Integrating Thermal Energy Storage and Nuclear Reactors: A Technical and Policy Study

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Combining Thermal Energy Storage (TES) and sodium fast reactors has been previously considered, but only at a conceptual level. This work expands on those concepts and creates a detailed engineering and system design for an integrated nuclear Thermal Energy Storage (nTES) system. The design uses General Electric-Hitachi's Power Reactor Innovative Small Module (PRISM) and combines it with a TES that uses a binary eutectic sodium and potassium nitrate salt commercially known as "solar salt".

Beginning with a policy and economic survey, key attributes are identified that the nTES design needs to meet so that it can be economically viable in the current United States energy market. These attributes are then included in the plant design. Care was taken to ensure that common commercially available materials were used in constructing the system. The basic design was then modeled using a state space representation used to create a modern control architecture with H_∞ synthesis. The control system design achieved stable salt outlet temperatures, minimal control rod motion, and a 13.3 %/minute rate of power change under full automatic control.

A detailed nodal model was created in RELAP5-3D to assess the safety implications of hybrid PRISM-nTES. The reactor performed similarly to the reference PRISM design for bounding events that did not include a Loss of Heat Sink (LOHS). In those events where a LOHS occurred, the reactor hot pool never exceeded 630 °C, ensuring that structural limits for the reactor vessel were always met.