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A conceptual study on the use of a regenerator in a hybrid energy storage unit (LIQHYSMES)

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Wind and FV parks raise the issue of a discontinuous electrical generation. The unavoidable demand for a buffering system that balances the grid is binding as is the need for new solutions. As energy carrier with its high volumetric energy density, liquid hydrogen is an inevitable choice for large-scale energy storage. But, since balancing loads or rapidly evolving fluctuations on the grid with just hydrogen is unrealistic, due to its slow response, it is necessary to integrate it with an electrical energy storage device that enables rapid response. This approach combines the use of a liquefaction plant for hydrogen, and a superconductive magnetic energy storage (SMES): the synergy obtained with a cryogenic infrastructure and a SMES, i.e. a compact LIQHYSMES storage unit, allows a steady operation mode of the hydrogen, buffering the unpredictable requests from the electrical grid and restraining costs. Besides, in this case, conventional liquefaction methods (e.g. Claude system) are not a viable solution, meaning that a substantial simplification of the process is possible where a regenerator/recuperator is employed and only if a temporary/intermediate storage is required. The use of a regenerator results in an advantageous solution allowing to recover at least partially the exergy stored in the form of liquid hydrogen, even though it does not represent a standard application in cryogenics. A study is conducted to develop a regenerator (among other parts) for a proof of concept small scale LIQHYSMES system. A 1D model of differential equations is implemented to investigate the regenerator performances, addressing parameters such as regenerator configuration, material and fluid properties, temperature profiles, etc. Results are then analysed and discussed. Moreover, given the advanced manufacturing phase of all components, the implementation of the Fiber Bragg Grating sensor for mapping temperature profiles within the regenerator is also addressed.

Primary author: BRIGHENTI, Flavio (Karlsruhe Institute of Technology)

Co-authors: Dr NEUMANN, Holger (Karlsruhe Institute of Technology); RAMALINGAM, Rajinikumar

Presenter: BRIGHENTI, Flavio (Karlsruhe Institute of Technology)

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