Supply Resilience: Generation Hardening, Fuel Supply Assurance, and Generation Adaptation

Technical Brief — *Heat Rate and Flexibility: Generation Fleet Optimization*

Research Question: What Are the Technologies Needed for Ensuring Generation Supply Resilience Under Future Scenarios?

Issue

Supply resilience is a critical issue for the generation fleet and an important area of research for EPRI. It includes generator hardening and fuel supply assurance, as well as activities to adapt generation supply for future scenarios.

The topic of supply resilience was addressed by EPRI in a white paper in August 2020 [1]. Within this paper, EPRI identified high-level strategies that could be employed to enhance resilience.

This technical brief outlines generation supply activities that could be steps toward improving supply resilience.

Generator Hardening

Generator hardening can take many forms. The most common—and often least costly—are improvements in cold weather hardening. For thermal plants, this includes low-cost cold weather readiness operational activities, but can also include steps to heat trace drain lines, insulate critical instrumentation, etc. [2, 3]. Freeze-up of an instrument or drain line during a cold spell can trip a large generator, which may not restart until after the freeze has passed. Hardening can also improve flood resistance with modifications such as berms, raising critical equipment, or continuing operation even in a flooded condition (e.g., remotely operating a combined cycle plant in simple cycle mode, if bypass operation is possible). Inlet cooling or fogging modifications are examples of hardening to help maintain capacity during extreme heat conditions on gas-turbine-fired power plants. Other modification to enhance or support heat rejection (cooling) can also support extreme heat hardening. Opportunities for enhancing hardening include controls improvements and ensuring major equipment redundancy. Common hardening examples include the addition of a spare feedwater pump (particularly in plants with a single point-of-failure vulnerability) and the adoption of a critical spare program (for items like generation step-up transformers). For renewable generation, cold weather can be an issue for wind generators if they are not designed or modified for cold weather operation [4]. Freeze-up can also become an issue for hydropower—particularly for the operation of spillway gates [4]. For solar photovoltaic, snow cover can also significantly impact output [4]. Modifications to limit these cold weather impacts can enhance the resilience of power systems. Cyber security enhancements in generating facilities is also a critical form of hardening [5].

Fuel Supply Assurance

Diversification of fuel supply is a key contributor to fuel supply assurance. Many coal-fired power plants have undergone conversion to dual fuel. The secondary fuel most often selected in the U.S. is natural gas [6]. This fuel diversification helps with fuel supply assurance but can also add to the plant's ability to operate flexibly. For plants fueled only by coal, a common supply assurance activity outside the U.S. is the adoption of a covered coal yard. This protects the coal pile from the elements, reducing the likelihood of bunkering frozen or wet coal—which can significantly reduce plant output during weather extremes. For natural gas fired power plants, having back-up oil tankage and the ability to fire oil can add to fuel supply assurance. Additional steps to diversify the methods of transporting fuel to the plant and receiving facilities (such as adding additional rail loops, and truck or barge unloading) can also enhance fuel supply assurance.

> *Supply resilience is the ability to harden supply resources (including associated fuel and all supply components) against—and quickly recover from—externally driven high-impact, low-frequency (HILF) events.*

Adaptation

In the short-term, supply resilience focuses largely on hardening and fuel supply assurance. However, it is important to understand how to adapt to a changing climate to ensure long-term resilience. The need to reduce carbon emissions has led to increasing use of variable energy in the generation mix, which results in the need to enhance the flexibility of existing and future power plants. These enhancements can include operational changes, but may also include gas turbine upgrades, inclusion of bypass lines, power augmentation, enhancements to preservation systems, and additional modifications to enhance flexibility. Another area of adaptation to ensure supply resilience is the incorporation of energy storage in combination with standard generation facilities [7]. This includes shorter-duration lithium ion batteries, as well as longer-duration storage (such as compressed air or thermal energy storage) [8]. To lower carbon dioxide emissions from generation, some utilities have begun to deploy or incorporate alternative fuel supplies—such as renewable natural gas, ammonia, and hydrogen—as part of generation facilities. For ammonia and hydrogen options, this includes assessing low-carbon production, storage, transportation, and—ultimately—use in existing and future generating plants [9]. Finally, adaptation to ensure supply resilience from the increasing pressures of climate change can take many forms depending on predicted climate scenarios for different regions. These changes can be modifications to hydropower plant hardware (to handle variations in precipitation) or further hardening of generation from rising sea level or changing inland flood risks [10].

EPRI continues to work with the industry, conducting collaborative R&D to enable the continuation of a resilient electricity supply—advancing approaches and technologies for hardening, fuel assurance, and adaptation of the generation supply.

EPRI's Generation sector provides information, processes, and technologies to improve the flexibility, reliability, performance, and efficiency of all non-nuclear generation assets and fleets around the world.

References

1. *Power System Supply Resilience: The Need for Definitions and Metrics in Decision Making*. EPRI, Palo Alto, CA: 2020. 3002014963. https://www.epri.com/research/products/000000003002014963
2. *Seasonal Readiness Guideline*. EPRI, Palo Alto, CA: 2014. 3002003216. https://www.epri.com/research/products/000000003002003216
3. *Severe Weather Equipment Readiness Guide.* EPRI, Palo Alto, CA: 2016. 3002008692. https://www.epri.com/research/products/000000003002008692
4. *Quick Insights: Impact of Polar Vortex on Bulk Renewables Generation.* EPRI, Palo Alto, CA: 2020. 3002016793. https://www.epri.com/research/products/000000003002016793
5. *Generation Plant Equipment Cyber Security Hardening Field Guidebook.* EPRI, Palo Alto, CA: 2019. 3002017094. https://www.epri.com/research/products/000000003002017094
6. *Studies on Coal and Natural Gas Cofiring: Simulation of Tangentially-Fired Furnace Cofiring Strategies*. EPRI, Palo Alto, CA: 2018. 3002013004. https://www.epri.com/research/products/000000003002013004
7. *Hybrid Gas Turbine (GT) Working Group.* EPRI, Palo Alto, CA: 2019. 3002017089. https://www.epri.com/research/products/000000003002017089
8. *Energy Storage Technology Database Report: 2019: Annual Year-End Snapshot of Energy Storage Technology Database*. EPRI, Palo Alto, CA: 2019. 3002016307. https://www.epri.com/research/products/000000003002016307 https://energystorage.epri.com/
9. Low Carbon Resources Initiative https://www.epri.com/lcri
10. *Exploring Climate Impacts in Utility Operations and Planning Interest Group*. EPRI, Palo Alto, CA: 2020. 3002019431. https://www.epri.com/research/products/000000003002019431

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