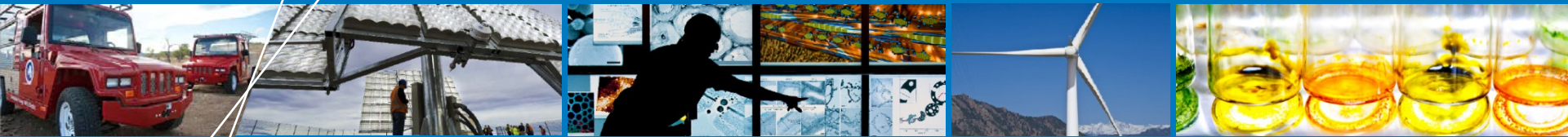


Electrolytic Hydrogen Production Workshop



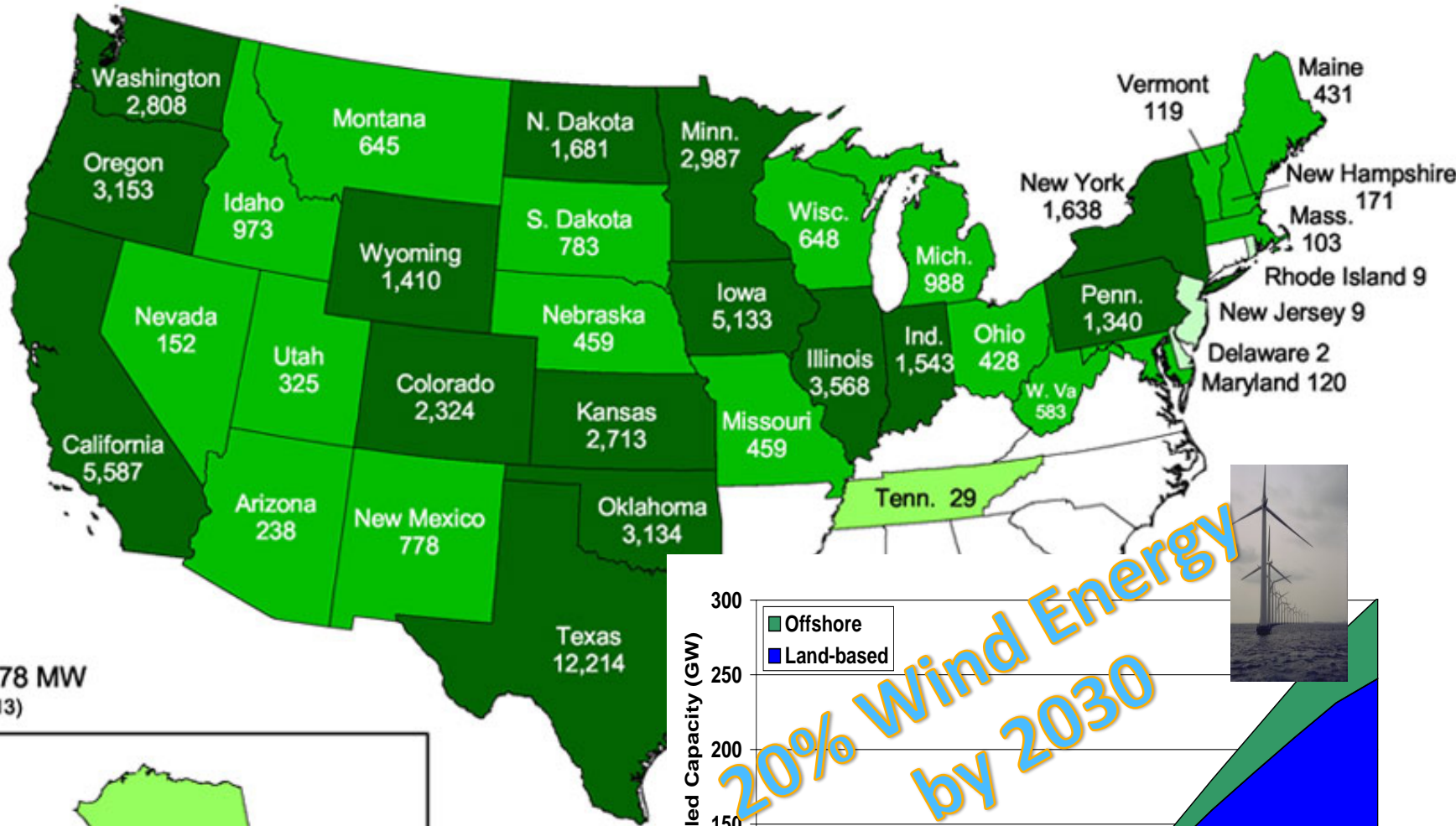
Renewables and Grid Integration

February 28, 2014

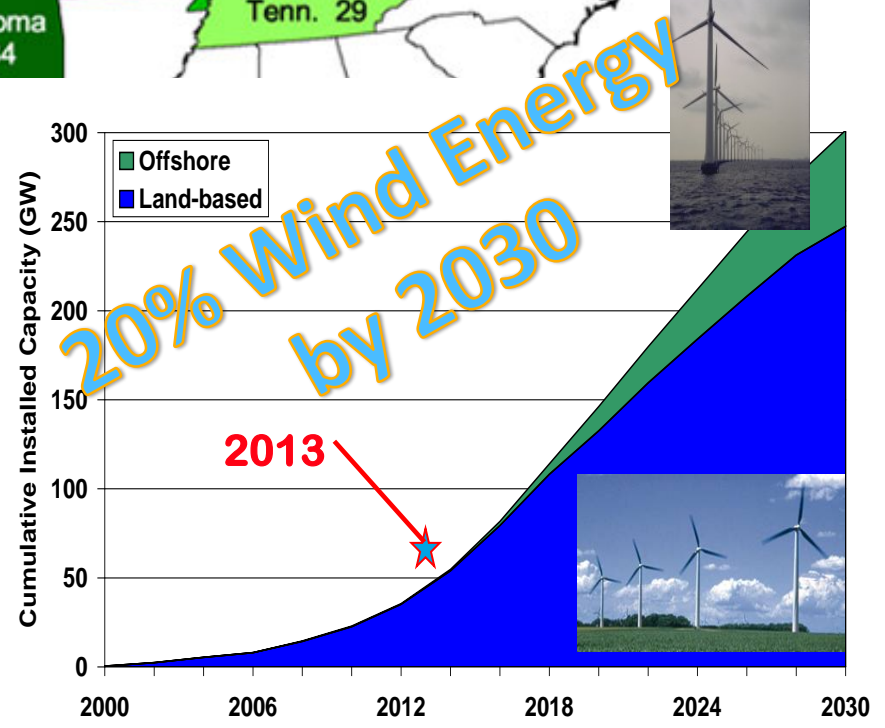
Kevin Harrison

National Renewable Energy Laboratory

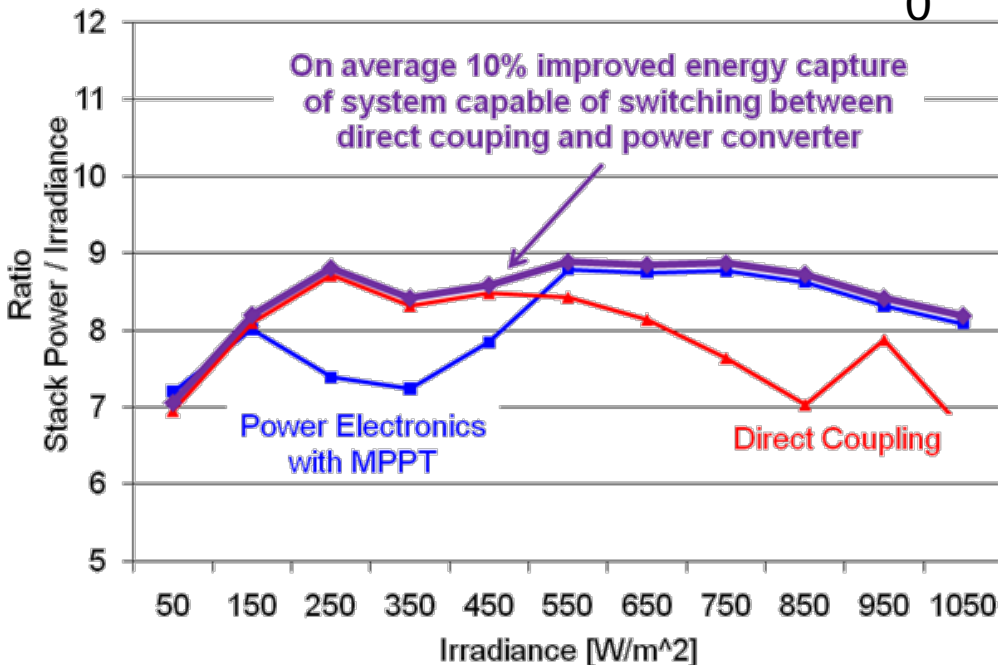
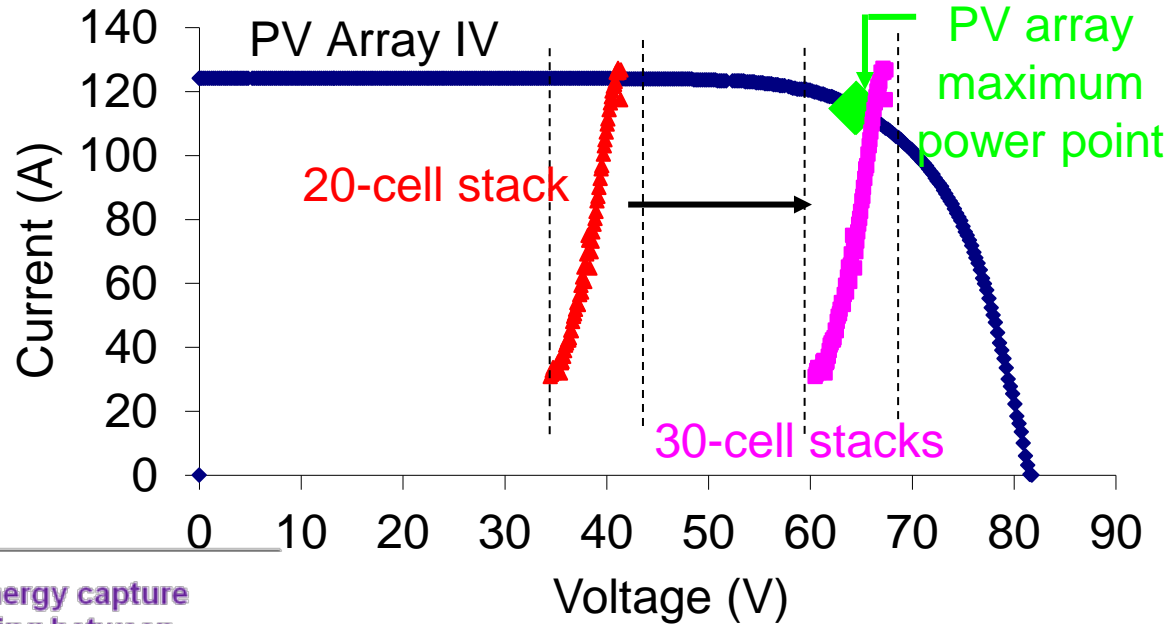
Current Installed Wind Capacity (MW)



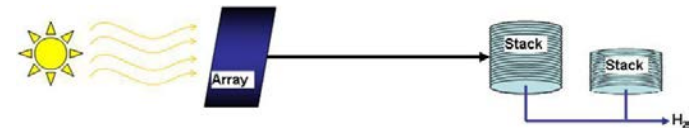
Total: 60,078 MW
(As of 09/30/2013)



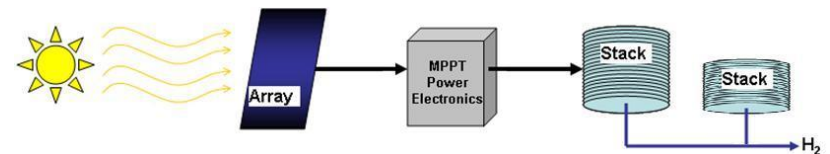
PV to Stack – Direct and Close Coupling



Direct Coupling



Close Coupling



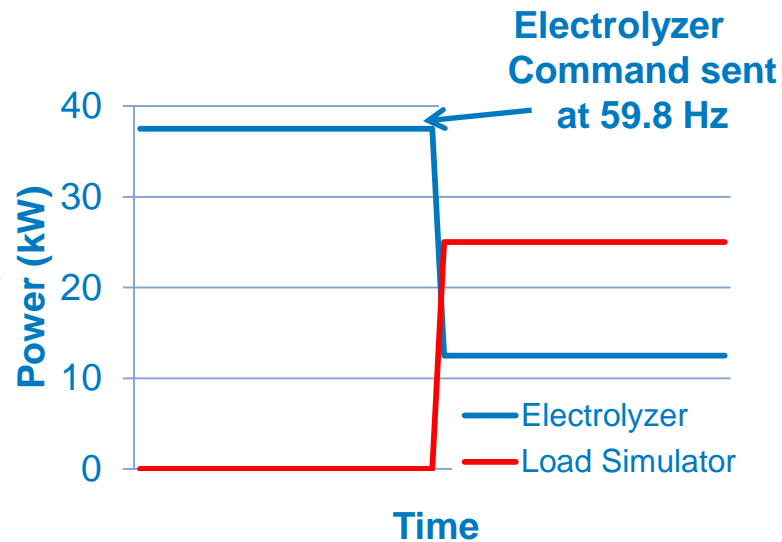
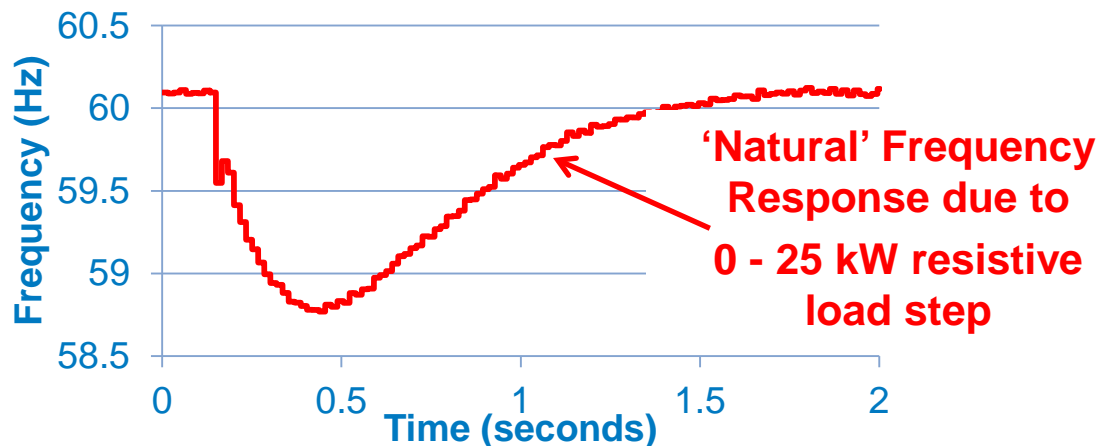
Electrolyzer – Grid Frequency Support

AC
microgrid



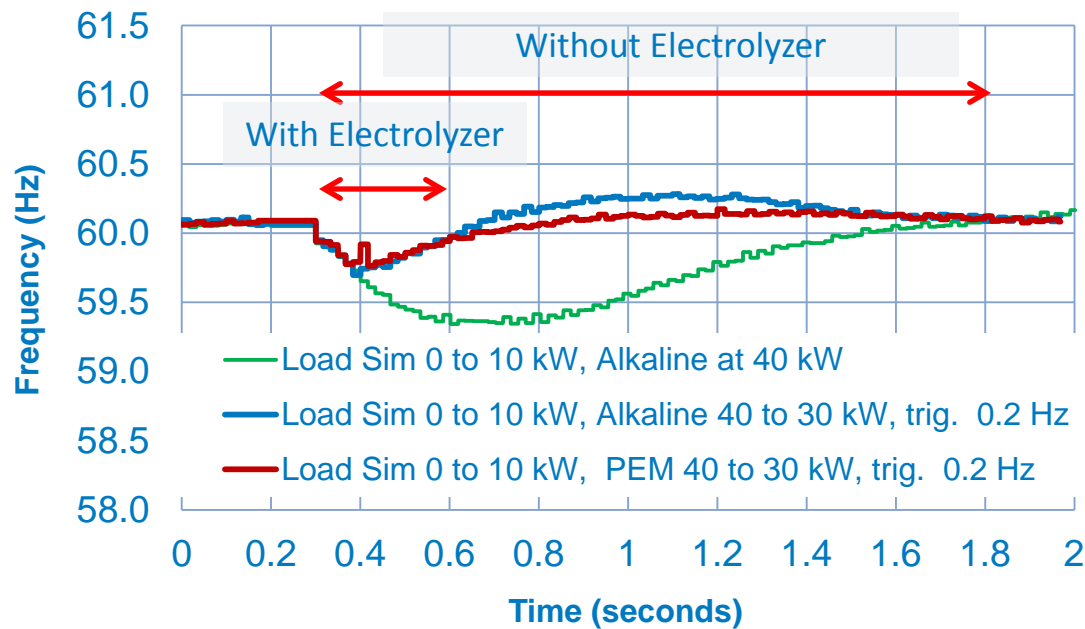
Purpose – Compare system-level response of PEM and alkaline electrolyzers

Result – Demonstrated ability to quickly mitigate frequency disturbance (i.e., ramping renewable power)

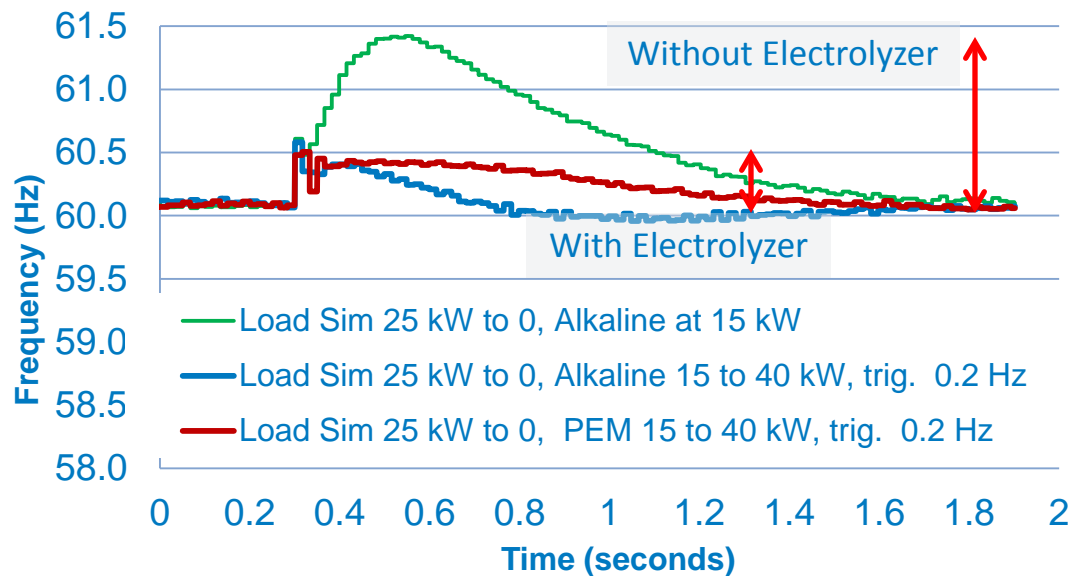


Electrolyzer – Grid Frequency Support

10 kW steps - PEM and alkaline systems shorten magnitude and duration of under-frequency disturbance on AC micro-grid



25 kW steps - PEM and alkaline systems shorten and reduce magnitude of over-frequency disturbance on AC micro-grid



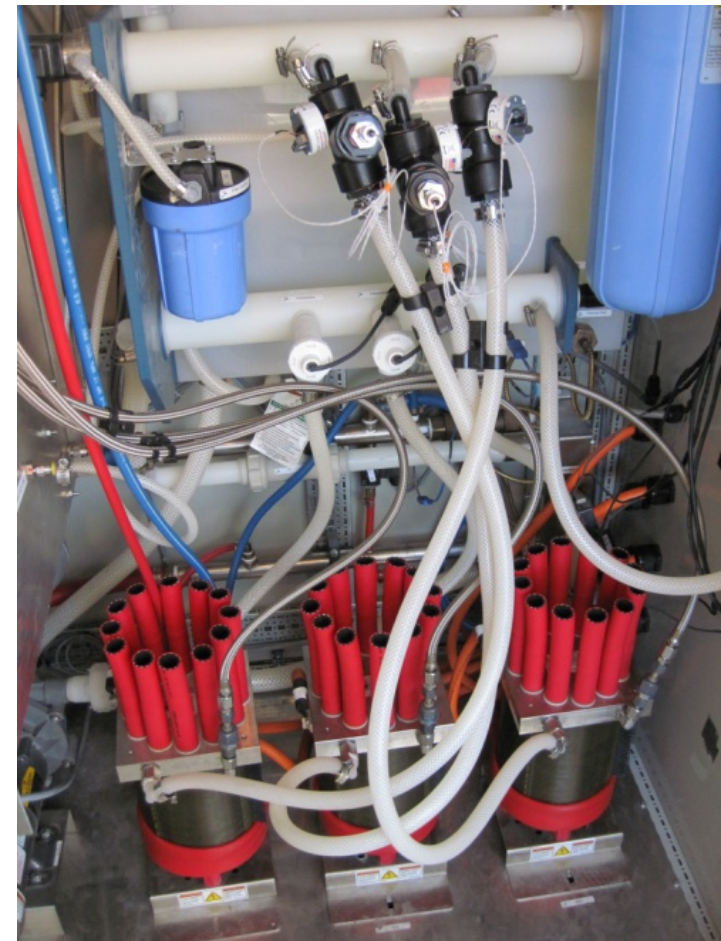
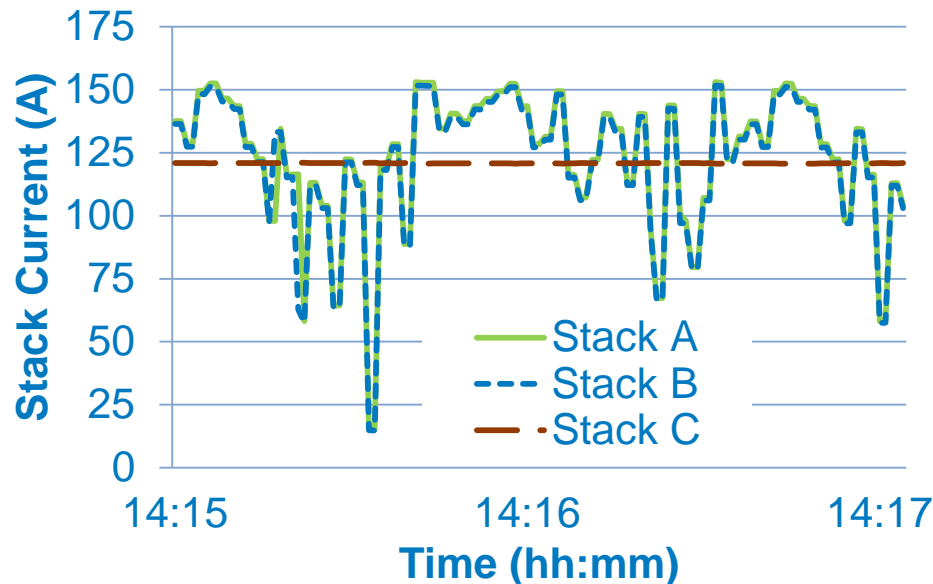
Decay Rate – Variable Power Stack Testing

Summary – Completed 10,000 hours on neglected stacks. Variable and constant power decay rates were within 10%.

Path Forward – Two new stacks installed. (1200 hours to date)

Monitoring and Control

- Stack input and output temperature
- Stack voltage and current
- Individual control over each of 3 stacks
- Programmable wind/solar profiles



PEM Electrolyzer Stack – Bi-Polar Operation

Opportunity – Intentionally size # of cells to take advantage of variable-speed wind turbines DC buss

Results – Demonstrated operation of 20 cell PEM stack with ± 22.5 V using power supplies instead of 45 Vdc.



Thank you!

20% Wind Energy by 2030

http://www.20percentwind.org/20percent_wind_energy_report_revOct08.pdf

PV – Stack Coupling

http://www.hydrogen.energy.gov/pdfs/progress11/ii_e_4_harrison_2011.pdf

http://www.hydrogen.energy.gov/pdfs/review11/pd031_harrison_2011_o.pdf

PEM & Alkaline Electrolyzer Response Testing

http://www.hydrogen.energy.gov/pdfs/progress12/ii_d_3_harrison_2012.pdf

http://www.hydrogen.energy.gov/pdfs/review12/pd031_harrison_2012_o.pdf

Giner Electrolyzer and Stack Decay Testing

http://www.hydrogen.energy.gov/pdfs/progress13/ii_a_2_harrison_2013.pdf

http://www.hydrogen.energy.gov/pdfs/review13/pd031_harrison_2013_o.pdf

