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Fuel Cell Research at the National Renewable Energy Laboratory

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Scientists and engineers at the National Renewable Energy Laboratory (NREL) are advancing hydrogen and fuel cell technologies through materials R&D, fuel cell system simulation and field evaluation. Susan Hock, Director of the Center for Electric & Hydrogen Technologies & Systems (E&HT&S), is responsible for coordinating these efforts and explains, "The E&HT&S Center is able to tap into expertise from basic sciences, solar, wind, biomass, transportation, distributed power systems and other core NREL capabilities to tackle the challenges of hydrogen in new and unique ways."

NREL, located in Golden, Colo., is the US Department of Energy's (DOE's) premier laboratory for renewable energy research. Fuel cell, fueled with hydrogen produced from renewable resources, are a key enabling technology for the hydrogen future envisioned by DOE. NREL's fuel cell R&D activities are focused on improving the efficiency and durability and reducing the costs of polymer electrolyte membrane fuel cell (PEMFC) systems.

Fuel Cell Component Materials

New low-cost materials for improved PEMFC stack and system performance are central to achieving DOE goals. Thin metallic bipolar plates could significantly reduce the cost of a PEMFC. However, the aggressive environment in a PEMFC stack can corrode the metal plates, leading to electrical losses and contamination of the polymer membrane.

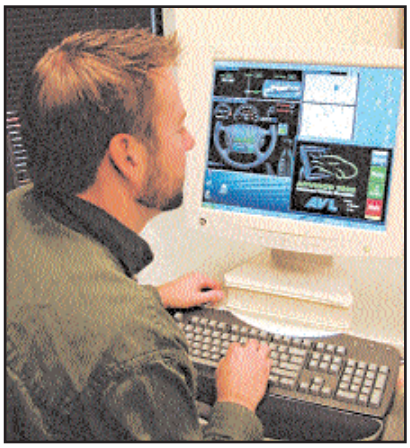
Originally developed at NREL for solar cells, conductive oxide coatings, which are made up of tin oxides, zinc oxide and tungsten oxide, are now being evaluated for corrosion protection in PEMFC applications. In addition, stainless steel alloys are being screened to identify a low-cost material that, in a PEMFC environment, will form a stable film without degrading contact resistance. NREL's innovative test protocol, which simulates PEMFC conditions, has identified austenite 349 and duplex 2205 alloys as possible candidates. Metal plates developed at Oak Ridge National Laboratory, which are based on a conductive nitride surface layer, have also shown promise in initial screening tests. Future research will focus on aluminum alloys, which could offer a lighter weight alternative for transportation applications.

The expensive platinum catalyst used in PEMFCs is susceptible to poisoning at the PEMFC's operating temperature (less than 90°C). Solid electrolyte systems that can operate from ambient to 350°C can increase impurity tolerance and reduce the cost of PEMFCs. A system operating in this range would also be able to generate medium-temperature steam for increased efficiency in building applications.

Inorganic solid-state proton conducting systems, such as heteropoly acids (HPAs), are one promising option for high temperature fuel cell membranes. HPAs exhibit high proton conductivity at elevated temperatures. Prototype HPA-based films have shown a fuel cell response from ambient to 200°C. The ultimate goal of this research is to develop HPA-based composite membranes for use in higher temperature fuel cells.

Fuel Cell System Analysis and Modeling – Designing for Manufacturability

Robust and durable fuel cell designs are necessary for fuel cells to successfully compete with existing mature technologies. NREL analysts are working with fuel cell industry leaders to accelerate implementation of fuel cell technologies by integrating advanced computer-aided engineering (CAE) methods to improve reliability, performance and cost. Probabilistic modeling of material, loading and manufacturing variations is used to develop improved designs that achieve the desired quality level (i.e., six-sigma)



Keith Wipke uses ADVISOR software to guide fuel cell vehicle development efforts.

and performance requirements. NREL has partnered with Plug Power and Ballard Power Systems to achieve robust designs of fuel cell, reformer and heat exchanger components.

Over the last 10 years, NREL has worked with automobile manufacturers to guide the development of hybrid vehicle technologies. According to Barbara Goodman, Director of NREL's Center for Transportation Technologies and Systems (CTTS), "Working closely with the auto industry helps us understand their challenges and ensures the work we are doing is relevant." NREL developed the ADVISOR (ADvanced Vehicle SimulatOR) modeling tool to facilitate vehicle system analysis. The ADVISOR software was recently licensed to AVL Powertrain Engineering, Inc. for commercialization.

ADVISOR is now being used to advance fuel cell vehicle technologies. To date, battery sizing for fuel cell hybrids, fuel economy impacts of fuel cell reformer start-up and water management over typical drive cycles have been analyzed. NREL's new Technical Targets Tool, combined with design of experiments methods, quickly assesses the sensitivities of various technical targets and the relative importance of each.

NREL's Test Facilities Designing Integrated Systems for Distributed Generation

NREL is using its world-class test facilities and expertise in systems integration to optimize stationary applications for fuel cells. The Distributed Energy Resources Test Facility is used to evaluate the interconnection and integration of distributed power with the electrical grid. The viability of co-producing hydrogen, for use as an energy storage medium, from wind power in an integrated system is now under investigation. Hydrogen will be used to produce electricity in a fuel cell when wind power is not available.

NREL's Advanced Heating, Ventilating and Air-Conditioning (HVAC) Test Facility is used to evaluate the performance of integrated combined heat and power (CHP)/distributed power systems. Identification of innovative techniques for upgrading the low-temperature waste heat from a PEMFC will be investigated to optimize the thermal integration of CHP and PEMFC systems.

Fleet Testing and Evaluation On the Street

NREL works with fleet managers and industry groups to evaluate advanced technology vehicles in service. This information is also used to "feed research needs and technology gaps back into the R&D process to further the technology toward commercialization," according to Keith Wipke, Fuel Cell and Technology Validation Task Leader.

NREL's Fleet Test and Evaluation Team monitors the performance of SunLine Transit Agency's fuel cell buses.

NREL is currently monitoring the experiences of three California transit agencies as they add hydrogen fuel cell buses to their fleets and set up infrastructure for fueling and maintenance. Non-proprietary performance data are provided to others who are considering adding such vehicles to their fleets.

NREL will assist DOE in its upcoming Controlled Hydrogen Fleet and Infrastructure Demonstration and Validation project, in which teams of automobile manufacturers and energy companies will validate integrated hydrogen and fuel cell technologies under real-world operating conditions. Highlighting the issues of introducing hydrogen-powered vehicles and infrastructure simultaneously will focus R&D efforts to overcome the technical barriers.

For more information about NREL's fuel cell research, contact Keith Wipke at keith_wipke@nrel.gov.

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