NREL
NATIONAL RENEWABLE ENERGY LABORATORY

Scalable Electrolytic Systems for Renewable Hydrogen Production

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National Renewable Energy Laboratory
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DOE Hydrogen and Fuel Cells Program
2018 Annual Merit Review and Peer Evaluation Meeting

Project ID: h2001

Overview

Timeline and Budget

- Project start date: 02/26/18
- Project end date: 01/01/19
- Total project budget: $150,000
  - Total partner share: $25,000
  - Total federal share: $25,000
  - Total partner in-kind: $100,000
  - Total DOE funds spent*: $0

* As of 3/31/18

Barriers

- Utilization of remote off-shore wind resources
- Capital cost reduction

Partners

- GTA
- NREL

Relevance

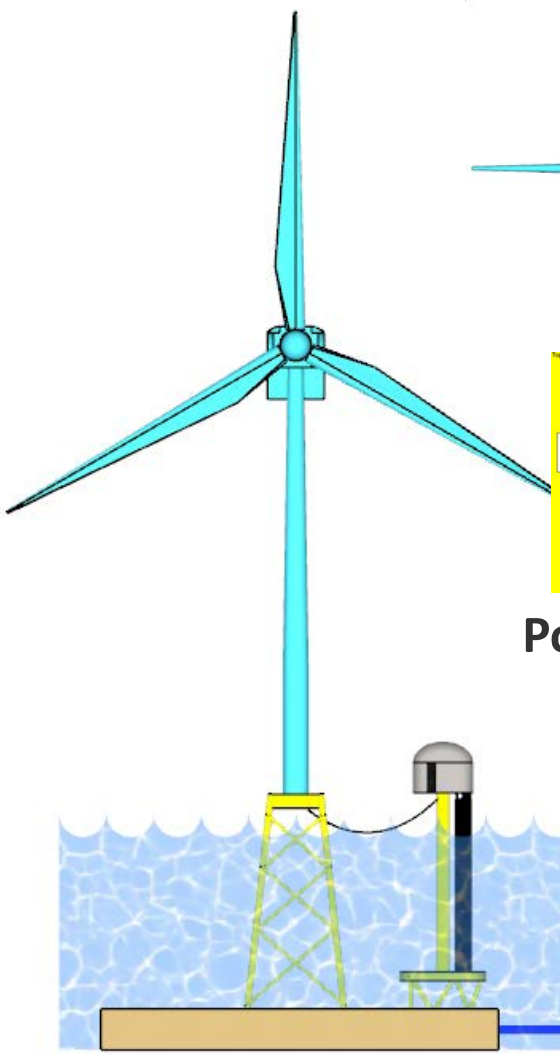
- Relevance (H2@Scale CRADA call)
  - Support development of multi-MW (typically 10-12 MW) low temperature water electrolysis system that integrates with off-shore wind farm
- Objectives:
  - Verify technology at TRL4 level
  - Create input for advancement to TRL5 level

Approach

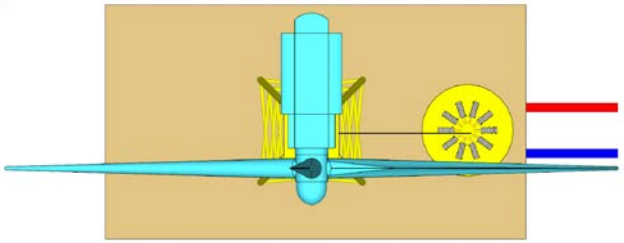
- Approach
  - Project will leverage NREL in-situ testing capabilities
  - GTA will provide prototype electrolysis cell of ≤700W and other specific laboratory equipment as needed
  - NREL will integrate and commission test equipment
  - NREL will perform a series of VI tests and provide trace gas analysis on the product hydrogen
  - NREL may run ~100 hour durability tests as funding allows
  - GTA will utilize information from exchange into next development step

Approach

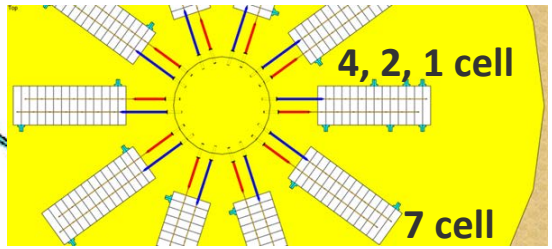
Schematic of Offshore System Installation



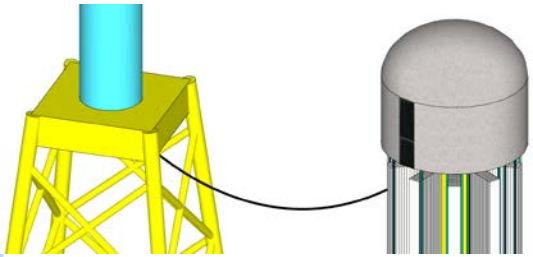
Front View



Top View



Power Management Detail



Short Power Transmission

- Offshore system installation on fixed base
- Hydrogen production at wind site
- Negligible electrical power transfer loss
- Hydrogen delivery via gas lines
- 70:1 turn down ratio

Approach

Power Management Table

Exemplary Power Levels

Power Level [%]	Cells per Module			
	7	4	2	1
0	0	0	0	0
20	2	0	0	0
25.7	2	1	0	0
50	5	0	0	0
50.3	5	0	1	0
100	9	1	1	1

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Probability distributions for offshore wind speeds

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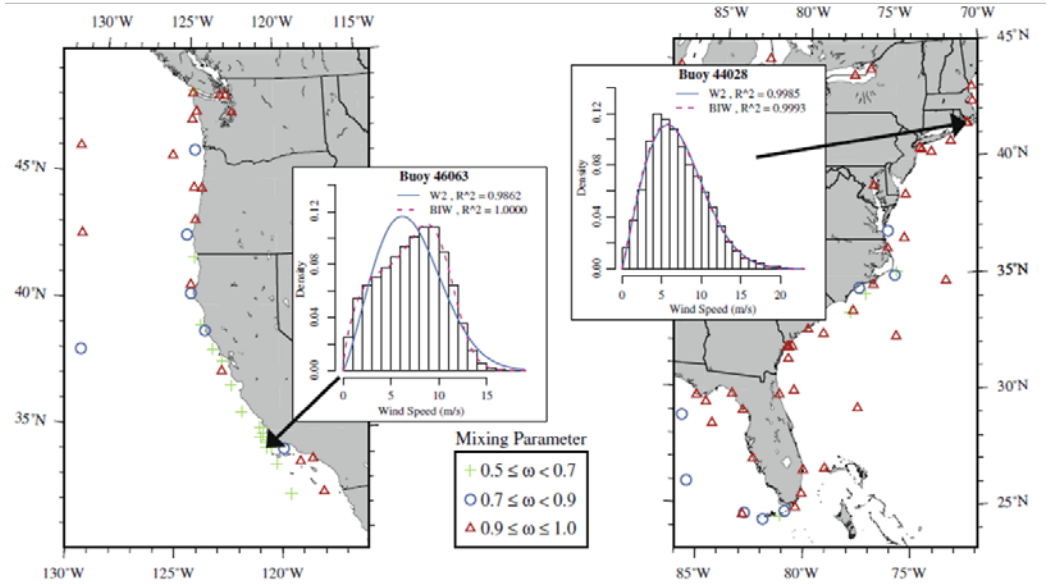
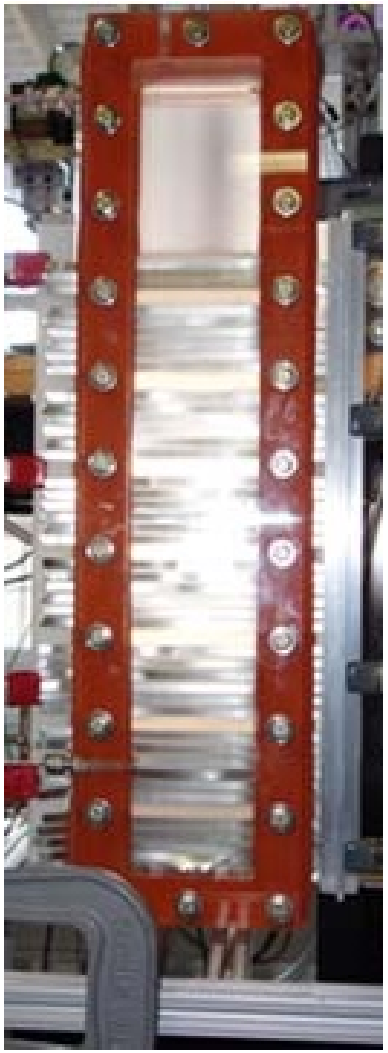


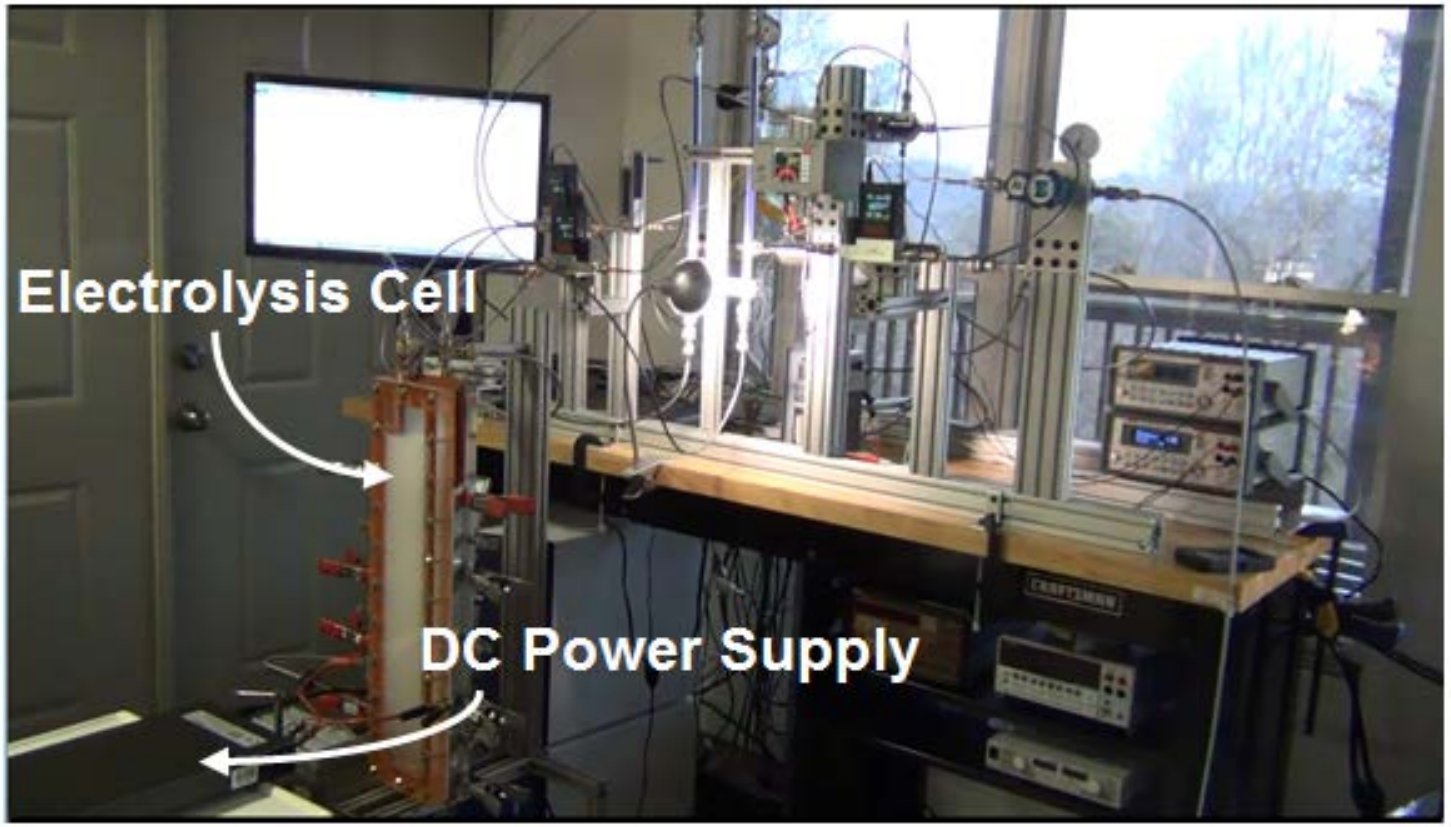
- **Online electrolyzer optimization with regards to wind speeds**
- **Modular configuration with respect to location and expected wind profiles**

Approach

Electrolysis Cell



Laboratory Scale System



Approach

NREL 3kW test system

- Integration of GTA electrolysis cell for off-shore wind platform into NREL's electrolysis test system
- GTA cell ≤700W
- NREL system 12V / 250A
- Integration with additional pumps and sensors to allow operation with KOH solution as needed for AEM technologies and non-PGM catalysts

Approach

- Milestones

Deliverable title	**Description**	**Producer**	**Due date Month (M)**
Equipment transfer	Deliver stack and required ancillary equipment to NREL.	GTA	M3
Verify cell performance	Conduct performance test and trace gas analysis of the product hydrogen.	NREL	M6
Report results	Complete report and return all equipment	NREL	M12

Accomplishments and Progress

- CRADA
- Funding has been received in 03/17/18
- Bailment list has been completed
- Timing for delivery of equipment has been set to end of April ‘18

Accomplishments and Progress: Responses to Previous Year Reviewers' Comments

- This is a newly awarded project, and thus was not previously reviewed

Collaboration and Coordination

- Industry partner: GTA
  - Defines objectives
  - Defines operating conditions
  - Provides information about specific operating procedures
  - Provides specialized equipment
  - Provides data measured at GTA
- National lab partner: NREL
  - Performs system setup in NREL lab for ≤700W cell
  - Conducts VI experiments
  - Characterizes hydrogen quality via trace gas analysis
  - Depending on available time and funding conducts long term test of ~100 hr

Challenges and Barriers

- Integration of AEM technology, for example:
  - Flow stream with KOH solution into PEM technology test stand without contamination of equipment
  - Utilization of advanced diagnostics such as AC impedance spectroscopy

Proposed Future Work

- Potential expansion to TRL5 level
- Expansion of power levels >700W

Technology Transfer Activities

- This project is not expected to result in technology development
- NREL will assist GTA with the data interpretation which may influence TRL5 level design

Summary

- Project awarded under H2@Scale CRADA call
  - Industry partner: GTA
  - Lab partner: NREL
- Approach: leverage NREL in-situ testing capabilities developed for water electrolysis
- Relevance: verification of existing TRL4 level technology with respect to performance, hydrogen quality
- Accomplishments/Future Work: Project just initiated

Acknowledgements

GTA

- Elias Greenbaum, Industry Partner PI

NREL

- Matthew Post, system integration sub-lead

Thank You

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Publication Number

NREL is a national laboratory of the U.S. Department of Energy, Office of Energy Efficiency and Renewable Energy, operated by the Alliance for Sustainable Energy, LLC.

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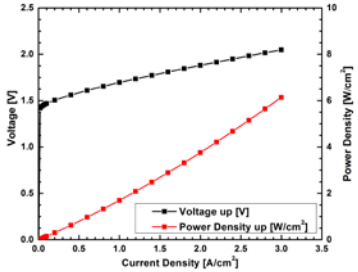
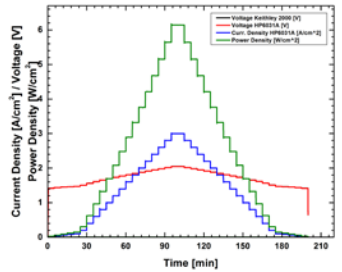
Technical Back-Up Slides

NREL Capabilities: In-Situ Electrolyzer Testing

- 5x NREL built electrolyzer system
  - 150 A power supply
  - Up to 1.5 bar operation
  - AC impedance
- 2x Greenlight G40 system
  - 12V/250A power supply
  - Up to 50 bar operation
  - individual cell voltage monitors
  - AC impedance up to 30A
  - Anode & cathode product gas analyzer
  - H2 pump option





Project Task Details

- **Task 1:**

  GTA will send to NREL prototype electrolysis cells of less than 700W total power. To facilitate the collaboration and optimize resources, GTA will also send to NREL ancillary equipment such as pumps, dryers, programmable DC 750 W power supply, and catalytic O2 cleanup of the hydrogen. NREL will prepare the KOH electrolyte solution in distilled water.

- **Task 2:**

  NREL will run a series of steady-state hydrogen and oxygen producing polarization (IV) tests on the stack, and measure the output quantity and quality of the hydrogen. Oxygen will be vented. NREL will run a trace gas analysis on the product hydrogen. Once the system is set up, NREL may run an initial ~100 hour durability test to look for early signs of degradation.

- **Task 3:**

  NREL will prepare a report for GTA, and return all GTA equipment at the end of the project.