206

Steady Heat, Flexible Power: Flexibility by Proxy in Nuclear–Thermal Energy Storage Systems

Nicolas Trosino[1,2,3], John E. Parsons[2], Yannick Perez[1], Ruaridh Macdonald[2], Charles Forsberg[2]

[1]CentraleSupélec, Gif-sur-Yvette, France. [2]Massachusetts Institute of Technology, Cambridge, United States. [3]HEXANA, Aix-en-Provence, France

Extended Abstract

Download file

Abstract Summary

Thermal Energy Storage (TES) is a promising technology to reconcile the economic constraints of capital-intensive low-carbon thermal generators such as nuclear power plants with the operational flexibility required to ensure reliability in deeply decarbonized systems. While nuclear and renewable generation capacities are expected to grow significantly to reach decarbonization targets, this paper aims to demonstrate that TES has significant value in facilitating the introduction of next-generation technologies. The increasing penetration of variable renewable energy drives a growing spread in the marginal value of generation across hours through a day and throughout the year. On the one hand, when renewables are plentiful and residual load is small or even zero, the marginal value of generation is zero. On the other hand, when there is a drought of renewable energy and residual load threatens to exceed firm capacity, the marginal value of generation spikes. Integrating Thermal Energy Storage enables baseload production of heat, even during hours when the marginal value of electricity is low, which can then be converted to electricity when the marginal value of generation is high. This creates a new operational paradigm in which nuclear assets can behave simultaneously as firm baseload providers to maximize rate-of-return and as flexible resources to match system needs. We unpack the primary drivers of TES value and illustrate (i) the significant value of Thermal Energy Storage in raising the breakeven cost of nuclear assets and (ii) the high concentration of profits in a small number of hours and a few years of a 20-year sample.

This contribution is expected to be impactful in enhancing the decision-making about future nuclear-TES investments and necessary capacity accreditation to enhance the system reliability and, ultimately, the energy security.

Presenting Author Biography

Nicolas Trosino is a PhD Candidate conducting research at the Laboratoire de Génie Industriel (LGI) of CentraleSupélec (Paris-Saclay University) and at MIT Energy Initiative. He has graduated from the Ecole normale supérieure Paris-Saclay in 2023, in both applied physics and economics, and from CentraleSupélec in 2023 in energy physics and engineering. His research focuses on advanced nuclear reactors and energy storage couplings. His PhD research is funded by HEXANA, a FRANCE2030 nuclear start-up designing a modular sodium-cooled fast reactor and leveraging on combined heat and power to foster industries' decarbonization.