

Aging Fossil Unit Evaluation: Oldest Combustion Turbines (CT)

August 2019

Aging Fossil Unit Evaluation: Overview and Background

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



Coal



Nuclear



Hydro



Solar/Wind



Storage



EE & DR

Continue Evaluation of Market Options

Modernize the Combustion Turbine Fleet

Retire
 • Paradise 3 2020
 • Bull Run 2023
 • Shawnee ~2034

Coal End-of-Life Evaluations

Browns Ferry Extended Power Uprates

Performance Improvement Plan

Browns Ferry Second License Renewal

Hydro Major Maintenance

Dam Stabilization

Evaluate Flexibility Opportunities

Add Solar as Economics Approach Parity

Partner with Customers to Meet Demand for Renewables

Demonstrate Battery Storage Use Cases

Continue Research and Price Monitoring

Expand Low Income EE Pilot Valley-wide

Conduct EE Market Potential Study

Support Distribution Resource Planning efforts



Transmission

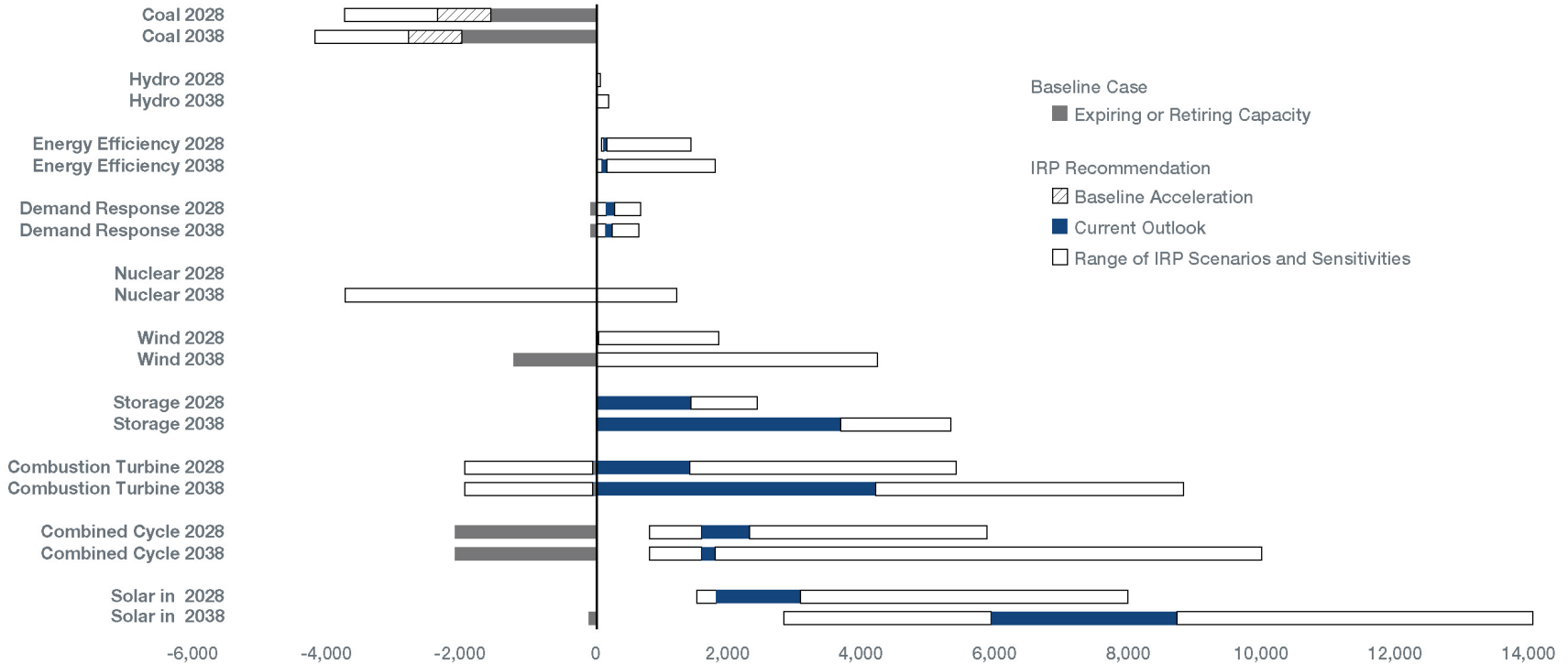
Reliable & Integrated Grid

Expansion for Economic Development & Local Load Growth

Regulatory Compliance

IRP Guideline Ranges Included the Potential for Aging Fossil Retirements

Range of MW Additions and Subtractions by 2028 and 2038



- 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

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

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

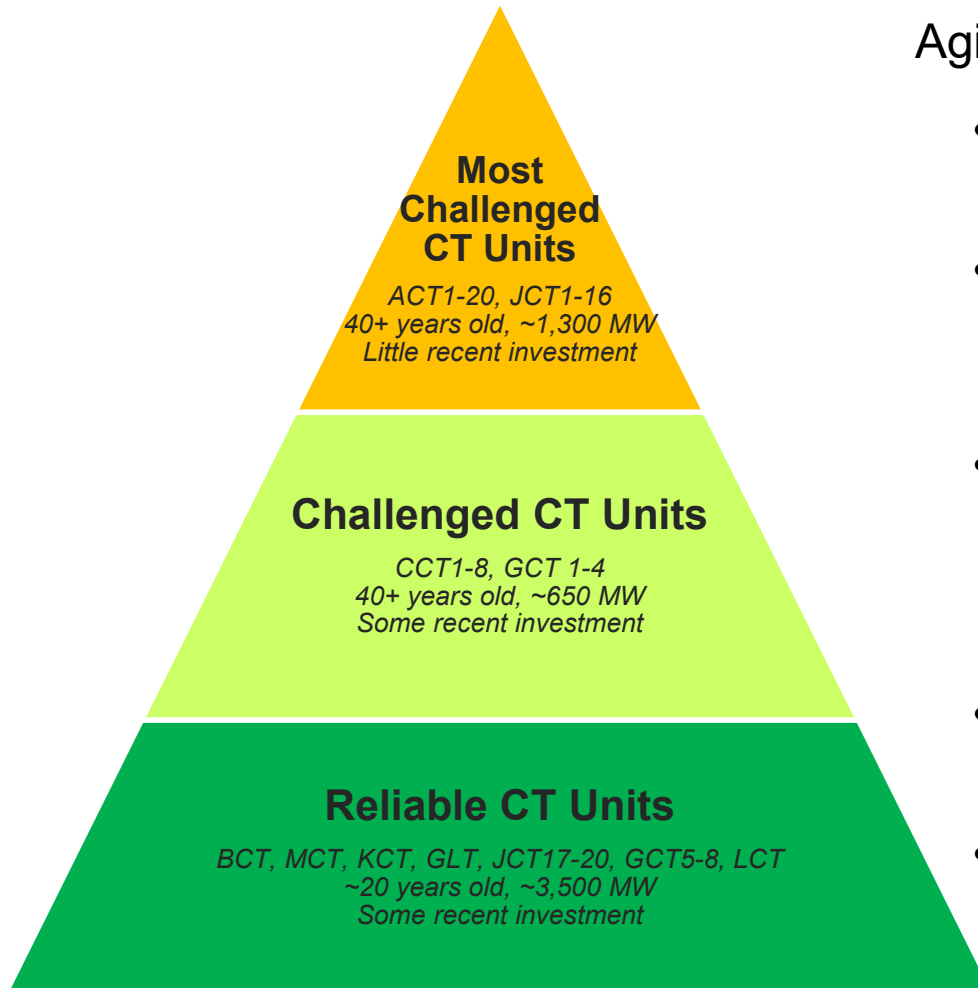


- Demand for electricity
- Natural gas prices
- Customer expectations
- Regulatory requirements
- **Operating costs for existing units**
- Solar and wind costs
- Emerging and developmental technologies

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

Aging Fossil Unit Evaluation: Oldest Combustion Turbines (CT)

- 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



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

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

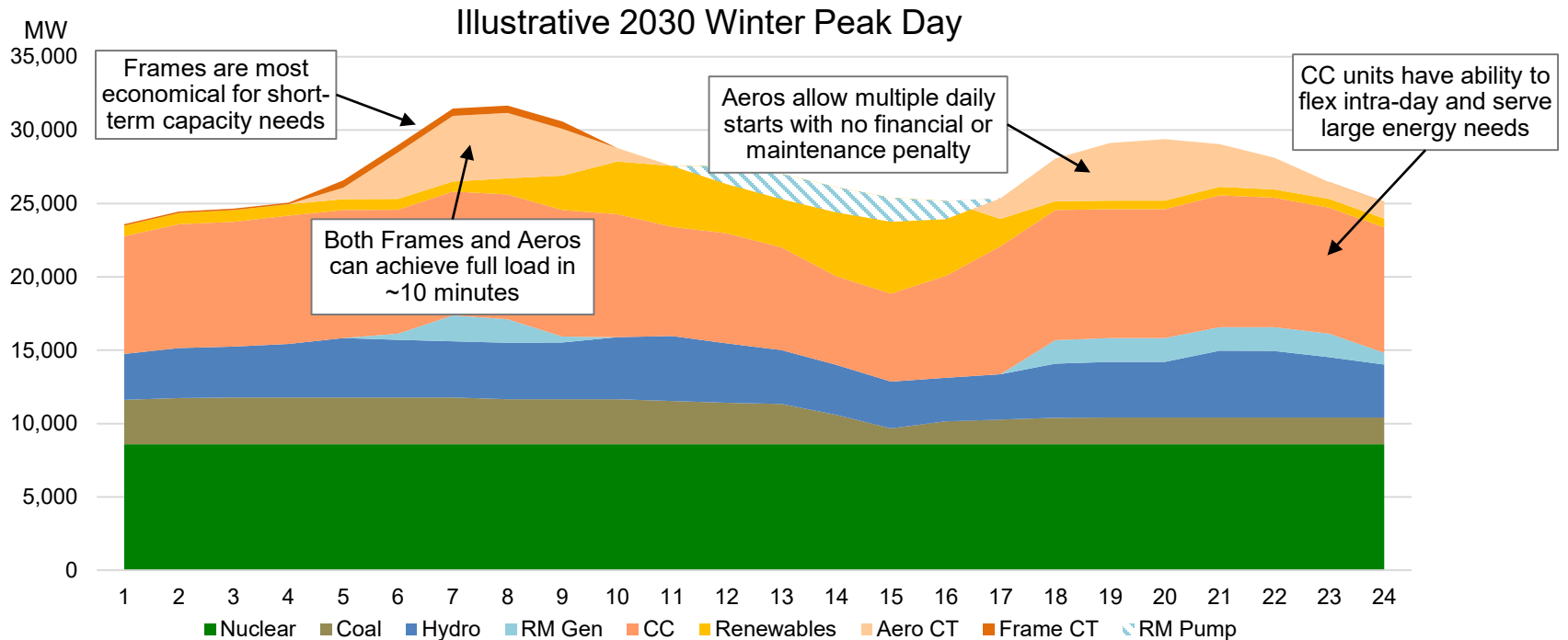
Efficient, black start capable, peaking unit that can ramp very quickly at no start cost to integrate renewables and provide grid support

Capacity Factor: 10-45%

Combined Cycle

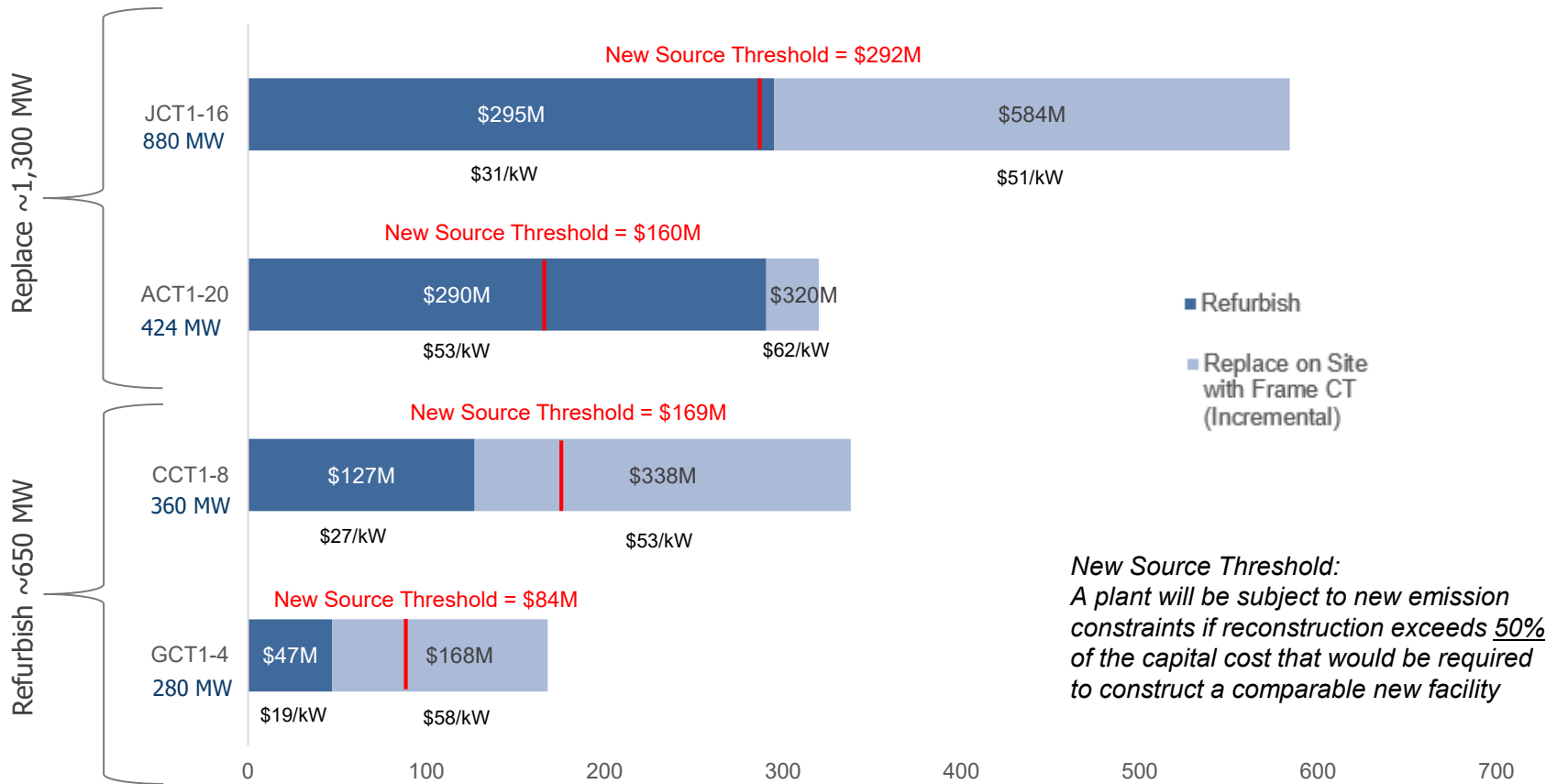
Efficient intermediate unit with large energy potential as well as the ability to provide grid support and follow load

Capacity Factor: >50%



Challenged Units Must be Refurbished or Replaced to Ensure Reliability

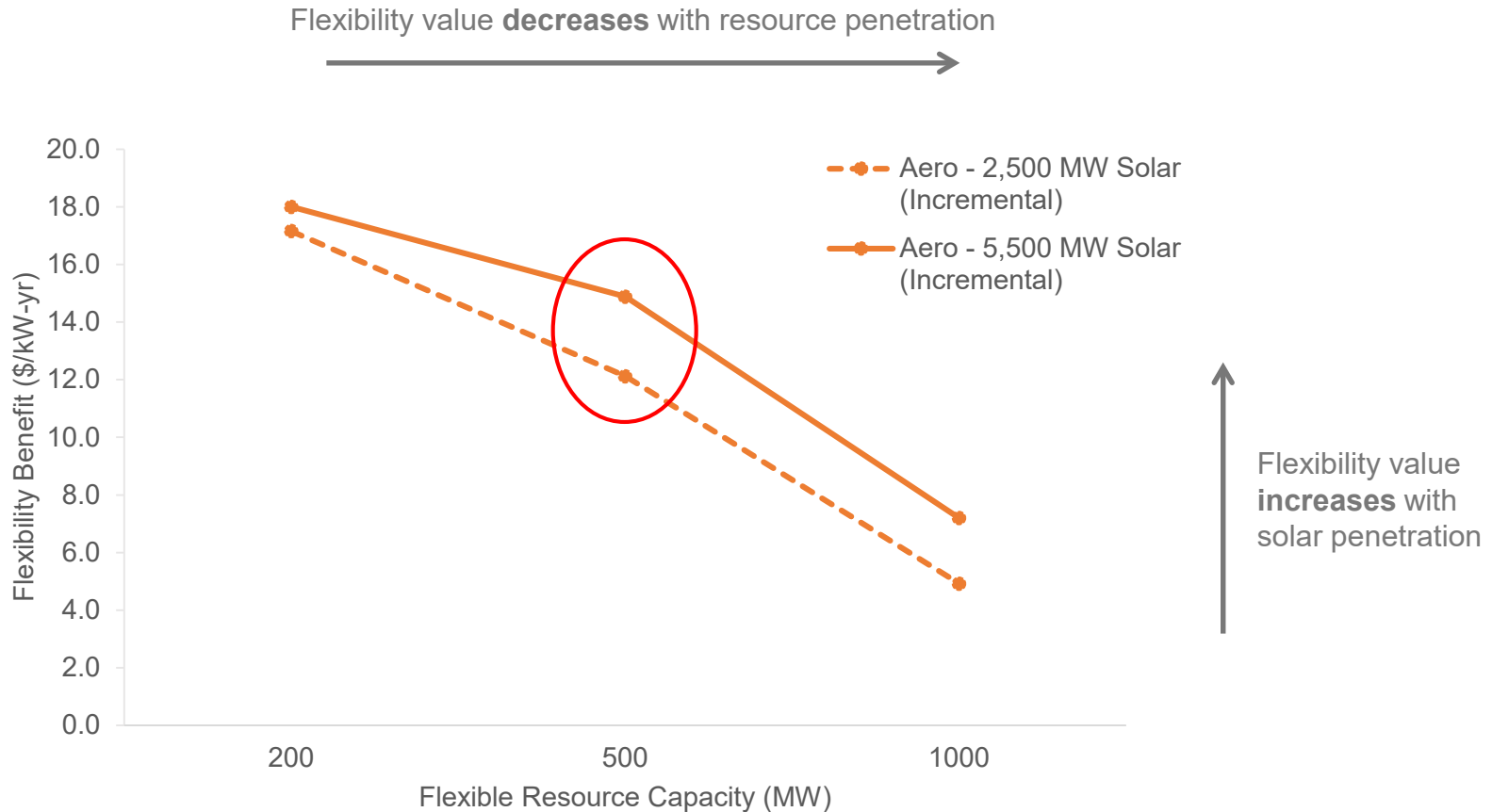
Refurbishment capital spend exceeds the new source threshold for Allen CT Plant and Johnsonville Units 1-16, pointing to retirement and replacement of these units



Value below each bar represents the NPV \$/kW

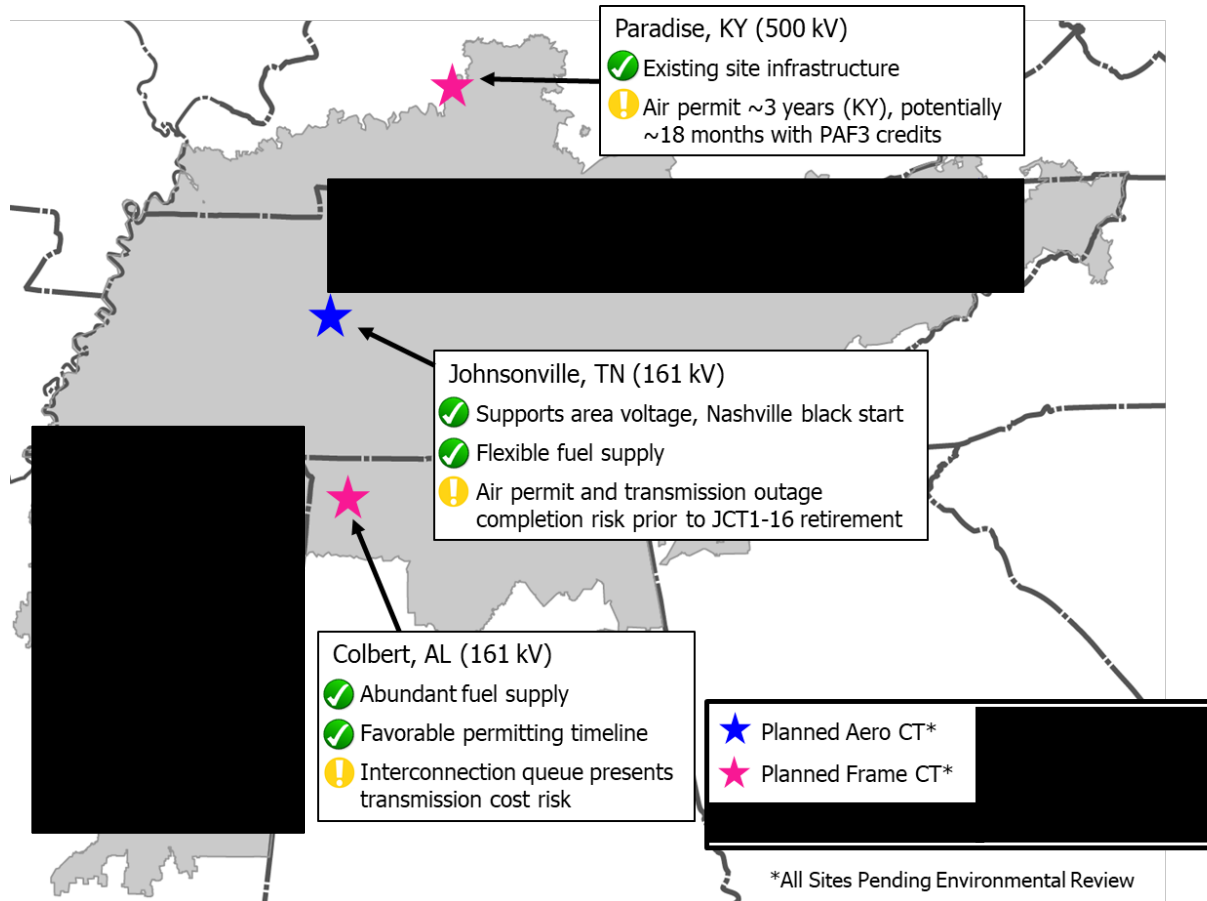
Flexibility Study Indicates that 500 MW of Aero CTs are a No Regrets Addition

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

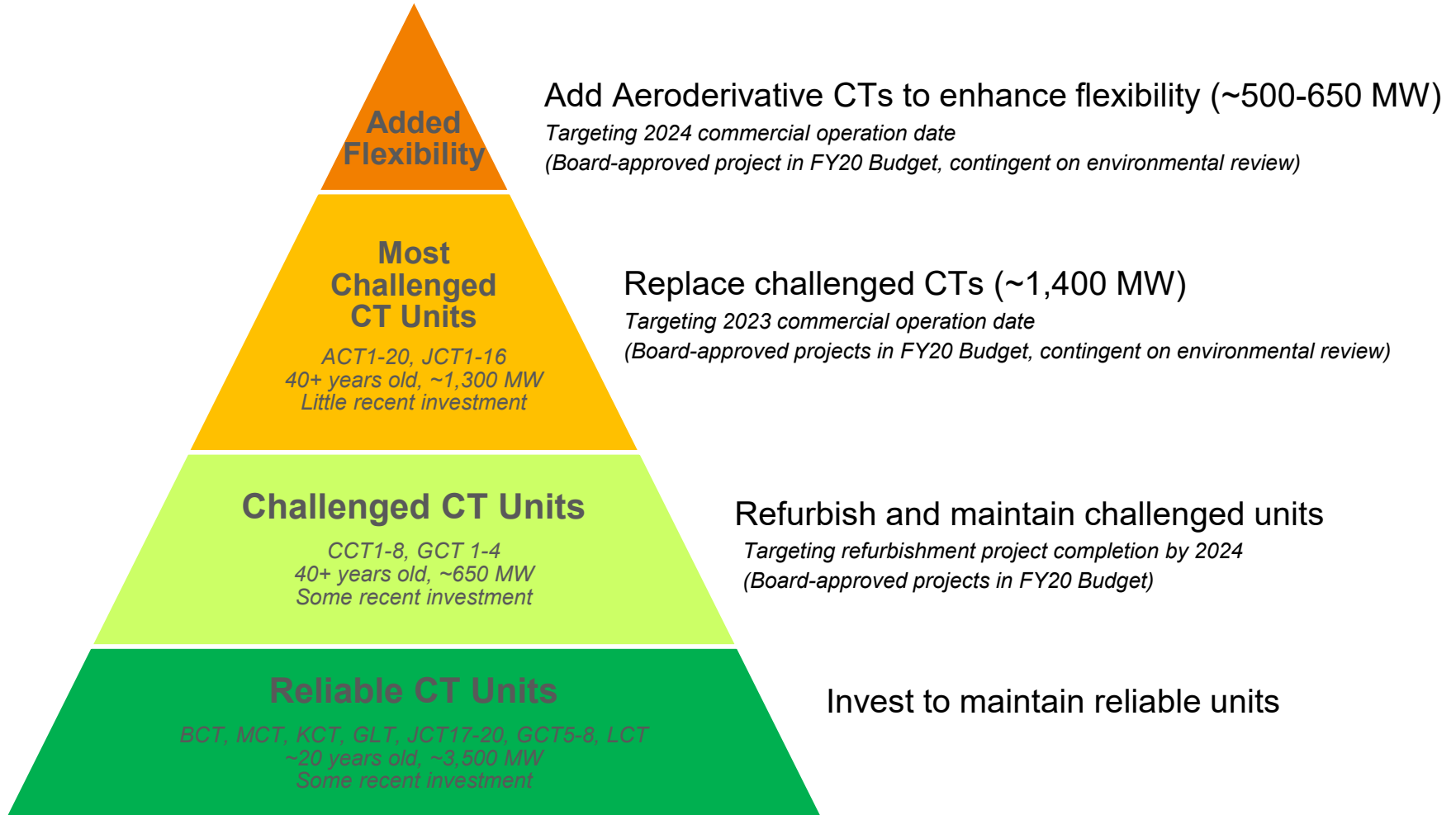


Siting evaluation indicated:

- 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 Modernization Helps Sustain a Reliable and Flexible Peaking Fleet



- 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