PRODUCT TEST

BY GARRETT LAMBERT

A Fuel Cell for Christmas?

Pacific Yachting tests out EFOY's fuel cell system on three different boats, and the results might bring you some holiday cheer

IF YOU WANT TO CRUISE long distances, spend extended periods at anchor and still enjoy modern conveniences, you have to find a replacement for shore power. On boats, battery capacity and electricity consumption are rated in amp-hours (Ah). Increasing the Ah of the house bank by adding batteries will add time on the hook, but they will still have to be recharged at some point.

One of the newest options on the market is the fuel cell, and we recently had the opportunity to test EFOY's fuel cell system out on three different boats.

The Options

High-Output Alternators There are a limited number of ways to charge your batteries while out on the water, and we've all been taught that running the main engine just to charge batteries is a bad thing. However, $1,100 plus labour will replace an OEM low-efficiency alternator with a high output unit controlled by a three-stage external regulator. Together, they will recharge batteries much more quickly and effectively when the boat is underway.

Independent generators can be noisy, require space and maintenance, and just like the main engine, should be under load when running. Unless other appliances are also drawing electricity simultaneously, a generator's efficiency declines markedly as the batteries pass the bulk charging stage and can no longer accept anything like the 90–100 amps the generator is capable of providing. On the plus side, a generator can power anything, and even be set up as a get-home engine. Unfortunately, a retrofit could easily total $25,000.

Solar panels cost about $5 per watt, declining as technology improves; but they are awkward to place, and the largest cost component of a solar installation is often the custom stainless steel required to carry the panels.

More importantly, whether and when that solar watt is actually delivered—12 of which are required to produce a single amp in a 12-volt system—depends on latitude, time of day and clouds. One rule-of-thumb is to expect about four hours per day, less as you go farther north.

According to an internet blog, one sailor's experience with 300 watts of solar in the ideal conditions of the tropics was an average production of 50 Ah a day. However, a local sailor with 520 watts of solar spent almost five months cruising to Alaska last summer, and in one of the rainiest seasons in years averaged about 30 Ah a day.

Wind Generators Sailors are also familiar with wind generators, and know that their noise is not the only drawback. These too are subject to the vagaries of weather. A *Practical Sailor* test of five units from different manufacturers produced average results of 26–64 Ah per day over four days in wind speeds averaging about 11 knots.

Trolling generators, according to another internet blog, provide about six amps at six knots at the cost of a load drag of about 15 kg.

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Enter the EFOY fuel cell

Ever since Ballard Energy developed the hydrogen fuel cell for buses, boaters have wondered when we might have access to the technology. The Canadian Coast Guard has just called for proposals to study the installation of multi-million dollar fuel cells on its next generation ships, but for pleasure boaters realizing that dream remains a long way off as far as motive power is concerned.

However, the EFOY fuel cell that runs on methanol is available to us right now. Reliable, silent, and ecologically friendly, it is designed specifically to recharge battery banks. Two models are sold in Canada: the 1600 ($4,000) rated at 130 Ah per day, and the 2200 ($5,000) rated at 180 Ah per day. (They have the same physical dimensions—about the size and shape of a small sewing machine case.)

The package includes everything required for an easy DIY installation. Because the test unit was going to be moved among three different boats, I screwed the tie-down pans to a piece of plywood and strapped the EFOY and a four-litre fuel canister into them. The electrical connections are made by attaching two pairs of wires to two terminals and took only a few minutes.

One of the pairs feeds 12-volt electricity to the battery bank, the other is for the remote control unit and is long enough to mount at the helm station. Very small quantities of water and CO_2 by-products are vented into the bilge, or if preferred, into a container and outside respectively.

Hoses for both are in the kit. A flexible, shielded fuel tube from the EFOY terminates in a screw-on cap with a probe that fits into the non-spill, recyclable, polyethylene fuel canister.

Does it Produce? Frankly, I was hopeful but skeptical when asked to test one. That perspective was shared by Randy Diamond and Brian Dodsworth, friends who agreed to help me by trialling the unit on their boats as checks against my own experience.

One sailboat, two differently equipped powerboats, and electricity consumption that varies remarkably among the three of us provided a good basis for evaluation. Although we were using the EFOY 1600 whose specifications suggest it is under-powered for the size of our house banks, I think it's fair to say we were each impressed at how well it delivered.

The EFOY is fully automatic, switches itself on when the batteries drop to 12.3 volts and continues to deliver 5.4 amps to 7.5 amps from the 2200—until the batteries reach 14.2 volts when it goes

How It Works

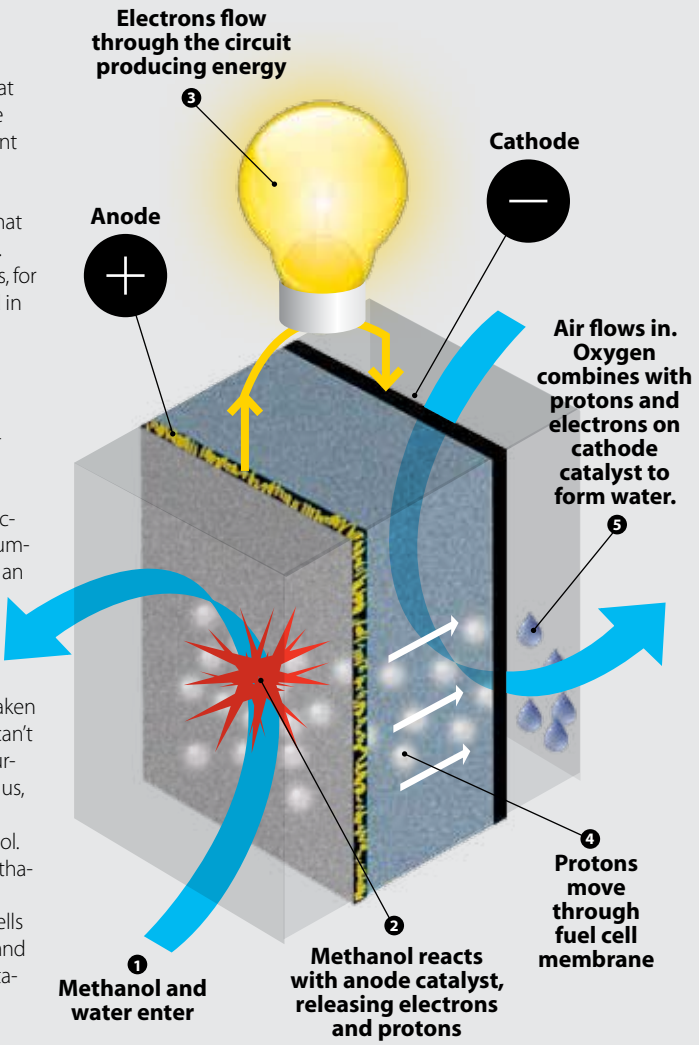
Dree Diamond, Randy's wife, may have referred to the EFOY as "that magical machine," but it's just science that seems like magic. There are more than half a dozen fuel cell technologies based on different inputs, some of them quite exotic. Of these, two are of particular interest to consumers.

The Ballard cell and its kin use expensive, complex technology that produces large amounts of electricity sufficient to power vehicles. The fuel is hydrogen, normally a gas and required in quantity. Thus, for buses and the like, it's compressed into liquid form and contained in big, reinforced tanks.

The other consumer technology is the Direct Methanol Fuel Cell (DMFC). Methanol is attractive for consumer purpose because it's normally a liquid, and its energy density is an order of magnitude greater than even highly compressed hydrogen. Surprisingly, perhaps, methanol fuel cells are comparatively so simple that educational kits can be purchased for less than $200.

The EFOY converts the chemical energy of methanol into electricity. At its core is "the stack," which is a structure that consists of a number of cells. Analogous to a lead-acid battery, each of the cells has an anode (positive terminal) and a cathode (negative terminal). A membrane separates them and also acts as an electrolyte. On the anode side, a catalyst causes methanol and water to react, yielding carbon dioxide, protons and free electrons. The protons pass through the membrane where they combine with oxygen taken from the air and together form water. Because the free electrons can't cross the membrane, they flow through the anode as electrical current before completing the circuit by returning to the cathode. Thus, the EFOY's capacity to provide a continual supply of energy to recharge lead-acid batteries is limited only by the supply of methanol.

As far as hazards are concerned, the degree of confidence in methanol packaging is such that in 2005, the International Civil Aviation Authority voted to allow passengers to carry and use micro fuel cells and methanol fuel cartridges aboard airplanes to power laptops and other devices. In 2008, the United States Department of Transportation followed suit.



back to stand-by mode. These start/stop parameters can be changed by the owner.

Installation is DIY and easy.

Catalina 42 Randy has a Catalina 42 with a house bank of 630 Ah, and typically uses about 100 Ah of electricity a day. He summarized his fuel cell experience after a nine-day cruise.

"I was very pleased with its operation," he said. "It performed well and did what it was supposed to do without any issue. It is quiet, automatic and completely unobtrusive. In comparison to a generator, it produces a smaller amount of power over a longer period of time. So, it would work best in boats that either have a reasonable bank of battery capacity to act as a large buffer to cover intermittent periods where the draw is greater than the EFOY output, or in boats with smaller battery bank capacity that do not have large occasional draws."

Nordic Tug 32 Brian installed the unit on his Nordic Tug 32 with a house bank of 470 Ah, from which he draws about 60 Ah per day.

"We used it on a cruise from 16:00 on Friday, September 21 to 13:30 on Monday, September 24," he said. "At the time of installation the house batteries were close to fully charged. There is very little noise from the fuel cell, so little that I had to listen carefully to hear anything. The main load on our house batteries is the fridge, which was on during the test. The interior lights are the next highest use of power, and with the EFOY on board we used more lights than if we had not had the fuel cell. Battery voltage indicated the fuel cell did its job in keeping the batteries charged."

American Tug 34 I installed it on my American Tug 34, which came to us set up for East Coast marina cruising with two reverse cycle heat pumps, two 120-VAC built-in floor heaters, and so on. Although the house bank is a modest 400 Ah, it is supported by a 6 kW generator that makes wasteful electricity consumption all too easy.

The original plan was to put the

EFOY aboard for a three-week cruise along Vancouver Island's west coast, but I had to leave before the test unit was available. However, on my return I installed it for a total of about three weeks that included a pair of three-day mini-cruises, and a couple of weeks in and out of our slip. During those two weeks, with the full-size 12V fridge running, the inverter supplying some gadgets and a computer, and shore power turned off, the EFOY had no problem maintaining the batteries against a draw averaging about 50 Ah per day.

At anchor it was a different story, for we were consuming about 150 Ah per day and thus exceeding the EFOY 1600's output. (The 2200 would have managed comfortably.)

Nevertheless, the 1600 made a significant energy contribution, and because the net deficit was only 20 Ah per day, we probably could have stayed on the hook for more than a week versus 1.5 days before having to resort to the generator.

Randy and Brian, on the other hand, would have been able to remain at anchor as long as they had fuel. One of the reasons the EFOY is successful is that its modest but continual charge rates allow the batteries to accept all of the energy it puts into them, even when they've reached float stage.

The Concerns

A major concern about buying into expensive new technology is assurance about reliability and support. The EFOY is manufactured by SFC Energy in Germany (*www.sfc.com/en*), which has sold more than 25,000 of them worldwide to

Installation Footnote

Randy's business background is in high-voltage transformers, and he quickly recognized an important installation issue. We all have inverter chargers on board, but because each of us had connected the EFOY directly to our battery banks per the instructions we'd received, the battery monitors had no way to sense the EFOY's charging input. Thus, rather than using state of charge, we evaluated the EFOY's performance by using voltage, and so long as voltage remains at 12.3 or above, the EFOY is doing its job.

Since I have a Magnum Energy inverter-charger on board, I subsequently spoke to a company technician who suggested connecting the EFOY's negative output lead to the inverter side of the battery monitor's shunt rather than directly to the battery bank. (Much easier to do than it sounds.) That will enable the battery monitor to take the fuel cell's charging input into account.

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owners of recreational vehicles, boats and fleet operators including Volkswagen.

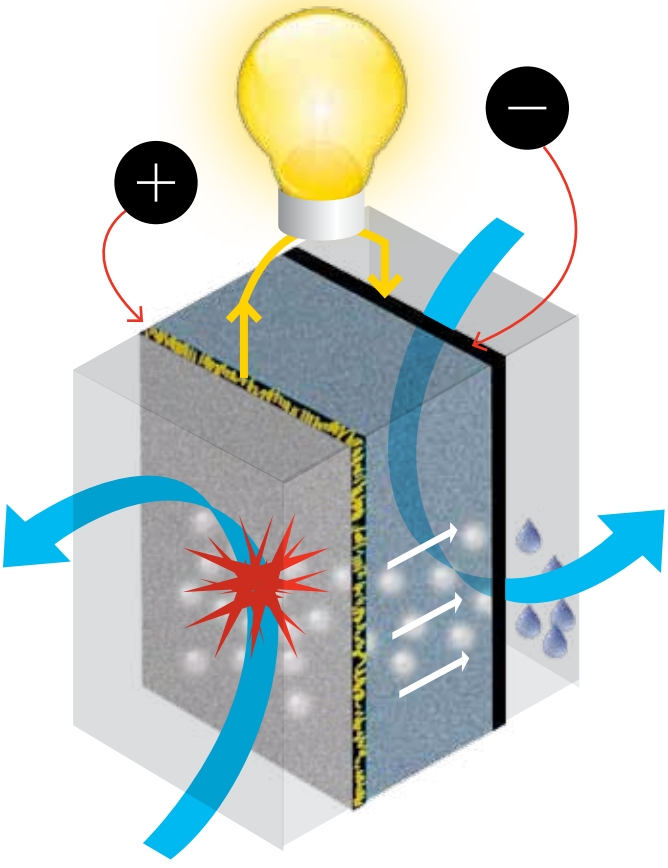
To back up its statement that the units are reliable, SFC provides a three-year warranty during which repairs are free. EFOY units have been sold in the U.S. for several years under the Max Power brand, and if service is required, the North American facility is in Maryland. That's far away, but the units are compact, weigh less than eight kilos, and can be easily removed from the boat, thus making shipping relatively easy.

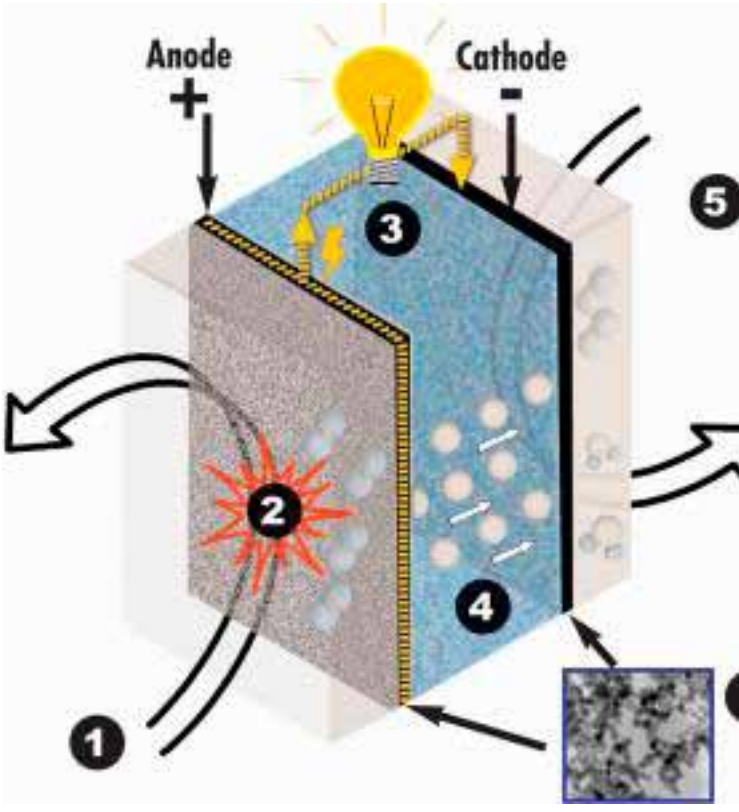
SFC has dealer networks on both Vancouver Island and the mainland. Craig Goodings (*www.standard-hydrogen.com*) is the west coast marine distributor who loaned me the EFOY with two four-litre fuel canisters, one full and one about two-thirds full. When I suggested that any methanol from a reputable supplier ought to work, Goodings disagreed. He said that SFC would happily get out of the fuel side of the business because it runs at small loss, but the methanol must be certified to be of ultra-high purity to ensure that the fuel cell itself will not be contaminated, so for now users must use the canisters supplied by Standard Hydrogen. Craig suggested that a canister should last for about 10 days of cruising, but collectively we managed almost twice that, and the tests were completed with about a half litre of methanol remaining.

A canister distribution network is being established, but until it's sufficiently widespread, fuel is available from Standard Hydrogen who guarantees it will deliver canisters as, when, and where required. A canister costs $65, or between $3 (our collective experience) and $6 per day (SFC's estimate) of cruising.

Is It For Everyone?

Is this technology the answer to every boater's needs? Not quite. It can't replace the consumption of major appliances such as heaters, air conditioners, washer-dryers, water-makers, furnaces and so on—only shore power or a generator can do that. However, if you don't need that capacity, or require it only rarely, our experiences on three different boats indicate the EFOY is a viable, convenient, eco-friendly and cost-effective way to extend cruising range and duration.

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