Aging Coal Fleet Evaluation

May 2021

Overview and Background

Optimal Portfolio: Principles & Initiatives

Cost Effectiveness – Take a long-run, risk-informed approach to least-cost planning

Environmental Stewardship – Reduce environmental impacts and support customer goals

Efficiency (Portfolio Fit) – Provide reliability and flexibility in the portfolio

Portfolio Diversity – Provide rate stability by utilizing diverse fuel sources

Natural Gas

- Continue Evaluation of Market Options
- Modernize the Combustion Turbine Fleet

Coal

- Retire
  - Paradise 3 2020
  - Bull Run 2023
  - Shawnee ~2034
- Coal End-of-Life Evaluations

Nuclear

- Browns Ferry Extended Power Uprates
- Performance Improvement Plan
- Browns Ferry Second License Renewal

Hydro

- Hydro Major Maintenance
- Dam Stabilization
- Evaluate Flexibility Opportunities

Solar/Wind

- Add Solar as Economics Approach Parity
- Partner with Customers to Meet Demand for Renewables

Storage

- Demonstrate Battery Storage Use Cases
- Continue Research and Price Monitoring

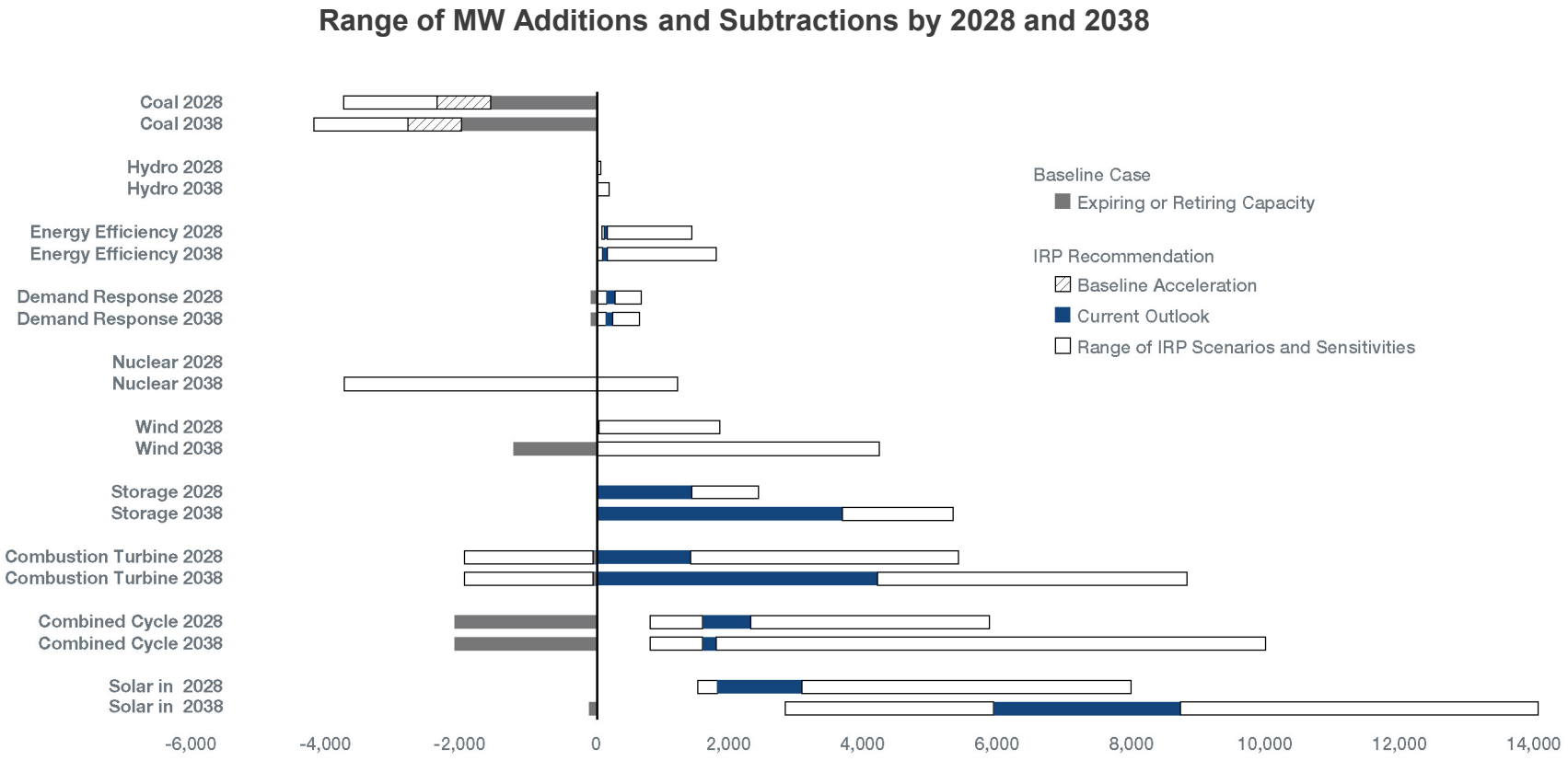
EE & DR

- Expand Low Income EE Pilot Valley-wide
- Conduct EE Market Potential Study
- Support Distribution Resource Planning efforts

Transmission

Reliable & Integrated Grid | Expansion for Economic Development & Local Load Growth | Regulatory Compliance

2019 IRP Guideline Ranges Included the Potential for Aging Fossil Retirements



- *MWs are incremental changes from 2019 forward. Baseline case represents expiring and retiring capacity assumed for all cases..*
- *Browns Ferry Nuclear Plant license is not extended in the No Nuclear Extensions Scenario (outside of TVA control).*
- *Upper bounds of potential natural gas and solar additions are driven by the Valley Load Growth Scenario.*
- *Solar and wind are shown in nameplate capacity.*
- *Solar, gas, and storage ranges include utility-scale and distributed additions (where promoted in a strategy).*

2019 IRP Also Recommended a Near-Term Action to Further Evaluate the Aging Fossil Fleet

RENEWABLES & FLEXIBILITY

- Add solar based on economics and to meet customer demand
- Enhance system flexibility to integrate renewables and distributed resources
- Evaluate demonstration battery storage to gain operational experience

EXISTING FLEET

- Pursue option for license renewal for TVA's nuclear fleet
- **Evaluate engineering end-of-life dates for aging fossil units to inform long-term planning**

ENERGY USAGE

- Conduct market potential study for energy efficiency and demand response
- Collaborate with states and local stakeholders to address low income energy efficiency
- Collaboratively deploy initiatives to stimulate the local electric vehicle market

DISTRIBUTION PLANNING

- Support development of Distribution Resource Planning for integration into TVA's planning process

Signposts Indicate Increasing Cost and Reliability Challenges in the Aging Fossil Fleet

The 2019 IRP recognized that portfolio shifts will be driven by changing market conditions, more stringent regulations, and technology advancements, such as:

- Demand for electricity
- Natural gas prices
- Customer expectations
- Regulatory requirements
- **Operating costs for existing units**
- Solar and wind costs
- Emerging and developmental technologies

Operating cost and reliability challenges in the aging fossil fleet driven by age, condition and system flexibility requirements signaled the need for further evaluation

Aging Coal Fleet Evaluation

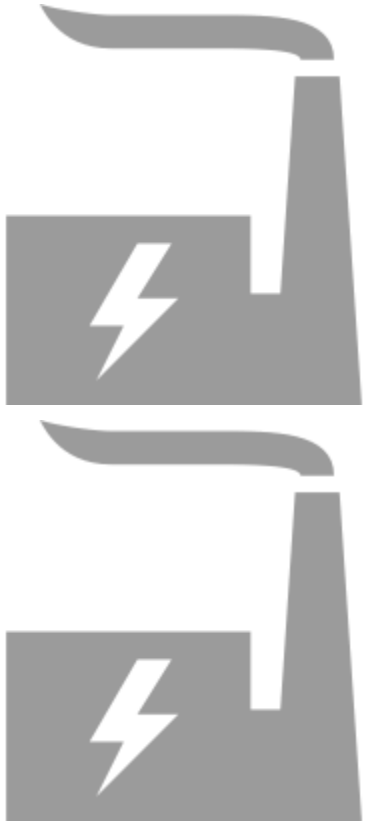
Key Drivers for Aging Coal Fleet Evaluation

- Substantial performance and cost risk is carried by operating a coal fleet reaching the end of its useful life
- Public, political, regulatory and marketplace pressures to reduce coal generation and environmental impacts are increasing
- Integration of increasing amounts of renewables and distributed resources drives the need for increased system flexibility
- Long-term financial health of the coal mining industry could influence the ability to procure coal and/or the price of coal
- Developing a plan to systematically replace coal plants reaching end-of-life allows for more effective and proactive management of financial, logistical and workforce impacts

Coal Fleet Demographics

Large Coal Units
Serving Baseload

Cumberland (CUF)
2,470 MW



Large Coal Units
Operating on the Margin

Paradise (PAF)
971 MW (Retired)

Bull Run (BRF)
865 MW (Announced Retirement)

Small Coal Units
Meeting Load Swings

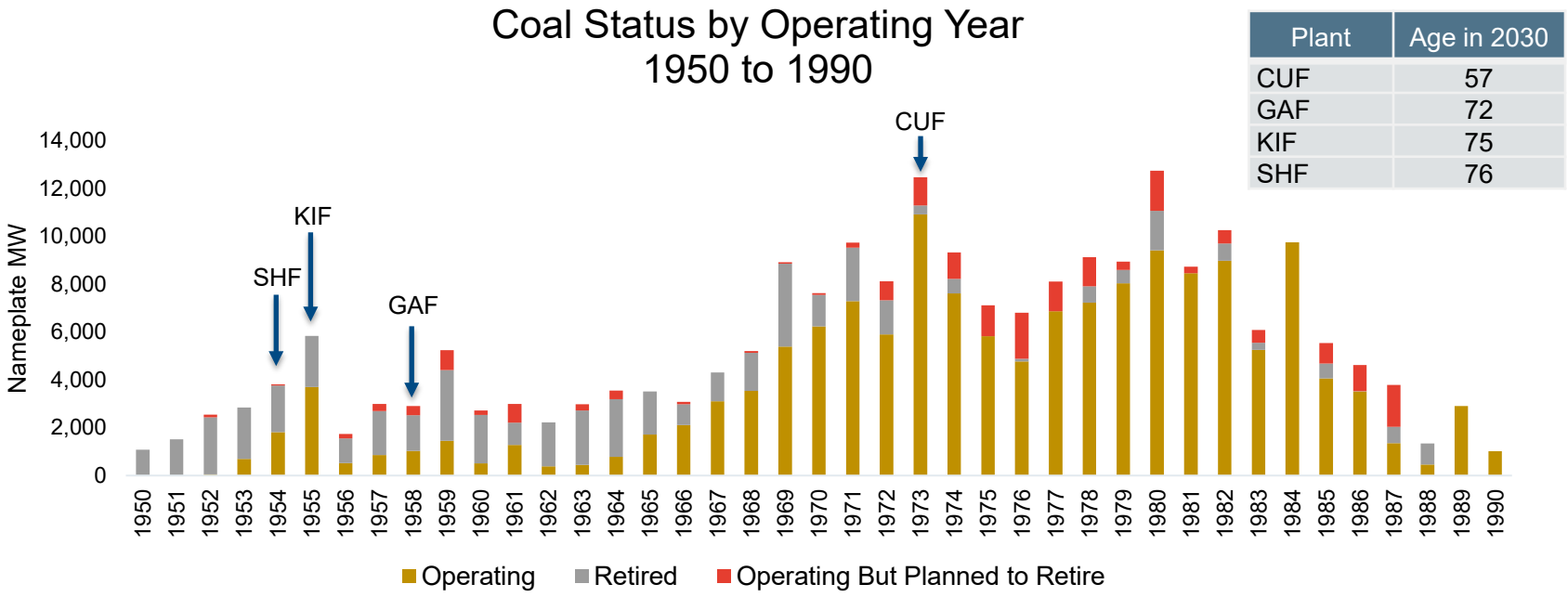
Gallatin (GAF)
976 MW

Kingston (KIF)
1,398 MW

Shawnee (SHF)
1,206 MW

** 2019 10-K capacities noted*

Most Coal Built in the 1950s & 1960s is Retired



Plant	Age in 2030
CUF	57
GAF	72
KIF	75
SHF	76

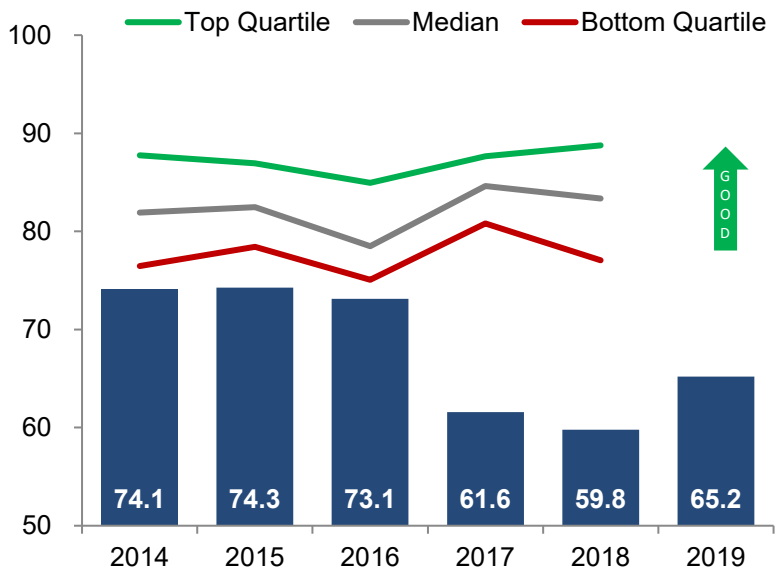
- TVA's coal plants are operating well beyond their original book life and are among the oldest still in operation in the nation
- CUF is 15-20 years younger than TVA's other coal plants, but frequent cycling of the super-critical units presents reliability challenges that are difficult to anticipate and very expensive to mitigate
- The CUF silo failure and KIF and GAF mud drum issues are symptomatic of age-driven material condition issues that are difficult to proactively address

Weighted Average of Operating Date; Source: EIA

Coal Fleet Performance is Challenged, Driving Cost and System Reliability Pressure

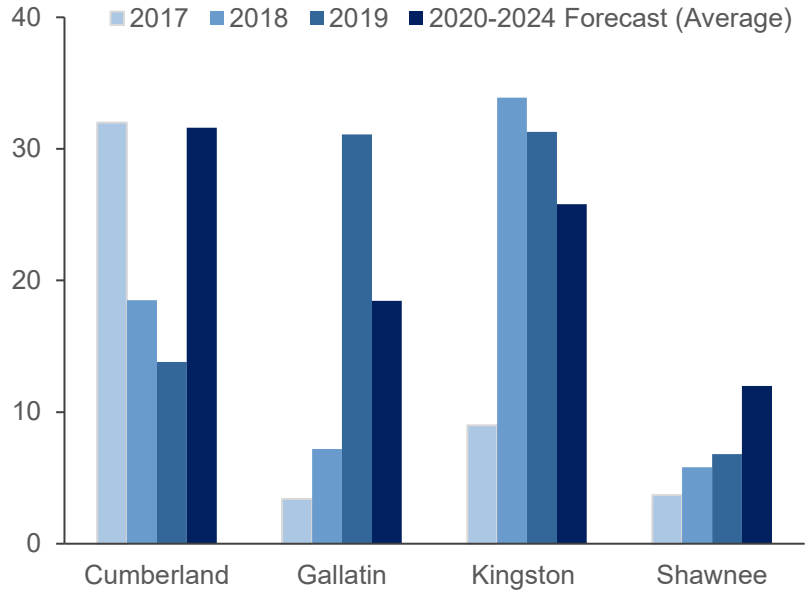
- TVA's coal fleet availability ranks in the bottom quartile in a regional peer comparison
- Unplanned outage rate, a component of availability, is the primary driver of challenges at CUF, GAF, and KIF and is also exhibiting a deteriorating trend at SHF

TVA Coal Fleet Comparison to Peers
Equivalent Availability Factor %



Peer data to calculate CY 2019 quartile values were unavailable at the time of report generation.

TVA Coal Plant Performance
Unplanned Outage Rate (%)



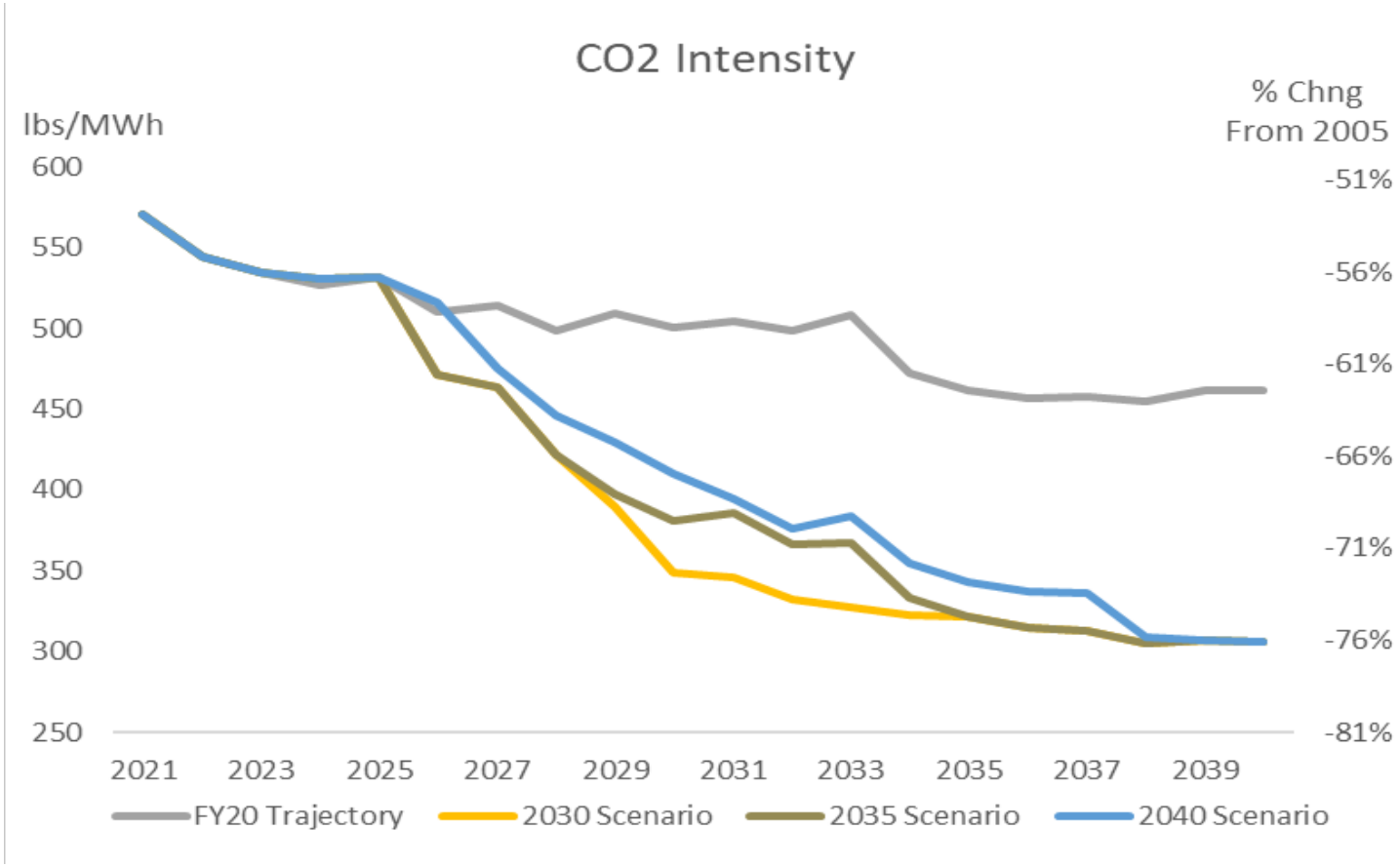
Coal End-of-Life Evaluations

- 2030 evaluation compresses replacement schedule, driving significant execution risk and financial pressure
- 2040 evaluation is slightly more economic than the 2035 scenario, but introduces more system reliability risk given the age, condition, and fit challenges of the coal fleet
- 2035 evaluation achieves the best balance between economics and system reliability, and the timeline allows for a high confidence of execution
- KIF & CUF are retired sooner due to KIF's high cost and challenged condition and CUF's lack of flexibility; SHF & GAF are retired later due to relatively better condition; SHF retirement currently projected by 2034 to meet anticipated air quality compliance requirements

First Calendar Year Units Not Available	2025	2026	2027	2028	2029	2030	2031	2032	2033	2034	2035	2036	2037	2038	2039	2040
FY20 Trajectory										SHF x9						
2030 Evaluation		CUF2 KIF7-9		KIF 1-6	CUF1 GAFx4	SHF x9										
2035 Evaluation		CUF2 KIF7-9		KIF 1-6	CUF1			GAF x4		SHF x9						
2040 Evaluation			CUF2 KIF7-9		KIF 1-6		CUF1			SHF x9				GAF x4		

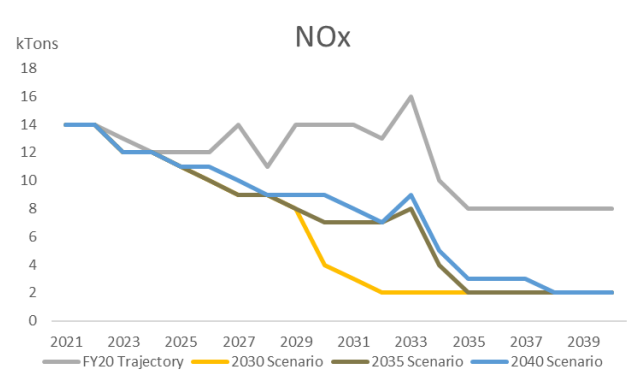
Coal Evaluations: Carbon Impacts

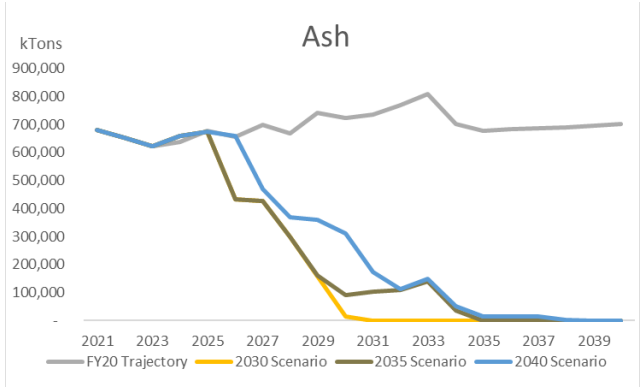
- Coal end-of-life puts TVA on a path to over a 75% reduction in carbon intensity from a 2005 baseline (2040 carbon emissions rate is about 30% lower than FY20 Trajectory)

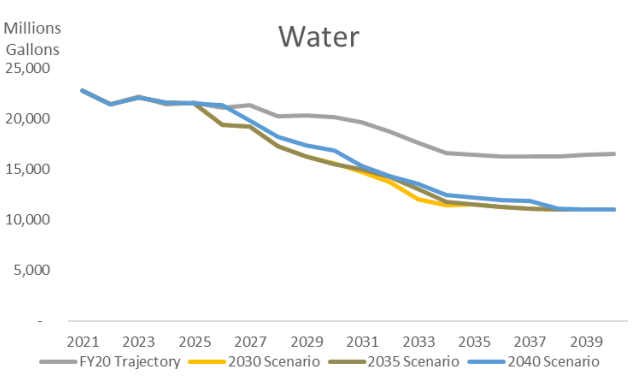


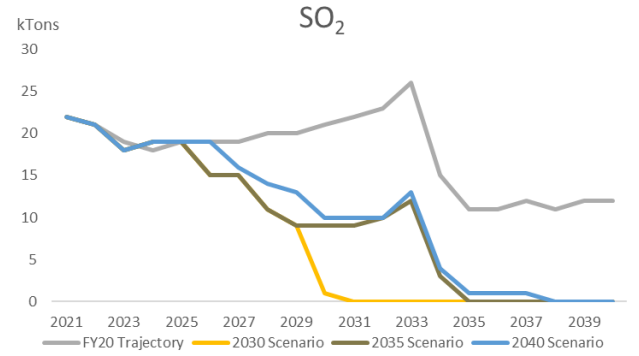
Coal Evaluations: Other Environmental Impacts

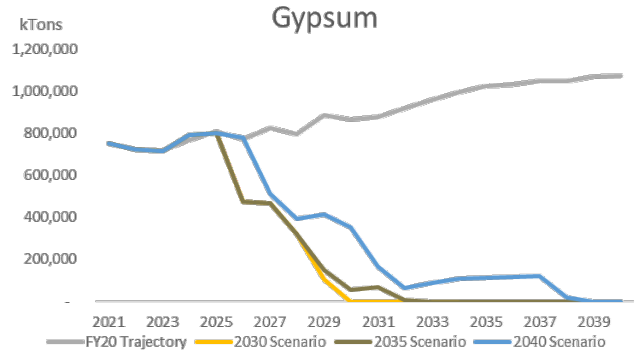
- Coal end-of-life also drives reductions in other environmental impacts
- Sulfur oxide emissions are eliminated, and nitrogen oxide emissions are greatly reduced
- Ash and gypsum waste byproducts are eliminated, and water consumption is reduced











Coal Evaluations: Fuel Resiliency Considerations

- An IHS Markit study completed in January 2019 evaluated the fuel resiliency of TVA's generating fleet and concluded that TVA's overall fuel supply position is among the most resilient in the nation, driven by several key factors:
  - A well-diversified generation portfolio
  - Access to hydro resources
  - A nuclear fleet with a strong and resilient program to secure nuclear fuel
  - Advantageous location with respect to major gas transportation pipelines
  - Access to multiple coal supply and transport options
  - Recognition that many utilities are reducing coal capacity and relying more on gas capacity, and that TVA is well positioned with a diverse fleet and resilient gas supply

- A SERC-commissioned study completed in November 2018 evaluated the potential impacts of severe natural gas supply disruptions, and the probabilistic study showed no impact in the SERC North region (primarily TVA) from gas supply disruptions with respect to:
  - Loss of Load Expectation
  - Loss of Load Hours
  - Loss of Expected Energy

Risks to Executing Coal End-of-Life

- Delays in construction timelines for replacement generation and associated transmission, fuel supply, or other supporting infrastructure
- Delays in required environmental assessments or permitting required for replacement generation, fuel supply, or supporting infrastructure
- Depth or availability of contractor workforce to support major generation projects
- Long-term financial health of the coal mining industry that could influence ability to procure coal and/or the price of coal during the transition

Coal Evaluations: Environmental Review

- Coal retirements and corresponding replacement generation will be further evaluated in environmental reviews under the National Environmental Policy Act (NEPA)
- Pursuant to NEPA, TVA will study the environmental impacts associated with proposed retirements of the coal plants, along with alternatives for replacement generation
- Alternatives will align to 2019 IRP recommendations, which pointed to near-term generation additions of solar, gas, and storage resource types
- Environmental reviews will be site specific and staggered to reflect evolving signposts, such as system needs and development of emerging technologies

Coal End-of-Life: Summary and Recommendation

- Summary: Coal fleet end-of life, expected by around 2035, is aligned with least-cost planning and reduces economic, reliability, and environmental risks.

- Recommendation: Based on the end-of-life evaluations of aging coal units and consideration of TVA's portfolio needs as reflected in the 2019 IRP and ongoing resource planning, TVA staff recommends the following planning assumptions for coal unit retirement dates:

Fossil Plant	Retirement Planning Assumption
Bull Run Fossil Plant (1)	December 1, 2023
Cumberland Fossil Plant - 1 Unit (2)	December 31, 2026
Kingston Fossil Plant - 3 Units (2)	December 31, 2026
Kingston Fossil Plant - 6 Units	December 31, 2027
Cumberland Fossil Plant - 1 Unit	December 31, 2028
Gallatin Fossil Plant	December 31, 2031
Shawnee Fossil Plant	December 31, 2033

(1) Listed for reference, as the Board approved the retirement of the Bull Run Fossil Plant in February 2019.
(2) Planning assumption is one year later than analyzed to align to practical timelines for replacement generation.

- Environmental Assessment: Coal retirements and corresponding replacement generation will be further evaluated in environmental reviews under the National Environmental Policy Act (NEPA).