



## Using Fuel Cells To Replace or Recharge Batteries

*Ted Etter, Project Leader*

**P**ortable or isolated electronic devices can only run as long as their batteries hold up. Larger batteries can continue providing power longer than small batteries, but batteries can only be so large and still be useful. It might be easier to recharge batteries than to replace them with fresh ones, particularly if the batteries could be recharged by a fuel cell.

This tech tip reviews two reasonably affordable fuel cells that run on methanol and can function as battery chargers. Other reasonably affordable fuel cells were being reconfigured by their manufacturers when evaluation was conducted. Because those fuel cells were not available at the time, they were not evaluated.

### Fuel Cell Technologies

Most fuel cells that produce less than a kilowatt of power run on hydrogen or methanol. The weight of hydrogen or methanol in its respective container is considerably less than the weight of a lead-acid battery with the same energy capacity. Although hydrogen was the fuel of choice for early fuel cells, methanol is now preferred for small to medium fuel cells (figure 1) because it is easier to transport; hydrogen requires a heavier container. Because neither fuel can be transported in significant quantities on commercial aircraft, fuel must be shipped by ground to a local cache or to the site where the fuel cell is installed.

### Highlights...

- Small fuel cells can provide from 25 to 250 watts of electrical power in remote areas.
- It may be easier to transport fuel for a fuel cell to charge batteries in a remote location than to transport fresh batteries.



Figure 1—The EFOY Pro 600 fuel cell with a 10-liter fuel container and a typical sealed lead-acid battery.

Hydrogen fuel cells can generate power within seconds once fuel becomes available. The byproducts of the hydrogen fuel cell's operation are water and heat; the water typically is emitted as vapor. Because water is produced as the fuel cell operates, freezing conditions can harm hydrogen fuel cells, limiting their deployment in northern or high-elevation sites.

Methanol fuel cells convert methanol and water vapor into hydrogen and carbon dioxide. The liberated hydrogen combines with oxygen from the air to generate electricity and water, the same process used in fuel cells that run on hydrogen. Separating hydrogen from methanol and water requires heat. During a cold start, methanol fuel cells need 15 to 20 minutes to warm up before they begin to operate. Methanol fuel cells borrow some energy from the battery system when they're warming up. Depending on how the methanol fuel cells purge water from the fuel cells when they power down, methanol fuel cells can be more tolerant of subfreezing temperatures than hydrogen fuel cells.

Fuel cells consume fuel based on the demands of the fuel cell's internal hardware and of the load circuit (the power that operates the portable device or battery charger). Fuel cells require several watts of power to operate their internal hardware. Methanol fuel cells require more power to operate than hydrogen fuel cells because integrated fuel pumps are needed to move the methanol and a heater is needed to break down the methanol. Because methanol fuel cells consume power when they are warming up, fuel cell batteries need to be matched to the fuel cell's capacity. Otherwise, the fuel cell may power down and have to warm itself back up more frequently than necessary.

Adaptive Materials, Inc., manufactures solid oxide fuel cells that can run on propane and have nominal outputs of 25 or 150 watts. These units can operate at temperatures well below freezing, but they cost considerably more than the methanol-powered models discussed in this tech tip.

## Portable Power: EFOY Fuel Cells From Germany

The leading product line for portable methanol fuel cells is the EFOY series from SFC Smart Fuel Cells AG of Germany. The current line of three fuel cells is being replaced by EFOY Pro models that start more reliably, making them better suited for charging batteries than earlier

models. The EFOY Pro models also can operate in hotter—and colder—temperatures than earlier models. While some methanol fuel cells require a mixture of water with methanol, the EFOY Pro series (table 1) consumes pure methanol, producing more watt-hours of electricity per liter of fuel.

Table 1—Comparisons of the EFOY Pro and IdaTech iGen methanol fuel cells.

	<b>EFOY Pro 600/1200/1600</b>	<b>IdaTech iGen</b>
<b>Maximum power</b>	25/50/65 W	250 W
<b>Output voltage (nominal)</b>	12 V	12 V/24 V
<b>Portability</b>	Portable	Stationary
<b>Fuel</b>	Methanol (high purity)	Methanol-water mixture
<b>Fuel energy density</b>	900 Wh/L	500 Wh/L
<b>Operating temperatures</b>	-4 to 104 degrees F	-4 to 122 degrees F

## Economics

The EFOY Pro portable methanol fuel cells cost from \$4,000 for the 25-watt model (the EFOY Pro 600) to \$6,400 for the 65-watt unit (the EFOY Pro 1600). The methanol fuel for EFOY fuel cells produces about 70 amp-hours of electric energy per liter. Standard containers are 5, 10, and 28 liters. A 5-liter container of methanol weighs just under 10 pounds and costs \$66 plus shipping. A 28-liter container weighs 53 pounds and costs \$183 plus shipping.

## More Power

Users who need more than 25 to 100 watts of power can consider IdaTech's methanol-powered fuel cell that delivers 250 watts (see table 1). The iGen (figure 2) is designed for stationary deployments and can operate at temperatures as low as -4 degrees Fahrenheit; an optional cold weather kit enables operation down to -32 degrees Fahrenheit. The price quoted for government agencies is \$5,250. One gallon of





Figure 2—The IdaTech iGen fuel cell can generate 250 watts of electrical power. —Photo courtesy of IdaTech.

methanol-water fuel mixture called HydroPlus (\$5 per gallon plus shipping) produces 2 kilowatt hours of electric energy.

IdaTech also offers an integration kit that includes an electrical interface in a steel NEMA (National Electrical Manufacturers Association) enclosure plus a 12-gallon fuel tank, filter, and fuel pump for \$1,850.

The iGen is available with 12-volt and 24-volt dc outputs. Potential applications include backup power at sites with poor solar coverage or vandalism issues. With several deep-cycle batteries, the fuel cell can deliver enough power to operate 1-horsepower well pumps and similar loads. A pump may draw more than 1,000 watts, but operate only for brief periods. The batteries will provide most of the power for the pump. The fuel cell can recharge the batteries when the pump is not operating.

## Where's the Nearest Filling Station?

Methanol is available in a variety of containers from the various fuel cell manufacturers. The different brands of fuel cells have different connections for their respective storage vessels. Furthermore, the different manufacturers use unique mixtures of methanol and water, so fuel from one vendor probably will not work properly in a different vendor's fuel cell.

## Ventilation

Both hydrogen and methanol fuel cells require fresh air to operate and emit water or water vapor. Methanol fuel cells also emit carbon dioxide and, sometimes, small quantities of carbon monoxide. Heat also is a byproduct of all fuel cells. This is especially true for methanol fuel cells, which have a high-temperature reformer to separate hydrogen from methanol and water.

Some level of ventilation is required, no matter which type of fuel cell is used. Unless water or water vapor is removed, water can accumulate around the fuel cell and its load circuits. In freezing conditions, measures must be taken to prevent frost or ice buildup.

## Applications

Fuel cells are well suited for providing power in covert applications and where solar power is unavailable or unreliable. The battery-charging models can be used to reduce the number of solar panels and deep-cycle batteries needed to provide continuous power at a site. In areas where vandalism or thefts are common, the fuel cells can be placed in secure containers or concealed from plain view. Possible applications include providing power for lighting, fans, telemetry, communications, and recharging batteries for field work.

Because of their initial expense, fuel cells are unlikely to replace existing photovoltaic power installations. However, fuel cells are easier to justify for new installations. Fewer batteries are required for fuel cells than are needed to backup photovoltaic systems. The mechanical work required to house and wire fuel cells is typically simpler than the work required for photovoltaic systems.

## Fuel Cell Suppliers

Adaptive Materials, Inc.: <http://www.adaptivematerials.com>

IdaTech, LLC: <http://www.idatech.com>

Sandpiper Technologies (EFOY Pro models):

<http://www.sandpipertech.com>

SFC Smart Fuel Cell AG: <http://www.sfc.com>

## About the Author

**Ted Etter** joined MTDC in 2002 as an electronics engineer and project leader. He has 20 years of experience working for private industry in the design of test equipment, display devices, and medical instrumentation. For 6 years before joining MTDC, Etter taught courses in the electronics technology program at the University of Montana College of Technology, Missoula. His work at MTDC includes projects in wireless communications, alternative energy sources, instrumentation, and process control. Ted received a bachelor's degree in mathematics from the University of Oregon and a master's degree in teacher education from Eastern Oregon State University.

## Library Card

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Small fuel cells can provide from 25 to 250 watts of electrical power in remote areas. Unlike photovoltaic panels, fuel cells can operate in the dark. Unlike portable generators, fuel cells are quiet. It may be easier to transport fuel for a fuel cell in a remote location than to transport fresh batteries. Fuel cells that run on methanol take longer to begin producing power than those that run on hydrogen, but they're less likely to encounter problems when temperatures are below freezing.

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