FUEL CELLS FOR POWER GENERATION

US Fuel Cell Council

The Voice of the Fuel Cell Industry

> “Environmental criteria demand near-zero emissions and ultra high efficiency from new electric generating capacity...These environmental characteristics are inherent in fuel cell systems.”
>
> — Department of Energy 2003 Distributed Generation Brochure

Fuel cells are commercially available today for power generation ranging in sizes from under one kilowatt (kW) to scalable multi-megawatt (MW) systems – suitable for applications ranging from residential and small industrial backup power, to large industrial “base load” grid applications. These systems have achieved billions of kilowatt hours (kWh) of successful operation at customer sites worldwide. In selected markets fuel cell systems are cheaper to own and operate on a life-cycle basis than incumbent technologies. State incentives and a 30% federal tax credit are also helping early adopters reduce the initial cost of fuel cell systems.

Fuel cell power systems are quiet, clean, highly efficient onsite electrical generators that use an electro-chemical process – not combustion – to convert fuel into electricity. In addition to providing electricity, they can supply thermal energy for hot water and space heating, or absorption cooling. Fuel cells have the potential to reduce facility energy service costs by 20% to 40% over conventional power service.

The principle of the fuel cell has been known since the 19th century. In the 1960s, NASA dramatically advanced fuel cell technology by developing it for use in space vehicles, using hydrogen (H_2) fuel. Current fuel choices include natural gas and propane, methane gas from landfills, biogases, methanol and other renewable hydrocarbons. Fuel cells operating on hydrogen are also available in certain applications/situations.

FUEL CELL BENEFITS

As a power technology, fuel cell systems provide a unique combination of features and benefits, making them one of the most environmentally friendly technologies available today. They also provide an economic advantage based on their high operating efficiency.

Fuel Cells are Clean, Efficient & Economical

EFFICIENCY:

- High temperature fuel cells deliver upwards of 47% net electrical efficiency – well above the average U.S. central station efficiency of 33%.
- Hybrids, systems that combine high temperature fuel cells with a turbine, can operate at electrical efficiencies estimated at up to 70% – higher than even the most efficient combined cycle turbine plants now available, which are operating at 60%.
- Fuel cells can be designed to offer Combined Heat and Power (CHP) which enables the fuel cell's heat to be used to warm water or space or even cool air with absorption chillers. With CHP, a fuel cell can offer overall energy efficiencies exceeding 80%.

EMISSION REDUCTION:

- Fuel cells have near zero, ultra low air emissions and provide environmental performance unmatched by any other fuel-consuming technology
  - » **Carbon Dioxide (CO_2)**, is a greenhouse gas implicated in global warming. CO_2 emissions are reduced by high efficiency fuel cell power plants. Fuel cells consume less fuel and therefore emit less CO_2 per kWh than comparably sized fossil fuel fired engines or turbines.
  - » Since there is no combustion in the basic reactions of a fuel cell, **Oxide of Nitrogen (NOx)** production is essentially zero. Boilers, gas turbines and reciprocating engines produce NOx because high temperature combustion takes place.
  - » Fuel cell **Sulfur Oxide (SOx)** emissions can be essentially zero because many types of fuel cells require a fuel treatment system that separates the sulfur out of the fuel before it enters the fuel cell itself. Fuel cells that do not require a reformer, such as those that use hydrogen directly as a fueling option, produce zero SOx emissions.
  - » Fuel cells using hydrogen fuel emit no **Carbon Monoxide (CO)** at all. Fuel cells using hydrocarbon fuels may emit small amounts of CO, but the amount emitted is so small that fuel cells meet even the most stringent requirements for emissions of CO, particulates, or reactive gases.

NOISE POLLUTION REDUCTION: Since a fuel cell has no moving parts it operates silently and reduces noise pollution, unlike a noisy combustion system.

RELIABILITY: Fuel cells have highly consistent performance with reliability estimates in some configurations reaching 99.9999%.

FUEL FLEXIBILITY: Fuel cells can operate on a variety of locally available fuels such as natural gas, anaerobic digester gas, propane, ethanol, biogas or hydrogen.

OFF-GRID CAPABILITY: Fuel cells can provide full energy needs to any location with stand-alone capability, thus eliminating the need for expensive electricity grid expansion in remote locations.

ENERGY SECURITY: Because they don't have to be attached to the electric grid, fuel cells allow the country to move away from reliance on high voltage central power stations which might be targeted in an attempt to cripple our energy infrastructure.

DEPENDABILITY: Fuel cells offer high quality power for critical applications and are part of a distributed generation solution that can reduce the impact and occurrence of blackouts, brownouts and voltage sags. On-site applications locate power near the consumer, thus eliminating transmission and distribution losses.

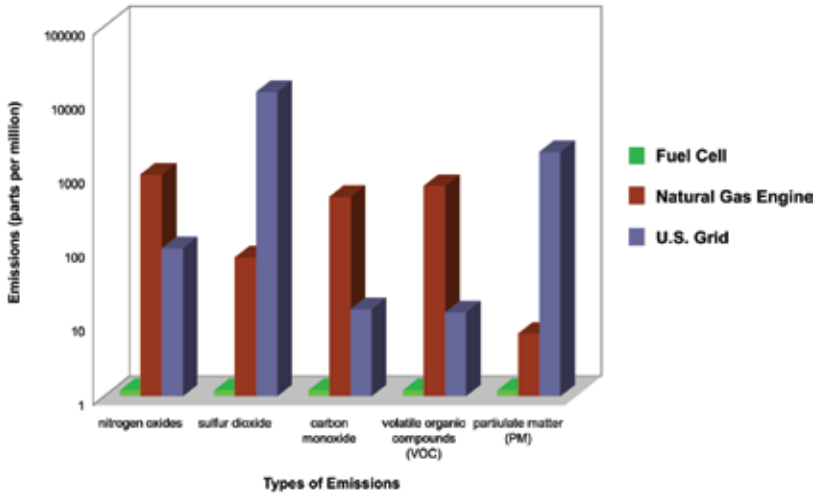
ENERGY PORTFOLIO DIVERSIFICATION: Fuel cells enable Municipal Utility Districts, Co-Ops and Utilities to offer customers an option for buying green, clean, and/or renewable power.

GREEN BUILDING CERTIFICATION: Fuel cells can be an integral part of achieving Leadership in Energy and Environmental Design (LEED) certification – the National Green Building Rating System established by the U.S. Green Building Council (USGBC).

HOW ENVIRONMENTALLY FRIENDLY IS A STATIONARY FUEL CELL?

In Los Angeles, the strictest air quality permitting agency in the country, the South Coast Air Quality Management District, has ruled that fuel cells do not need a clean air permit at all (SCAQMD Rule 219, www.aqmd.gov/rules/reg/reg02/r219.pdf).

FUEL CELL EMISSIONS BENEFITS



HOW A FUEL CELL WORKS

How A Fuel Cell System Works

Fuel cells use electro-chemical reactions, rather than combustion (burning a fuel) to produce electricity. The process is the reverse of electrolysis. In electrolysis the action of an electric current decomposes water into hydrogen and oxygen, whereas in a simple fuel cell the two gases can be combined electro-chemically to produce electricity, heat and water. In practice, the process is more involved, and each type of fuel cell has its characteristics, operating temperature, materials, and flows. What they have in common are high electrical efficiency, no combustion in the basic reactions, and a clean exhaust stream.

Fueling The Stationary Fuel Cell

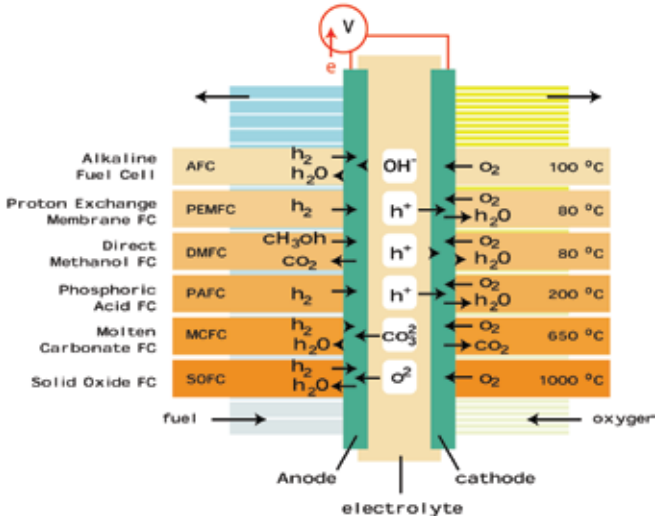
A fuel cell needs H2 for fuel and some fuel cells such as molten carbonate (MCFC) and solid oxide (SOFC) can also utilize carbon monoxide (CO). Hydrogen may either be directly supplied to the fuel cell or produced from other fuel sources such as natural gas, methanol, propane, bio fuels or non-carbon compounds. A fuel processor or electrolyzer (see diagram below) may be used to supply onsite hydrogen to the fuel cell.

Fuel Processor: Separates H2 from hydrogen carrying sources for use within the fuel cell stack. Production, storage, and dispensing equipment may also be included. Some stationary fuel cells do not have a fuel processor. In these models the H2 source is directly available to the fuel cell stack.

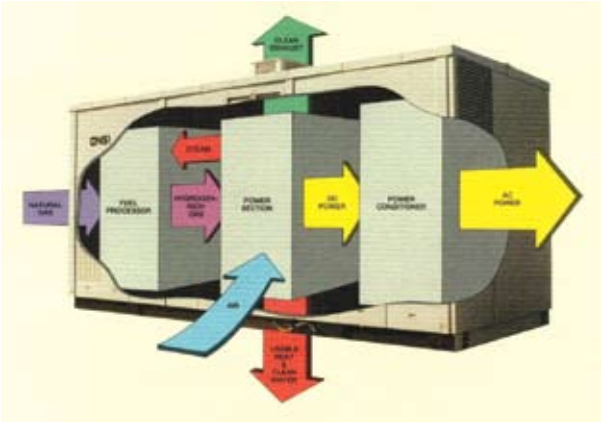
Power Section: Hydrogen-rich gas and oxygen from the air are combined in an electro-chemical process that produces Direct Current (DC) power, pure water, and heat. The byproduct water is usually recirculated or put to use by the customer. The exhaust-heat is available for use in meeting other facility thermal energy requirements.

Balance of Plant: Balance of plant includes the supporting components based on the power source or site-specific requirements and integrated into the fuel cell. System can include components such as filters, seals, gaskets, valves, spray nozzles and/or sensors.

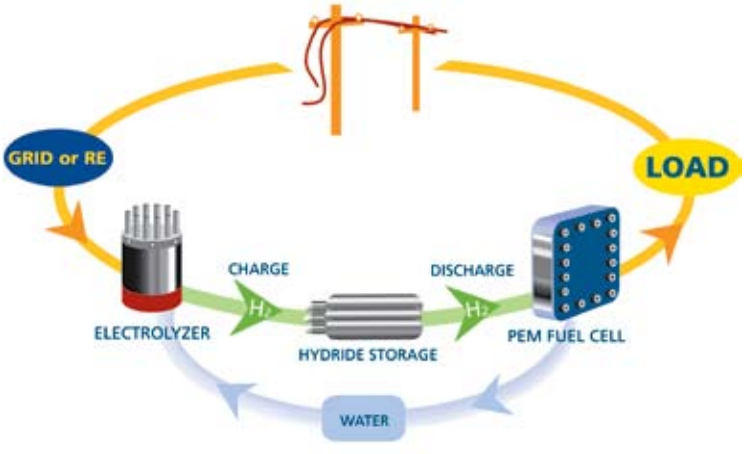
Power Conditioner: A fuel cell generates DC electricity. The power conditioner is used to supply high-quality direct current (DC) or alternating current (AC) depending on the application.



Basic mechanism of how a fuel cell works, using a PEM fuel cell as an example. Fuel and air into the system and electricity, heat and water out of the system.



Schematic for a fuel cell system with fuel processor present; courtesy UTC Power



This schematic, provided by Distributed Energy Systems, depicts one possible source of hydrogen. Surplus electricity from the grid (renewable or traditional) can be utilized to create and store hydrogen for use in an efficient fuel cell system.

TYPES OF FUEL CELL SYSTEMS

The common types of fuel cells are phosphoric acid, molten carbonate, solid polymer (or proton exchange membrane) and solid oxide, all named after their electrolyte. Because of their different materials and operating temperatures, they have unique characteristics, but all share the potential for high electrical efficiency and reduced emissions.

All fuel cells require H2 as a fuel, but some fuel cells like molten carbonate (MCFC) and solid oxide (SOFC) can also utilize carbon monoxide (CO). Hydrogen may be acquired from any of several gas distribution companies worldwide or can be produced from hydrogen rich fuels such as natural gas by a process called steam reforming or auto thermal reforming. Use of liquid fuels like diesel, gasoline, and other fossil fuels is possible but more complicated because of their high sulfur content and more complex molecular structure.

STATIONARY FUEL CELL SYSTEM APPLICATIONS

Stationary fuel cell systems can power a broad range of commercial, industrial and in some cases, residential applications. Accepting a wide range of fuels, these systems have the potential to supplement or replace any application presently served by the electrical grid. Fuel cell systems can meet the changing requirements of critical backup and remote power applications.

Stationary fuel cell systems can be built in sizes from less than 1 kW to greater than 2 MW in capacity. These systems can be used in continuous operation as primary power and some types can be used intermittently as backup or occasional power. Since fuel cell systems also generate heat, steam or hot water from the fuel cell can be used to supplement the customer's energy needs as part of a combined heat and power system.

Commercial fuel cell applications include telecommunication sites, remote communications facilities, office buildings, industrial plants, laboratories, hospitals, computer centers and small businesses, among many others.

Fuel cell systems can be used as backup power generators, primary power generators, or in combination with the electrical grid, providing high reliability. These systems can power all or part of the electrical requirements, serving the total power demand or that of selected critical circuits such as those for computer rooms, telecommunication, emergency response, life support, national defense and homeland security systems. Commercial fuel cell systems provide base load or backup power to a facility, and some can provide intermittent power during periods of high demand and high grid power cost. This peak-shaving has the ability to save money for commercial and industrial customers by leveling out demand on the local provider and preventing peak charges.

Industrial fuel cell applications include using industrial byproducts as fuel for fuel cell systems.

Hydrogen, anaerobic digester gases (ADG), landfill gases and other fuels from an array of sources and processes can be fed to an onsite fuel cell system to produce high grade electrical power and heat. In many applications, these fuels are often regarded as a noxious waste and vented, otherwise disposed of or not used to their fullest potential.

THE COMMERCIALIZATION OF FUEL CELLS

FUEL CELL TYPE	CHARACTERISTICS		COMMERCIALIZATION STATUS
	ELECTROLYTE USED	OPERATING TEMPERATURE	
Phosphoric Acid Fuel Cell (PAFC)	Liquid phosphoric acid	Approximately 400°F	PAFCs were the first to be offered commercially for stationary applications, initially at 40 kW and then at 200 kW.
Proton Exchange Membrane Fuel Cell (PEMFC)	Thin solid polymer membrane	Relatively low temperatures – around 150°F	PEMFCs have entered the stationary market in the 1-30 kW range, and are also becoming available in a variety of other applications. They have also been demonstrated in the 75 – 250 kW sizes.
Molten Carbonate Fuel Cell (MCFC)	Carbonate salt mixture	Approximately 1200°F	MCFCs are being offered commercially today in the 300 kW and MW class ranges.
Solid Oxide Fuel Cell (SOFC) *Planar SOFC* *Tubular SOFC*	Hard, non-porous ceramic compound	Between 1300-1800°F	SOFCs are expected to follow into the stationary market soon.
Alkaline Fuel Cell (AFC)	Potassium hydroxide	Approximately 160°F	AFCs have so far been used in specialty applications as they tend to be very susceptible to carbon contamination.

STATIONARY FUEL CELL SYSTEM INSTALLATION

As with any power generation installation, it is important to consider various site features when choosing a location to install a stationary fuel cell system:

- > Fuel and Facilities Availability
- > Local Code Compliance
- > Power and Feature Requirements
- > Type of System
  - >> Thermal requirements
- > Grid Support
  - >> Site voltage
  - >> Location of fuel cell: Indoor or Outdoor
  - >> Space requirements

FUELCELL ENERGY, INC.

www.fce.com

FuelCell Energy (FCE) designs, manufactures and markets large scale, ultra-clean, high efficiency stationary fuel cell power plants. FCE's commercial infrastructure includes a state-of-the-art 50 MW manufacturing facility, 24/7 worldwide service organization and several prominent domestic and international distribution partners. Today's product line, ranging in size from 300 kW to 2.4 MW, is designed for a wide range of applications, including manufacturing and industrial facilities, hospitals, universities, hotels, wastewater treatment plants, office buildings, data centers, utilities and natural gas pipeline operations.

FuelCell Energy's Direct FuelCell® (DFC®) product line is regarded as one of the most reliable and electrically efficient and as having the lowest cost per kWh by todays market standards. The firm's DFC product line is so named because of its ability to generate electricity directly from a hydrocarbon fuel, such as natural gas and digester gas, by reforming the fuel within the fuel cell to produce hydrogen. This one-step process significantly reduces costs while maximizing electrical efficiency.

DFC power plants provide an electrical efficiency of 47% and generate high quality by-product heat energy (700°F) that can be harnessed for Combined Heat and Power (CHP) applications using hot water, steam or chilled water to heat or cool buildings, boosting electrical efficiency up to 70%. FuelCell Energy's Direct FuelCell-Energy Recovery Generation™ (DFC-ERG™) fuel cell for natural gas applications combines a DFC power plant with an unfired gas expansion turbine to achieve up to 60% electrical efficiency with low noise and virtually zero smog emissions.

FCE's products are gaining worldwide recognition as an ultra-clean, firm renewable resource qualifying for participation in an ever increasing number of state Energy Portfolio Standards (EPS). Since 2001, the firm has delivered more megawatts of installed fuel cell power than any other company in the world.

A 1 MW DFC power plant installation at Sierra Nevada Brewing Co. in Chico, California

A 1 MW DFC power plant installation at Alameda County's Santa Rita Jail in Dublin, California

NUVERA FUEL CELLS, INC.

www.nuvera.com

Nuvera Fuel Cells develops and sells multi-fuel processing and Proton Exchange Membrane (PEM) fuel cell technology for clean, safe and efficient power solutions. With offices located in Italy and the USA, Nuvera is advancing the commercialization of hydrogen fuel cell power modules for material handling and chemical process industry applications, natural gas fuel cell power systems for cogeneration applications, and on-board gasoline fuel processors and fuel cell stacks for automotive applications. Generating energy on location, on demand and independently of existing power grids is now becoming a leading option for many commercial businesses.

FORZA™ Nuvera has designed its Forza™ high power fuel cell system specifically for the chemical process industry. By-product hydrogen is not properly utilized by the majority of the chemical industries, making fuel cells an ideal electricity generating system for these applications. Utilizing a three-phase approach in the research and design of Forza, Nuvera has ensured a technically-advanced, reliable product. Phase one involved proving the fuel cell technology in a large-scale, industrial laboratory, while phase two saw the implementation of a field trial in Brescia, Italy, which produced more than 185,000 kWh of electricity on actual by-product hydrogen. Nuvera is currently entering the third and final phase of development, designing and validating the industrial-grade balance of plant in order to meet the rigorous demands of the chemical process industry, while still offering a positive value proposition. Forza can provide power ranges from 500 kW to several MW, with an average net efficiency of 56%, and is designed to run unattended 24 hours a day.

Forza, while ideal for the chemical process industry, can also be used wherever large amounts of electricity and heat are needed. Nuvera is developing the Forza Rail Power Module (RPM), a 150 kW (gross) power module designed for rugged locomotive applications. Nuvera delivered its first RPM to an international locomotive customer in early 2006.

NUVERA'S AVANTI™ fuel cell power system is designed specifically for cogeneration/distributed generation applications. Consisting of a natural gas reformer and PEM fuel cell technology, Avanti can provide 4.6 kW of electricity and about 7 kW of heat. The fully integrated unit incorporates an electronic control system, designed by Nuvera engineers, that allows unattended operation. The overall efficiency is 75-80%, with less than 10ppm CO, NOx or unburnt HC. An extensive international field test of the Avanti will run through 2007.

Nuvera's Avanti fuel cell power system

Forza modular fuel cell system installed at a customer site in Brescia, Italy

UTC POWER
www.utcpower.com

United Technologies Corporation, based in Hartford, Connecticut, provides high-technology products and services to the building and aerospace industries. Its UTC Power Corporation unit, based in South Windsor, Connecticut, is a full-service provider of environmentally advanced power solutions. UTC Power has more than 40 years of experience in developing and producing fuel cells for onsite power, transportation, space and marine applications.

UTC Power manufactures, markets and services the PureCell™ system, a stationary fuel cell power plant that converts natural gas into 200 kW of clean, efficient and reliable electric power, and about 900,000 Btu/hour of heat for combined heating and power applications. When all the heat is utilized, the overall efficiency can reach 90%. Remote monitoring capability has supported field reliabilities greater than 95%.

Since 1991, UTC has installed more than 260 systems in 19 countries and accumulated more than 1.3 billion kWh of operating time in a wide variety of applications.

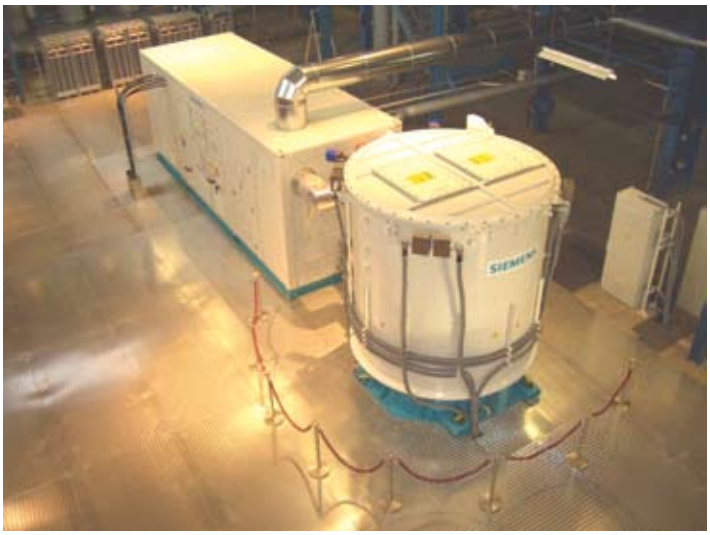
With proven field reliability, the PureCell™ system is suited for applications requiring assured power such as banks and telecommunications operations. It is virtually pollution-free and meets or exceeds air emission standards throughout the United States. Low emissions combined with a low noise profile make the PureCell™ system a great fit for hotels, hospitals, and office buildings, and other facilities in urban environments. Some notable installations include the New York Police Department's Central Park station, Verizon's calling center on Long Island, and the 4 Times Square building in New York. Another installation at the South Windsor High School in Connecticut enables the school to be designated as an emergency shelter.

The PureCell™ system also can operate on renewable fuels such as anaerobic digester gas (ADG) and has accumulated more than 300,000 hours in these applications.

The world's largest commercial fuel cell installation – seven 200-kW UTC Power fuel cell units (1.4 MW total), installed at Verizon's calling center in Garden City, New York

SIEMENS POWER GENERATION, INC.
www.powergeneration.siemens.com/products-solutions-services/products-packages/fuel-cells/

Siemens' Stationary Fuel Cells division, located in Pittsburgh, Pennsylvania, is dedicated to the commercialization of Solid Oxide Fuel Cells (SOFC). The Company has been the leader in developing tubular SOFC as part of the U.S. Department of Energy's advanced fuel cell research program, and is in the pre-commercial development phase with commercial orders planned in the 2011 time frame. Market entry products will serve the distributed generation segment of the power generation market, initially with the SFC-700, a cogeneration system of approximately 700 kW that can be configured in multiple units for ratings up to several MW, with an electrical efficiency of 46%. These units will operate unattended, provide hot water, and will have an availability of greater than 98%. Options for steam and chilled water will also be available. These first products will operate at atmospheric pressure; somewhat later SOFC/gas turbine hybrid systems will follow. As production increases and costs become more competitive, the product range will expand to include larger power plants, as well as smaller systems for remote power and other applications.



Siemens' SFC-200 cogeneration system

BALLARD POWER SYSTEMS
www.ballard.com

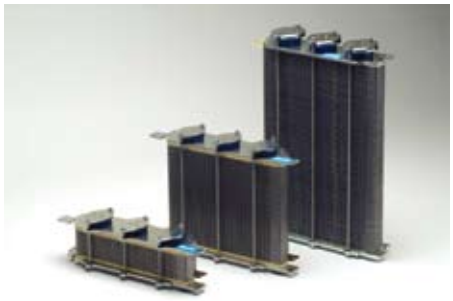
Ballard Power Systems designs, develops and manufactures zero-emission proton exchange membrane fuel cells. We are leveraging our automotive fuel cell technology for less demanding non-automotive applications. We currently provide fuel cell products to the following markets:

THE BALLARD MARK1020 ACS FOR BACKUP POWER

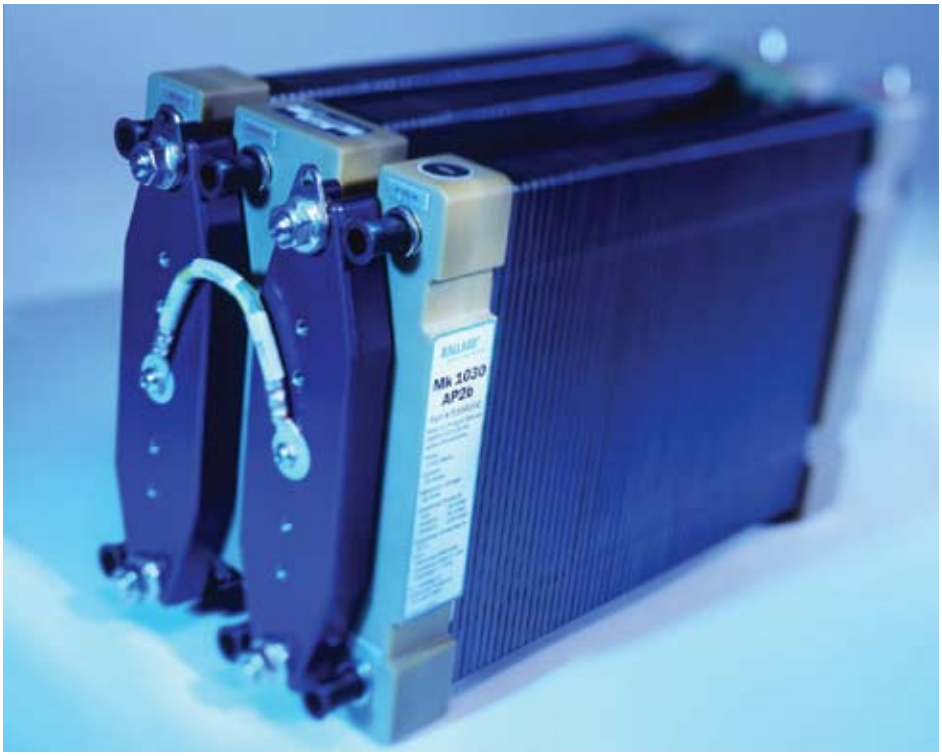
The Mark1020 ACS, provides durability and performance for those requiring high availability backup power solutions for mission critical applications, such as in the telecommunications industry. Fuel cell backup products offer increased runtime, ensuring performance during extended power interruptions greater than five-to-six hours and even operate without performance loss in a wide range of climatic conditions. Fuel cells have demonstrated longer durability than batteries and can therefore offer significant lifecycle advantages. Fuel cells offer service benefits as well, and in the case of an eight-hour backup system, fuel cells occupy 20% of the space compared to that of a battery solution.

THE BALLARD MARK1030 FOR RESIDENTIAL COGENERATION

The Mark1030 was designed to provide electricity; heat and hot water, as well as environmental benefits for homeowners currently experiencing high electricity costs in comparison to gas costs. The product actually satisfies two audiences, driving more business and therefore increased revenue to gas companies as well as providing an alternative for homeowners to shift energy usage from high priced electrical grids to lower cost energy products for maximum savings.



Ballard Mark1020 ACS



Ballard Mark1030

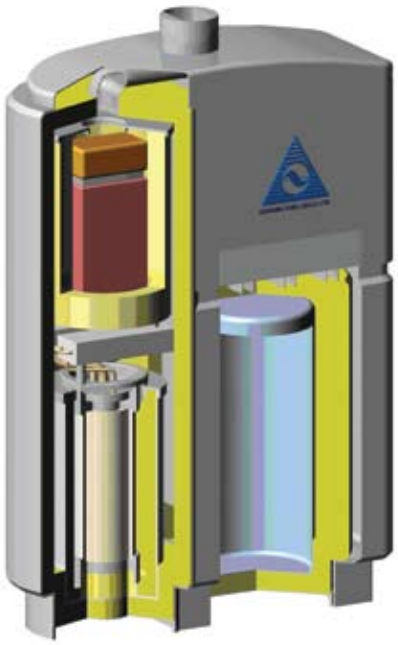
CERAMIC FUEL CELLS LTD.
www.cfcl.com.au

Ceramic Fuel Cells Ltd (CFCL) has been developing flat plate SOFC technology since 1992. CFCL is developing SOFC products for small-scale on-site micro combined heat and power (m-CHP) and distributed generation units that co-generate electricity and heat for domestic use.

CFCL has experience with many SOFC designs and materials, having successfully designed, built and operated both 'all-ceramic' and 'metal supported' kW size fuel cell stacks. CFCL has also created highly engineered "balance of plant" that surrounds the fuel cell stack and controls the inputs (fuel, air and water), outputs (heat and electricity), timing, and temperature controls. This broad expertise is reflected in CFCL's intellectual property portfolio, including 28 patent families.

CFCL has extensive R&D, testing and manufacturing facilities in Melbourne, Australia. CFCL plans to build a large scale fuel cell manufacturing facility in Europe. The Company will also construct a plant in Europe to produce high quality ceramic powders, which are a key component of solid oxide fuel cells, using the Company's patented technology.

CFCL is currently demonstrating prototype units in field trials with customers.



Ceramic Fuel Cells has patented Solid Oxide Fuel Cell Technology that can be incorporated into this small Combined Heat and Power (CHP) unit. It will generate power and provide hot water service for homes.

HYDROGEN CORPORATION
www.hydrogenllc.net

HydroGen Corporation is working to meet the growing need for distributed energy generation by providing affordable, alternative energy to large industrial customers.

The company designs and manufactures a 2MW power island utilizing its proprietary Phosphoric Acid Fuel Cell (PAFC) technology originally developed by Westinghouse Corporation. The company targets its multi-megawatt, zero-emission power generation product for market applications where drivers favoring the adoption of fuel cells are present and by-product hydrogen is currently available, such as the chlor-alkali industry and coke oven gas producers.

HydroGen's core product is built up from five identical 400 kW air-cooled PAFC modules. This core technology, the 400 kW module, is composed of four 100 kW stacks within one pressure vessel. HydroGen uses standard balance-of-plant (BOP) components with very little customization in its multi-megawatt fuel cell systems. This approach, unique in the fuel cell industry but common in standard chemical plant construction, significantly reduces cost and technical risk.

HydroGen's primary market, providing distributed energy in the 5 to 30 MW range, is a mature growing segment. Current worldwide orders for combustion turbines in 5 to 30 MW range represent a $2-6 billion annual market, and the HydroGen technology is a clean solution for hydrogen-producing customers.

HydroGen Corporation manufacturing 400 kW PAFC modules – the building blocks of its 2 MW commercial system – at its plant in Versailles, Pennsylvania.

HYDROGENICS CORPORATION
www.hydrogenics.com

Hydrogenics Corporation, headquartered in Toronto, Ontario, develops and sells PEM hydrogen and fuel cell systems. The company's product development efforts are focused on its HyPM® product line of fuel cell power modules. HyPM XR power modules, ranging from 8 to 65 kW, are designed for integration into a wide range of stationary applications and have been deployed in sites throughout North America, Europe and Asia. Hydrogenics is providing HyPM power modules for AC and DC backup power applications to original equipment manufacturers (OEM), system integrators and end users. Hydrogenics also provides its HyPM LP power modules configured for mobility and portable/auxiliary power applications.

The Hydrogenics HyPM 12-XR (12 kW, rack mounted) fuel cell power module is used by American Power Conversion (APC) in their new InfraStruXure™ FCXR10-30 uninterrupted backup power supply (UPS) product. The system is mounted in standard 19" server racks and is scalable from 10 to 30 kW utilizing up to three HyPM 12-XR modules and the associated power electronics in a single rack. When integrated with APC's existing UPS product line, the result is a highly reliable, extended run, turnkey solution designed for indoor installations with indoor or outdoor hydrogen storage and an integrated ventilation system.

Hydrogenics is also providing 8 or 16 kW, 48 volt DC systems in complete outdoor enclosures for the DC backup power market utilizing one or two 8 kW modules, respectively with integrated hydrogen storage and thermal management. Hydrogenics has delivered systems utilizing both ultra-capacitors and batteries as bridging power to telecom carriers and offers a wide range of customer solutions to address specific operational priorities.

Hydrogenics' HyPM 8-XR DC Backup Power System deployed at a Bell Canada telecommunications site with Emerson Network Power

Hydrogenics' HyPM XR Fuel Cell Power Module for backup power applications

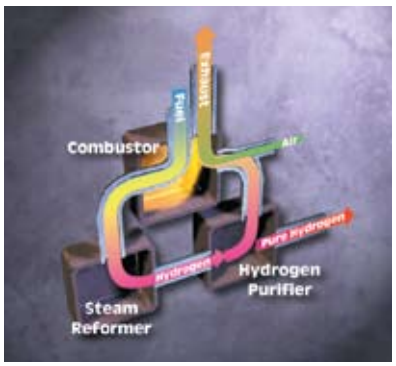
IDATECH, LLC
www.idatech.com

IdaTech develops and sells fuel processors and integrated fuel cell systems for critical backup power and remote power applications in the telecommunications, utilities and military industries. IdaTech is ISO 9000:2001 certified, signifying a commitment to quality and continuing advancements in the power generation fuel cell industry.

IdaTech's core technology is its patented fuel processing technology, capable of converting a variety of fuels into high purity hydrogen needed by fuel cells. IdaTech's portfolio of fuel cell solutions includes the ElectraGen™ family of backup power systems in the 1.5 to 15 kW range, the ElectraGen™ XTR Module, a liquid fuel reformer that enables extended run times, and the iGen™ system, a 250 W battery charger.

IdaTech's CE, ANSI/CSA FC 1 and NEBS Level 3 certified ElectraGen™ family of backup power systems are offered for markets such as telecommunications, utilities, UPS and other applications requiring critical backup power with long lifetimes. The ElectraGen™ family is based on proton exchange membrane (PEM technology. The ElectraGen™3 system manages loads of up to 3 kW and the ElectraGen™5 system can be paralleled to produce backup power of up to 15 kW, or five kW individually. These backup power solutions feature fueling options that enable extended run times, including hot swappable hydrogen cylinders and the reformer-based ElectraGen™ XTR Module, a methanol reformer providing extended run capabilities.

IdaTech's CE certified ElectraGen™ XTR Module is a liquid-fueled extended run module built to produce high purity hydrogen on demand for the IdaTech family of ElectraGen™ backup power solutions. The module efficiently reforms HydroPlus, a methanol/water fuel mixture. Solutions such as traditional battery strings are only practical for a limited number of hours, while some backup power applications require run times of days instead of hours. The ElectraGen™ XTR Module avoids the traditional challenges associated with hydrogen delivery and storage by producing hydrogen on-site and as needed. It is an ideal solution for remote locations such as telecommunications towers where frequent hydrogen delivery is not possible.



IdaTech's hydrogen reformer

IdaTech's ElectraGen™ family of critical backup power systems

An IdaTech ElectraGen™5 installation at European telecommunications site

PLUG POWER INC.
www.plugpower.com

Plug Power, a global leader in clean, reliable on-site energy, develops and manufactures stationary proton exchange membrane fuel cells that supply power to the wireless, telecom, and utility industries.

Plug Power's core technology is its GenSys®, which utilizes a natural gas or propane reformer to supply hydrogen to the stack. The 5 kW GenSys product, which has been deployed in over 400 installations, was designed to run in parallel with the grid, transferring to standby mode to provide uninterrupted power to critical loads.

GenCore® is Plug Power's first product designed to run directly on hydrogen and offers the telecommunications, cable broadband and uninterruptible power supply markets an alternative backup power solution. GenCore produces up to 5 kW of backup power and has an expected stack life of ten years under normal operating conditions. The system is light weight, low noise and zero emission. GenCore is among the first economically-viable commercial fuel cell products, with a competitive first-installed cost and lower lifecycle cost compared to the incumbent battery technology. The GenCore product now serves such telecom clients as Orange and Verizon.

Plug Power's strategic partners include Engelhard, Honda R&D Co., Ltd. of Japan, PEMEAS, Tyco, and Vaillant GmbH. The Company's headquarters are located in Latham, New York, with offices in Washington, D.C. and The Netherlands.

Plug Power 5 kW Backup GenCore Unit

Plug Power 5 kW Combined Heat and Power (CHP) GenSys Unit

DISTRIBUTED ENERGY SYSTEMS
(formerly Proton Energy Systems)
www.distributed-energy.com

Distributed Energy Systems Corp. designs, develops, and manufactures PEM electro-chemical products that it employs in hydrogen generating devices and in regenerative fuel cell systems that function as power generating and energy storage devices. Distributed Energy Systems' HOGEN® hydrogen generators produce hydrogen from electricity and water in a clean and efficient process using its proprietary PEM technology. Markets served by this technology include industrial, fueling systems, backup power systems, military and aerospace as well as linking hydrogen to renewable energy technologies.

BACKUP POWER SYSTEMS
The utilization of Distributed Energy Systems' Regenerative Fuel Cell (RFC) system technologies meet present and future backup power needs, offer modularity and scalability not easily achievable by traditional battery systems. High pressure gaseous storage is achieved without mechanical compressors using our high pressure electrolyzer systems. Distributed Energy Systems' product platforms integrate PEM fuel cells with high pressure PEM electrolyzers and hydrogen storage subsystems to deliver backup power systems that you can rely on. Our engineering teams provide a complete solution including associated packaging, power conditioning, and controls.

RELIABLE, DURABLE, CLEAN POWER
The core technology is based on high reliability electrolyzer subsystems and is designed for low life cycle cost. The PEM regenerative fuel cell systems are environmentally friendly. The high quality uninterruptible power output from our systems is suitable for sensitive electronic equipment. And since the energy carrier is stored hydrogen, power availability and run time is predictable. Distributed Energy Systems' technology platform also allows for integration into systems where peak shaving can be leveraged for reduced power costs.

MANY APPLICATIONS FOR THE POWER MARKETS
Distributed Energy Systems' regenerative fuel cell technology can be used in a wide range of applications including backup power for telecom and other critical loads, peak shaving, and load leveling in premium power markets and for remote applications. The technology has been used and validated with renewable sources of energy such as wind and solar.

Distributed Energy Systems' hydrogen technology group is actively developing and demonstrating capability in domestic and global wireline and wireless telecom backup power applications.

Other markets for our technology include UPS markets based upon our regenerative fuel cell technology, Generator Set markets – our systems offer storage flexibility – and backup power for utility substations and cable television markets.

Proton H-Series Electrolyzer at Wallingford Electric Utility Substation in Wallingford, Connecticut

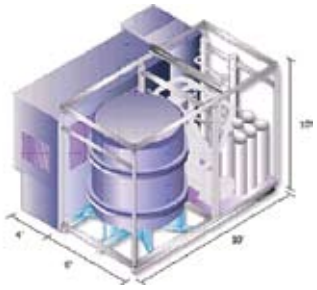
ZTEK CORPORATION
www.ztekcorporation.com

Ztek Corporation is a solid oxide fuel cell and hydrogen reformer development company founded in 1983 to produce the world's cleanest and most efficient fossil fuel energy conversion devices.

Ztek offers the following highly efficient, compact and environmentally friendly products for power generation and hydrogen production applications:

High Performance Steam Reformer (HPSR)
High Efficiency Hydrogen and Electricity Co-production System (HECP)
Solid Oxide Fuel Cell and Microturbine Hybrid System (SOFC/MT)

The HECP and SOFC/MT systems are available with or without heating and air conditioning.



Ztek's Solid Oxide Fuel Cell with Microturbine Hybrid System generates 50 to 200 kW and is capable of 50% efficiency. Unit also offers Direct Integration using Precuperation Technique.

RELION
www.relion-inc.com

ReliOn produces the only modular, cartridge-based fuel cell system in the world and has its technology backed up by a strong patent program. ReliOn products meet power requirements from below 600 W to 12 kW. We have sold more than 850 kW of product to customers as diverse as the wireless and wireline telecommunications, utility and government sectors.

The ReliOn solution is designed for superior performance when compared to battery strings and generators, without the drawbacks associated with either system. Additionally, ReliOn fuel cells provide cost benefits over other backup power options on a life cycle cost basis – and, in many cases, provide lower initial cost as well. Products may be rack-mounted in 19" or 23" racks and configured for multiple outdoor requirements. ReliOn fuel cell solutions are designed with the ability to grow as customer power requirements increase. Modular architecture for power generation and system control enables a cost-effective backup solution with a seamless upgrade path. By adding power cartridges or electronics cards, equipment operators are able to leverage initial investments in fuel cell backup systems, balancing capital and operational expenditures.

T-1000®

The T-1000® hydrogen fuel cell is designed specifically for communications backup power applications within telecommunications, government and utility. The T-1000® uses patented Modular Cartridge Technology® for hot-swappable® high reliability, ease of maintenance and simplicity of design. The product incorporates modular electronics cards which enable scalability by providing flexible configuration from 600 W to its full rated 1,200 W capacity. T-1000® outdoor configurations provide customers with runtimes between 8 and 96 kWh of backup power.

T-2000™

The T-2000™ hydrogen fuel cell is designed for higher power needs within communications backup power applications. Using similar architecture to the T-1000®, the T-2000™ is configurable from 600 W to its full rated 2,000 W capacity in one chassis and is scalable to 12 kW.

ReliOn is headquartered in Spokane, Washington.

ReliOn's T-1000® hydrogen fuel cell

ReliOn's T-2000™ hydrogen fuel cell

ReliOn configurable power solution – telecommunications site

DEVELOPMENT

DELPHI
www.delphi.com

Delphi Corporation's Solid Oxide Fuel Cell (SOFC) power system, currently under development, is intended for a variety of mobile and stationary applications – including residential, industrial, utility, and military power generation.

The company's capabilities cover component manufacturing and system integration, including cell and stack build, fuel processing for multiple fuels, balance of plant, system controls, and power conditioning electronics.

The system is capable of operating with many types of fuels including natural gas, diesel, propane, and gasoline. The SOFC has also been demonstrated operating from coal-derived fuel gas. In stationary applications, the high quality by-product heat can be utilized in Combined Heat and Power systems.

Delphi is working with the Department of Energy's Solid State Energy Conversion Alliance (SECA) program to accelerate the development and commercialization of SOFC technology. Delphi's current generation system weighs 80 kg and has a potential power output of 3 kW. Delphi is working with SECA to apply this technology to larger power systems.

Delphi's current generation SOFC Power System

FUELCELL ENERGY, INC.
www.fuelcellenergy.com

FuelCell Energy is working to develop the next generation fuel cell products. Currently the company is focused on the combined cycle Direct FuelCell/Turbine® (DFC/T®) power plant, Co-production of Hydrogen, electricity and heat (DFC/H2), Liquid Fueled Military Applications, and Solid Oxide Fuel Cells (SOFC).

High Efficiency Hybrid Power Plant – The company's Direct FuelCell/Turbine® (DFC/T) hybrid system integrate a full-size DFC stack with a Capstone C60 microturbine. Tests showed that the unit performed better than the CARB (California Air Resources Board) 2007 emission standards and achieved 56% electrical efficiency.

Co-production of Hydrogen – DFC power plants can be used to cost-effectively co-generate hydrogen as well as electricity and heat (DFC/H2). Hydrogen can be made available for on-site industrial use and other applications. The company is actively developing this application with development partners to enable the evolving hydrogen infrastructure.

Liquid Fuel Military Applications – FCE and CTC/CERL demonstrated the operation of a DFC power plant on liquid propane fuel. This work also demonstrated duel fuel capability and the unit's ability to switch fuels on the fly while on load without interruption. FCE is also developing diesel marine applications for its DFC® technology under programs with the U.S. Navy. FCE is adapting its commercial natural gas (DFC®) technology for shipboard use with diesel and other naval logistic fuels.

Solid Oxide Fuel Cell (SOFC) – FCE is a prime contractor for a 10-year Solid State Energy Conversion Alliance (SECA) program by the U.S. Department of Energy to accelerate the commercialization of low-cost solid oxide fuel cells in the 3 to 10kW size. FCE acquired Global Thermoelectric of Canada, a developer of SOFC technology and invested in Versa Power Systems, a company formed to produce distributed generation products from reduced temperature SOFC systems to support this effort. FCE was also selected by U.S. Department of Energy's National Energy Technology Laboratory (DOE-NETL) to re-direct its SECA program to coal-based solid oxide fuel cell power plant development. The objective of this new 3-phase, 10-year program is to develop multi-MW class SOFC power plants based on coal-based syngas.

A Direct FuelCell/Turbine® installation at the Billings Clinic in Billings, Montana

GENERAL MOTORS
www.gmability.com

GM's stationary Fuel Cell demonstration project with Dow Chemical was initiated in early 2004, and has since expanded. Following a brief trial period, the two companies broadened the test from a single 75 kW PEM system to an array of units for the project's second phase. The second installation, which can supply up to 1 MW of electricity, is connected to the facility's internal power grid and is used to power the facility. We are currently producing up to 250 kW of power and the company is periodically hot-swapping fuel cell power modules to test updated technologies.

GM continues to improve quality, reliability and durability through the testing of power modules at Dow. The testing uses various automotive-type load schedules and reduces testing time by operating 24/7. GM and Dow are also working on fuel specifications and their impact on system performance. The company remains committed to commercializing an automotive competitive fuel cell system for vehicles by 2010, and believes that utilizing stationary power applications will help accelerate the testing and learning cycles that will allow the company to gain valuable knowledge and help bring down system costs.

A GM Stationary Fuel Cell Unit

The first General Motors fuel cell trailer is in place at the Dow Chemical Company plant in Freeport, Texas, helping to power one of the world's largest chemical plants

HYDROGENICS CORPORATION
www.hydrogenics.com

Hydrogenics continues to focus on applying its rack-mountable HyPM XR Fuel Cell Power product to innovative mission critical applications for data centers, critical infrastructure, telecommunication sites, and other markets in response to a growing demand for reliable and space-efficient 'extended run' backup power. Hydrogenics is expanding its reach by introducing a 4 kW Fuel Cell Power Module to its HyPM XR product line for the backup power market.

In addition to fuel cell products, Hydrogenics is a world-wide leader in hydrogen infrastructure technology and products with more than 55 years spent in the development, manufacture and installation of on-site hydrogen generation systems for energy and industrial markets. This presents a unique opportunity to advance the development of fully integrated 'Energy Station' systems suited for future distributed generation installations. Hydrogenics will continue to work on bundling its fuel cell and hydrogen generation technologies to meet the growing needs for clean and sustainable stationary power.

MILLENNIUM CELL INC.
www.millenniumcell.com

Millennium Cell is focused on the development of hydrogen storage and generation systems for backup power. Its patented chemical process utilizes a non-flammable or pressurized liquid fuel, sodium borohydride and water, which, in the presence of a catalyst, releases hydrogen.

Our Hydrogen On Demand™ technology provides a hydrogen fuel system that can be readily sited in both indoor and outdoor locations without the restrictions imposed by fire codes on compressed hydrogen storage. A system delivers high purity hydrogen and can be designed to outlast compressed hydrogen systems at a lower cost of ownership. Our fuel can be conveniently delivered to and refueled at all types of remote and easy-to-access installations throughout the existing standby power infrastructure. Hydrogen On Demand™ systems provide immediate start-up capability for hydrogen fuel cell backup power installations.

RELION
www.relion-inc.com

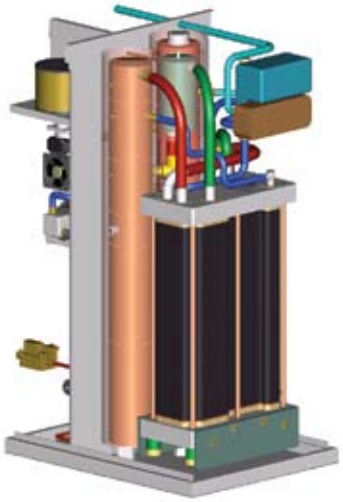
ReliOn is currently doing business with customers in the telecommunication, utility, and government sectors. Over the next year, ReliOn will increase market penetration in those sectors using its fully certified T-1000® and T-2000™ fuel cell products.

NUVERA FUEL CELLS, INC.

www.nuvera.com

Nuvera is investigating the uninterrupted power supply (UPS) market. Its Powerflow™ fuel cell module is well suited for UPS applications due to its modular design and compact footprint. Running on hydrogen, its only byproducts are heat and water, allowing it to comply with many indoor locations' strict emission standards. Powerflow utilizes cathode water injection, simplifying the balance of plant to offer a longer service life. Built to rigorous industrial standards, it has a lifetime of more than 10 years. Powerflow is available in a number of sizes ranging up to 10 kW, and has an efficiency of 52%.

Nuvera's 5 kW Powerflow fuel cell module



PLUG POWER, INC.

www.plugpower.com

Plug Power is working collaboratively with PEMEAS GmbH and Vaillant GmbH on the development of a high-temperature fuel cell system. High-temperature PEM technology offers the potential for significant improvements in system reliability, cost and performance, as well as the capability of providing higher-grade heat than current lower-temperature technology. Plug Power has received support from the National Institutes of Standards and Technology (NIST), the New York State Energy Research and Development Authority (NYSERDA) and the Department of Energy (DOE) in advancing this technology.

High-Temperature PEM Fuel Cell Technology

ZTEK CORPORATION

www.ztekcorporation.com

Ztek Corporation is continuing its products development and demonstrations that include a 25 kW Solid Oxide Fuel Cell (SOFC) and a 200 kW SOFC/Microturbine Hybrid System for distributed generation applications, with or without heating and air conditioning. Ztek's hydrogen reformer systems are capable of producing 600 standard cubic feet per hour (scfh) of hydrogen for refueling applications, with a 4000 scfh system in development.

Ztek has begun to introduce to the marketplace its Hydrogen Electricity Co-Production Systems (HECP) that will produce 300 scfh of hydrogen with 10 kW of electricity or 2000 scfh of hydrogen with 75 kW of electricity. All of Ztek's systems are highly efficient and compact. The HECP systems offer unmatched environmental benefits that reduce CO_2 emissions by 50% when compared with traditional energy systems.

A 25 kW Solid Oxide Fuel Cell (SOFC) demonstration is underway to provide power and air conditioning for Dinosaur Sate Park, Connecticut for the Connecticut Clean Energy Fund (CCEF). Another demonstration project will be supported by the CCEF for a SOFC-Microturbine hybrid system demonstration for AT&T and CCEF in the Southwest Connecticut Corridor.

Ztek and the U.S. Navy have agreed to develop a cluster of hydrogen fueling stations in Los Angeles County and San Diego County, centered on the Camp Pendleton Marine Base in Oceanside, California. This demonstration project will showcase Ztek's "Affordable Hydrogen Station" business model to be implemented first in California providing intra-city connections.

Construction of a Ztek SOFC/HPSR hydrogen service station with the capacity of supplying 600 scfh of hydrogen is in due process with Pacific Gas & Electric in Northern California to support the fuel cell vehicles hydrogen needs of the California Fuel Cell Partnership and the California Hydrogen Highway Network Initiative.

Ztek 25 kW Solid Oxide Fuel Cell with 4 ton HVAC on Roof Top

VERSA POWER SYSTEMS, INC.

www.versa-power.com

Versa Power Systems (VPS) is a leading designer and developer of planar solid oxide fuel cell (SOFC) power systems. Evaluations of its fuel cells under realistic conditions affirm their robust performance, maintaining their power-generation profiles through hundreds of thermal cycles and operating over the thousands of hours required for use in commercial settings. The anode-supported planar architecture not only provides higher power density and durability than certain other SOFC prototypes, its structure and component makeup are especially amenable to low-cost and high-volume production. Independent analyses of engineering and factory costs confirm the technology can be manufactured on an economic basis.

At its 32,000 square foot development facility, VPS operates an integrated cell and stack pilot production line with a capacity of 2 MW per year. The company is a key technology supplier for the U.S. Department of Energy's Solid State Energy Conversion Alliance (SECA) program under which VPS and its partners are targeting megawatt-scale coal-based power plants capable of reducing greenhouse gas emissions by 90%. VPS is also exploring small-scale markets, including stationary and mobile applications (such as auxiliary power units for trucks and recreational vehicles), as well as airborne and underwater military applications.

Versa Power Systems has demonstrated a range of complete systems that can run on commercially available fuels, exhibiting stack power density results that are consistent with commercial targets

UTC POWER

www.utcpower.com

UTC Power is now actively working to develop an advanced phosphoric acid fuel cell stack and fuel processor with a design life of 85,000 hours and significantly reduced life cycle cost. This next generation power plant will offer significant improvements in the cost of generation, maintenance costs, electrical efficiency and area power density. In addition, the advanced phosphoric acid fuel cell will offer advantages relative to other commercially available products with high cogeneration efficiency through thermal flexibility, ease of installation through integral heat recovery, no site makeup water requirements through water balance designs, lower emissions and lower noise relative to reciprocating engines and microturbines and less maintenance relative to reciprocating engines.

UTC Power's significant experience in the automotive industry with PEM fuel cells also positions UTC Power to participate in the backup power market for smaller systems, 5 kW to 10 kW in size. Currently customers are evaluating a 5 kW fuel cell power plant.

UTC Power is working jointly with the United Technologies Research Center (UTRC) to develop Solid Oxide Fuel Cell (SOFC) stack technology for future commercialization by UTC Power. Target SOFC applications include distributed and auxiliary power generation.

The 5 kW PEM based fuel cell currently being evaluated. Scheduled for commercialization in 2008.

UTC Power next generation fuel cell offering more than 80,000 hours stack life and reduced life cycle cost

SIEMENS POWER GENERATION, INC.

www.powergeneration.siemens.com/products-solutions-services/products-packages/fuel-cells

Siemens continues the development and testing of SOFC/gas turbine hybrid systems and plans to introduce a hybrid product in approximately five years. In 2000, the world's first fuel cell/gas turbine hybrid system, a 220 kW hybrid proof-of-concept system, was tested by the Company in California, featuring a pressurized SOFC module coupled with a microturbine-generator. This system demonstrated an electrical efficiency of 53%, setting what was then a new efficiency record for a fuel cell system operating on natural gas. A second pressurized hybrid system was also tested at the Company's facilities in Pittsburgh.

Under DOE's coal-based SECA program, Siemens plans to develop low cost SOFC power systems, initially in the 2.5 – 5 MW range, using a new seal-less Delta-8 SOFC capable of 1 kW/cell. By the conclusion of the 10-year program the Company expects to be positioned to introduce commercial SOFC systems for central power plants and other large industrial applications.

Siemens' revolutionary new Delta-8 SOFC technology

CERTIFICATIONS

In order to be accepted for use by customers, fuel cells will benefit from attaining safety and performance certifications. CSA and UL are certifying agencies in North America. Some certifications may be required by specific customers or industries purchasing fuel cells.

Independent Fuel Cell Testing Programs:

CSA INTERNATIONAL is an OSHA accredited Nationally Recognized Testing Laboratory (NRTL) whose certification marks appear on billions of products globally. CSA America leads fuel cell standards development and product certification in the United States. Across America and the World, CSA has 85 years of experience developing standards, testing and certifying products. CSA America is an ANSI accredited consensus standards development body developing, managing and maintaining standards for stationary, portable and micro fuel cells, hydrogen generators, hydrogen & CNG dispensing systems, onboard cylinders and pressure relief devices. CSA America is also the U.S. TAG Administrator to IEC/TC105, Fuel Cell Technologies.

www.csa-international.org

CONCURRENT TECHNOLOGIES CORPORATION (CTC) advances all major types of fuel cells and fuel cell applications. CTC operates the U.S. Department of Defense (DoD) Fuel Cell Test and Evaluation Center (FC*Tec*), a national resource facility for the independent, unbiased testing and validation of fuel cell and fuel processor systems for both military and commercial applications. The FC*Tec* has 40,000 square feet of floor space and includes 14 independent stations for testing multiple systems simultaneously, 24/7. The FC*Tec* provides comprehensive test and evaluation services towards the advancement of stationary fuel cell technologies – PAFC, PEMFC, SOFC, MCFC – ranging in power output levels from 100 W to 250 kW. CTC is now advancing its capabilities in the research, development, test and evaluation of alternative power and energy systems.

www.ctc.com or **www.fctec.com**

UNDERWRITERS LABORATORIES INC. (UL) is an independent, not-for-profit product safety certification organization that has been testing products and writing Standards for Safety for more than 110 years. UL tests more than 19,000 types of products annually, and more than 19 billion UL Marks appear on products each year. Worldwide, UL's family of companies and its network of service providers include more than 58 laboratories, and testing and certification facilities.

UL has been actively involved in the development of both domestic and international fuel cell and related hydrogen equipment standards. UL is also a major certifier of fuel cell equipment. UL's mark on a fuel cell product represents UL's extensive experience in product certification and reputation as a leader in product safety.

www.ul.com/dge/fuelcells

CODES & STANDARDS

Fuel cells are regulated by national and international product safety and consumer protection regulations. Manufacturers of consumer products typically follow a "common sense" approach whereby the standards of the industry are used as guidance for new offerings. Fuel cells also may be used in and around public and private buildings covered by zoning laws and building regulations. The use and storage of fuel cell fuels may be controlled by regulations that have been in place for years, restricting their use in new applications. The number and extent of regulations can be daunting, but the fuel cell community has responded pro-actively – bringing regulations in line with fuel cells and their fuels.

For information on stationary fuel cell codes & standards work, please visit the Fuel Cell Codes & Standards Website at **www.fuelcellstandards.com**.

SOLID STATE ENERGY CONVERSION ALLIANCE (SECA)

A new model for joint government and private industry technology research and development is found in SECA. This alliance is a partnership between the U.S. industry, universities, and other research organizations and was formed to accelerate the commercial readiness of Solid Oxide Fuel Cells by cost reduction and coal-based systems development for use in stationary, auxiliary, and military applications.

FUEL CELL STANDARDS

	NORTH AMERICAN	INTERNATIONAL
Design and Construction for Safety	CSA America FC 1	IEC TC 105 WG#3
Installation	NFPA 853	IEC TC 105 WG#5
Fuel Cell Module Design		IEC TC 105 WG#2
Performance (Efficiency, Noise, Emissions, Transient Response)		IEC TC 105 WG#4
Building Energy Usage	NIST (Preliminary)	
Electrical Interconnection	NFPA 70, Article 692	
Connection to the Local Utility Mains Grid	IEEE 1547 UL1741, Rule 21	
Performance (Efficiency)	ASME PTC 50 ASERTTI*	

*National Program for the Development and Perfomance Testing of Distributed Power Technologies

The US Fuel Cell Council is the voice of the fuel cell industry, and its trade association. Our membership includes producers of all types of fuel cells, major suppliers, automakers and their suppliers, universities, end users, hydrogen and other energy providers, government agencies, nongovernmental organizations and many others. The US Fuel Cell Council is open to anyone seeking to foster the commercialization of fuel cells.

1100 H Street NW, Suite 800 | Washington, DC 20005 | T. 202.293.5500 | F. 202.785.4313