Development of Nuclear Hybrid Energy Systems: Temperature Amplification through Chemical Heat Pumps for Industrial Applications

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ABSTRACT:

Nuclear plants, historically designed for baseload electric power generation, are also increasingly expected to provide energy for non-power process heat applications and deal with fluctuating power demand. Chemical heat pumps (CHPs) can be the enabling technologies for the nuclear hybrid energy systems (NHESs) by providing a temperature boost for direct utilization of nuclear heat for industrial process applications.

The overall goal of the proposed research is to develop and demonstrate through modeling and experimental investigations temperature amplification capabilities of a chemical heat pump system that can be coupled to a conventional light water reactor, or a near term small modular reactor.

Specific objectives of the research are:

- To develop an integrated system model comprised of coupled sub-models for individual components of the system,
- To conduct experimental investigations on the system components to verify and validate the theoretical model, and obtain data and system parameters for scale-up and design, and
- To demonstrate the technical feasibility of the proposed concept through experimental investigations on a bench scale integrated system.

These objectives will be accomplished through the execution of three research tasks: the first task involves development and validation of a dynamic model through development of a detailed process flow diagram, followed by development of preliminary, steady state, thermodynamic submodels for the system components, and integration of these submodels for the overall model of the system. The second task involves conducting detailed experimentation on component systems to obtain data and characteristic system parameters needed to verify and validate the model. The third task will involve developing an integrated system based on component data to prove the technical feasibility of the proposed concept for temperature amplification.

The expected outcomes of the research are: NHES architecture involving chemical heat pump mediated temperature amplification increasing the industrial process applications of nuclear heat, mathematical model describing the behavior of the dynamic behavior of NHES that can be integrated with the various modeling tools developed by DOE investigators, and experimental data that can be used for model verification and validation, as well as scale-up and design of an integrated CHP-NHES. Research proposed herein thus supports the DOE missions in enhancing energy security, and increasing the role of nuclear energy in nation's energy system.