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Aging Fossil Unit Evaluation: Oldest Combustion Turbines (CT)

August 2019

Aging Fossil Unit Evaluation: Overview and Background

Optimal Portfolio: Principles & Initiatives

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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

IRP Guideline Ranges Included the Potential for Aging Fossil Retirements

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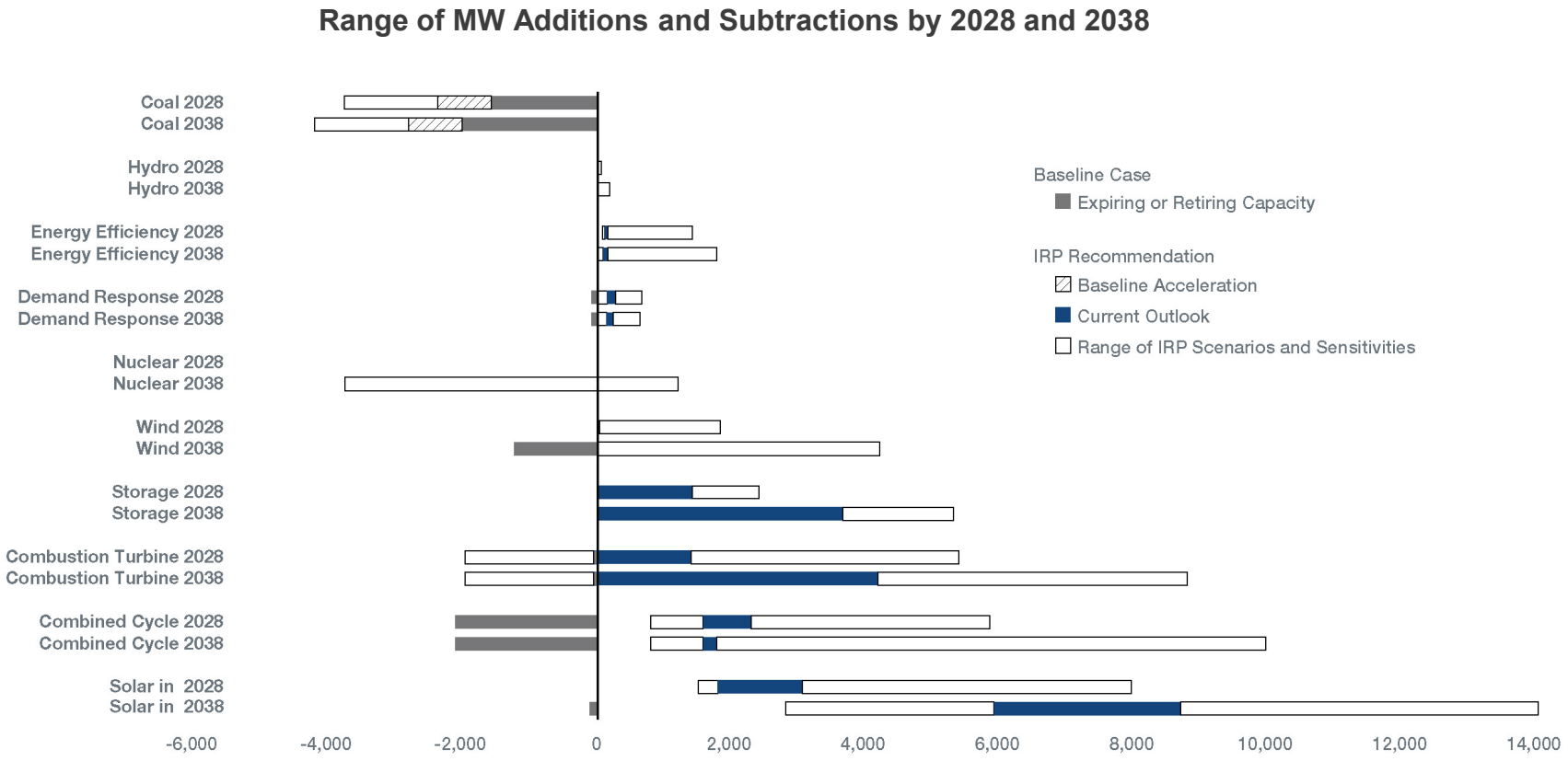

- *MWs are incremental changes from 2019 forward. Baseline case represents expiring and retiring capacity assumed for all cases..*
- *Browns Ferry Nuclear Plant license is not extended in the No Nuclear Extensions Scenario (outside of TVA control).*
- *Upper bounds of potential natural gas and solar 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).*

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

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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

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The 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

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Aging Fossil Unit Evaluation: Oldest Combustion Turbines (CT)

Key Drivers for Aging CT Fleet Evaluation

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- The gas fleet, particularly Combustion Turbines (CT), will play a critical role in providing the flexibility needed to integrate renewables and distributed resources
- About one-third of the CT fleet is at least 40 years old and in challenged condition
- To prepare for a future system that can effectively integrate renewables and distributed resources, an evaluation of the aging CT fleet was needed
- The evaluation considered whether it was more economical to refurbish or replace the aging CT units

Ensuring a Reliable and Flexible Peaking Fleet

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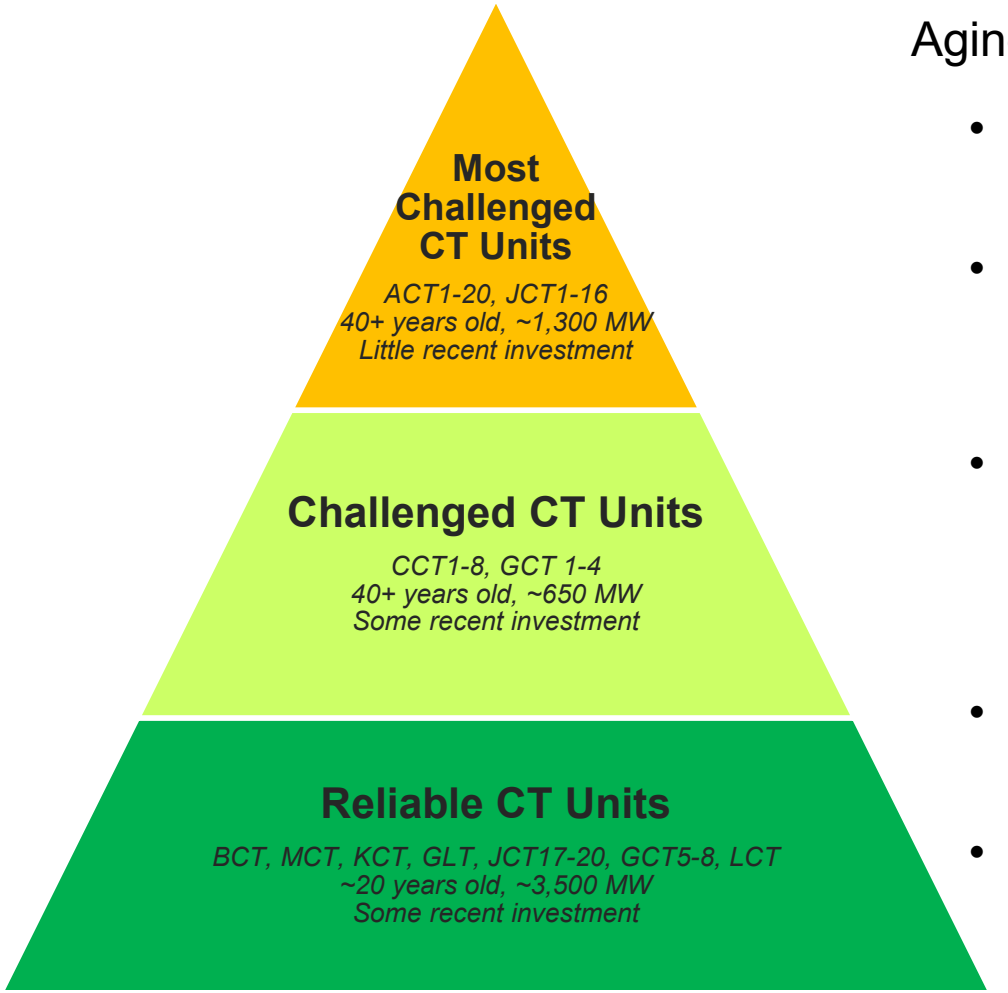

Aging CT Fleet Evaluation Approach:

- Evaluated economics of refurbishment versus replacement
- Considered Aero CTs, Frame CTs and Combined Cycles as replacement options to support integration of solar in the plan
- Considered New Source Performance Standards (plant subject to new emission constraints if reconstruction exceeds 50% of cost to construct a comparable new facility)
- Ensured recommendation aligns with long range capacity needs
- Identified opportunities for increased flexibility to integrate renewables

Gas Technology Roles

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Frame CT

Peaking unit with the ability to ramp quickly to meet capacity needs during short periods for the lowest installed capital cost

Capacity Factor: 1-10%

Aeroderivative CT

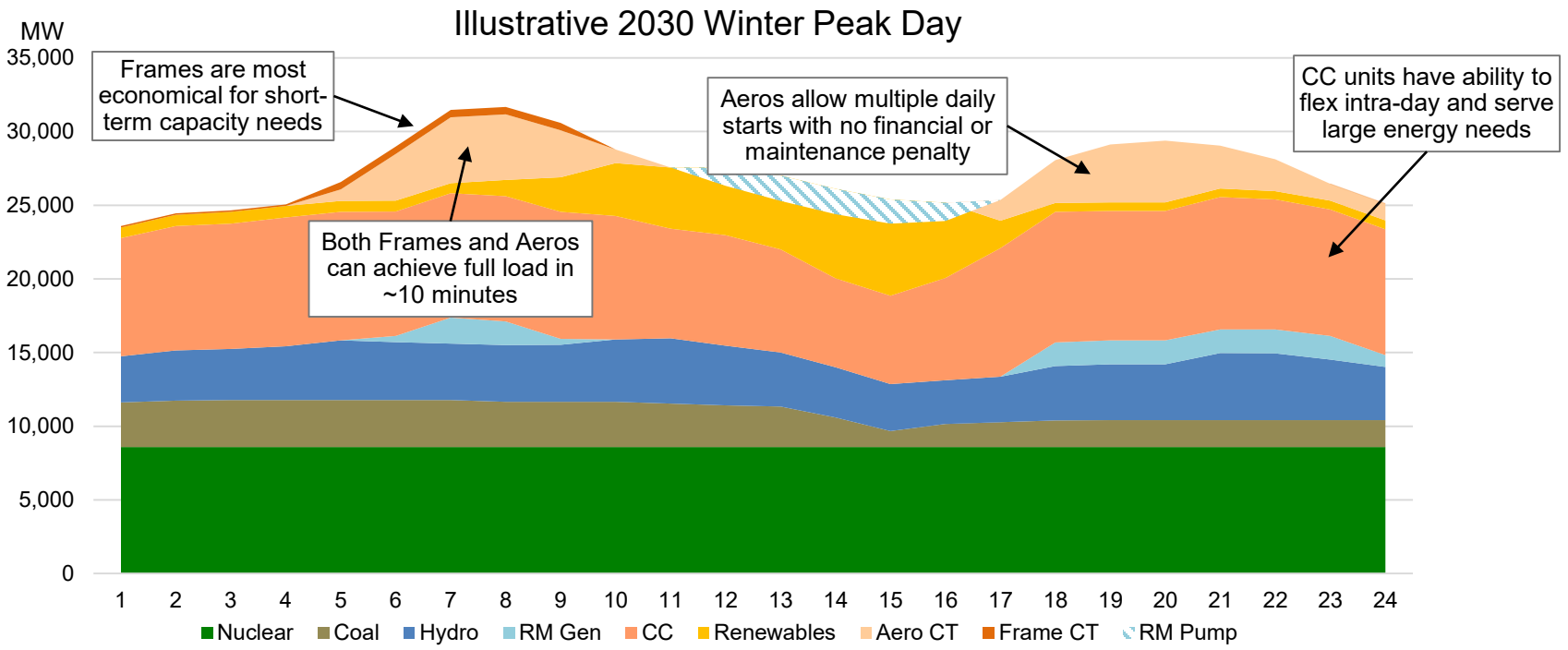
Efficient, black start capable, peaking unit that can ramp very quickly at no start cost to integrate renewables and provide grid support

Capacity Factor: 10-45%

Combined Cycle

Efficient intermediate unit with large energy potential as well as the ability to provide grid support and follow load

Capacity Factor: >50%



Challenged Units Must be Refurbished or Replaced to Ensure Reliability

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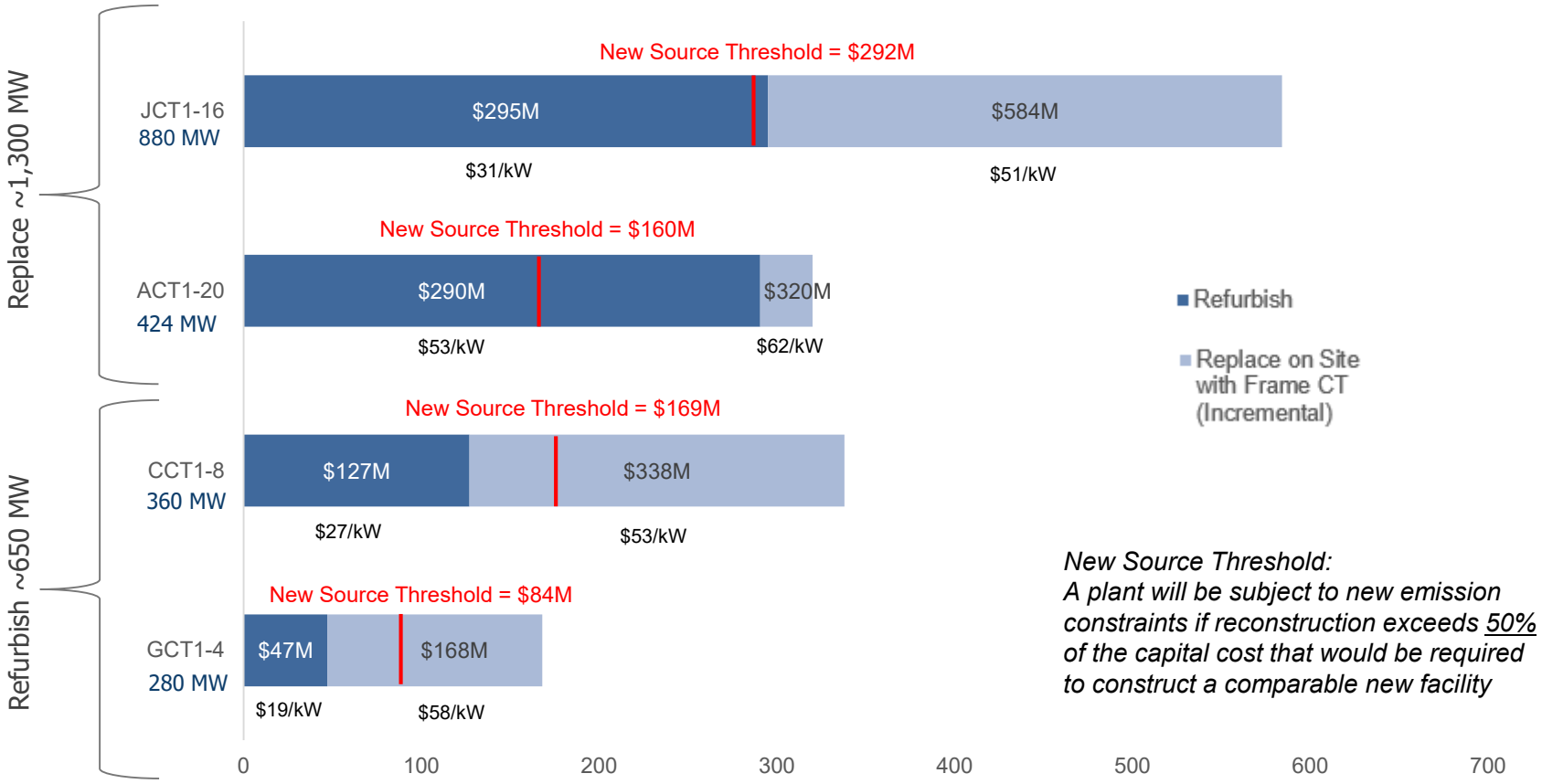
Refurbishment capital spend exceeds the new source threshold for Allen CT Plant and Johnsonville Units 1-16, pointing to retirement and replacement of these units



New Source Threshold:
A plant will be subject to new emission constraints if reconstruction exceeds 50% of the capital cost that would be required to construct a comparable new facility

Value below each bar represents the NPV $/kW

Flexibility Study Indicates that 500 MW of Aero CTs are a No Regrets Addition

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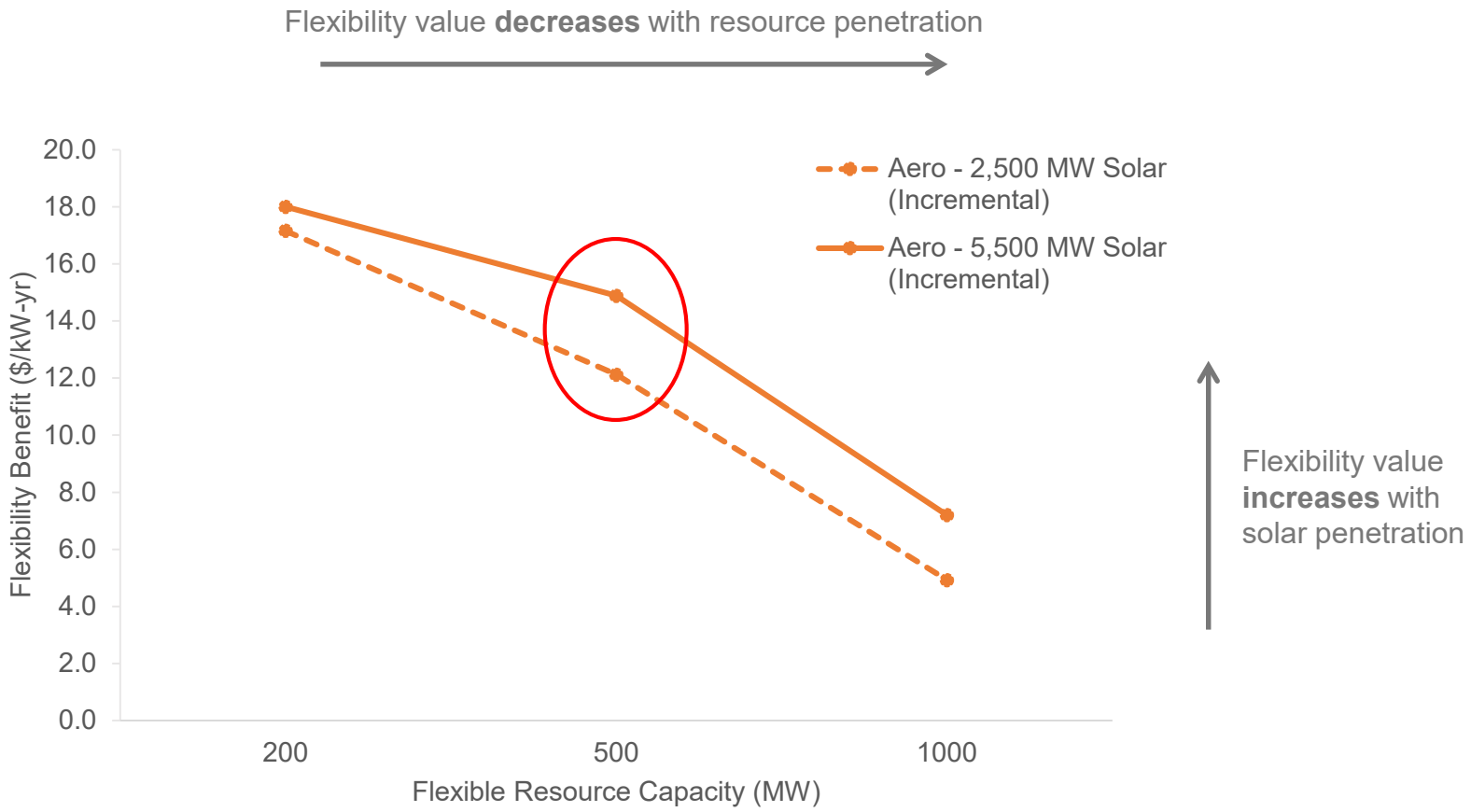
Adding 500 MW of Aeroderivatives helps meet timing of capacity need and provides optimal flexibility benefits for integrating renewable capacity in all load futures



Source: TVA 2018 Flexibility Study

Preliminary Siting Evaluation

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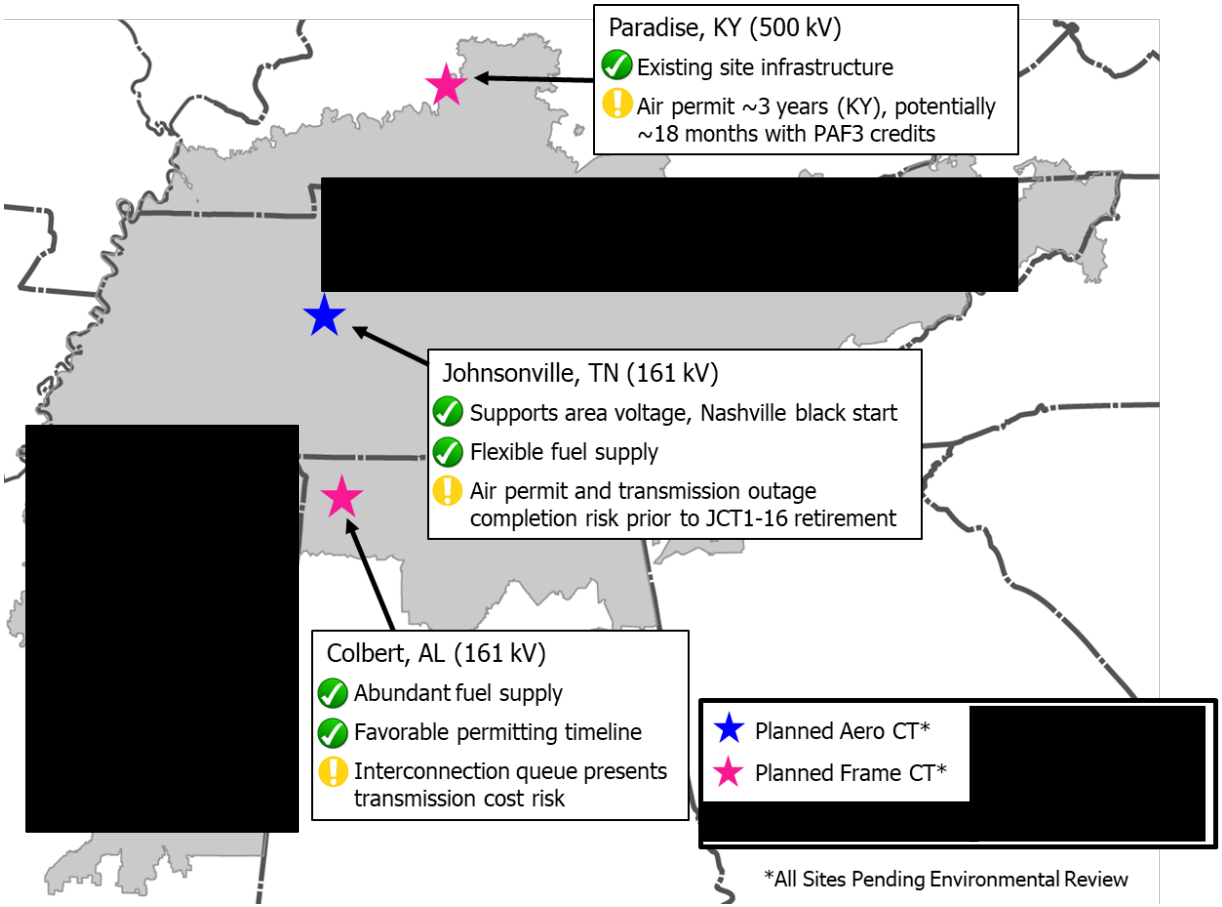
Preliminary siting work evaluated transmission, fuel, environmental, and project scope and cost considerations for numerous brownfield and greenfield options for gas generation



Siting evaluation indicated:

- Paradise and Colbert are the two best sites for Frame CT installation
- Johnsonville is the best site for Aero CT installation

Siting recommendations are preliminary and pending environmental review

CT Fleet Modernization – Recommendation

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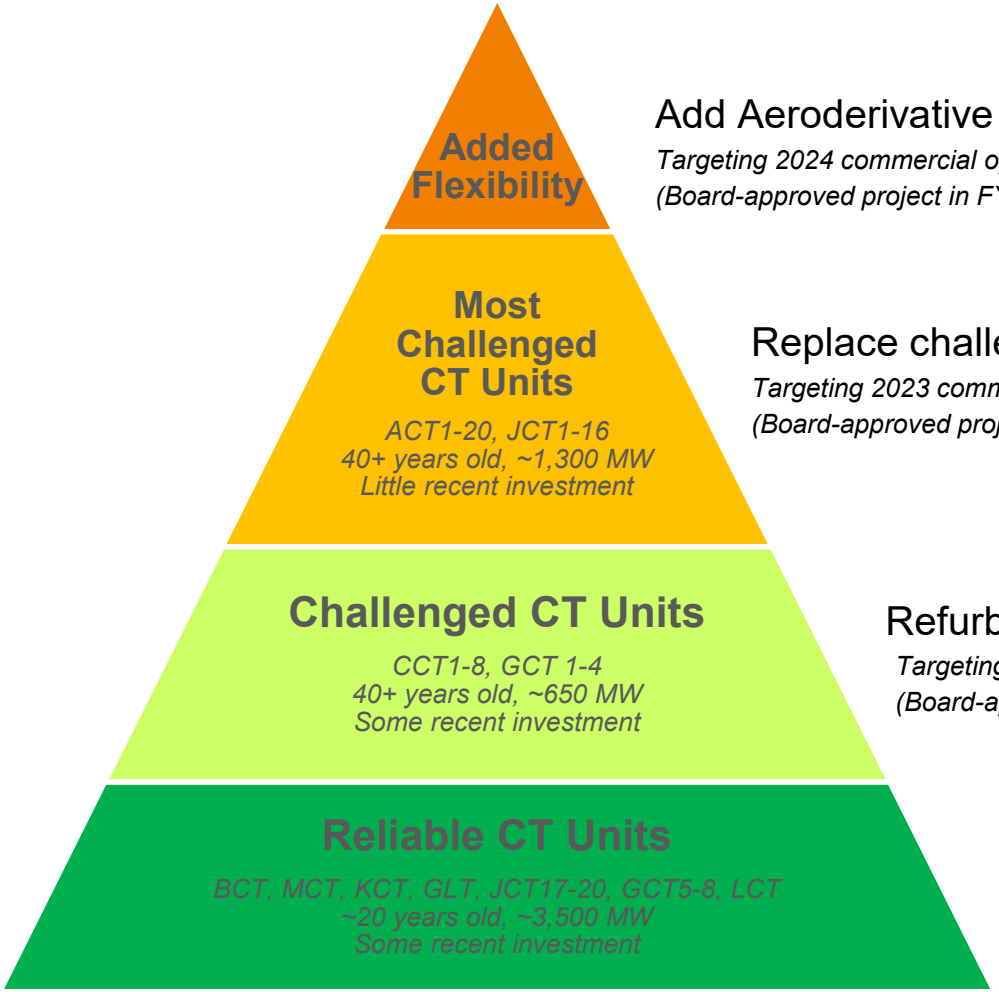
CT Modernization Helps Sustain a Reliable and Flexible Peaking Fleet



Add Aeroderivative CTs to enhance flexibility (~500-650 MW)

Targeting 2024 commercial operation date

(Board-approved project in FY20 Budget, contingent on environmental review)

Replace challenged CTs (~1,400 MW)

Targeting 2023 commercial operation date

(Board-approved projects in FY20 Budget, contingent on environmental review)

Refurbish and maintain challenged units

Targeting refurbishment project completion by 2024

(Board-approved projects in FY20 Budget)

Invest to maintain reliable units

CT End-of-Life: Summary and Recommendation

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- Summary: Retirement and replacement of the most challenged CT units is aligned with least-cost planning

- Environmental Assessment:
  - Site-specific impacts from the potential retirement of the oldest CT plants were evaluated in the 2019 IRP Environmental Impact Statement
  - Environmental Assessments for the replacement projects will be conducted and completed to inform a final decision on path forward