Innovative Enhanced Automation Control Strategies for Multi-unit SMRs

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ABSTRACT:

In the commercial nuclear power sector, a significant driver in profitability, and therefore marketability, of plants is the cost and complexity associated with operations and maintenance (O&M). This is particularly relevant for small modular reactors (SMRs) where the capital costs have reduced importance in the levelized cost of electricity (LCOE), but where the smaller unit size does not necessarily lead to a corresponding reduction in staffing and complexity of operating procedures. Additionally, the nuclear power industry has struggled to adapt to the increased penetration of inherently intermittent renewables on the electricity grid, which challenges power generation that works in a purely baseload capacity.

The current fleet of large-scale light water reactors has the capability to load follow, but, except for the relatively long-term power maneuvers at Columbia Generating Station in Washington state, this is largely not done in the US. The demands for flexible power operation (FPO) capabilities are likely to continue to increase as nations push for reduced carbon emissions by increasing renewable energy generation complemented by nuclear generation. Therefore, FPO capabilities are an increasingly valued and important requirement for future nuclear power plant designs.

The most likely deployment scenarios for SMRs assume multi-unit sites; this provides flexibility to replace traditional gigawatt generating stations with grid-appropriate generation and flexible outage planning. Operation of a multi-unit site represents a step function increase in complexity.

This proposal seeks to address these challenges through enhanced automation control strategies for multi-unit SMRs. Specifically, the objective of this project is to develop a hierarchy of automation control strategies for FPO using the NuScale plant as the reference SMR design. This entails innovative work in the area of automation for control of systems necessary for providing (1) supervisory control for load following, (2) tactical control for prognostic health management (PHM), and (3) strategic control for the operation of multiple units at a single site.

Through these enhancements, SMR technology gains improved marketability through potential deployment to a broader range of markets. The enhanced automation control can also lead to reduced O&M costs for a SMR site increasing the overall profitability. Developing a link between PHM and FPO maneuvers also enables optimized operation to support system and component longevity further improving economics of operation. Each proposed enhancement also advances the state-of-the-art in a unique way and tightens the integration of systems analysis with high fidelity modeling and simulation.