Methodology Review of the Tennessee Valley Authority Integrated Resource Planning Process

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January 2025

This report is available online at:
https://nuclearinnovationalliance.org/resources

TVA Resource Planning: Basis and Approach

Tennessee Valley Authority (TVA) resource planning culminates in an integrated resource plan (IRP) every five years, the process for which is noticed in the Federal Register and features stakeholder involvement and comments. The last full IRP was released in 2019 and TVA took comments on their draft 2025 IRP through December 10, 2024, with an expected release date in the spring of 2025.

This NIA document discusses the planning process and reviews the methodologies, scenarios, and results in the context of nuclear energy. This report is a companion to the Nuclear Innovation Alliance comments submitted to TVA during the planning process.

"Integrated Resource Planning" vs. "Least Cost Planning"

TVA generally uses the term "Integrated Resource Planning" to describe their process but sometimes refers to the process as Least Cost Planning. Least Cost Planning is a somewhat outdated statutory term, which originates from Section 113 of the Energy Policy Act of 1992, entitled "Tennessee Valley Authority Least Cost Planning Program". That section used then-common terminology to prescribe a planning approach featuring the minimization of system costs while "treating demand and supply resources on a consistent and integrated basis" and taking into account "necessary features for system operation such as diversity, reliability, dispatchability and other factors of risk." Section 113 describes an optimization analysis but does not specify how to address the inherent uncertainty around future conditions, including markets, regulations and technology developments that will substantially affect the costs and performance of a resource portfolio over a multi-decade timeframe. In the decades that followed the Energy Policy Act of 1992, utilities adopted new approaches to depict and assess the role of uncertainty in analyzing future resource portfolios, which has evolved into modern integrated resource planning.

In practice, TVA's current methodology appears consistent with current resource planning norms and methods. The methodology balances overall system costs of pursuing specific resource plans with other criteria such as reliability, financial risks and long-term environmental objectives. While minimizing cost remains a primary objective (and underlies the modeling effort), the overall approach enables TVA to give other factors considerable weight in assessing the value of obtaining resources under significant uncertainties surrounding future market conditions.

TVA Planning

TVA uses a scenario/strategy approach, which has become a prevalent methodology in resource planning. Under the scenario/strategy approach, utilities develop different – sometimes profoundly different – independent outlooks for the future ("Scenarios"), defined by different exogenous conditions (aspects of the future that utilities cannot affect with their own policies or decisions) over a multi-decade horizon. After composing several significantly different but reasonably plausible future scenarios, the utility then defines several proposed policies or resource plans ("Strategies") that they could pursue over the time horizon. Each strategy is evaluated for costs, emissions, reliability, etc. under each scenario, meaning that the number of cases considered (i.e., modeled outcomes) are the number of strategies multiplied by the number of scenarios.

In contrast, more traditional resource planning methods rely on a simulated projection of future conditions (typically an extrapolation of current trends) as a baseline future and then use an optimization algorithm to simulate the portfolio of resources that will produce the needed amount of electricity at least cost (subject to a variety of constraints on reliability, environmental requirements, etc.). Extensions of this method use selected departures from baseline conditions to evaluate the going-forward cost of different resource development programs. This baseline-sensitivity method is a familiar and still useful way to examine policies (for example, it is used in EIA Annual Energy Outlooks) but many utilities – especially those in market settings – prefer using a scenario/strategy approach that may better capture a wide range of potential futures and reflect the inherent uncertainty in rapidly evolving market conditions and policies.

TVA IRP Methodology

Scenario Construction

Scenarios are sets of alternative external (exogenous) conditions that are not affected by any decisions or actions taken by TVA. Scenarios (and the narratives that underlie them) should be feasible and internally consistent, avoiding mutually exclusive or highly unlikely combinations. For example, high load growth is unlikely to accompany depressed economic conditions and low load growth is unlikely to occur under federal policies aimed at promoting electrification. For the 2025 IRP, TVA developed six scenarios of future conditions that extended through 2050:

IRP Scenarios (Future Conditions)

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

The Reference (without GHG rule) scenario is equivalent to a "baseline" scenario that depicts expected future conditions based on current trends. The other scenarios diverge from the Reference scenario primarily in terms of projected load growth and greenhouse gas regulation.

Strategy Development

Strategies are actions or programs that TVA can undertake to affect the outcomes (cost, emissions, etc.) of their operations, typically reflecting objective(s) that may depart from a singular focus on minimizing cost in the Reference scenario. The 2025 IRP examines five possible strategies:

IRP Strategies (Business Approaches)

- **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

The Baseline Utility Planning strategy assumes future resource opportunities, costs, and performance at expected levels, that is, a relatively neutral "baseline" set of input parameters that reflect current trends or anticipated changes. TVA implements the focused strategies by manipulating various input parameters from their baseline or assumed values to represent investment incentives that reflect the emphasis of the strategy, e.g., using commercially available technology or innovative technology to reduce carbon emissions, investing in distributed and demand-side resources, etc. In some cases (for example, promoting nuclear technologies in Strategy B "Carbon-free Innovation Focus" and Strategy E "Resiliency Focus") TVA both mandates a specific minimum investment and reduces the modeled capital cost to incentivize additional investment beyond those minimum levels.

Optimization Modeling

TVA evaluates each strategy under every scenario – by conducting an optimization model run for each pair (5 strategies x 6 scenarios = 30 "cases"). This is the core of the analysis, where the model finds the least-cost solution (in terms of TVA resources) to satisfy the myriad constraints, under the parameters assumed in each case. The actual cost metric in the objective function (i.e., the cost that is minimized) is the present value of revenue requirements (PVRR), which is the discounted stream of direct costs over 20 years that is used in traditional ratemaking. This cost metric is consistent with the definition of system cost in Section 113 of EPAct 1992:

> *"system cost" means all direct and quantifiable net costs for an energy resource over its available life, including the cost of production, transportation, utilization, waste*

management, environmental compliance, and in the case of imported energy resources, maintaining access to foreign sources of supply."

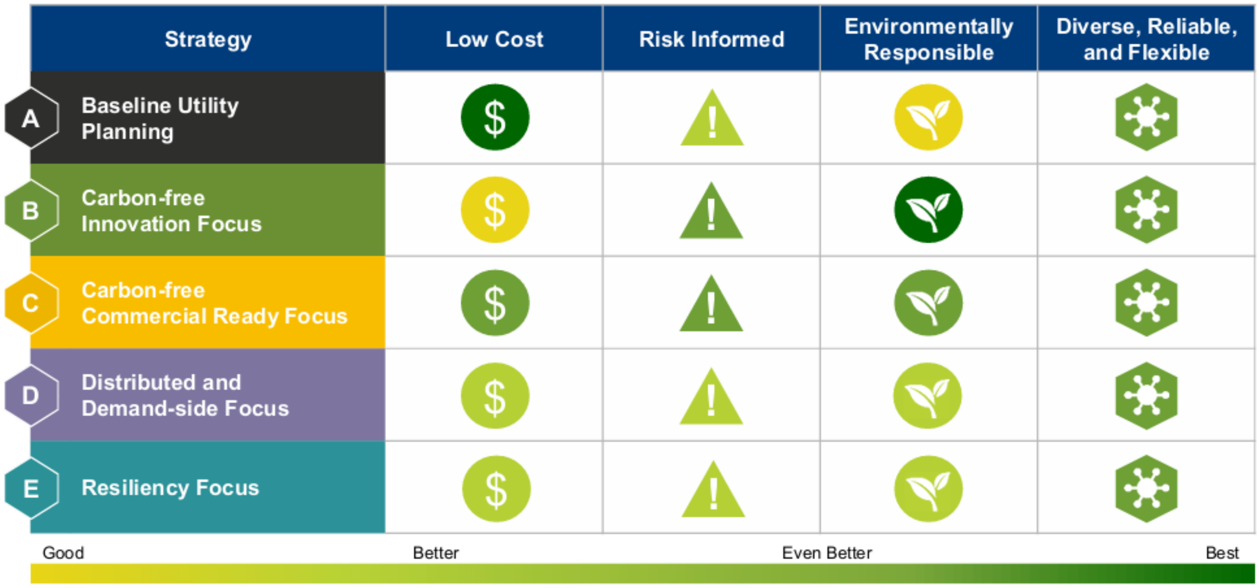
It is important to note that where TVA modelers simulate incentivizing investment in a particular technology by assuming a reduction in its cost, they add back the actual cost into the PVRR calculated by the model: "where a cost signal was used for resource promotion, the artificial cost reduction was later removed to accurately calculate cost metrics" (p. 3-11). This is critical to understanding and interpreting the results of the simulation modeling.

Metric Construction

In addition to the cost (PVRR) of each strategy under each scenario, the optimization model reports a variety of other outcomes – capacity builds, generation, fuel use, emissions, land and water use – that are used to construct metrics of financial risk, environmental impact, and system reliability and flexibility. These metrics, along with costs, help inform the selection of a strategy by illustrating tradeoffs among different objectives. The specific metrics calculated are:

Metric Category	Metric	Definition
Low Cost	Present Value of Revenue Requirements (PVRR) ($B)	Total plan cost (capital and operating) expressed as expected present value of revenue requirements
	System Average Cost ($/MWh)	Average system cost expressed as levelized average annual revenue requirements divided by average annual sales
	Total Resource Cost ($B)	Total plan cost (capital and operating) expressed as PVRR plus participant costs net of bill savings and tax credits
Risk Informed	Risk / Benefit Ratio	PVRR above expected value divided by PVRR below expected value based on stochastic analysis
	Risk Exposure ($B)	PVRR above expected value based on stochastic analysis
Environmentally Responsible	CO_2 Direct Emissions (Million Tons)	Average annual tons of CO_2 emitted
	CO_2 Intensity (lbs/MWh)	Average annual CO_2 emissions divided by average annual energy generated and purchased
	Water Consumption Intensity (Million Gallons/MWh)	Average annual gallons of water consumed divided by average annual energy generated and purchased
	Waste Intensity (Million Tons/MWh)	Average annual quantity of coal ash and gypsum produced divided by average annual energy generated and purchased
	Land Use Intensity (Acres/MWh)	Acreage needed for expansion units divided by energy generated and purchased in 2050
Diverse, Reliable, and Flexible	Operating Cost Stability (%)	Stochastic volatility of operating cost ($/MWh) expressed as a percentage
	Flexible Resource Coverage Ratio	Flexible capacity available to meet maximum three-hour ramp divided by flexible capacity requirement in 2050
	Energy Curtailment Ratio (%)	Expected average annual curtailed energy divided by average annual energy generated and purchased

The metrics that arise from analyzing various strategies in the defined scenarios are then summarized in the following array:



While these additional considerations go beyond the narrow least-cost requirement of Section 113 of EPAct 1992, they are entirely consistent with the requirements to account for "necessary features for system operation such as diversity, reliability, dispatchability and other factors of risk" and incorporate "waste management" and "environmental compliance" costs into the definition of costs to be minimized. Section 113 requires a least-cost planning process – which the current IRP satisfies – but does not explicitly preclude the consideration of other factors in selecting a resource portfolio. By employing a least-cost optimization algorithm augmented with tools to incorporate additional information into decision-making processes, TVA's integrated resource planning methodology reflects current best practice across the electricity sector and conforms with the requirements of Section 113 of EPAct 1992.