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NATIONAL RENEWABLE ENERGY LABORATORY

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Office of Energy Efficiency and Renewable Energy
Operated by the Alliance for Sustainable Energy, LLC

MW-Scale PEM-Based Electrolyzers for RES Applications

Kevin Harrison, Owen Smith & Monjid Hamdan (Giner ELX)
15 June 2018 • Project ID#: h2007

RELEVANCE

At current levels of renewable electricity generation there are already regions in the U.S. and around the world when the supply of electrical power significantly exceeds the level of demand. The growing penetration of renewable energy sources (RES) requires a long-duration energy storage solution which can include hydrogen generated via polymer electrolyte membrane (PEM) electrolysis.

In response, Giner ELX has developed a MW-scale PEM-based Electrolyzer Stack designed that is ideal for RES applications. To facilitate commercial production of this technology, validation of the stack efficiency, membrane lifetime, catalyst performance, and cell component durability are needed. The validation of Giner ELX's high-current-density MW-scale electrolyzer requires large test platforms and electrical requirements currently available at the National Renewable Energy Laboratory (NREL).

OBJECTIVES

This work enables the scaling of PEM-based Electrolyzer Stack designed for renewable energy generation applications from the current 150 kW platform to 1 – 5 MW platforms, thereby enabling greater storage of renewable generation. Utilities and consumers can benefit from the expanded storage capacities through this method.

SUMMARY

- CRADA (CRD 18-742) agreement executed in March 2018. Giner ELX invoiced for $7k.
- ESIF F&I funded the purchase and installation of 2 additional 250 kW power supplies to support this R&D
- Funds arrived and task # established in March 2018
  - $30K Federal Share
  - $30K Giner ELX
  - $240K in-kind equipment loan of stack
  - $0 spent of DOE funds as of 3/31/2018

FUTURE WORK/ CHALLENGES & BARRIERS

Systems & demos that address
- Cost performance models
- Capacity factors
- Optimization

Power Electronics
- Collaboration with industry on developing hardware and control strategies to couple RES to electrolyzers

Economical gas storage

Regulatory support & tax incentives
- Funding to enable Infrastructure Acceleration

Any proposed future work is subject to change based on funding levels

Collaborations

- Giner ELX
- ESIF Operations (F&I budget)

APPROACH

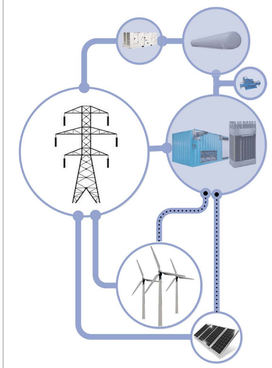
Stack operational data will be used to calculate stack voltage efficiency, stack decay rate and predict lifetime based on stack current, fluoride release rates, average stack temperature and anode/cathode pressures.

Giner ELX and NREL will report on the operational conditions, voltage-current curves as a function of temperature and pressure, fluoride release data, time-series of the stack voltage and histogram/summary tables of hours of stack current levels, cathode pressures and stack temperatures over 5,000 hours of operation.

NREL's ESIF F&I Budget

- Purchased and installed 2 new (4 total) 250 kW power supplies (AC/DC)
- Each power supply is capable of 250V and 1000A
  - The 250V supplies limits the number of cells to about 120 under the assumption of 2V per cell
- In current sharing mode, all supplies will provide the required current 3800A to the Giner ELX stack
- New fluoride probes will monitor release rates from the stack

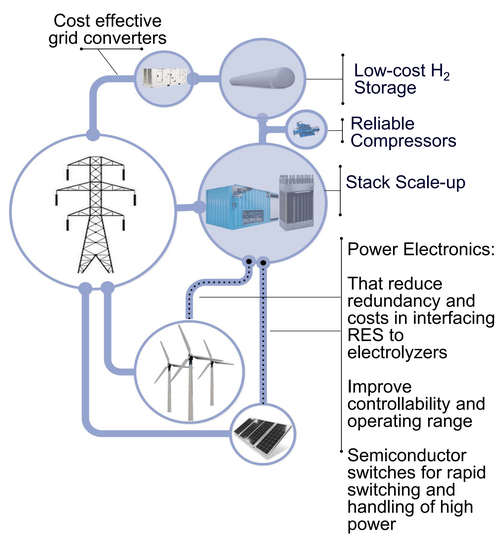
MW Large Scale Projects Wind-to-Hydrogen & Microgrid Applications



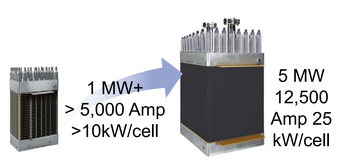
- Power to Gas (P2G): Vast opportunities in Biogas
- Power to Mobility (P2M)
- Power to Hydrogen (P2H) Integration of Renewable Energy Sources
  - Large reserves of stranded energy (need to store/shift)
    - Ongoing broad developing **wind energy** sector
- Backup power for grid outages and load shedding

Challenges

Emerging Markets & Drivers



New Market Trends Require Larger Stacks



- 5MW Stack Platform
  - Operating Pressure: 600 psig
  - Active Area: 3,000+ cm²
  - Current Density: 3,000+ mA/cm²
- Development 2018/19
- Economics
  - Accelerates market opportunities

RESULTS

Giner ELX designed and assembled a stack;
- ¼ MW
- 29 cells
- Undergoing resistance and leak checks

To facilitate commercial production of this technology, validation of the stack efficiency, membrane lifetime, catalyst performance, and cell component durability are needed. The validation of Giner ELX's high-current-density MW-scale electrolyzer requires large test platforms and electrical requirements currently available at NREL's Energy Systems Integration Facility (ESIF).

To address critical aspects for the successful commercialization of Giner ELX's MW PEM-based electrolyzer stacks, three (3) primary tasks will be performed.

Task 1: the active area of the electrolyzer stack will be scaled-up from 290 cm² (150 kW platform) to 1,250 cm² (1 MW platform). In this task Giner ELX will assemble a multi-cell stack based on their 1 MW stack platform having an active area of 1,250 cm². The number of cells will be determined based on the power capabilities at NREL's Energy Systems Integration Facility (ESIF) test site. Future scale-up of the 1 MW stack technology to an active area of 3,000 cm² (5 MW platform) or greater is feasible.

Task 2: includes integration, and operational testing, of the MW-stack platform at NREL's ESIF facility. The stack will be operated cyclically between a current density of 0 to 3,000 mA/cm² over a 5,000-hour period. During operation, NREL will monitor individual cell voltage, cross-cell leakage (%H_2 in O_2), and collect fluoride samples. The fluoride samples will be delivered to Giner ELX and analyzed to determine membrane/stack lifetimes.

Task 3: Data analysis will be conducted by Giner ELX and NREL to evaluate performance (efficiency, durability, lifetime) of the stack. This includes the effect of the additive on voltage performance and on the stability of the additive during extended operation (5,000 hours) at current densities of 3,000 mA/cm². Voltage performance data will also be used to determine the effect on cell components and catalyst utilized in the MW stack platform.

Acronyms

AC/DC – Alternating current/Direct current
kW – kilowatt
MW – Megawatt
F & I – Facilities and Infrastructure
PEM – polymer electrolyte membrane
RES – Renewable Energy Systems
ESIF – Energy Systems Integration Facility
IV – Current voltage polarization curve

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