Design and Prototyping of Advanced Control Systems for Advanced Reactors Operating in the Future Electric Grid

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ABSTRACT:

The economic conditions faced by the current fleet of nuclear power plants suggest that traditional base-load operation is not sufficiently profitable to survive in deregulated electricity markets. To address this and make nuclear power competitive again, one envisioned solution is the deployment of advanced reactors that can operate under a new paradigm in the power grid, the so-called integrated energy system (IES) that couples advanced reactor concepts with energy storage technologies.

The proposed research investigates the control system issues and requirements that arise with IES technology, specifically an advanced reactor design coupled to an energy storage system. To address the operational complexity of coordinating these two plants while meeting highly variable grid demand, a control system of greater sophistication that the single-loop controllers found in existing nuclear plants is required. We propose an architecture comprised of an automated reasoning system that closely interacts with a multi-layer advanced control system. The former provides automated monitoring of the conditions of components and engineered systems in the plant with the objective of minimizing the staffing costs and the frequency of the maintenance. The latter will allow automating and enhancing the control procedures to accomplish the coordinated operation of the systems across the two plants with the objective of semi-autonomous operation. Both combine for a reduction of Operations and Maintenance (O&M) costs. The research will demonstrate the proposed control system architecture by simulating the operation of the IES system and the embedded digital twins. The reduction of O&M costs will be confirmed by a cost benefit analysis. This approach is cross-cutting, i.e., it is equally applicable to advanced reactors as it is to currently operating light water reactors.