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Hybrid Energy Storage System with Modified CAES and Desalination Process for Nuclear Power Plant in Saudi Arabia

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Maintaining a constant power output of a nuclear power reactor, NPP, is preferred due to operational factors such as xenon poisoning and optimizing the capital investment. However, constant output does not match variable demand, requiring making it a baseload source or storing excess energy giving larger flexibility. Compressed air energy storage (CAES) is an ideal solution due to its high capacity, power rating, long lifespan (~40Y), and technical maturity. This makes it a suitable choice for nuclear power plants to store and utilize excess energy.

To incorporate CAES technology, the nuclear power plant utilizes two tanks of phase change material (PCM): one for hot and one for cold. The nuclear heat is utilized to power an absorption chiller process, which produces cold ice storage. The heat that has degraded by 20-40℃ is then used to charge the hot PCM storage tank with a suitable temperature that is lower than the reactor output.

To optimize the integration of CAES in NPP for Saudi Arabia, the desalination process has been incorporated into the CAES charging process. This involves utilizing saline water to absorb heat during the compression process through direct contact heat exchange. By using a cold PCM tank, the compression process can be made to be nearly isothermal just above the freezing point of water, resulting in the conversion of compression heat into fresh water while keeping the compression work low and near the isothermal limit.

During the expansion process, the compressed air regains its original state by expanding nearly isothermally, with energy coming from the hot PCM tank powered by nuclear heat. This setup ensures that the CAES process does not interfere with the nuclear power operation, thereby making the CAES system more effective and efficient in Saudi Arabia.

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