

# FUEL CELL QUARTERLY

## New Players in the Hydrogen Game

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Industry, government and partnerships worldwide are working together to advance the hydrogen economy, with the United States, United Kingdom, Canada, Japan, and Germany, among others, having long histories of funding critical hydrogen and fuel cell research and demonstration activities. However, some bold European governments and communities have now raised the bar by committing to projects that are both expansive in scope and challenging in their projected timeframe. Motivated to wean themselves from imported oil by expanding the use of renewable technologies, as well as to reduce greenhouse gas emissions, these visionaries are strongly embracing the potential of hydrogen and fuel cells. The scope of some projects is enormous.

### Iceland

Iceland is planning to end its reliance on imported oil by 2050, when it intends to have in place a model society of the future that uses renewably-derived hydrogen for all automotive and maritime applications. The country's abundant renewable energy resources – geothermal heat and hydroelectric power, which currently supply about two-thirds of the country's energy needs - will be used to produce hydrogen by electrolysis. Milestones have already been set: hydrogen will power all city buses within the next decade; the country's vast fishing fleet will begin using fuel cells to provide auxiliary power by 2015 to provide primary power; and, by 2050, all of Iceland's vehicles will be converted to powered operation. By converting the transportation sector to hydrogen power, Iceland anticipates a reduction in greenhouse gas emissions by about 66 percent. To implement this vast agenda, [Icelandic New Energy](#) was formed as a project manager for hydrogen demonstrations and research. The group has already led the European Commission (EC)-supported ECTOS (Ecological City TranspOrt System) project to test three Citaro fuel cell buses in Reykjavik. The buses, which operated under ECTOS between 2003 and 2005, are continuing to operate through 2006 as part of the EC's subsequent CUTE (Clean Urban Transport for Europe) project to demonstrate fuel cell buses in nine European cities.



Shell Station in Reykjavik

### Sweden

Sweden plans to become the world's first oil-free economy by 2020, replacing its fossil fuel consumption, mainly by the transportation sector, with renewably-produced energy.

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Jennifer Gangi, writer/editor  
[jennifer@fuelcells.org](mailto:jennifer@fuelcells.org)

Sandra Curtin, writer  
[sandra@fuelcells.org](mailto:sandra@fuelcells.org)

To read complete newsletter, please go to [www.fuelcells.org/info/newsletter.html](http://www.fuelcells.org/info/newsletter.html)

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Questions or comments? E-mail us at [jennifer@fuelcells.org](mailto:jennifer@fuelcells.org).

## Ruling the Road

Fuel cell vehicles have been hitting the road in many forms – new car models and announcements, utility vehicles and bus programs – and are helping drive the technology closer to commercialization.

At the recent Los Angeles Auto Show, Ford unveiled a six-passenger fuel cell-powered Explorer that combines a 60-kW Ballard fuel cell with a 50-kW hybrid battery. In less than one year, the fuel cell Explorer has accumulated more than 17,000 miles, including a world-record drive of 1,556 miles in a single 24-hour period, the most of any fuel cell vehicle to date. Another area where Ford has bested previous vehicles by any automaker is range. The fuel cell Explorer can travel 350 miles on a single tank of hydrogen. Ford designers tried something new and placed the 10 kg storage tank in the center space now used for the 6-speed automatic transmission in current Explorer models.



Ford fuel cell Explorer

A few months ago, Honda unveiled its next-generation FCX Concept fuel cell vehicle. The FCX Concept features a newly developed compact, high-efficiency Honda fuel cell stack as well as a low-floor, low-riding, short-nose body. This new fuel cell stack is 20% smaller and 30% lighter than the current FCX stack, yet its power output is 14kW greater. The car gets about 270 miles per tank of hydrogen. Honda plans to develop its new fuel cell vehicle based on this concept model and begin limited marketing in Japan and the U.S. in 2008. Honda's president recently said that mass-production could begin by 2018.

General Motors Corporation (GM) announced plans to build a fleet of more than 100 fuel cell vehicles for on-road testing next year. Under its "Project Driveway" plan, GM will supply California, New York City, and Washington, D.C. with Chevrolet Equinox vehicles with its fourth-generation fuel cell system. The systems are designed to run for 50,000 miles. GM already has delivered one fuel cell Equinox to the U.S. Army to be used for non-tactical transportation purposes, primarily on military bases in Virginia and California. GM's other fuel cell vehicle, the HydroGen3, was added to the U.S. Postal Service's Irvine, California fleet.

On the utility vehicle side, the Energy research Centre of the Netherlands (ECN) has built the first car to be powered by a fuel cell developed entirely in the Netherlands. The *HydroGEM*, a modified DaimlerChrysler GEM, can be refueled quickly and is extremely quiet and clean, making it suitable for use at airports, railway stations, industrial

locations, as well as nature reserves and hospitals.

## Buses

Fuel cell buses have been around for some time, but recently there has been some major new efforts announced as well as project extensions.

The Center for Transportation and the Environment in Atlanta, Georgia, the Northeast Advanced Vehicle Consortium in Boston and Westart/CALSTART of Pasadena, California, all non-profit organizations, were selected to receive a share of \$49 million from the Federal Transit Administration (FTA) to develop commercially viable hydrogen fuel cell buses. The program's goal is to have fuel cell buses represent 10 percent of new U.S. transit bus purchases in the year 2015. The money will be matched with another \$49 million in grants. The projects involve getting fuel cell buses on the road in Boston, Washington, DC, Alabama, South Carolina, Connecticut, New York and various cities in California.

In Connecticut, the Greater Hartford Transit District has contracted with UTC Power for a 40-foot hybrid electric fuel cell-powered transit bus that will be used in revenue service. As part of the agreement, UTC Power will also provide two years of program support, including the use of a hydrogen refueling station located at UTC's headquarters.



As part of the fuel cell demonstration program of the Ministry of Economy, Trade and Industry's (METI) [Japan Hydrogen & Fuel Cell Demonstration Project](#) (JHFC), Toyota Motor Corporation and Hino Motors, Ltd.'s FCHV-BUS, which operated on public routes in mid-March around the Central Japan International Airport (Centrair), has renewed its operation, including expanded service to and within the airport. The buses will be fueled at the JHFC Centrair Hydrogen Station, which will be set up within Centrair as part of the JHFC's Demonstration Study of Hydrogen Fueling Facilities for Fuel Cell Vehicles.

In Germany, Proton Motor Fuel Cell GmbH has delivered a fuel cell bus to the City of Barth (Mecklenburg-Vorpommern) to be operated in urban and regional public transport.

All of these demonstrations and projects around the world are helping increase the visibility of fuel cell vehicles while supplying critical research and information to help improve the technology and bring them to the road for good. (JG)

The country has already successfully reduced oil consumption by 77 percent between 1970 and 2003 and now meets most electricity needs with nuclear and hydroelectric power. Hydrogen will play a role in achieving the zero-oil goal - more than 100 organizations have collaborated to form [HyFuture](#), a group working to introduce hydrogen infrastructure and fuel cell demonstrations in Western Sweden. The Western region is well suited for promoting renewable technologies as it is home to the country's shipping and automaking industries (Saab, Volvo) which could benefit from environmentally-friendly hydrogen and fuel cells. Also present is a strong petrochemical industry that produces 1,000 kilograms/hour of pure hydrogen, sufficient annual production to provide fuel for 50,000 fuel cell vehicles traveling 15,000 kilometers each, or to provide 7,500 households with



CUTE fuel cell bus

15,000 kilowatt hours per year of electricity. To further its hydrogen goal, HyFuture has joined with partners Denmark and Norway to create the

[Scandinavian Hydrogen Highway Partnership](#) to make the Scandinavian region one of the first in Europe with a network of commercially-available hydrogen refueling stations. The country has also held bus demonstrations under EC's CUTE project, operating three fuel cell transit buses in Stockholm during 2004 and 2005.

## Denmark

Beyond Denmark's participation in the Scandinavian Hydrogen Highway Partnership through the national [Hydrogen Link](#) initiative,

a unique regional project is currently underway. The Municipality of Nakskov, located on the Danish island of Lolland, has entered into a partnership with Danish fuel cell developer [IRD Fuel Cell](#), and project development organization [Baltic Sea Solutions](#) to become a living "full scale Danish Community Testing Facility" for IRD's fuel cell technologies. The project began in April 2006 and involves the deployment of fuel cell-based combined heat and power generation (micro CHP) systems to private households within the Municipality to enable production of electricity and heat on-site. The final phase of the project will include the complete conversion of a small rural community to hydrogen, where different fuel cells will be tested. Hydrogen for the project will be derived by electrolyzer from the island's surplus wind power resources and delivered to households using a new hydrogen micro-grid distribution system. The two-year project is partly funded by the Danish Energy Authority.



IRD's 6 kW CHP unit

## Driving a Hydrogen Future

These notable European countries are helping to spur the development of hydrogen and fuel cell technologies as they pursue their goals of energy self-sufficiency and reduction of greenhouse gas emissions. It will be interesting to follow the development of these ambitious programs. By setting demanding goals, these pioneering governments are forging a path toward the hydrogen economy. Hopefully others will take note and follow their lead. (SC)

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## New York State Plans New Hydrogen and Fuel Cell Projects

In October 2006, New York's governor announced plans for one of the world's largest hydrogen projects, a \$21 million effort to produce hydrogen from existing hydropower resources located in the western part of the state. The project will include two new hydrogen generation facilities, with a daily production capacity of 120 kilograms (equivalent to about 120 gallons of gasoline). The fuel will be used in hydrogen-powered work and passenger vehicles and transit buses and will be distributed from hydrogen refueling stations located adjacent to the two production facilities. Initial project studies have indicated that hydrogen produced at the facilities could fuel a fleet of light- and heavy-duty vehicles and stationary fuel cells at a price competitive with gasoline. Hydrogen production is anticipated to begin in late 2007, with full implementation of the project by the end of 2009. The effort will be coordinated by the New York Power Authority (NYPA), the New York State Energy Research and Development Authority (NYSERDA) and the Long Island Power Authority (LIPA), with various other state and federal government organizations and corporations expected to partner in the project.

NYPA is also working with the New York State Police in a \$434,000 program to deploy fuel cells for backup power at 22 public safety communications facilities. Plug Power will provide the GenCore® 5 kW fuel cells. (SC)

## Fuel Cells Take Flight

Fuel cells hold promise for powering unmanned aerial vehicles (UAVs), the remotely or self-piloted aircraft that can carry cameras, sensors, or communications equipment for military reconnaissance and combat duties. UAVs also have the potential for civil and commercial applications such as homeland security missions, hurricane and storm tracking, wildfire detection and support, environmental monitoring, and aerial imaging and mapping.

Recently, several small, fuel cell-powered, unmanned aircraft completed successful test flights. The first, designed by students at Georgia Tech's Aerospace Systems Design Laboratory, took to the air in June 2006. Powered by a 500-watt PEM fuel cell operating on compressed hydrogen, the 22-foot wingspan aircraft completed several trials over the Atlanta Dragway flying up to a minute at a time. A second UAV, developed by a student team from Cal State L.A.'s Multidisciplinary Flight Dynamics and Control Laboratory, was tested in September 2006. The 480-watt fuel cell UAV, achieved a two minute flight with a payload of 28.5 pounds, attaining an altitude of 100 feet.



CalState's UAV

To date, only two other entities have flown hydrogen-powered aircraft. In November 2005, the U.S. Naval Research Laboratory flew their 5.6-pound 'Spider-Lion' micro UAV for more than



Aerovironment's liquid hydrogen UAV

three hours, using fuel cell system powered by compressed hydrogen. Also in 2005, AeroVironment, producer of military UAVs, tested the first liquid hydrogen-powered aircraft. Using the company's prototype High Altitude Long Endurance (HALE) platform, the hydrogen-powered UAV, with a 50-foot wingspan, flew repeatedly and reliably for over an hour at a time using both manual control and autonomous waypoint navigation. The company is developing the HALE UAV platform to allow the unmanned aircraft to fly at 65,000 feet for over a week with payload-carrying capacity of up to 1,000

pounds. AeroVironment also developed and demonstrated the world's first hydrogen-powered UAV in March 2003, using a fuel cell that was shaped to serve as the UAV's wing.

In related news, Boeing announced plans for developing a manned, 2-seater light aircraft that will be powered by a PEM fuel cell-lithium battery hybrid system. The fuel cell, developed by Intelligent Energy, will provide power for the entire flight. Supplemental energy will be delivered by the lightweight batteries during take-off and while climbing. Boeing states it is developing this craft to improve the company's knowledge of the technology for potential applications in aviation. (SC)

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## USFCC Releases Worldwide Survey, Product List

Members of the US Fuel Cell Council (USFCC), Hydrogen & Fuel Cells Canada, Fuel Cell Europe, and the Fuel Cell Commercialization Conference of Japan participated in a voluntary industry survey conducted by PricewaterhouseCoopers. The [2006 Worldwide Fuel Cell Industry Survey](#) reveals significant year-to-year increases in sales, research spending and employment from 2004 to 2005. Reported sales were up 7% to \$353 million. Reported research and development spending was up 11% to \$796 million and reported employment specific to the fuel cell industry was up 12% to 7,074 employees. The USFCC has also released a comprehensive list of [fuel cell products](#) available for purchase from manufacturers headquartered in the United States, Canada and Europe. The list of 50 products include fuel cells for micro, portable, stationary and transportation applications.

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## Name Changes

Alchemy Enterprises has changed its name to [Ecotality](#).

Power Air Corporation and H-Plus Eco Ltd. Have formed H-Plus PAC.

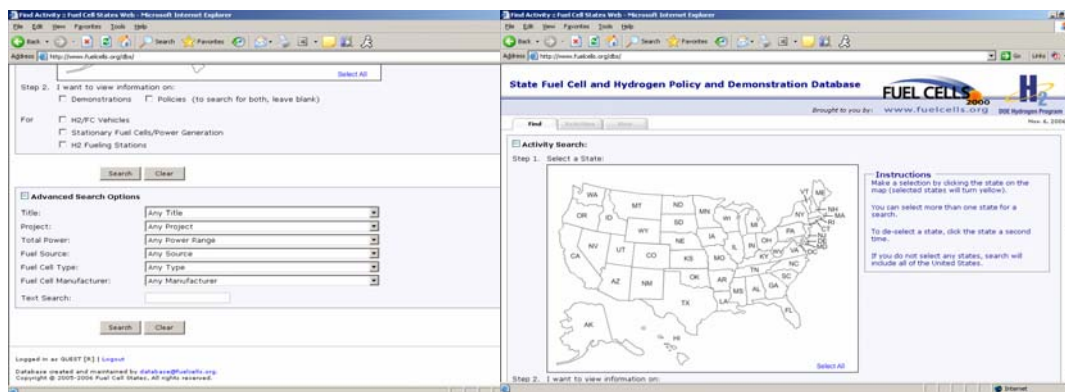
Cabot Corporation has changed the name of its Cabot Energy Materials business to Cabot Fuel Cells.

## New Database of State Activity

Fuel Cells 2000 and the U.S. Department of Energy (DOE) Hydrogen Program have launched a new searchable database that documents fuel cell and hydrogen activity in the United States – stationary installations, vehicle demonstrations, fueling stations, and policies, initiatives, and legislation designed to advance the development and use of hydrogen and fuel cell technologies. The database builds on the recent Breakthrough Technologies Institute report, *State Activities That Promote Fuel Cells and Hydrogen Infrastructure Development*, with additional information about demonstrations and installations in a searchable format that provides more utility.

Forty-seven states and the District of Columbia have some sort of fuel cell or hydrogen legislation, demonstration or activity taking place today, including 15 with hydrogen fueling stations. Users can search for relevant information and activity within the entire United States, an individual state, or a cluster of states. Advanced search options include fuel cell size/power range, fuel source, fuel cell type, fuel cell manufacturer, and vehicle manufacturer. A text search is also available. Images and links for further information are included with most entries.

The free database is available at <http://www.fuelcells.org/statedatabase.html> and will be updated regularly. Fuel Cells 2000 welcomes any additions or feedback - please email information to [database@fuelcells.org](mailto:database@fuelcells.org).



## President Bush Extends Energy Tax Credit for One Year

President Bush approved a bill that extends federal tax credits for renewable energy and energy efficiency projects. The wide-ranging Tax Relief and Health Care Act of 2006 provides a one-year tax credit extension for homeowners that purchase fuel cell systems and for businesses that purchase fuel cell power plants. The 30% tax credit is capped at \$1,000 per kW for systems 0.5-kW or larger with a minimum efficiency of 30%.

## Converting to Hydrogen

We are probably all familiar with the many hydrogen development projects being undertaken by federal, state and local governments (see our [State Fuel Cell and Hydrogen Policy and Demonstration Database](#)).



However, individual entrepreneurs should also be given credit for their efforts to promote clean, sustainable hydrogen transport. We recently heard from [Intergalactic Hydrogen](#), a vehicle conversion and technology advancement company that designs and installs alternative fuel systems for fleets and retail customers. Intergalactic's conversions have included a prototype flex-fuel Toyota Tacoma V-6 internal combustion engine (ICE) pick up truck that was the first hydrogen-fueled vehicle to drive across the United States. The Tacoma is able to operate on multiple fuels, including hydrogen, compressed natural gas, ethanol, gasoline, or a combination. The company has also modified a Hummer H2 to run on CNG, hydrogen, CNG/hydrogen blend, E35 ethanol, or gasoline (all emission controls are unmodified and operational). Intergalactic's philosophy is that multi-fuel vehicles in a flex-fuel configuration can be economically deployed today, yielding immediate air quality benefits and creating the demand for more hydrogen fueling sites. (SC)