NUCLEAR INNOVATION ALLIANCE

Flexibility of Advanced Nuclear Reactors

Summary

- Future electricity grids will need to incorporate high levels of variable renewable energy and manage concerns about grid reliability and resilience in the face of extreme weather.
- Advanced reactors are well suited to provide flexible and resilient electricity supply in these future grids using a variety of strategies.
- Some of these flexible strategies, such as hydrogen production or desalination, can help decarbonize other energy-intensive economic sectors.

Overview

Electricity markets require closely matching electricity supply to demand on an instantaneous basis. Power system operators "dispatch" or adjust the production of power from electric generating units so that total generation matches variation in demand throughout the day. As the share of variable renewable energy sources continues to grow, the rest of the electric grid must feature increased flexibility to economically balance load while maintaining reliability. As states grapple with how to balance variable renewables, advanced reactor developers can offer multiple solutions to provide increased flexibility to electricity markets.

A common misconception about conventional nuclear reactors is that they are not designed to load-follow. Existing reactors, like Westinghouse's Pressurized Water Reactor (PWR) designs, can perform both frequency control and load following but do not do so in the United States because it is more profitable to operate continuously at full power (i.e., as a baseload electricity resource). Reactors in other countries, like France, flexibly dispatch nuclear units to balance the grid. In the French electricity transmission network, nuclear power plants operating in the load-following mode can change power output from 100 to 30% in half an hour, and also support unplanned load-following techniques in the case of an emergency.

Advanced reactor designers are pursuing multiple strategies to expand these technical capabilities and incorporate operational flexibility into their designs:

- TerraPower's Natrium reactor is a sodium-cooled fast reactor paired with a molten salt energy storage system that will allow the power plant to produce an average of 345 megawatts and ramp up to a maximum of 500 megawatts for 5.5 hours to balance the grid
- Some designs, like NuScale's Power Module, consist of multiple units that can be managed separately or rapidly vary reactor power to meet fluctuating supply or demand
- Other advanced reactors, such as X-energy's Xe-100 reactor, are designed to integrate process heat, hydrogen production, desalination, or other types of coproducts to enable flexible dispatch of energy and electricity

Beyond flexible dispatch, advanced reactors can also enhance grid reliability and resilience. Black-start capabilities enable restart of the grid in the event of a significant blackout. Many advanced reactors do not require large amounts of water for cooling and are thus more resilient to drought and heat waves. Finally, advanced reactors have high fuel efficiency and long refueling timelines, limiting the impact of fuel supply disruptions on their operations. Advanced reactors with continuous on-line fueling and on-site fuel storage can deliver capacity factors near 100%, further improving on nuclear power's status as America's most reliable energy source.