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Dynamic modelling of a nuclear hybrid energy system with hydrogen production via high temperature steam electrolysis

Integrating Small Modular Reactors (SMRs) into nuclear hybrid energy systems (NHES) represents a promising approach to improving energy utilisation efficiency while balancing the intermittency of variable renewable sources. In particular, by flexibly allocating the SMR's thermal power either for electricity generation or to drive industrial processes, these systems can contribute to the energy transition and benefit from revenue streams from multiple markets. However, the strong coupling among the various subsystems leads to complex challenges in designing and operating the NHES.

In this context, it is of paramount importance to investigate the dynamics of the system and to develop effective control strategies to meet variable load and industrial user requirements while complying with the operational constraints of the system. In this paper, an illustrative NHES architecture integrating a light-water cooled SMR with a high-temperature steam electrolysis hydrogen production plant is studied. The object-oriented modelling language Modelica is used to analyse the response of the system for different demand variations. The results show the potential impacts of varying commodity demands on the SMR's balance of plant and on the nuclear island, indicating that the NHES can meet highly variable demands while maintaining the reactor's power at a stable level.

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