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Integration of Small Modular Lead Fast Reactor with Energy Storage for load-following operation in high V-RES penetration electricity markets

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Energy decarbonisation, through the transition from fossil fuels to V-RES electricity production and the electrification of transport & heating sectors, may jeopardise the electricity supply security on the long term, because of the growing power demand and the increased production volatility. While advanced and modular reactor designs can make nuclear an attractive low-carbon solution to diversify the energy mix and address the power demand increase, a paradigmatic change is required in both NPP design and operation to increase load-following mode attractiveness. Indeed, although the current nuclear Gen-III/III+ fleet provide good load following capabilities and some operators (especially in high nuclear share markets as France) find profitable operating NPP in load-following mode, most of nuclear generating units are operated in baseload mode. This paper investigates the feasibility and the potential of integrating a cost-effective Energy Storage system into a Small Modular Lead Fast Reactor, to achieve load-following performances while maintaining the reactor at high power levels minimizing power excursions. Indeed, the integration of Energy Storages in Gen-IV reactors may significantly boost nuclear competitiveness in high V-RES penetration electricity markets, by combining the economic benefits of running nuclear reactors at high power (i.e., efficient use of capital invested in plants, simplicity and reliability of the operations) with the plant load-following capacity, compensating V-RES volatility. The paper investigates the Energy Storage option under a wide and comprehensive perspective, from the description of the reference electricity market with the identification of specific national grid requirements down to the Energy Storage technology selection, integration with the balance-of-plant and preliminary sizing, to best-fit the load-following demand and LFR specificities. Romania has been selected as reference scenario for the investigation, due to the representative energy-mix with high RES penetration (42%), a large use of hydropower (27%) to compensate for wind and solar volatility as well as the consolidated use of nuclear power (18%) as baseload.

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