

## FUEL CELL Q U A R T E R L Y

### Fuel Cells - Flying High!

Future aircraft will likely need to meet enhanced emissions reduction requirements, necessitating new, clean energy technologies to improve both ground and airborne performance. Current research, development and demonstration (RD&D) is exploring the use of more electrically-driven components to replace hydraulic and pneumatic systems. Fuel cells are a promising technology to help meet this challenge.

The International Air Transport Association (IATA) states that air transport contributes 2% of global manmade CO<sub>2</sub> emissions and is predicted to grow to 3% by 2050. Gas turbines used to power a plane's electronic systems when operating on the ground also emit CO, NO<sub>x</sub>, hydrocarbons, and noise pollution. Because of these challenges, IATA has created a vision is for the industry to attain carbon-neutral growth from 2020 and reach a 50% reduction of emissions by 2050, and has also set a long-term goal for zero air transport emissions. Accordingly, major aircraft manufacturers Boeing (in conjunction with Sandia National Laboratory), and Airbus (in conjunction with German national aerospace agency DLR) are conducting research into promising fuel cell applications on future aircraft that can assist with emissions reductions and improve energy efficiency.

DLR, and Airbus (whose Aerotec Fuel Cell Test Center opened in Hamburg in August 2009), have identified a number of fuel cell applications and are investigating them for use in research aircraft. Fuel cell systems can potentially be used to provide power, emissions-free ground operation (autonomous taxiing, maintenance bus supply and cargo reloading), electrical main engine start, electrical environmental control system supply (air conditioning), water generation (potable water and water for toilets), heat generation (icing prevention and hot water generation), explosion and fire prevention and sup- DLR-H2 during maiden flight  
pression (inerting of tanks, cargo and electrical bay flight compartment), and cockpit and cabin air humidification. The multiple fuel cell applications may be able to reduce a plane's payload, lower maintenance costs and reduce emissions, potentially justifying the present higher cost of fuel cells compared to current technologies.



Boeing has examined conceptual solid oxide fuel cell (SOFC) -micro gas turbine hybrid configurations and found a large benefit in their use. These high temperature systems attain a high level of energy efficiency and operate at a similar temperature as in the fuel reforming process. The company is presently working on a SOFC system that operates using Jet A fuel. Boeing, however, believes that SOFC technology is not yet mature enough for use in aircraft and anticipates that proton exchange membrane (PEM) fuel cells will be deployed sooner. In collaboration with Sandia National Laboratories, Boeing is exploring the use of

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# Fuel Cell Hot Spots

## Taking a road trip this year? Why not make it a fuel cell road trip?

We've compiled a handy guide to some interesting US fuel cell installations. Many of these fuel cells are used to power public establishments, giving you a chance to visit, view a fuel cell, or ask a few questions of the proprietors.

We've arranged our listing by region and covering the Northeast, Mid-Atlantic and the South in this issue. For those of you traveling further west, be sure to view the next edition where we'll travel the Mid-West, Great Lakes region, West Coast, Alaska and Hawaii.



### Northeast

**Maine** – Start your trip off with a visit to the Chewonki Foundation Environmental Education Center, which uses a proton exchange membrane (PEM) fuel cell to provide backup lighting. “Green” hydrogen is produced onsite by electrolysis of water, via renewable power from solar panels atop the center and purchases of “green” electricity.

**Massachusetts** – Hungry from your long drive? Stop by Whole Foods Market (located in Dedham) or Star Market (in Newton). Both grocery stores have installed 400 kW fuel cells that generate 90% of the store's energy onsite.

**Connecticut** – There is a lot going on, fuel cell-wise, in Connecticut. First, check into the Mohegan Sun (Uncasville) and visit the Casino's 400 kW fuel cell installation. Phosphoric acid fuel cell (PAFC) units are used to generate electricity for the entertainment complex, with waste heat recovered to preheat boiler feed water and generate domestic hot water. The indoor installation is open to the public, allowing visitors to view the fuel cells and learn about the benefits of the technology.



UTC fuel cell at Mohegan Sun

Feeling hungry? Drive by the Pepperidge Farm Bakery (Bloomfield) for some wonderful aromas. The bakery uses two molten carbonate fuel cells (MCFC) – a 250 kW (installed in 2003) and a 1.5 MW (deployed in 2008) – to provide 70% of the bakery's power. Excess heat from the newer fuel cell is channeled to support bakery processes, helping to reduce the amount of fuel needed for the plant boilers.

Time to buy some sneakers for all the walking you'll be doing on your trip. Stop by Cabela's Sporting Goods (East Hartford) – the store uses four 200 kW PAFC units to baseload power. And if you missed the trip to the Massachusetts's Whole Foods Market, stop by the one in Glastonbury that uses a 200 kW PAFC to produce half of the store's power and almost all the hot water.

Ready for more education? Visit the Connecticut Science Center (Hartford), which features 150 hands-on exhibits, a state-of-the-art 3D digital theater, four educational labs, plus daily programs and events. The Center is installing a 200 kW fuel cell that will supply most of the power demand. Surplus electricity, generated at night when the Center's power demand is lower, will be sold the local power grid.



CTTransit's fuel cell bus

And while you're in Hartford, be sure to ride CTTransit's fuel cell hybrid bus. Up to 50 kg of hydrogen is stored on the roof using 5,000 psi tanks, which gives the bus a travel range of 250-300 miles. The bus is typically deployed on the Star Shuttle Route, but be sure to check with the agency since it also plans to deploy the bus on other routes.

And don't forget to get in touch with nature with a visit to Dinosaur State Park (Rocky Hills), where a 25 kW fuel cell provides part of the baseload power, and heating and air conditioning, for the Park's Visitor Center.

### Mid-Atlantic

**New York and New Jersey** – Check into the Hilton New York Hotel or Sheraton New York Hotel and Towers, or the Sheraton Hotels located in Parsippany or Edison, New Jersey, where fuel cells are used to provide heat and power. At the Hilton, a 200 kW PAFC provides power and 100% waste heat recovery for hot water in guest rooms, kitchens and laundry. At the Sheraton New York, The 250 kW MCFC meets about 10% of the power and hot water requirements of the 1,750

room facility; at the New Jersey Sheratons, 250 kW MCFCs provides 25% of the hotels' electric and hot water requirements.



Next, head down to Times Square to check out the NASDAQ ticker atop the Conde Nast building. Did you know that two 250 kW PAFCs are used to power this sign?

Everyone visiting New York has to spend some time in Central Park. Jog on by the Central Park Police Headquarters, where a 200 kW PAFC provides all the power for the station, completely independent of the electric grid. In fact, during that big, multi-state power outage in 2003, the fuel cell kept the station operating normally - the officers didn't even know the city's power was out until they looked outside.



Central Park NYPD fuel cell

4 Times Square

While you're communing with nature, stop by the Bronx Zoo and the New York Aquarium. The Bronx Zoo's historic Lion House, home to lemurs and other wildlife of the island nation of Madagascar, features gushing waterfalls, desert cactuses, and a lush rain forest—all supported by a 200 kW PAFC. The Aquarium's 200 kW PAFC provides 20% of the aquarium's power needs and enough waste heat to warm domestic hot water and boiler supply water for buildings and tanks.

**Pennsylvania** – Ready to go camping? Visit Parker Dam State Park and check out the Fuel Cell Pavilion. Here you'll see a 5 kW solid oxide fuel cell (SOFC) that provides heat to cabins and administration buildings and hot water for showers. Also note that the SOFC is fueled with natural gas derived from Pennsylvania forests.



UofD fuel cell bus

Next, head on over to Pittsburgh and see Phipps Conservatory and Botanical Garden, where a 5-kW SOFC provides heat and power to the 12,000 sq. foot tropical forest conservatory.

**Delaware** – If you're visiting Newark, stop by the University of Delaware and hop on board a fuel cell hybrid bus used on regular UD transit bus routes. There is another fuel cell bus at the Wilmington campus.



DC hydrogen Shell station

**District of Columbia** – Need more gas to continue your journey? Pull into the Shell filling station on Benning Road in Washington's northeast quadrant. While you're filling your tank with gas, stroll over to view the hydrogen pump and visit the station's hydrogen education center. If you're lucky, you'll see a fuel cell vehicle being filled up with hydrogen!

## South

**South Carolina** – While you're visiting this beautiful state, take a ride on the Hydrogen Highway, a 59-mile route between Aiken and Columbia. Each city now has a hydrogen station – Aiken's station is used to fill fuel cell forklifts and will also support two hydrogen-powered internal combustion engine vehicles, while Columbia's will support a number of hydrogen projects planned by the city.



Fuel cell at Homosassa Springs State Wildlife Park

**Florida** – Why stay at a hotel when you can camp in warm and welcoming Florida? Pay a visit to Homosassa Springs State Wildlife Park where a 5 kW PEM fuel cell integrated with a solar photovoltaic system provides a portion of the power used at the Wild- life Encounter Pavilion. Hydrogen for the fuel cell is generated by an electrolyzer.

And while they're not fuel cell-powered, if you happen to be visiting Sea World be sure to take a ride on their hydrogen-powered internal combustion engine shuttle buses.

Now you've completed your east coast fuel cell tour! Time to return home and plan your next fuel cell vacation - remember to check out our next issue which heads westward!

And be sure to learn more about these and other US fuel cell installations at our [State Fuel Cell and Hydrogen Database](#). (SC)

PEM fuel cells to provide backup power for critical subsystems in emergency situations, such as dedicated battery power, in-flight operation of the auxiliary power unit, ram air turbine, or other technologies.

### Up and Away

In 2008, Boeing conducted three test flights of a manned, two-seater motor glider airplane powered by an Intelligent Energy PEM fuel cell, operating in a hybrid configuration



with a Li-ion battery. The system was used to power an electric motor coupled to a conventional propeller. The hybrid system was used during take-off, but once the plane reached a cruising altitude of 3,300 feet the battery power was disconnected and

Boeing fuel cell plane

the plane flew for 20 minutes using solely fuel cell power

(you can check out Boeing's video of the flight at [http://www.boeing.com/news/releases/2008/q2/080403a\\_nr.html](http://www.boeing.com/news/releases/2008/q2/080403a_nr.html).) While Boeing does not anticipate using fuel cells for primary power on larger aircraft, the company is examining the use of fuel cells to improve environmental performance.

DLR is also developing PEM fuel cells for auxiliary power unit (APU) applications. When on the ground, an aircraft's main engine is shut down and auxiliary power, compressed air and hydraulic pressure are delivered from gas turbine APUs located in the plane's tail end. The gas turbine APU can also be used to operate avionics (aviation electronics, such as communication systems and navigation systems), environmental systems (air conditioning) and de-icing equipment, and is used in starting the plane's main engines. These gas turbine systems operate at quite low efficiencies - less than 20%, and only around 10% efficiency when idling - and are also a source of CO, NOx and noise emissions at the airport. Replacing gas turbine APUs with fuel cell power would allow a gain of up to 50% efficiency, as well as elimination of noise and polluting emissions.

The German national project, ELBASYS, focuses on integrating fuel cells onto aircraft, beginning with the application with the easiest technology requirements, then adding additional applications to attain a multi-functional fuel cell system. In the first phase of the project, DLR, in collaboration with Airbus and Michelin, integrated a fuel cell system into a research aircraft (D-ATRA) to provide emergency power for the electric motor pump, the back up hydraulic circuit and the ailerons. Michelin provided the 20-kW fuel cell for the project. Several test flights were conducted in 2007 and 2008 in which the fuel cell showed "robust behavior" under high gravity loads ("g"s), as well as during turns and zero gravity aircraft maneuvers.

The current Ram air turbine (RAT) emergency power technology, which deploys from the plane's body to generate power from the airstream, is dependent upon air flow speed (greater air speed means greater power generation) and,

once deployed from the body of the aircraft, cannot be retracted if main engine power is restored. The RAT system also experiences high maintenance costs. A fuel cell emergency power system used in place of a RAT would deliver maximum power independent of flight velocity, would also require less maintenance, and could be switched off if the main engine function was restored.

In the second phase of the ELBASYS project, further functions will be added to demonstrate the environmental and economic benefits of fuel cells. In addition to providing power, the fuel cell will provide water for toilets and the air condition system, reducing the amount of water to be loaded onto the aircraft, and provide low-oxygen containing exhaust for inerting of the jet fuel tank (for fire retardation and suppression, or explosion prevention), eliminating the nitrogen-based inerting system. The fuel cell system could also potentially be used for heat generation and de-icing of the wings.

DLR has determined that the extra weight of the fuel cell can potentially be compensated by the multi-functionality of the fuel cell system, with weight benefits of over a ton, which increase further with mission duration, compared to a gas-turbine generator. These gains are attained by eliminating other technologies, and through payload reductions (carrying less water). Further weight benefits can be attained since less weight means less jet fuel is required, as well as other "snowball" effects.

The third phase of the ELBASYS project will demonstrate emissions-free ground operation, using four 12.5-kW fuel cells for ground taxiing of the Airbus A320 jumbo jet. Ground taxiing is usually performed by the main engines, but this project will instead use the fuel cell's power for operation of the nose wheel.



ELBASYS plane fueling up

DLR and Lange Aviation have developed a new fuel cell test bed, the Antares DLR-H2, a motor glider aircraft with two pods attached below the wings to carry the fuel cell system (left wing) and hydrogen tanks (right wing). A BASF fuel cell powers the plane's electronics, electric motor and propeller, delivering up to 25 kW of energy. This new test bed permits testing of multiple factors at once, such as the effects of varying acceleration and vibration loads on the fuel cell. The Antares DLR-H2 made its maiden flight in Hamburg, Germany during July 2009. Learn more about Antares flight here: [http://www.dlr.de/en/DesktopDefault.aspx/tabid-1/86\\_read-18278/](http://www.dlr.de/en/DesktopDefault.aspx/tabid-1/86_read-18278/).

DLR is also looking into other special requirements that fuel cells will need to meet for operation in aircraft. The agency's laboratories are examining fuel

# India Making the Call on Fuel Cells

In 2003, India joined 15 other countries to form the International Partnership for the Hydrogen Economy (IPHE) and in 2006, India released a [National Hydrogen Energy Roadmap](#) which identified the paths for India to gradually transition the country to hydrogen. The Roadmap hoped to accelerate a hydrogen infrastructure and increase development of all facets of the hydrogen industry, including production, storage, delivery, as well as codes and standards and education.

Now, just a few years later, India is emerging as a key player in the fuel cell and hydrogen game. In 2008, India's Standing Committee on Emission Regulation approved the addition of up to 20 percent hydrogen to compressed natural gas (HCNG) for use in motor vehicles. And while there has been some research and development on the vehicle front with companies such as Tata Motors and Reva Electric Car Company Ltd., the country is mostly focusing on the telecommunications sector for the near future. The telecommunications and backup power market is a rapidly growing one for fuel cells. India has entered into several strategic agreements with fuel cell manufacturers for a market that is expected to grow with approximate addition of 50,000 towers annually in the country over the next three to five years.



Plug Power GenSys system in India

Plug Power, through its affiliate Plug Power Energy India Pvt. Ltd., has entered into a 5-year agreement with SFO Technologies (a NeST Group Company) to manufacture Plug Power's GenSys<sup>®</sup> fuel cell systems in India. Plug Power has

sold 200 units to WTTIL, the cellular tower division of Tata Teleservices Limited (TTSL), so this agreement will help Plug Power fulfill the goal of having the units delivered and installed by March 2010. The fuel cells will be installed at cell towers with no or extremely unreliable electric grid service to replace the diesel generators currently employed. That number will increase to 1,000 systems installed throughout India by the end of 2010.

To fuel these units, Plug Power is also working with 3M on membrane electrode assemblies (MEA) to be used for the GenSys reformate stacks. The GenSys reforms Liquefied Petroleum Gas (LPG) into a hydrogen-rich reformate for the fuel cell stack. With minor adjustments, Plug Power's system can process a variety of hydrocarbon based fuel stocks such as natural gas. The LPG for the WTTIL towers will be provided by Hindustan Petroleum Corporation Limited (HPCL) who also entered into a five year contract with Plug.

IdaTech and Ballard are two other fuel cell manufacturers with sights on India. Back in October 2008, the companies entered into a supply agreement with ACME Telepower



IdaTech unit in Florida—similar to model for India

Group (ACME), a telecommunications company based in India. Under the agreement, IdaTech incorporated Ballard fuel cells into its ElectraGen<sup>™</sup> H2 system and delivered 310 5-kW direct hydrogen fueled systems. The contract called for 10,000 units to be delivered in 2009 and 2010 with potential to upgrade the order to

30,000 fuel cells over four years. The first batch of ElectraGen<sup>™</sup> H2 systems uses Ballard's FCgen<sup>™</sup>-1020 ACS fuel cell stack, while the remaining systems were going to utilize natural gas and will incorporate Ballard's new FCgen<sup>™</sup>-1300 fuel cell stack.

Since that initial agreement, things have shifted somewhat. The supply agreement has been terminated and IdaTech and ACME have re-entered into a Distribution Agreement to replace it. The main focus of this agreement is the continued development of natural gas fuel cell systems for large-scale deployment into the telecommunications market.

With the growth in the telecommunications industry and major players putting stock in the game, India is poised to make great gains from fuel cell installations both economically and environmentally. (JG)

### Fuel Cells Flying High, cont'd from page 4

cell performance under low pressure (equivalent to the pressure experienced at 30,000 feet), electro-magnetic compatibility and orientation. Researchers found that different orientations impacted fuel cell performance – a 30 degree angle decreased cell voltage, but this was successfully addressed by changing in the fuel cell's water management configuration.

Fuel cells appear to be a promising technology for aircraft, yielding multiple performance and environmental benefits. Keep reading the Fuel Cell Quarterly and we'll keep you posted on new aviation developments! (SC)

<http://www.cleancaroptions.com> is a new web site that provides technical details of the various alternative vehicles (hybrids, plug-ins, biofuels, battery EVs and fuel cell EVs), including quick links to the latest papers & reports in this field.

There will be lots more added in the near future, so check it out! Perfect fodder for letters to the editor, reports or presentations!

## CHP Systems Moving in Around the World

Fuel cells are already powering hundreds of installations world-wide, from cell phone towers to large-scale facilities. In the United States, fuel cells are providing low-carbon electricity to businesses such as Whole Foods grocery stores in Connecticut and Massachusetts to Sierra Nevada's brewery in California. Fuel cell power systems can also be used to generate power in your home. While only a handful of manufacturers are focusing on the residential market in the U.S. right now, Japan and Germany are committed to the application and have made tremendous strides in the past year.

Fuel cells can be used to generate efficient, grid-independent energy for a home, but when capturing the excess heat, known as "combined heat-and-power" (CHP) or cogeneration, the overall efficiency increases tremendously, in most cases to as high as 85-90%. In CHP systems, the waste heat is captured and used for hot water and space heating.

The Japanese government sees fuel cell systems as an integral tool to reduce emissions to 15% below 2005 levels by 2020 and has had several programs to subsidize and facilitate the installation of units into homes. Thousands of 1-kW fuel cells were installed to collect vital data and customer input, to address technical problems, reduce cost and improve durability which will accelerate the commercialization of fuel cells. This program was a joint effort between government, Japanese utilities and fuel cell manufacturers.

Since then, several major utilities and oil and gas companies, including Tokyo Gas, Osaka Gas, Nippon Oil Corporation, Toho Gas, Saibu Gas Co., and Astomos Energy (a joint venture between Idemitsu Kosan and Mitsubishi), have all joined to sell a residential fuel cell system, the ENFARM. In the first few months, the fuel cell sales have exceeded expectations, so many of the utilities are increasing the target number and producing more units.

The German government has set a more aggressive greenhouse gas emission reduction target of 40% by 2020. Fuel cells are set to play a large role to meet

this target, in both residential and transportation applications. The German government, joining with industry, is investing one billion Euros in the development and promotion of stationary fuel cells. In 2008, Germany launched the CalLux program to support residential CHP systems. Phase I of the program runs until 2012 and will install CHP systems in homes across the country. The plan is that these installations will lead to Phase II, which is commercialization of the fuel cell systems. To help with the effort, the Australian company Ceramic Fuel Cells Limited recently opened a new manufacturing plant in Heinsberg in the North Rhine Westphalia region of Germany. The plant has the capacity to as-

semble 10,000 fuel cell stacks per year, which can be expanded to up to 160,000 stacks per year.

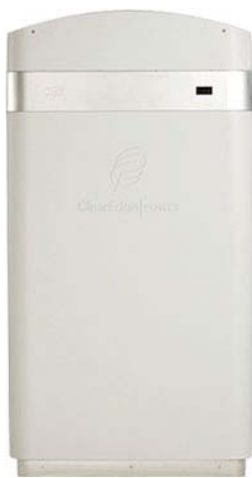
Currently, there are few commercial options for homeowners looking to install a CHP fuel cell system in their home in the US, but more and more companies are creating these products. ClearEdge Power offers the ClearEdge5, a compact CHP fuel cell system for homes. The system has an internal fuel processor that converts natural gas into hydrogen to power the fuel cell. The carbon and monetary savings depend on where you live, but a typical California user can save 39 cents per kW and reduce carbon emissions by one-third, according to calculations done by ClearEdge. The unit can be installed anywhere in, or outside of the home, and is virtually silent, making it a great option for those who wish to be more grid-independent.

Plug Power, another fuel cell manufacturer, offers two GenSys residential CHP systems. The fuel cell runs off of natural gas, and can generate enough electricity for the entire home. Plug Power created the system so that the waste heat captured is compatible with most radiant, forced air, or baseboard heating systems. The company advertizes energy savings between 20-40% and carbon savings of 15-25%. In July 2009, Plug Power announced a \$1.4 million dollar award from the New York State Energy Research and Development Authority. Plug Power will use the award to install and operate three residential GenSys CHP systems in homes in New York State. The installations will test how the systems work in a real world setting.

Hydra Fuel Cell Corp., a company out of Oregon, has installed residential fuel cells in Texas and Florida as part of a beta test.

The price of residential CHP fuel cell systems can be high, in the short term, before energy savings are realized. To help consumers and encourage early adoption, the federal government and certain states offer tax incentives to those who install CHP fuel cell systems. Currently, tax incentives for stationary fuel cells favor business and joint occupancy dwellings. Single family homes, or even second homes, do not receive as much of a tax credit. To lessen this disparity, Congressman David Wu and Congresswoman Mary Bono-Mack have cosponsored the Fuel Cell Tax Parity Act of 2009. This bill would amend the current tax code to create parity between residential and commercial fuel cell tax credits as well as between fuel cells and other alternative technologies. The bill would also remove the requirement for residential fuel cells that the system be installed in a primary residence. If you would like to write your Congressman or Senator about this issue, visit <http://www.capwiz.com/fuelcells/home/>

The current tax credit for single-family residential systems is 30% of installation cost, up to \$1,000 per kW. If this bill passes, it would mean larger tax incentives for homeowners who install fuel cell systems, to an incentive up to \$3,000 per kW. For joint occupancy residences, the tax incentive would go up to \$10,000 per kW.



ClearEdge Power's fuel cell

States and utilities are also offering incentives for homeowners to install green energy systems. In California, the Emerging Renewable Rebate Program gives cash rebates on fuel cell systems that use renewable sources of hydrogen. California customers of San Diego Gas&Electric, Pacific Gas&Electric, Southern California Edison, and Southern California Gas are eligible for rebates from the Self-Generation Incentive Program (SGIP). The SGIP is a financial incentive for the installation of new, self-generating, equipment installed to meet some or all of the energy needs for a facility. For fuel cell systems using hydrogen from non-renewable sources the incentive is \$2.50 per watt of output. For a Plug Power system that has an output of 2.5 – 5 kW, the incentive would add up to \$6,250 to \$12,500. In New York, fuel cells installed in a principal residence are eligible for a 20% tax credit up to \$1,500. However, the systems must be a proton exchange membrane (PEM) fuel cell that produces at least 25 kW of energy. Many other states have green building, renewable energy, or alternative energy tax incentives and grant programs to help consumers. To find out if your state has any grants, incentives or tax credits, check out our [State Fuel Cell and Hydrogen Database](#).

Although the initial price tag of a residential fuel cell system might be high, tax incentives and energy and carbon savings are making these CHP systems attractive to many consumers. Because CHP systems are so efficient, users can see immediate energy savings. Currently, ClearEdge is focusing on the California market, and Plug Power is testing in New York. As these early adopters show the benefits of fuel cells, and as other countries forge ahead, hopefully we will start to see more residential CHP fuel cell systems in homes across the United States. (ED)

## Japan Delving into SOFCs for Homes

With a pretty aggressive program in place for installing proton exchange membrane (PEM) fuel cell systems for homes in Japan, Toyota Motor Corporation (TMC) is joining with Aisin Seiki Co. Ltd. are going a different route. The companies will provide 30 residential, solid-oxide fuel-cell (SOFC) cogeneration systems developed jointly by Osaka Gas Co., Ltd., Kyocera Corporation, TMC and Aisin to five Japanese gas companies, as part of the New Energy and Industrial Technology Development Organization's (NEDO's) Solid Oxide Fuel Cell Verification Project for 2009.

Osaka Gas will receive the most, 23 fuel cell systems; Tokyo Gas Co. Ltd. will receive four systems; Toho Gas Co., Ltd. and Saibu Gas Co. Ltd. will each receive one and Hokkaido Gas Co., Ltd. has already received theirs.

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## Tenth Edition of Fuel Cells 2000's Fuel Cell Directory Now Available!

The Tenth Edition of the *Fuel Cell Directory* is here! Keep your finger on the pulse of the hydrogen and fuel cell industry with more than 850 companies and organizations in this comprehensive and searchable database. Listings include address, phone number, email, company URLs, stock symbols, investor, sales/purchasing, media and human resource contacts, and the name of the President or CEO, as well as a description of current research projects and fuel cell type.

The Tenth Edition of the *Fuel Cell Directory* is available as a MS Excel database and costs \$500.00. Non-profit organizations, college and university libraries, and news outlets may request a free PDF copy of the *Fuel Cell Directory*.

To order your copy, please go to <http://www.fuelcells.org/directoryorderform.pdf>.

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FROM FUEL CELLS 2000!**

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