation system that is well-positioned to meet future demand; has the capacity to incorporate renewable energy sources and DER along with more traditional resources; and has the capability to respond in a variety of circumstances well into the future.

TVA POWER SYSTEM

As the nation's largest public power provider, TVA delivers safe, reliable, clean, competitively priced electricity to 154 local power companies and 58 directly served customers. TVA's power portfolio is dynamic and adaptable in the face of changing demands and regulations. This portfolio has evolved over the past decade to a more diverse, reliable and clean mix of generation resources, which today provides 54 percent carbon-free power.

In Fiscal Year (FY) 2018, TVA efficiently delivered more than 163 billion kilowatt-hours of electricity to customers from a power supply that was 39 percent nuclear, 26 percent natural gas, 21 percent coal-fired, 10 percent hydro, and 3 percent wind and solar. The remaining one percent results from TVA programmatic energy efficiency efforts.

STAKEHOLDER & PUBLIC INVOLVEMENT

Throughout the IRP process, TVA has engaged external stakeholders to understand diverse opinions and to challenge assumptions. TVA established the IRP Working Group (IRPWG), whose 20 members represent diverse interests in the Valley. The IRPWG has met approximately monthly to review input assumptions and preliminary results and to enable its members to provide their respective views to TVA. TVA also presented IRP progress updates to the Regional Energy Resource Council (RERC), a federal advisory committee that provides advice to the TVA Board of Directors on a range of energy-related matters, including the IRP.

During a 60-day scoping period from February 15 through April 16, 2018, TVA obtained public comments on the scope of the effort to develop this IRP, which helped shape the draft IRP and EIS. With the release of this draft, TVA is holding meetings across the Tennessee Valley as well as an online meeting on the 2019 IRP webpage at **tva.com/irp** to gather public input. Comments can be made through April 8, 2019. After input is incorporated, the final IRP and EIS will be made available to the public for at least 30 days before it is presented to the TVA Board of Directors for approval. TVA expects to request approval of the IRP from the Board in August 2019. Once approved, a Record of Decision will be published.

Developing the Integrated Resource Plan

OVERVIEW

Developing the 2019 IRP is an approximately 18-month process that began in February 2018 and will conclude when a Record of Decision is released. The process is focused on ensuring that the final plan is low-cost, risk-informed, environmentally responsible, reliable, diverse and flexible. To date, the IRP process has included the following activities:

Winter/ Spring 2018	Scoping which took place in winter/spring 2018 and identified issues important to the public and laid the foundation for developing this draft.
Spring/ Summer 2018	Development of Model Input and Framework which occurred in spring/summer 2018 and included identifying and developing scenarios, resource options and business strategies to evaluate how a future portfolio might change under different conditions.
Fall 2018	Analysis and Evaluation which occurred in fall 2018 and included developing and evaluating the performance of the 30 "resource portfolios."
Occurring Now	Presentation of Initial Results which is occurring now with the presentation of this draft IRP and EIS.

During the remainder of this IRP process, TVA will incorporate the input received during the public comment period that ends on April 8, 2019, perform additional sensitivities, and identify the preferred plan in the final IRP and EIS expected to be issued in summer 2019.

PLANNING APPROACH

TVA's IRP is based on a "scenario" planning approach that provides an understanding of how future decisions would play out in future scenarios, considering a wide variety of resource options and business strategies in those scenarios. This approach improves the likelihood that TVA's plan will provide reliable, least-cost solutions to meet demand for electricity, regardless of how the future plays out. TVA worked with internal experts, the IRPWG, the RERC and external consultants to identify and hone underlying assumptions that ensure robust modeling inputs were used.

UNCERTAINTIES AND SCENARIOS

With input from the IRPWG, TVA designed scenarios that are outside of TVA's control but represent possible futures in which TVA may find itself operating. TVA created a list of uncertainties that could alter the future operating environment and affect the cost of electricity and/or mix of optimal resources. The uncertainties considered in the 2019 IRP are electricity demand, market power price, natural gas prices, coal prices, solar prices, storage prices, regulations, CO2 regulation/price, distributed generation penetration, energy efficiency adoption and economic outlook.

The scenarios are:

	SCENARIOS
1	**CURRENT OUTLOOK** which represents TVA's current forecast for these key uncertainties and reflects modest economic growth offset by increasing efficiencies;
2	**ECONOMIC DOWNTURN** which represents a prolonged stagnation in the economy, resulting in declining loads (customers using less power) and delayed expansion of new generation;
3	**VALLEY LOAD GROWTH** which represents economic growth driven by migration into the Valley and a technology-driven boost to productivity, underscored by increased electrification of industry and transportation;
4	**DECARBONIZATION** which is driven by a strong push to curb greenhouse gas emissions due to concern over climate change, resulting in high CO_2 emission penalties and incentives for non-emitting technologies;
5	**RAPID DER ADOPTION** which is driven by growing consumer awareness and preference for energy choice, coupled with rapid advances in technologies, resulting in high penetration of distributed generation, storage and energy management;
6	**NO NUCLEAR EXTENSIONS** which is driven by a regulatory challenge to relicense existing nuclear plants and construct new, large-scale nuclear. This scenario also assumes subsidies to drive small modular reactor (SMR) technology advancements and improved economics.

STRATEGIES

With input from the IRPWG, TVA developed five "strategies," which are business decisions or directions within TVA's control that TVA could employ in each scenario. Within each strategy, TVA varied key attributes of resources to test business options within TVA's control. The first strategy is a base case strategy; the other four promote a certain set of resources to achieve a strategic objective. As it relates to strategies in the draft IRP, the word "promote" means an incentive was modeled to make the resource more attractive for adoption or selection.

The five strategies are:

	STRATEGIES
A	**BASE CASE** which represents TVA's current assumptions for resource costs and applies a planning reserve margin constraint. This constraint applies in every strategy and represents the minimum amount of capacity required to ensure reliable power;
B	**PROMOTE DISTRIBUTED ENERGY RESOURCES** which incents DER to achieve higher, long-term penetration levels. The DER options include energy efficiency, demand response, combined heat and power, distributed solar and storage;
C	**PROMOTE RESILIENCY** which incents small, agile capacity to maximize operational flexibility and the ability to respond to short-term disruptions on the power system;
D	**PROMOTE EFFICIENT LOAD SHAPE** which incents targeted electrification (by incentivizing customers to increase electricity usage in off-peak hours) and demand response (by incentivizing customers to reduce electricity usage during peak hours). This strategy promotes efficient energy usage for all customers, including those with low income;
E	**PROMOTE RENEWABLES** which incents renewables at all scales (from utility size to residential) to meet growing or existing consumer demand for renewable energy.

MODELING ASSUMPTIONS AND CANDIDATE TECHNOLOGIES

TVA uses an industry standard model to derive an optimal capacity plan, considering the focus of each strategy evaluated in each scenario. Modeling assumptions, the framework of IRP planning, are the constraints and planning guidelines that are put into the model. The reliability constraint is especially critical as it ensures TVA has enough capacity at all times to provide reliable electricity to customers. For the 2019 IRP, it also is crucial to understand how the system would operate with the projected increase of renewables and DER on the system, which drives a greater need for operational flexibility. TVA considered both mature and emerging technologies in this IRP. Data on mature options is readily available, and although there is less data on emerging resource options, there is sufficient, solid information to model these technologies.

Evaluating the Portfolios

The modeling process applied each strategy to each scenario, resulting in 30 resource portfolios. The model analyzed how to achieve the lowest-cost portfolio with each strategy in each scenario, looking for the optimal solution within that particular combination.

TVA used metrics to evaluate tradeoffs among the 30 resource portfolios. With input from the RERC and the IRPWG, TVA identified 14 metrics that reflect desired goals and priorities in areas related to cost, risk, environmental stewardship, operational flexibility, and Valley economics.

Strategy Performance

	COST	RISK	ENVIRONMENTAL STEWARDSHIP		OPERATIONAL FLEXIBILITY	VALLEY ECONOMICS
			CO_2, Water, Waste	Land Use		
STRATEGY A: BASE CASE						All strategies have similar impacts on the Valley economy as measured by per capita income and employment
STRATEGY B: PROMOTE DER						
STRATEGY C: PROMOTE RESILIENCY						
STRATEGY D: PROMOTE EFFICIENT LOAD SHAPE						
STRATEGY E: PROMOTE RENEWABLES						

Good — Better — Best

STUDY RESULTS

The key components of each scenario were translated into a forecast of firm requirements for both summer and winter which are based on projected demand and required capacity in each season. The forecast was used to identify the resulting capacity gap and need for power, which drove the selection of resources in the capacity planning model. The study identifies "incremental" capacity, which represents the portfolio of resources selected to fill the capacity gap, which may include replacement of capacity from expiring contracts and forecasted retirements.

TVA's preliminary observations about incremental capacity across the portfolios include the following:

- New capacity is needed in all scenarios modeled, even in the lower load futures, in part to replace expiring or retiring capacity.
- Solar expansion plays a substantial role, driven by its attractive energy value beginning around the mid-2020 time frame.
- Varying levels of gas, storage, and demand response are added depending on strategic focus to ensure reliability and provide flexibility.
- No wind or hydro resources are added, indicating that solar backed up by gas and/or storage is the more optimal choice.
- No baseload resources are added, except in the case where Small Modular Reactors are promoted for resiliency.
- Key considerations when evaluating potential coal retirements are uncertainty around future environmental standards for CO_2 and the outlook for load and gas prices.
- Energy Efficiency (EE) levels are relatively similar across the portfolios and decrease over time as efficiency impacts from codes and standards increase over time.

STRATEGY ASSESSMENT

TVA assessed the performance of the five planning strategies using metrics to evaluate cost and risk, environmental stewardship, operational flexibility and effect on Valley economics. TVA's preliminary observations about portfolio performance include the following:

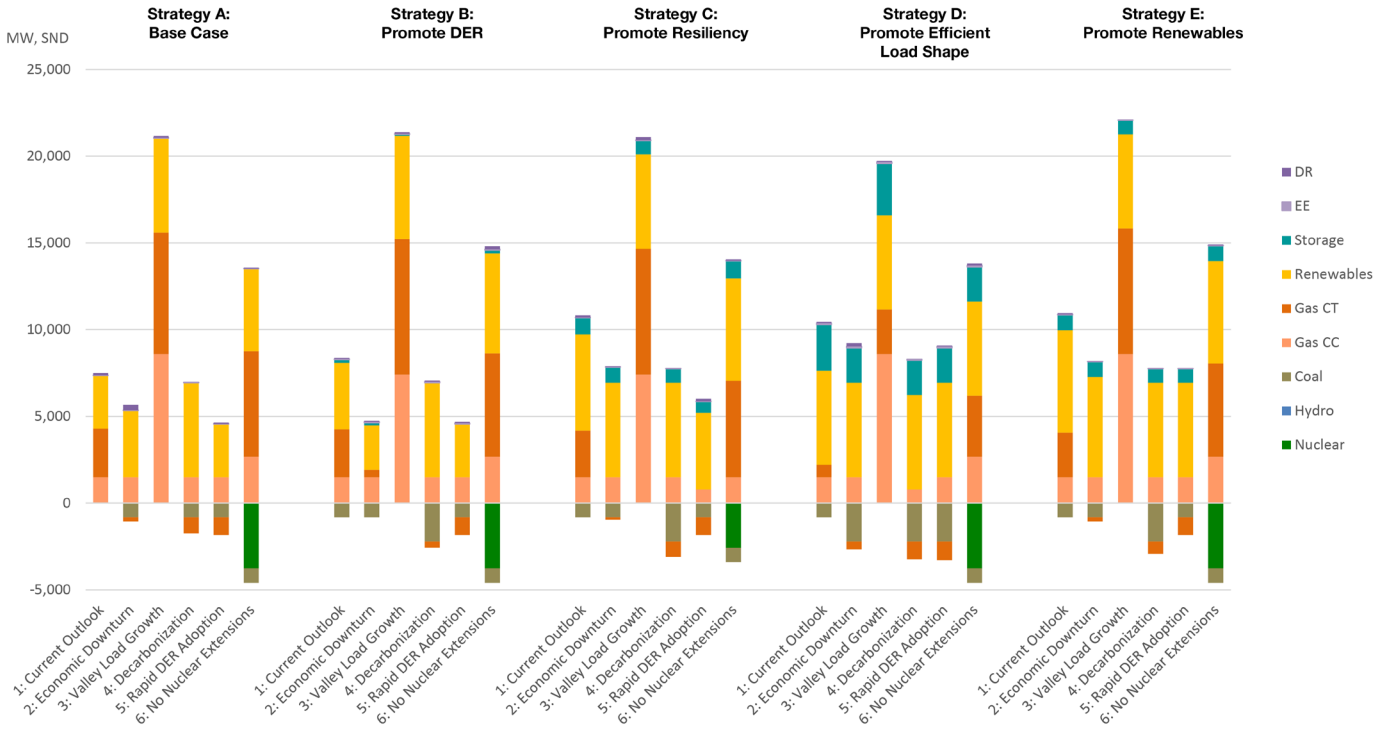
- The Base Case strategy, which most leverages utility-scale resources, is the most economic and has the lowest average cost and risk exposure.
- The DER strategy, which promotes distributed resources to the greatest extent, has similar revenue requirements to the Base Case but has the highest total resource cost including costs borne by participants.
- The Efficient Load Shape strategy, which heavily promotes storage, has the highest revenue requirements due to current projections for storage prices.
- Strategies that promote resiliency, load shape and renewables have the largest amounts of solar and storage expansion and coal retirements, resulting in lower environmental impact overall but higher land use.
- Strategies focused on resiliency, load shape and renewables drive higher levels of solar expansion, but tend to have lower operational flexibility.
- All strategies have minor but similar impacts on the Valley economy as a whole, as measured by per capita income and employment.

SENSITIVITY ANALYSIS

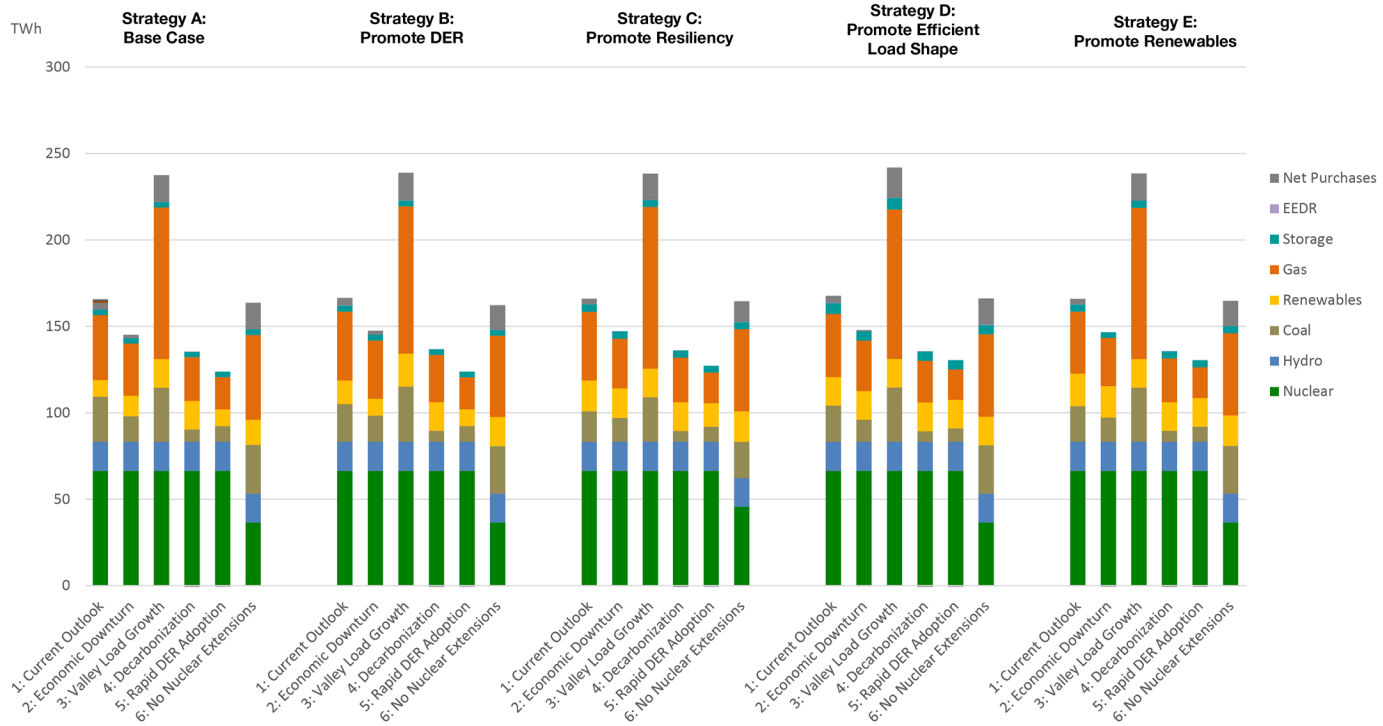
While developing the draft IRP, TVA identified issues that warrant further evaluation—or sensitivity analysis—prior to finalizing the study. In addition, it received helpful stakeholder feedback from the IRPWG and the RERC. TVA also will gain feedback through its public meetings and through written comments submitted during the formal comment period that helps identify key areas meriting further analysis. To address these issues and comments, TVA will perform detailed sensitivity analyses and review those results with the IRPWG and the RERC between the draft and final IRP.

One sensitivity was included in the 2019 Draft IRP and EIS, due to evaluations of the potential retirement of the Bull Run and Paradise coal plants. For the 2019 IRP, the expansion planning model was given the option of keeping or retiring coal plants to mitigate higher costs, except for in the Base Case in the Current Outlook. Running a variation on that case that includes Bull Run and Paradise retirements results in slightly lower costs and risk exposure as well as improved flexibility and environmental metrics, with the exception of land use, due to the nature of replacement resources added later in the plan. All portfolios, except for certain Valley Load Growth scenarios, include coal retirements, indicating that coal retirements would be part of any strategy.

Incremental capacity by 2038 consists of additions of new energy resources and retirement of existing energy resources for the portfolios associated with each strategy.



Total Energy in 2038 by resource type in the portfolios associated with each strategy.



The IRP and the Tennessee Valley Environment

TVA's EIS assesses the natural, cultural and socioeconomic impacts associated with the implementation of the 2019 IRP. The five strategies, including the Base Case, are the basis for the alternatives discussed in the EIS. The Base Case serves as the No-Action Alternative, and the remaining four are the Action Alternatives. The draft EIS analyzes and identifies the relationship of the natural and human environment to each of the five strategies considered in the IRP. The draft EIS evaluates the portfolios associated with each strategy quantitatively and qualitatively to determine the environmental impact, and it examines key effects—such as greenhouse gas emissions, fuel consumption, air quality, water quality and quantity, waste generation and disposal, land requirements, ecology, cultural resources, socioeconomic impacts and environmental justice. Public comments on the draft EIS will be addressed in the final EIS, which is expected to be released in summer 2019 to accompany the final IRP.

The primary study area described in the draft EIS includes the combined TVA service area; the Tennessee River watershed; and parts of the Cumberland, Mississippi, Green and Ohio Rivers in TVA's power service area. For some resources, such as air quality and climate change, the assessment area extends beyond the TVA region. For some socioeconomic resources, the study area consists of the 170 counties where TVA is a major provider of electric power and/or operates generating facilities.

ENVIRONMENTAL IMPACTS OF THE 2019 IRP

Under all the portfolios, there is a need for new capacity with a significant expansion of solar generation overall. Uncertainty around future environmental standards for carbon dioxide emissions, along with the outlook for loads and gas prices, are key considerations when evaluating potential coal retirements. Emissions of air pollutants, the intensity of greenhouse gas emissions and generation of coal waste decrease under all strategies. Strategies focused on resiliency, load shape and renewables have the largest amounts of solar and storage expansion and coal retirements, resulting in lower environmental impact overall but higher land use. For most environmental resources, the impacts are greatest for the No Action alternative. The exception is the land area required for new generating facilities, which is greater for the action alternatives, particularly strategies which focus on resiliency, load shape and renewables.

tva.com/irp