FUEL CELLS FOR BUILDINGS

WHAT ARE FUEL CELLS?

Fuel cells are modular electrochemical devices that produce power similar to a battery. However, unlike a battery, a fuel cell does not run down or require charging; they continue to operate as long as hydrogen fuel is supplied at the anode. The devices use a readily replenished fuel, such as hydrogen, and oxygen from the air to produce electricity, heat energy and water as a byproduct.

WHAT ARE THE MAJOR BENEFITS OF FUEL CELLS?

Fuel cells are two—three times more efficient than internal combustion engines for stationary distributed generation applications, such as providing primary power generation in remote rural communities. Unlike diesel and gas turbine generators, fuel cells can be scaled to match fuel supply and they do not loose efficiency when operating at "turned down" power levels. Fuel cells are much cleaner, quieter and more reliable than conventional distributed power generation systems. Fuel cells provide both electricity and useful heat energy when they are operating at their most efficient level.

HOW DO BASIC FUEL CELLS WORK?

The fuel stack is where the electromechanical process of converting hydrogen to energy and heat occurs. As hydrogen enters the fuel cell at the anode, the electrons are separated from protons. The electrons produce energy and the protons flow to the cathode, attaching to oxygen molecules to produce water.

Fuel cells have a power module to govern the delivery of hydrogen to the fuel stack. A fuel processor then converts the fuel supply into a hydrogen rich stream, which is purified to an acceptable specification. Maintaining hydrogen purity is critical to life of the system.

The electricity produced by the fuel cell is DC, but if required, conversion from DC to AC power is accomplished in the power electronics module.

WHAT TYPES OF FUEL CELLS ARE USED IN BUILDINGS?

There are over twenty fuel cell technologies (which differ in type by the electrolyte compound), but only five technologies are developed to the point of having reliable products in the market place.

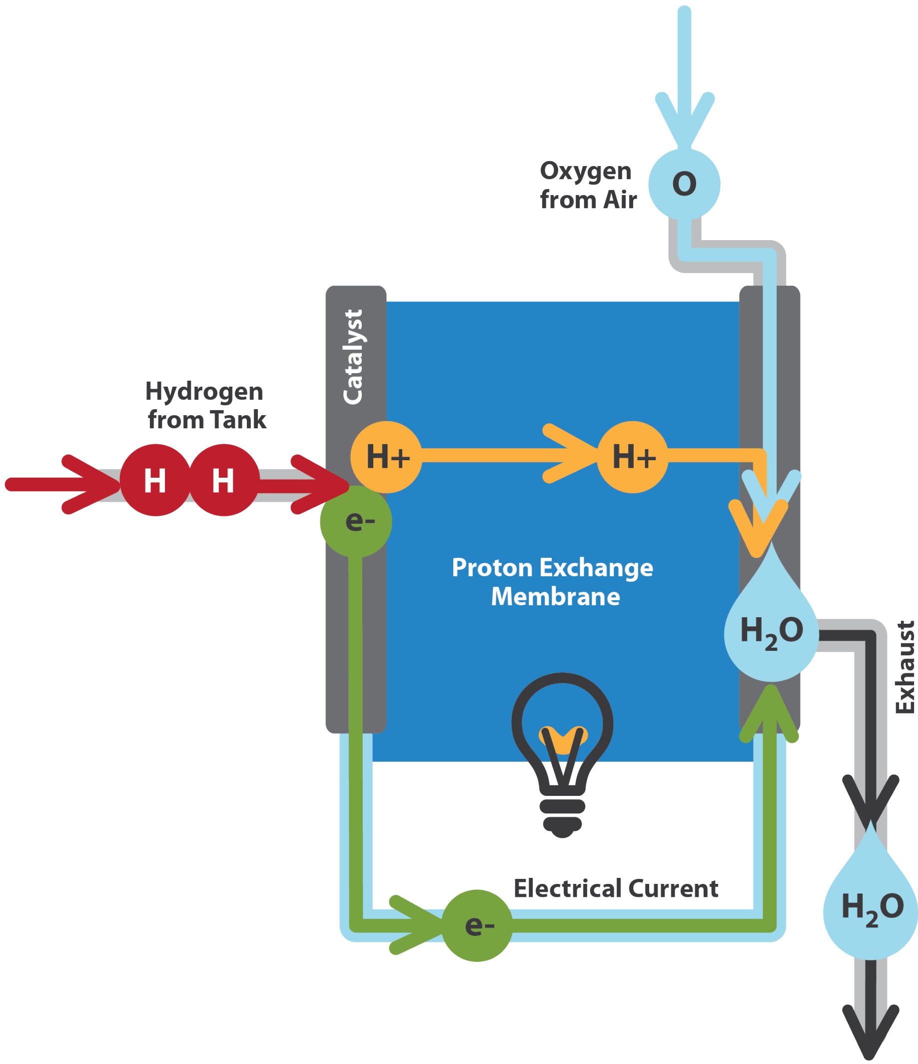
The common fuel cells and their applications are shown on the chart below:

DIFFERENT TYPES OF FUEL CELLS & APPLICABILITY

TYPE OF CELL	ELECTROLYTE	APPLICATION
Alkali	Potassium Hydroxide	Spacecraft and Drinking Water
Molten Carbonate	Carbonates	Large Stationary Power Generators
Phosphoric Acid	Phosphoric Acid	Commercial Stationary Power Generation for Large Vehicles
Proton Exchange Membrane	Acidic Polymer Membrane	Electric Cars and Energy Storage
Solid Oxide	Ceramics (Zirconium)	Cogeneration, Portable Storage

Three technically mature fuel cell technologies are available for stationary distributed generation applications in commercial or institutional buildings as described below:

The Phosphoric Acid Fuel Cell (PA) This "first generation" fuel cell is the most mature fuel cell technology. PA fuel cells are used in schools, colleges, office buildings, nursing homes and hospitals for primary power. These are large fuel cell systems that can deliver 100 KW to 400 KW of power and can achieve an electrical efficiency of 37% to 42% alone, and are up to 85% efficient when used for combined heat and power applications.



The Proton Exchange Membrane (PEM). This type of fuel cell does not require corrosive fluids like some fuel cells; PEM only requires hydrogen and oxygen to product electric power and they run at low temperatures of about 80 degrees C. The electrical efficiency for PEMs is about 45%, which can deliver 1 KW to 100 KW of power for applications. PEMs, which have quick start-up capability, are commonly used for both base power and non-primary power applications such as back-up power, peak load, high quality power and emergency service equipment applications.

Solid Oxide Fuel Cells (SO) These are very high temperature fuel cells used in residential and commercial settings, providing a wide range of power from 1 KW to 2 MW depending on size. The high temperature of SO fuel cells enables internal reformation of fuels. (The process of reformation means the plant can extract hydrogen from hydrogen rich fuels such as methanol.) SO fuel cells are being demonstrated for distributed generation, auxiliary power and electric utility applications.

WHAT ARE THE FUEL SOURCES FOR FUEL CELLS?

Some chemical industries (chlorine and sodium chlorate production) generate hydrogen a by-product. An estimated 1,000 MW of by-product hydrogen is available globally for potential on-site power generation purposes.

Unfortunately pure hydrogen gas is not yet cost-effectively available for most fuel cell building applications, but the natural gas industry has a mature supply infrastructure already in existence. Natural gas, LPG gas and alcohol fuels are often the source fuels for many stationary fuel cells installed today. This sometimes requires a reformer unit to extract hydrogen from the hydrogen-rich fuel. While a pure hydrogen fuel is non-polluting, any fuel conversion process results in some emissions to the air, but is still much less polluting than the cleanest fuel combustion processes.

WHAT ARE THE BEST APPLICATIONS FOR FUEL CELLS IN BUILDINGS?

The two best (and common) applications for distributed generation fuel cell systems are combined heat and power and critical backup power.

Combined heat and power applications for providing primary power offer multiple advantages including very high efficiency, off-the-grid self-sufficiency, reliability, quiet operation and low pollution. The heat generated by the fuel cell's stack can be used for heating through various hydronic heating systems and/or domestic water heating.

Backup power for critical computer and communication systems is a very popular use for fuel cells. PEM fuel cells, in particular, are highly suitable for this application because they are easily configured to seamless operation of critical systems, are capable of fast startup and load following, and have relatively low capital and operation cost.

FUEL CELLS CAN PROVIDE ENERGY STORAGE TO BALANCE LOADS FROM RENEWABLE POWER SYSTEMS

The fuel cell can store energy in the form of hydrogen gas that can balance energy loads from diverse and often intermittent alternative energy sources, such as photovoltaics and wind. Wind and solar may only produce power during certain times, and often are not timed for peak demand. The smart grid is an advanced energy management system that can match peak energy demand with small technologies that store energy to produce electric power and draw upon it as needed.

ECONOMICS

The decision to install fuel cells is often driven by the perceived need for high quality, reliable and consistent backup power for critical functions within the building, often computer systems and communications. Site-specific factors which determine the economics of fuel cells are site load profiles, the cost and availability of electric power from the grid, financial incentives for distributed generation and delivered fuel costs (often natural gas).

CONCLUSIONS

Fuel cells are a key technology in the growing hydrogen economy as well as the distributed generation "revolution." As the world moves away from reliance on polluting fossil fuel use from centralized power plants, scalable fuel cell applications offer a reliable, efficient, and clean source of electricity at the point of use. Hydrogen fuel can be generated by water electrolysis from clean alternative energy technologies, thus producing a viable energy storage capacity to balance the intermittent power generation profiles typical of solar and wind electricity generation. This type of hydrogen fuel is classified as a renewable fuel and energy resource under Federal rules.

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