BC HYDROGEN HIGHWAY BACKGROUNDER

Formed in 2006, the BC Hydrogen Highway has grown into the largest demonstration of hydrogen and fuel cells in the world.

These demonstration projects are helping to refine technologies, establish codes and standards, and inform end-users and investors of the benefits of hydrogen and fuel cells. While originally focused on infrastructure and on-road transportation, the Hydrogen Highway has expanded to include hydrogen and fuel cell applications such as materials handling, backup power, and portable electronics. Today, our voluntary network of Canadian technology providers, government partnerships and technology users are working together to demonstrate and promote our significant research and development achievements and early commercial products developed in BC.

Hydrogen and fuel cells can't wait to improve your quality of life.

Since the 1980's, British Columbia has become globally recognized for its leadership in the development, demonstration and deployment of hydrogen and fuel cell technologies. Hydrogen – a clean, safe and flexible fuel – is a vital component to a clean, sustainable energy system. In BC, we are producing hydrogen from a variety of sources including electrolysis from renewable hydro and solar power, natural gas steam reformation, and through the capture of a hydrogen-rich by-product waste stream.

Fuel cells – the key to a hydrogen transition and a clean energy future – are extremely efficient, fully scalable, reliable, virtually silent, and have no combustion.

Say H_2i.

H_2i is a simple icon representing a powerful assortment of hydrogen and fuel cell technologies and products being developed, or put to work, in British Columbia, Canada. H_2i symbolizes an improvement in the way we use energy. It could mean a cleaner running bus or car, a more secure way to back up cell phone towers and computer data networks, a more productive fleet of warehouse forklifts, or a way to produce hydrogen fuel cleanly and economically.

Brought to you by the British Columbia Hydrogen Highway, H_2i is showcasing unique, home-grown hydrogen and fuel cell applications in advance of and throughout the 2010 Olympic and Paralympic Games in British Columbia, Canada.

Why hydrogen and fuel cells?

The mass market potential of hydrogen and fuel cell solutions has grown as governments and others seek a reduction in pollution and greenhouse gas emissions, a diverse energy supply, and enhanced security.

One of the benefits of hydrogen fuel is that it can be produced from different sources such as renewable power including hydro, wind and solar; natural gas or other carbon-based fuels; and through the capture of waste-hydrogen being produced through various chemical plants. Diversity of supply is an important reason why hydrogen is such a promising fuel.

Fuel cell products, through improved energy efficiency, deliver significant reductions in greenhouse gas emissions and improvements in air quality. This clean energy technology is a vital part of the solution to our global environmental challenges.

What is the likely hydrogen production scenario for British Columbia?

While there are many variables that will determine how British Columbia ultimately sources hydrogen fuel in the future, our wealth of renewable hydro-electric power enables hydrogen to be produced from electrolysis and be totally emissions-free. In addition, a chlor-alkali chemical plant in North Vancouver is capturing waste-hydrogen and has the potential to fuel 200,000 fuel cell cars per year - this would equate to eliminating greenhouse gas emissions from over 65,000 cars. Hydrogen may also be produced from natural gas and take advantage of existing infrastructure and distribution networks.

Why now?

In 2008, total global emissions rose by 2% and per capita emissions hit an all-time high of 1.3 tonnes of carbon. Canada is among the world's worst emitters pumping out 4.5 tonnes of carbon per person. Hydrogen and fuel cells will help reduce Canada and British Columbia's carbon footprint and drive sustainable economic growth and health benefits.

By transitioning British Columbia to a clean, renewable, hydrogen transportation structure we can expedite the transition from a polluting petroleum infrastructure towards zero-emission hydrogen and fuel cell electric vehicles. British Columbia's early hydrogen fueling infrastructure could make hydrogen fuel available to British Columbia drivers and support several major auto manufacturer's plans for the early commercial introduction of hydrogen fuel cell vehicles in 2015.

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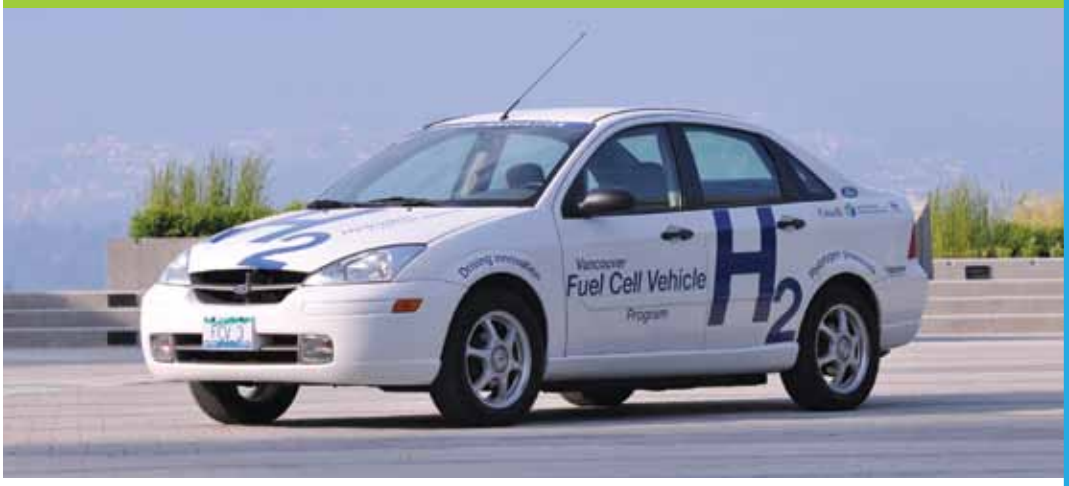
FACT SHEET: HYDROGEN-POWERED VEHICLES

Fuel cell electric vehicles are twice as efficient, with zero tailpipe emissions. All the huff, none of the puff.

In British Columbia, Canada, we are demonstrating two types of hydrogen vehicles - hydrogen internal combustion engine (ICE) vehicles and fuel cell electric vehicles (FCVs).

Hydrogen ICE vehicles use a regular combustion engine modified to use gaseous hydrogen. They burn hydrogen, but since there is no carbon in hydrogen, there are no CO2 emissions and only trace amounts of nitrous oxides. Hydrogen ICE vehicles are typically about 30% more efficient than comparable gasoline vehicles.



Fuel cell vehicles are electric, similar to battery vehicles. Hydrogen is pumped into a tank in the car, similar to gasoline. The hydrogen is then fed into the fuel cell where it is electrochemically converted into electricity -- with no combustion and no emissions other than water vapour. The electricity generated is used to power the vehicle. A fuel cell is also 2-3 times more energy efficient than a gasoline engine.

All fuel cell electric vehicles demonstrated in BC are hybridized and benefit from the use of battery, electric-drive systems and system controls, which are also being developed for battery, hybrid and plug-in hybrid vehicles. Hybridization of fuel cell electric provides a number of advantages including increased efficiency through brake energy recovery, reduced hydrogen consumption and system redundancy. These complementary technologies will in support the ultimate commercialization of fuel cell electric vehicles. It's the only electric vehicle technology that offers the promise of zero emissions, superior efficiency and uncompromised functionality.

Full performance, zero-emissions, sustainable mobility is the end-game for automotive manufacturers. GM, Toyota, Ford, Daimler and Honda are developing a portfolio of sustainable mobility solutions ranging from bio-fuelled ICEs, through hybrids and plug-in hybrids and hydrogen fuel cell electric vehicles.

While several alternative power technologies reduce greenhouse gas emissions, the fuel cell is the only powertrain that can meet the extended range and rapid fuelling desired by consumers. Most automakers have stated plans for early commercialization of fuel cell automobiles in the 2015 timeframe.

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Hydrogen and fuel cell vehicle activity in British Columbia

Vancouver Fuel Cell Vehicle Program: Since 2005, the Vancouver Fuel Cell Vehicle Program has assessed the performance of five Ford Focus fuel cell cars operating in "real world" conditions. This initiative has provided valuable information on vehicle durability, reliability and performance to enable the evaluation and improvement of system performance. It is also helping facilitate international codes and standards development and other activities critical to preparing the market for a clean-energy future. During the program, over 320,000 road kilometres have been collected by users including the City of Vancouver, BC Transit, BC Hydro, the National Research Council, and the Automotive Fuel Cell Cooperation.

Hydrogen Pick-up Trucks: Powertech Labs and Sacré-Davey Innovations have converted eight light-duty GMC Sierra trucks to run on compressed hydrogen gas in modified internal combustion engines. This conversion will significantly reduce the emission of greenhouse gases compared to conventional gasoline-powered operation. The vehicles are operated by private and public fleet operators and refuel at the Northlands Station in North Vancouver.

Hydrogen Shuttle Buses: Three Ford E-450 shuttle buses powered by a 6.8-liter V-10 engine have been supercharged and modified to run exclusively on hydrogen fuel. They are operating in Vancouver and utilize hydrogen at the Northlands Station in North Vancouver.

Fuel Cell Engine Development: Daimler AG and Ford Motor Company's Canadian joint venture Automotive Fuel Cell Cooperation Corp. employs 180 people developing the next generation automotive fuel cells. This significant investment by major automakers places British Columbia, Canada on the map for next generation automotive technology development

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FACT SHEET: FUEL CELL BACKUP AND DISTRIBUTED POWER

Fuel cell backup power isn't boring. But no service to that fancy smart phone of yours sure is.

Power outages lasting for many hours or days due to weather related events have encouraged telecommunication regulators to mandate much longer power backup for critical communications services like cell-phone towers.

Fuel cell backup power solutions offer numerous compelling advantages compared with conventional battery and diesel-powered systems in emergency backup power situations:

Improved Durability and Reliability: Fuel cell solutions are reliable with minimal servicing requirements and durability is minimally compromised by operations at extreme temperatures.

Scalability: Backup power run-time is directly proportional to the amount of fuel available for a fuel cell system, so the required backup time can be guaranteed by ensuring adequate on-site fuel storage.

Lifecycle Cost Savings: Fuel cell systems offer lifecycle cost savings for backup power at telecommunications sites, particularly in applications requiring relatively low power (less than 15kW) over a long duration (more than 8 hours). Fuel cell backup power systems are designed to operate for approximately ten years, while battery systems may need a replacement every three to five years. Additionally, fuel cell solutions require minimal annual maintenance compared to quarterly site visits to service diesel generators .

Environmental Benefits: Zero emissions combined with quiet operation make fuel cells highly suitable for indoor, outdoor, urban or rural applications. And, because they can be re-manufactured at the end of their useful lives, they generate low disposal and recycling costs in comparison to lead acid batteries.

British Columbia fuel cell companies are at the forefront of supplying this technology to the world. Ballard Power Systems of Burnaby, BC is partnering with Idatech LLC and Acme Group to supply 5kW natural gas fuel cell products for telecom backup power applications in India. A supply agreement provides a binding commitment for the purchase of approximately 1,000 fuel cell units in 2009 and 9,000 units in 2010, subject to meeting product design and acceptance specifications.

No more adding expensive wires to the electrical grid. The future of power is distributed. The idea of localized, distributed power means that electricity is generated by sources located near to the need. If an existing grid is operating a full capacity, then expansion may be expensive. Fuel cells are an ideal solution in rural areas where there is no power grid, or high-quality power is a necessity.

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Examples of distributed fuel cell power in British Columbia include:

Bella Coola, a remote area in BC without access to the grid, chose to reduce greenhouse gases from diesel generators by utilizing a supplemental fuel cell power unit to increase the utilization of renewable power. The Hydrogen-Assisted Renewable Power (HARP) project will reduce diesel fuel consumption by converting electricity from a renewable run-of-river source in off-peak periods into hydrogen through an electrolyzer, and subsequently into electricity through a fuel cell for power during periods of peak demand. This project will enable more than 300 communities across Canada who do not have access to the power grid or gas pipelines to evaluate a similar project for their community.

A Combined Heat and Power (CHP) system is being used at Easywash's environmentally friendly carwash in North Vancouver. The 150 kW fuel cell system uses purified waste stream hydrogen from a North Vancouver hydrogen station and provides electrical power for three carwash bays, pumps and dryers. In addition, heat produced as a by-product from the fuel cell is captured to preheat the wash water, further reducing the car wash's power requirements. Power from the fuel cell is also made available to BC Hydro's grid when it is not needed for the carwash in a process called net metering.

At the National Research Council Institute for Fuel Cell Innovation, located at the University of British Columbia, Canada, an on-site 5 kW solid oxide fuel cell (SOFC) generator utilizing a local natural gas supply is providing electricity and heat for a portion of the Institute's LEED Gold Certified building. The SOFC power system operates at a similar temperature to existing oil and gas furnaces, converting hydrocarbon fuels directly into electrical energy and heat without the use of an intermediate combustion process. The waste heat generated is being integrated to provide the building's hot water supply. The installation will reduce GHG emissions by more than 100,000 kg of C02 over the fuel cell's lifetime.

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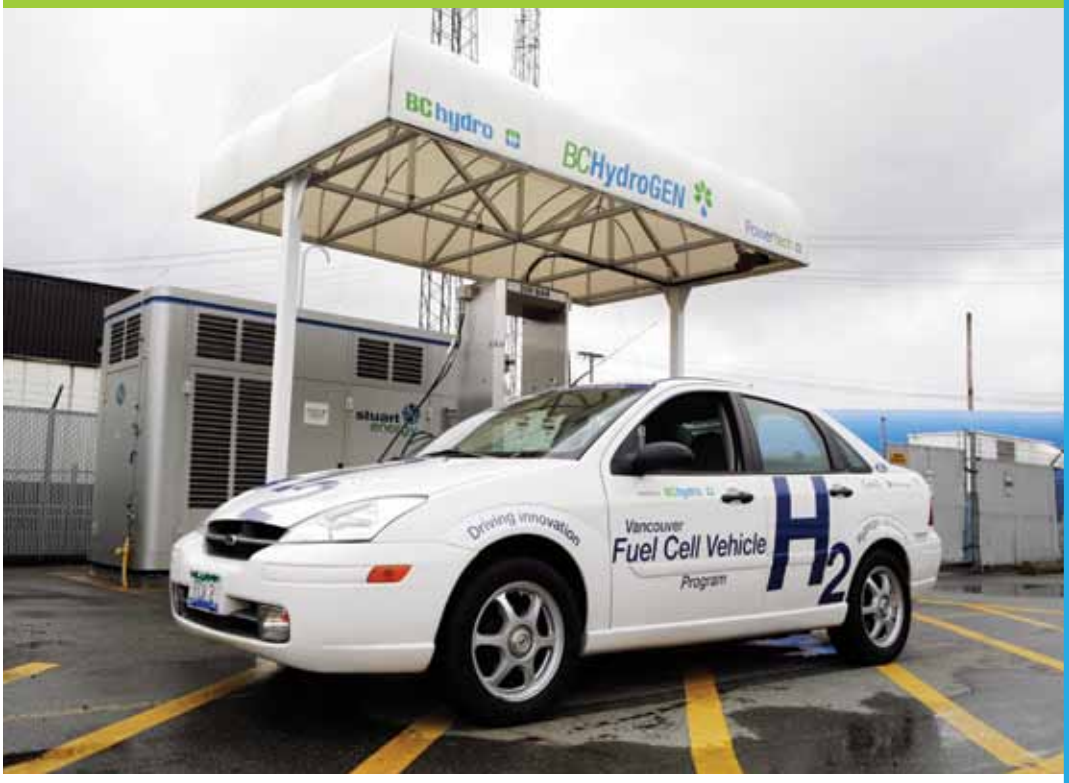
FACT SHEET: HYDROGEN INFRASTRUCTURE IN BRITISH COLUMBIA

Fuel in. Zero emissions out.

We are all thinking differently about energy - how we use it and where it comes from. Hydrogen is the universe's most common element. As a fuel, it provides benefits to energy security, the environment and economic growth. Invisible, odourless, and non-toxic, hydrogen has been used safely for many decades in a wide range of applications, including in the food, metal, glass and chemical industries. The global hydrogen industry is well established and produces more than 50 million tonnes of hydrogen per year.



Made of one proton and one electron, hydrogen does not occur in a naturally free state but is bonded to other elements. For example, when combined with oxygen, it forms water - H20.

Hydrogen is not a source of energy. It is an energy carrier and must be produced before it can be used as a fuel. There are many ways to produce hydrogen, including reformation of natural gas or electrolysis using hydroelectricity, solar, wind and nuclear power. With supplies of many other fuels diminishing, hydrogen will play an important role in extending the life of fossil fuels and optimizing renewable energy sources.

New hydrogen markets are continuing to appear (mass transit fleets, emergency backup power and forklifts) that will contribute to increased demand for hydrogen. As part of the Hydrogen Highway initiative in British Columbia, seven hydrogen fuelling stations are strategically positioned to produce and distribute hydrogen to support a fleet of hydrogen and fuel cell vehicles operating in Vancouver and Victoria regions, as well as infrastructure to support 20 fuel cell buses that will begin revenue operation in Whistler in 2010.

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Where does the hydrogen come from?

To encourage an evolutionary path to the production of clean hydrogen in British Columbia, hydrogen is provided to Hydrogen Highway projects in a clean and economical manner.

Waste Hydrogen Capture: Since 2006, a chlor-alkali plant in North Vancouver has been the source of a hydrogen-rich by-product waste stream. Sacré-Davey Innovations and Hydrogen Technology & Energy Corporation (HTEC) built the plant to capture, purify and compress hydrogen. By making use of an existing by-product stream, the plant significantly reduces the financial cost and energy required to provide 99.995% pure hydrogen. This facility has sufficient waste hydrogen to fuel 20,000 hydrogen fuel cell vehicles per year.

Electrolysis: Two fuelling stations in British Columbia produce hydrogen through the electrolysis of water using electricity generated from hydroelectric power. Electrolysis uses an electric current to split water into hydrogen and oxygen. Both stations then store the hydrogen fuel in pressurized storage cylinders and dispense it to power fuel cell automobiles and buses.

Solar hydrogen generation: The National Research Council's Institute for Fuel Cell Innovation (NRC-IFCI) on the campus of University of British Columbia uses renewable solar power to produce hydrogen. It allows storage of up to 20 kg of hydrogen for use in fuel cell test and research labs.

Compressed hydrogen storage and delivery: New aluminum-lined, light-weight carbon fibre cylinders safely store high pressure hydrogen and are transported on roadways via a standard transport trailer. Major industrial gas suppliers, such as Air Liquide and Linde, have a long record of distributing hydrogen in this manner.

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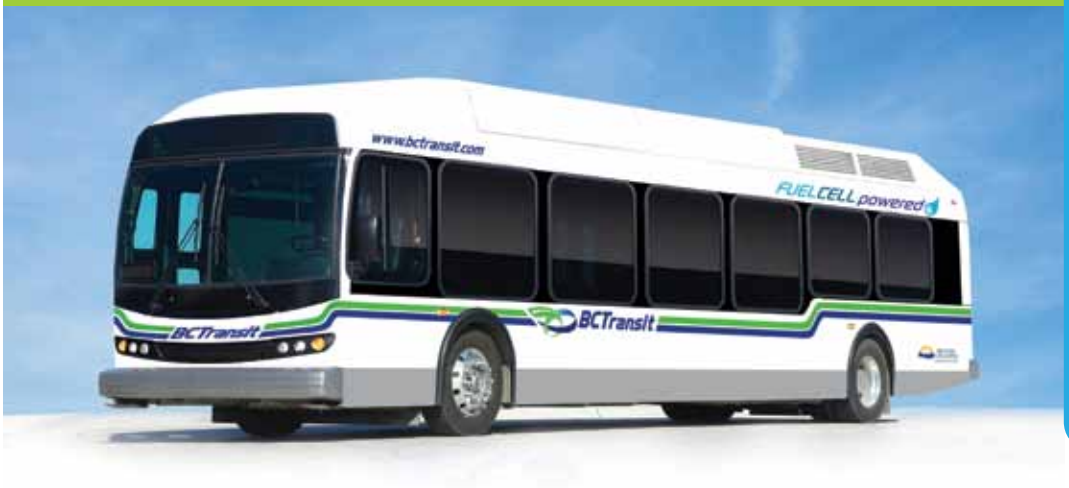
FACT SHEET: BC TRANSIT FUEL CELL ELECTRIC BUS FLEET

Hydrogen fuel cell buses emit nothing but water. Step aboard and help the environment.

BC Transit is supporting British Columbia's Hydrogen Highway by implementing the world's largest demonstration fleet of fuel cell electric buses in Whistler, BC.

In addition to producing zero greenhouse gas tailpipe emissions, hydrogen fuel cell electric buses contribute to a better quality of life. These benefits are attracting transit agencies worldwide to test and evaluate fuel cell electric buses in their fleets. BC Transit, a provincial Crown Corporation responsible for 81 transit systems in 52 communities throughout British Columbia, Canada, is committed to identifying, evaluating and adopting new technologies that support the environment and improve public transit.



Following a trial of earlier generation fuel cell electric buses from 1998 to 2000, BC Transit is again leading the way to cleaner air with 20 fuel cell electric buses and the hydrogen to fuel them. With assistance from the Province of British Columbia and the Government of Canada, the buses will be showcased in the Resort Municipality of Whistler during the 2010 Olympic and Paralympic Winter Games. Following the Games, the buses will be placed in regular service at Whistler. Benefits of Fuel Cell Electric Buses:

Improvement in air quality

Reduction in diesel fuel consumption

More pleasant riding experience for transit drivers and users due to their smooth ride

The 41' buses from Winnipeg bus manufacturer New Flyer will feature a Dynetek compressed hydrogen fuel storage, an ISE hybrid electric drive, Valence lithium-phosphate batteries for energy storage, and a 150 kW fuel cell module provided by Ballard Power Systems. Air Liquide is supplying hydrogen to the buses, and has built a 1,000 kg hydrogen fuelling station in Whistler, BC.

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Independent Market Research

A 2009 report sponsored by the US Federal Transit Association and prepared by the Center for Transportation and the Environment and the Breakthrough Technologies Institute drew these conclusions about recent fuel cell bus demonstration programs, where up to three buses were place in various cities in the US, China, Europe, Japan and Australia:

Better than expected performance by transit agencies

Strong passenger acceptance - 75% of passengers reported a quieter ride in comparison to diesel or CNG buses

Good performance over a wide range of operating conditions, including hilly and flat terrain, hot and cold temperatures, and high and low speed duty cycles

No major safety issues over millions of miles of service and thousands of vehicle fuellings

Governments should invest in hydrogen highways or other linked hydrogen infrastructure to maximize the benefits of hydrogen buses

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FACT SHEET: FUEL CELL FORKLIFTS

Hydrogen fuel cell forklifts deliver more consistent power. Productivity up, emissions down.

Already commercially viable, fuel cell-powered forklifts are operating in large warehouses, distribution centers and manufacturing plants for large corporations like Central Grocers, Wal-Mart and Nissan. One of the first fuel cell applications to enter the market, motive power fuel cell units are delivering economic, operational and environmental value to customers through improved productivity, additional commercial space, superior safety performance, reduced operational costs, and elimination of the handling and storage of toxic materials.

With a hydrogen fuel cell system, the forklift can be fuelled at an indoor station right in the warehouse in a matter of minutes, and its power won't decrease as the forklift uses the hydrogen. The fuel cell and hydrogen tank are a direct replacement for a typical battery – all the other equipment remains the same. And, because the fuel cell contains no hazardous materials, they avoid the storage and handling of toxic materials associated with the use of lead-acid batteries. By eliminating emissions and improving air quality, hydrogen fuel cells are demonstrating significant advantages, making warehouses safer and healthier for all employees. So where is productivity up?

Central Grocers: As one of the top retailer-owned wholesalers in the U.S., Central Grocers chose to maximize their productivity within its new 920,000 sq. ft. distribution center in Joliet, Illinois by handling their entire inventory with emission-free Plug Power GenDrive lift trucks and pallet trucks powered by Ballard fuel cells. By using hydrogen fuel cells, Central Grocers has eliminated the need to invest in a battery charging and changing infrastructure,

Wal-Mart: In 2006, Wal-Mart completed a four-month trial of Plug Power's hydrogen fuel cell GenDrive forklifts in two of its distribution centers, logging more than 18,000 hours and 2,100 indoor fuelings. The success of this demonstration led to Wal-Mart placing Plug Power's largest single order of GenDrive forklifts powered by Ballard fuel cells. By reducing energy and maintenance costs while minimizing waste and pollution, these forklifts help keep prices down for distributors ... and consumers as well! As a result, retailers have begun to see a more cost-effective and environmentally friendly option for their warehouse needs.

Nissan: Japan's third largest automaker has been developing its own fuel cell vehicle technology since 2001 and its Industrial Machinery Division is now conducting a five-month trial of Plug Power GenDrive forklifts powered by Ballard fuel cells at its Smyrma, Tennessee assembly plant. Seen as a way of reducing the environmental impact of the company's business activities, Nissan has determined that a complete conversion to fuel cell-powered forklifts would eliminate more than 2000 tons of carbon dioxide emissions per year while freeing up over 130,000 sq. ft. of valuable floor space for other purposes.

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Independent Market Research

In a 2008 report prepared by the Argonne National Laboratory and sponsored by the Fuel Cell and Hydrogen Infrastructure Program of the Energy Efficiency and Renewable Energy (EERE) Office of the US Department of Energy, fuel cells were identified as having several important advantages compared to battery-powered types including:

Higher productivity

Fuelling in less than 5 minutes, considerably quicker than the battery charging process

No degradation of power over time-constant voltage eliminates battery voltage drops towards the end of shifts or in cold locations

Fuelling infrastructure requires significantly less footprint

Additional fuelling points can be installed to reduce the distance travelled and associated downtown of refuelling

No tailpipe emissions and environmental concerns from acid run-off or lead

Lower total logistical costs

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