Power-to-Gas: Dynamic Operation of Electrolyzer Systems and Integration with Central Plant

OVERVIEW

A 7kW proton exchange membrane (PEM) electrolyzer is connected directly to solar photovoltaic panels to evaluate dynamic capabilities of such systems and assess performance gains associated with utilizing DC-DC power electronics.

We also have built and are evaluating the first U.S. integrated power-to-gas (P2G) pilot that uses a 60kW PEM electrolyzer system with natural gas pipeline injection followed by combined heat and power production. We are investigating both the dynamic capabilities of PEM electrolyzer systems when load following variable renewable energy resources, and the impacts of blending hydrogen into the natural gas fired combined cycle plant.

GOALS

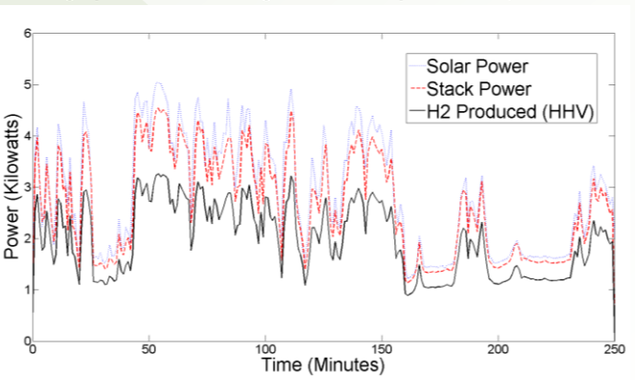
- Demonstrate load following of solar and wind electricity resources with PEM electrolyzer systems through direct connection to the resource, and through load following signals.
- Integrate a PEM electrolyzer system with high pressure injection and blending with natural gas to power a combined cycle power plant. Assess any deviations in plant behavior.
- Evaluate dynamic capabilities of PEM electrolyzer systems.
- Identify and analyze possible modifications to PEM electrolyzer systems to improve performance for P2G application.

RESULTS

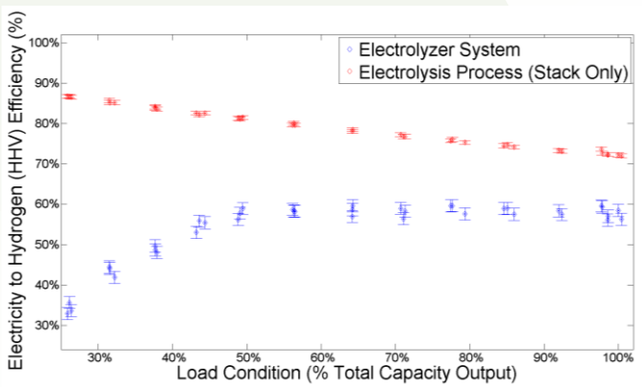
PEM electrolyzers are able to rapidly load follow solar photo-voltaic power dynamics through both direct connection and load signal following. Direct electrical connection of electrolysis to solar PV through DC-DC power electronics had a 7-8% advantage in efficiency over AC-DC for the 7kW system. The 60kW AC-DC power electronics were more efficient than both, though only slightly better than the DC-DC configuration of the 7kW system. The electrolysis process itself demonstrated a wide range of part load capability at high efficiencies, however, system level losses from ancillary components contributed to lower efficiencies at low part load conditions. The injection of hydrogen gas from the 60kW electrolyzer into the natural gas fired turbine did not affect performance or emissions to any measurable extent.

Photograph of the 60kW PEM electrolyzer used in the first U.S. pilot of P2G

The NFCRC in coordination with UCI Central Plant personnel demonstrated the U.S. first injection of hydrogen gas into a high pressure natural gas line on September 13, 2016.



Direct electrical connection solar PV load following with 7kW PEM Electrolyzer System



Stack and system efficiency at part load for 60kW PEM Electrolyzer

RECENT PUBLICATIONS

"Experimental Analysis of Photovoltaic Integration with a Proton Exchange Membrane Electrolysis System for Power-to-Gas" (Submitted to International Journal of Hydrogen Energy)

PERSONNEL

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