Evaluation of micro-reactor requirements and performance in an existing well-characterized micro-grid

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ABSTRACT:

Micro-reactors need not be confined to the niche market of earth's most remote outposts but should be aggressively developed as a transformative distributed energy technology that can revolutionize America's energy infrastructure. The strong social, political, and scientific support to move away from fossil-fuel consumption has resulted in a new vision for the next-generation energy sources. Small-scale nuclear reactors can provide a viable solution to decarbonizing our energy generation, but appropriate markets must be identified which can lead to large scale production of these reactor systems. The economics of these systems may be competitive with other energy forms once they become nth-of-a-kind, fully benefiting from their factory-built approach, and minimal operational and maintenance requirements. Deployment of micro-grid technologies within well-characterized embedded grids, applications of large electrical requirements such as supercomputing and data centers, heat supply applications such as steam production for building heating, and hydrogen production for transportation, may represent enough market space to drive innovation, if the systems can be shown to be technically and economically feasible. The proposed project will study the deployment of micro-reactors in semi-autonomous embedded- (micro-) grids. The University of Illinois at Urbana-Champaign (UIUC) campus will be used as the demonstration site to analyze the micro-reactor systems with actual real-time and historical data. The campus demand is 55 MW electrical and 50 MW thermal energy (average over the last three years) with significant daily and seasonal fluctuations. The campus also has a diverse power generation portfolio including solar power, wind power, biofuel, low-grade geothermal, and baseload power supplied through natural gas and coal. As the campus continues its aggressive push to carbon-free power generation, the use of micro-reactors on the campus grid can increase the resiliency and reliability of the carbon free energy dispatch.

The objective of the proposed work is to quantify the opportunities and challenges of operating micro-reactors in established micro-grids with diverse power generation sources. To this end, this work will develop the analysis capability for a diverse range of applications within Idaho National Laboratory's Hybrid Energy System (HES) environment modeled in Modelica. Using a well characterized prototypic environment the Modelica-based HES platform will be demonstrated in detail for a focused set of near-term micro-reactor applications. An analysis will be performed for the identified deployment opportunities to consider the market potential for micro-reactors on campuses and other similar existing micro-grids.