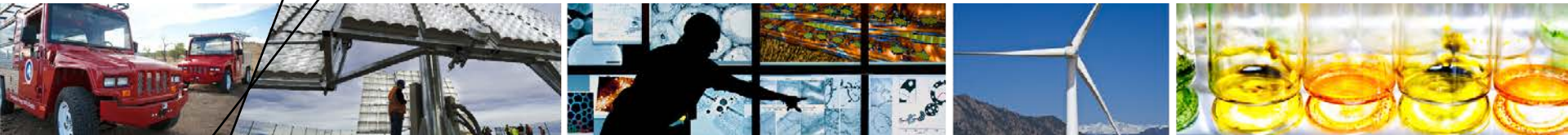


# National Renewable Energy Laboratory (NREL) Hydrogen and Fuel Cell Capabilities Overview



**2014 Fuel Cell Seminar and Energy  
Exposition**

**National Lab Showcase**

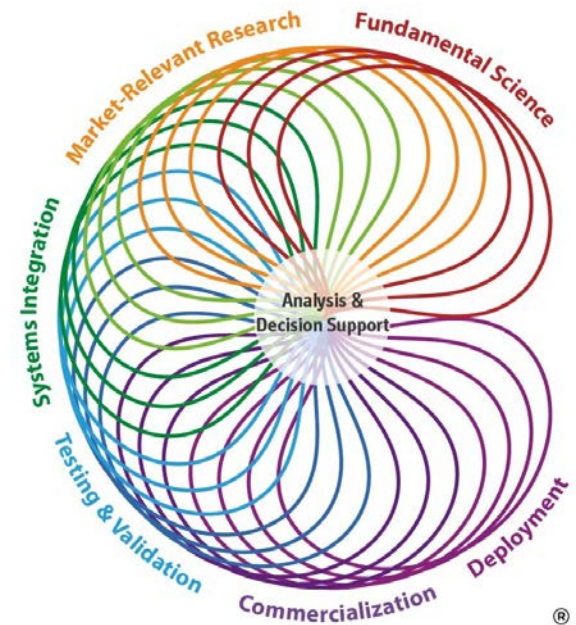
**Keith Wipke, NREL Fuel Cell and Hydrogen  
Technologies Program Manager**

**November 11, 2014**

# NREL Overview

The National Renewable Energy Laboratory (NREL) is the only national lab dedicated solely to advancing energy efficiency and renewable energy technologies

- Founded in 1977
- Location: Golden, Colorado
- ~1,750 full-time staff
- Full spectrum of RD&D, from basic science to deployment
- Unique research and testing capabilities across multiple scales
- Systems approach
- Strong history of partnering with industry to bring technologies to market



# NREL Hydrogen and Fuel Cell Core Capabilities

~35 employees in hydrogen and fuel cell R&D

## Core capabilities:

- Hydrogen **storage** sorbent material characterization
- National Fuel Cell Technology **Evaluation** Center
- Hydrogen **production** via fermentation
- Photobiological hydrogen **production**
- Photoelectrochemical hydrogen **production**

## Enabling capabilities:

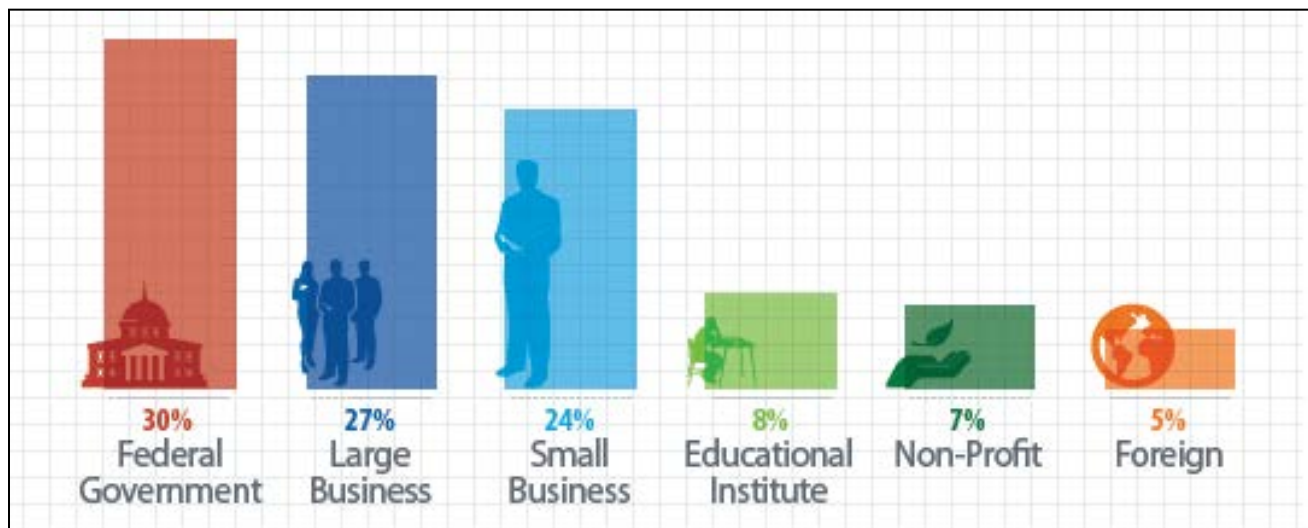
- **Fuel cells:** MEA and electrode development; alkaline exchange membranes/electrolytes; hydrogen PEM MEA testing and evaluation
- **Storage:** Solid state storage and regeneration; Engineering Center of Excellence
- **Analysis:** Total cost of fuel cell ownership energy analysis; hydrogen infrastructure scenario and techno-economic analysis; economic impact (jobs/competitiveness) and manufacturing/supply-chain analysis
- **Manufacturing:** Manufacturing quality control and metrology
- **Codes and standards:** Safety, codes and standards; hydrogen safety/detection sensors
- **Other:** Hydrogen Fueling Infrastructure Research and Station Technology (H2FIRST); renewable electrolysis and grid integration; objective (outside of R&D) systems integration of Fuel Cell Technologies Office analysis and activities



# NREL Technology Transfer Activities

NREL is best in class:

- More than **165** active CRADAs, the most in the DOE laboratory system
- More than **400** active industry partners
- Able to work with a variety of partners from small and large businesses to non-profits



# Energy Systems Integration

## NREL evaluates and optimizes the use of hydrogen and fuel cells in integrated energy systems

- Ability to test system performance in MW-scale testing and simulations
  - Unique megawatt research power bus
- Real-world integration of hydrogen production and high-pressure vehicle fueling infrastructure
  - Hydrogen made on site and dispensed through state-of-the-art 700-bar hydrogen research station (Fall '14)
- Opportunities to leverage other grid integration and transportation work at the lab
  - Energy storage, power to gas, vehicle to building, vehicle to grid

<http://www.nrel.gov/esif/>



# Component Design, Testing, and Validation

*Advancing technology development*  
through component design, testing, and  
validation

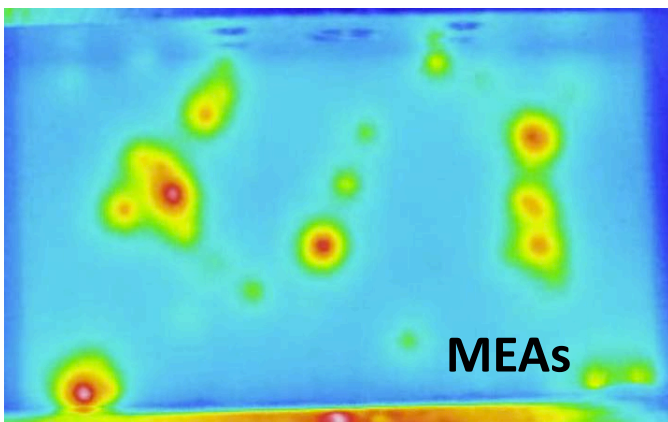
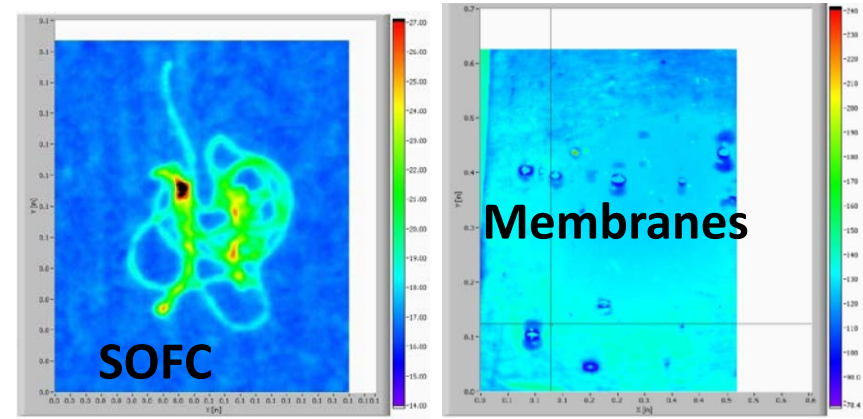
- Fuel cells
- System contaminants
- Hydrogen sensors
- Manufacturing quality control
- Accelerated component reliability
- High-pressure testing: hydrogen dispenser hose reliability and pressure relief devices
- Numerous models and tools



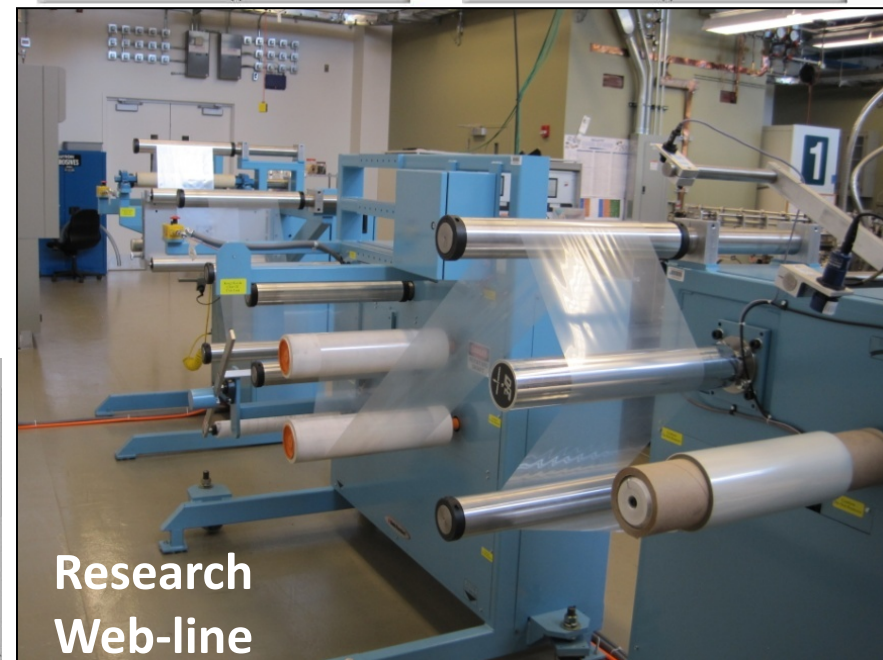
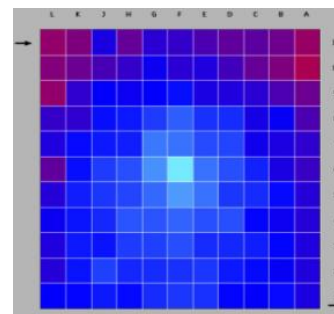
# Specific Example: Fuel Cell Manufacturing R&D

## Development of real-time quality control to support scale-up of fuel cell materials

- Development of in-line quality control techniques
- Validation of techniques on NREL's web-line
- Study of performance and durability effects of defects
- Transfer of techniques to industry



### Effects of Defects



# Research to Overcome Technical Barriers

## Advancing hydrogen production and delivery, hydrogen storage, and fuel cell technologies

- Renewable hydrogen production:
  - **World record PEC solar-to-hydrogen efficiency >16%** using state-of-the-art III-IV semiconductor materials
  - **O<sub>2</sub>-tolerant strains** for improved photobiological H<sub>2</sub> production
- Storage materials validation and testing
  - Measuring external samples to **characterize and validate** sorption capacities
  - Developing **hydrogen adsorption standards**

## Validating new technologies and systems in real-world operation

- National Fuel Cell Technology Evaluation Center (NFCTEC)
  - **Secure processing and analysis** of hydrogen and fuel cell related field data, publication of aggregate results
  - Helping industry **evaluate progress** toward technology readiness





# Sampling of Industry Partners



“The Department of Energy has developed **significant capability in fuel cell R&D, both in people and equipment**, within the national lab system. [The GM/NREL CRADA] provides the framework to efficiently apply the fundamental perspective and tools at NREL to address the real-world development challenges we are currently working to resolve.” – **Charles Freese, Executive Director, General Motors Fuel Cell Activities**

“Proton has built a strong relationship with NREL on topics ranging from **fundamental study to technology demonstration**...data from the simulated energy storage profiles being tested with our electrolyzers and stacks is **invaluable in establishing Proton’s credibility and robustness of the cell stack** under varying operating profiles.” – **Dr. Katherine Ayers, Director of Research, Proton OnSite**

“Toyota greatly benefits from NREL’s **unique expertise in vehicle and energy systems development and integration**. This past year we leveraged their new state-of-the-art ESIF to evaluate plug-in vehicle and grid interactions, and sought their expertise in renewable hydrogen production.” – **Nihar Patel, VP North American Business Strategy, Toyota Motor Sales, U.S.A., Inc.**

“Ion Power has engaged in a partnership with NREL over the past two years, focusing on development and validation of **in-line quality inspection techniques directly on Ion Power’s electrode manufacturing line**...this partnership has positively impacted Ion Power...The results demonstrated that this new material selection provided for a more uniform and higher quality coating.” – **Dr. Stephen Grot, President, Ion Power**

# Contacts for Follow-up

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- **Fuel Cell and Hydrogen Technologies Program Manager:**
  - Keith Wipke – [keith.wipke@nrel.gov](mailto:keith.wipke@nrel.gov)  
– 303-275-4451
- **Business Development:**
  - Ron Schoon – [ron.schoon@nrel.gov](mailto:ron.schoon@nrel.gov)  
– 303-275-4644
  - Alex Schroeder – [alex.schroeder@nrel.gov](mailto:alex.schroeder@nrel.gov)  
– 303-275-3790
  - Lauren Klun – [lauren.klun@nrel.gov](mailto:lauren.klun@nrel.gov)  
– 303-275-4410

***[www.nrel.gov/hydrogen/](http://www.nrel.gov/hydrogen/)***