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# M3Or2D-01: Techno-economic Analysis of the Cryogenic Flux Capacitor Compared to Other forms of Hydrogen Production and Storage

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The Cryogenic Flux Capacitor (CFC) is a cold, dense energy storage core that is being studied in the cryo-compressed, about 300 bar and 80K, region of gaseous hydrogen (GH<sub>2</sub>) storage and liquid hydrogen (LH<sub>2</sub>) region near the normal boiling point. The hydrogens storage is improved by physically bonding the molecules within the nanoscale pores of the aerogel composite blanket material. The process of bonding or debonding is governed by principles of physical adsorption (physisorption) and thermodynamics. The large surface area afforded by the nanoporous aerogel (˜1,000 m<sup>2</sup>/g) allows its storage performance to easily exceed capacities of high-pressure GH<sub>2</sub> storage for an equivalent volume. With the integrated aerogel, subscale tests have shown that storage is increased by about 49% over a simple tank filled with GH<sub>2</sub> at the same operating temperature and pressure. For LH<sub>2</sub> conditions, the CFC is shown to operate at equivalent densities.

For the techno-economic analysis (TEA), the source of hydrogen is compared between onsite steam methane reforming (SMR) and onsite solar photovoltaic (PV) panels providing power to electrolyzers to produce GH<sub>2</sub>. The TEA compares pure hydrogen burning in a combined cycle gas turbine (CCGT) to hydrogen fuel cells with an overall net power output of 650 MW. The SMR system uses natural gas as an input and includes a carbon capture and storage (CCS) system. The levelized cost of electricity is developed based on the capital cost and operating cost of the systems. Sensitivities are discussed around the cost of natural gas, ranging from 1.93 USD per MMBTU to 6.75 USD per MMBTU, and carbon dioxide disposal, ranging from 7 USD per tonne to 10 USD per tonne. For comparison to the conventional CCGT baseline, a baseload scenario is adopted with 85% capacity factor.

The results of the study show that onsite hydrogen generation from SMR is about 1 to 3 USD per kg over the life of the plant and the PV hydrogen production produces at 4 to 5 USD per kg. The cost of storage for CFC is compared to other systems, including high-pressure GH<sub>2</sub> and atmospheric LH<sub>2</sub>. The system is shown to provide the lowest costs for all these options at the grid scale, due to its higher capacity than high-pressure GH<sub>2</sub> and ability to operate at 80K, receiving refrigeration from liquid nitrogen systems reducing capital and operating costs when compared LH<sub>2</sub> storage systems. SMR is competitive with CCGT at the gas prices, both of which have lower LCOE than the PV system. When accounting for variability in gas prices, the PV and electrolyzer system is less sensitive to these changes and provides the lowest LCOE across the whole range.

**Author:** SCHMITT, Joshua (Southwest Research Institute)

**Co-authors:** SWANGER, Adam (NASA Kennedy Space Center); Prof. KAPAT, Jayanta (University of Central Florida); Dr OTTO, Marcel (University of Central Florida); COLLADO, Noemi (Air LIquide)

**Presenter:** SCHMITT, Joshua (Southwest Research Institute)

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