Fuel Cell and Hydrogen R&D
at
Argonne National Laboratory

Ted Krause
Laboratory Program Manager

Argonne at a Glance

➢ Founded: Our origin is traced to the Manhattan Project's "Metallurgical Lab" at the University of Chicago. Designated as the first "national laboratory" on July 1, 1946.

➢ Lab: 3350 employees, $722M budget

➢ Location: Lemont, IL

➢ Core Capabilities:

- Chemical Sciences/Chemical Engineering
- Materials Science/Materials Engineering
- Systems Engineering
- Computational Science
- Large-Scale User Facilities/Advanced Instrumentation
- Energy Storage and Conversion

➢ 20 PIs and co-PIs in fuel cell materials development, fuel cell modeling, H_2 delivery and storage modeling, life cycle and systems analysis, economic impact studies.
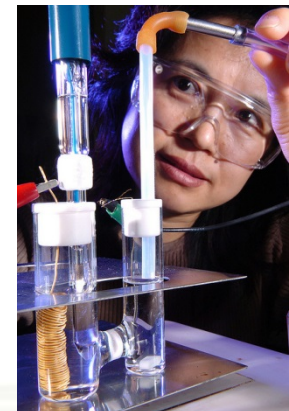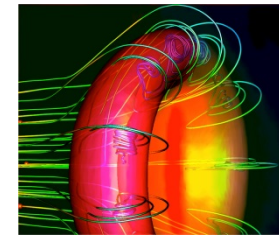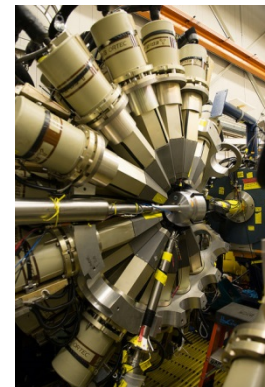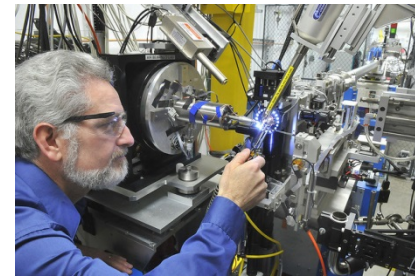
Comprehensive R&D program developing technologies and tools to accelerate bringing fuel cells to market

*Argonne-developed materials and technologies facilitate fuel cell deployment and the transition to a hydrogen-based economy*

Fuel Cell Materials

Hydrogen Production and Storage

World-Class User Facilities

Unique Characterization Tools
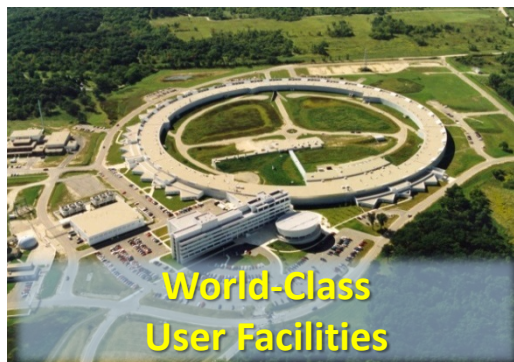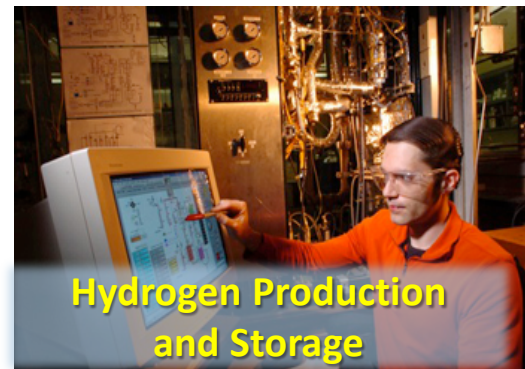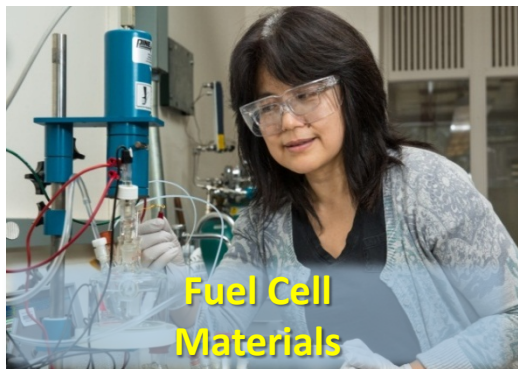
Argonne's unique characterization tools are supported by world-class user facilities to accelerate technology development

Argonne's modeling and analysis tools quantify the performance of new fuel cell technologies and the environmental impact and economic benefits of emerging fuel cell markets.

Modeling and Simulation

Environmental Impact & Economic Benefits
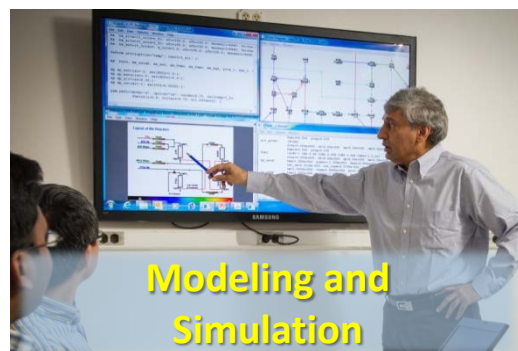
Our industrial and academic partners

Industrial Partners

- 3M
- Air Liquide
- Applied Nanotech Inc. (ANI)
- Atomic Energy of Canada Limited (AECL)
- BMW
- BP
- Chart Industries
- Chevron
- Ballard
- BASF
- dPoint
- Eaton
- Emprise
- Ford
- Gas Technology Institute (GTI)
- General Electric (GE)
- Gore
- GM
- Hexagon Lincoln
- Honeywell
- Jack Faucett Associates
- Johnson-Matthey
- Nexant
- Nissan
- Orion Industries
- PDC Machines
- PermaPure
- Pinnacle West
- RCF Economic & Financial Consulting
- Strategic Analysis, Inc (SA)
- Süd-Chemie (now Clariant)
- TIAX
- Toyota
- United Technologies Research Center

Academic Partners

- Brown University
- California Institute of Technology
- Indiana University Purdue University Indianapolis (IUPUI)
- Kettering University
- Massachusetts Institute of Technology
- National University of Singapore
- Northern Illinois University
- Pennsylvania State University
- Southern University
- Southern Illinois University
- Texas A&M University
- University of Alabama
- University of Arkansas – Little Rock
- University of California - Berkeley
- University of Chicago
- University of Illinois-Chicago
- University of Minnesota
- University of Nevada, Las Vegas
- University of North Carolina
- University of Wisconsin-Madison
- University of Pittsburgh
- University of Puerto Rico (Mayagúez)
- University of Texas at Austin
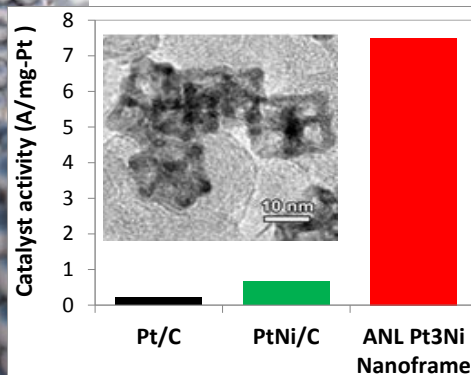- University of South Carolina
- Tulane

Fuel Cell Materials Development:

Developing higher performance, lower cost electrocatalysts for PEM fuel cells

Low Pt and Pt alloy catalysts

Non-precious group metal catalysts
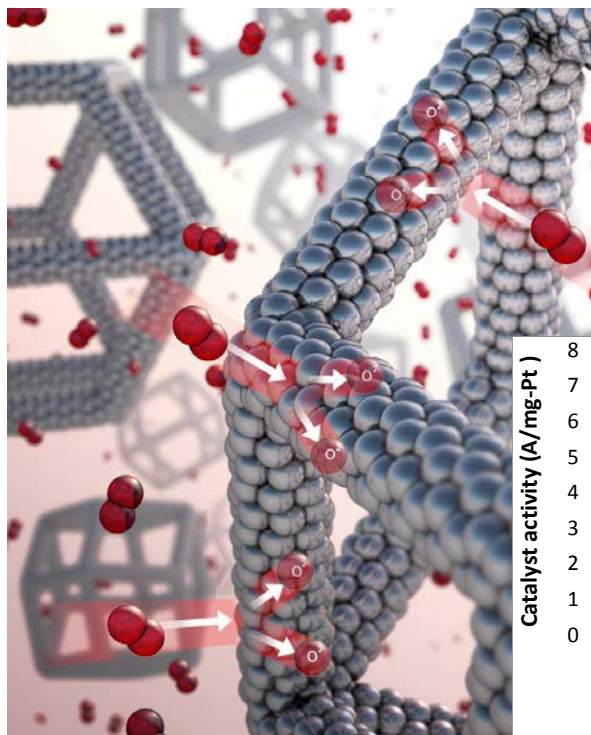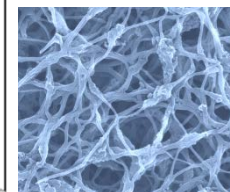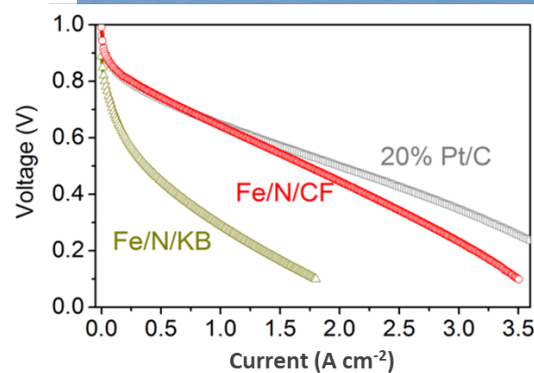

Science 21 March 2014, pp. 1339-1343.

Catalyst activity (A/mg-Pt): Pt/C, PtNi/C, ANL Pt3Ni Nanoframe

10 nm

➢ **35X performance per gram Pt vs. standard Pt/C catalyst**

➢ **No observed loss in activity after 10,000 voltage cycles**

20% Pt/C

Fe/N/CF

Fe/N/KB

Voltage (V) vs Current (A cm⁻²)
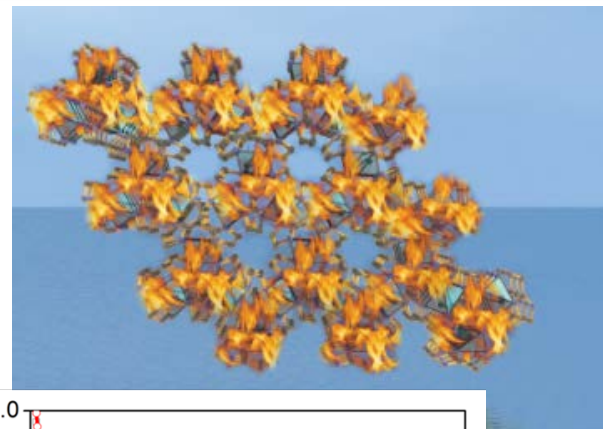
➢ **Oxygen performance of Argonne's Fe/N/CF catalyst is approaching that of Pt**

➢ **Among the highest reported specific activity of any non-PGM in the open literature**

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Fuel Cell and Hydrogen Storage Modeling and Simulation:
Employing modeling and simulation to aid component and system developers
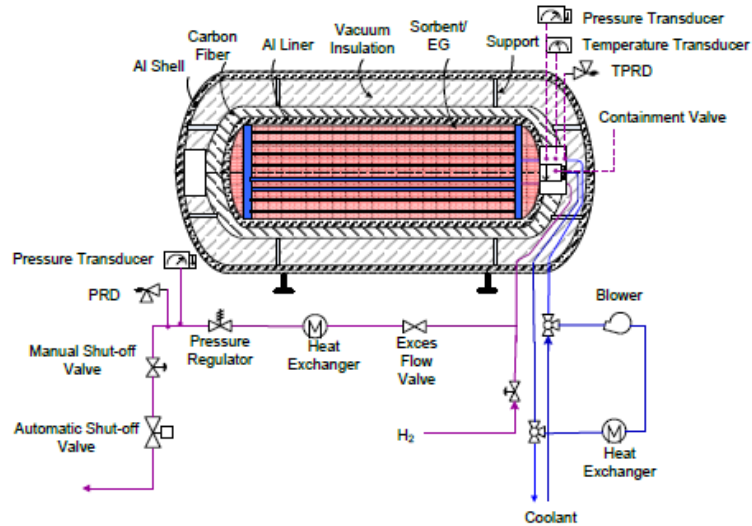
- *Reverse engineering* **to define component-level performance targets needed to meet system-level targets.**
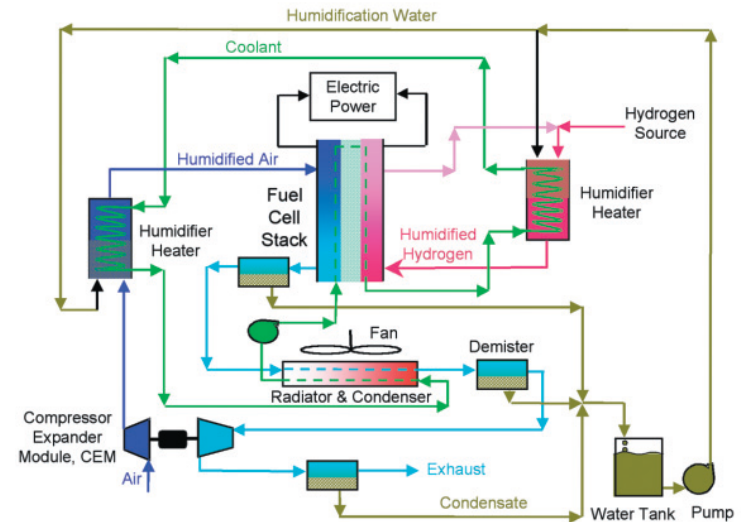
- *Process modeling and simulation* **to evaluate component performance in an integrated system.**

GCTool (General Computational Toolkit) - **software package that helps design, analyze, and optimize fuel cell system and hydrogen storage and production systems.**

Contact: Rajesh Ahluwalia (walia@anl.gov)

Systems Analysis:
Creating user-friendly analysis tools for understanding the cost and benefits of bringing hydrogen to market
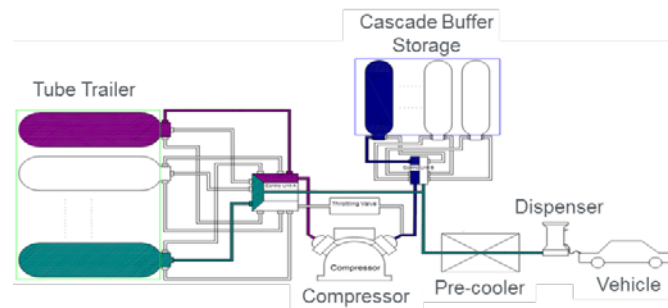
Hydrogen Delivery Scenario Analysis Model (HDSAM)

Hydrogen Station Cost Optimization and Performance Evaluation (H$_2$SCOPE)

JOBS H$_2$
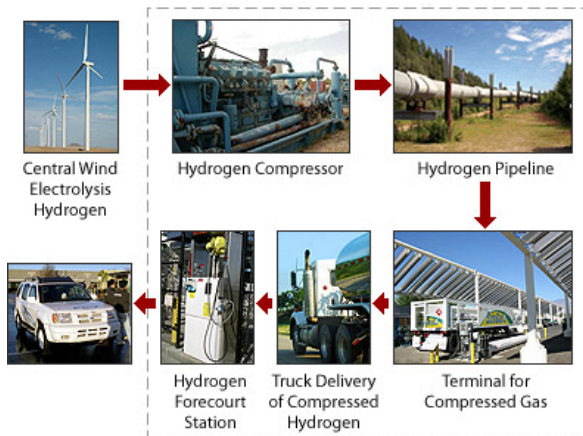
➤ **Compares the cost of alternative H$_2$ delivery and refueling options for various market penetrations of fuel cell vehicles**

➤ **Identifies refueling station cost reduction opportunity through a novel tube trailer consolidation concept**

➤ **Estimates economic impacts from the development and operation of H$_2$ fueling stations**

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Systems Analyses:

Quantifying the environmental benefits of emerging fuel cell technologies and markets with GREET

➢ ***GREET (Greenhouse gases, Regulated Emissions, and Energy use in Transportation)*** is a is a one-of-a-kind analytical tool that simulates the energy use and emissions output of various vehicle and fuel combinations.

➢ Widely recognized as the "gold standard" for evaluating and comparing the energy and environmental impacts of transportation fuels and advanced vehicles.

➢ The model is capable of evaluating 100 vehicle/fuel combinations from gas guzzlers and electric cars to Brazilian sugarcane ethanol and hydrogen fuel cells.

➢ EXCEL-based and in the Public Domain (it's free!)
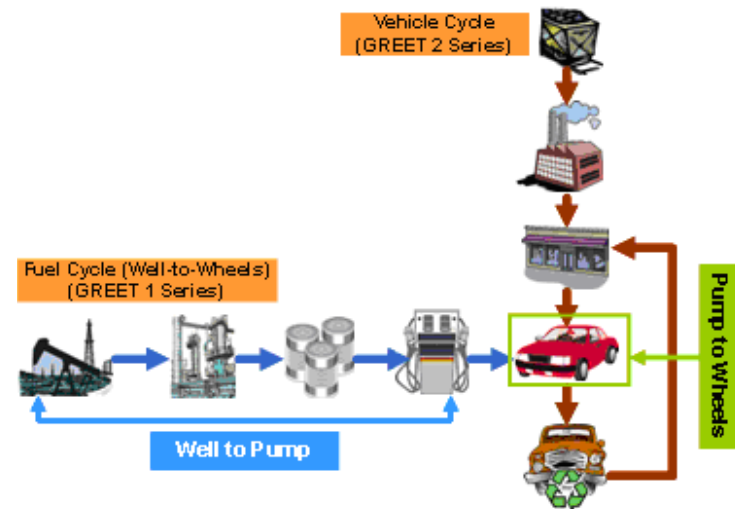
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www.transportation.anl.gov/fuel_cells/