



# Indo Marine Engineering Co. Pvt. Ltd.

A-7, Panna Industrial Estates, Plot T-204, MIDC, Bhosari, Pune 411-026. Maharashtra India  
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**The Marine Fuel Cell** can supply power for all 12 V on board equipment providing power while in an idyllic anchorage or on a long passage in total silence for the ever increasing list of 12V equipment; electronics, refrigerators, microwaves, inverters and even water makers all of which are being fitted to sailing yachts.

Weighing a mere 7kg, the MFC can deliver 100 A per day of clean 12 V dc power. The unit is compact and easy to use, installation is rapid with no need for insulation, wet exhausts or cooling water inlets.

Capable of running 24hr/day, the fuel cell continually supplies power as needed. This "constant power" approach reduces the Charge/Discharge cycles imposed on house batteries, thereby significantly increasing their service life.

Fuel cells are ecologically friendly and with the capacity to replace fossil fuel, they are now a reality with the potential to power the next generation of yachts.

## WHAT IS A FUEL CELL?

A 'Fuel Cell' is a device that converts the chemical energy of a fuel (hydrogen, natural gas, methanol, gasoline, etc.) and an oxidant (air or oxygen) into electricity. In principle, a fuel cell operates like a battery. Unlike a battery however, a fuel cell does not run down or require recharging. It will produce electricity and heat as long as fuel and an oxidizer are supplied. Both batteries and fuel cells are electrochemical devices. As such both have a positively charged anode and a negatively charged cathode and an ion-conducting material called an electrolyte. Fuel cells are classified by their electrolyte material. Electrochemical devices generate electricity without combustion of the fuel and oxidizer, as opposed to what occurs with traditional methods of electricity generation.





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Fuel cell construction generally consists of a fuel electrode (anode) and an oxidant electrode (cathode) separated by an ion-conducting membrane. Oxygen passes over one electrode, and hydrogen over the other, generating electricity, water and heat. Fuel cells chemically combine the molecules of a fuel and oxidizer without burning or having to dispense with the inefficiencies and pollution of traditional combustion.

## FUEL CELL FUNCTIONALITY

Fuel cells generate electricity from a simple electrochemical reaction in which an oxidizer, typically oxygen from air, and a fuel, typically hydrogen, combine to form a product, which is water for the typical fuel cell. Oxygen (air) continuously passes over the cathode and hydrogen passes over the anode to generate electricity, by-product heat and water. The fuel cell itself has no moving parts – making it a quiet and reliable source of power.

## FUEL CELLS VS. TRADITIONAL ELECTRICITY METHODS

In traditional methods of generating electricity, the fuel and air are burned, generating a high-temperature gas. In the case of a coal-burning power plant, heat is transferred from this hot gas to high pressure liquid water that is boiled. In the case of a gasoline, diesel or gas turbine engine, the hot gas itself is at high pressure. The high-pressure steam, or hot gas, is expanded in a mechanical device (e.g., cylinder, turbine) and ultimately turns an electrical generator.

In a fuel cell, the same basic chemical reactions occur, but generate electricity directly as an electrochemical device and therefore, never goes through the step of being a high-temperature gas through normal burning. This direct conversion of chemical energy to electrical energy is more efficient and generates much less pollutants than traditional methods that rely on combustion.

## WHICH IS BETTER?

As mentioned above, the direct conversion of fuel and air to electricity is much more efficient than internal combustion engines and other methods of generating electricity. Therefore, fuel cells can generate more electricity from the same amount of fuel.

Furthermore, by skipping the combustion process that occurs in traditional power-generating methods, the generation of pollutants during the combustion process is avoided. Some of the pollutants that are significantly lower for fuel cells are oxides of nitrogen and unburned hydrocarbons, (which together cause ground-level ozone), and carbon monoxide (a poisonous gas).





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## Frequently Asked Questions

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**Power supply ?** A modern yacht will invariably have more electrical equipment than previously: electronic navigation, fridges, microwaves, inverters & even water makers, are all adding to the ever increasing list of 12v equipment commonly fitted to sailing yachts. All this draws power from the yachts battery bank which therefore needs charging more frequently & for longer periods. Often the yachts service battery bank will even need to be increased in size.

**A new power concept.** Offering a new concept in power generation a fuel cell runs 24h/ day. Its power output therefore needs to be considered over a 24h period. This is a revolution in yacht power management as up until now yachts needed to store power generated in a short period for use over the day. Power from the main engine, a generator, or shore power were the only dependable power source a yacht had. None of these could run 24h day & all had a high nuisance factor.

**How about a wind generator ?** Almost useless in the Mediterranean summer or when sailing down wind, the wind generators on the market currently are both noisy & ugly. Add to this the fact that "protected from the wind" is considered to be an asset for an anchorage, the wind generator is not an all round solution.

**Solar panels ?** A typical solar panel with a 10 W rating will give an average of 4 A per day during the 6 best months of the year in Europe. For arguments sake lets make that 6 A in mid summer in the Med. Following that logic you would need 170 W of solar panels at nominal power, to produce the same power as an AHD 100 Fuel cell. With the best technology available today that's 18kg & 1956 mm x 715mm with a prayer that you don't get a cloudy day. Cost ? Around 2000 € including the Eiffel tower / Golden gate bridge construction over the cockpit.

**Yes, but with 5000€ ? I could almost fit a 2kw diesel gen set for that !** Almost ! a 2kw diesel gen set costs an absolute minimum of 5500€. With a Fuel cell the 5000€ is a net cost, with virtually no installations expenses. A diesel generator will need; A seawater inlet An expensive & voluminous exhaust system. Lifting of the yacht for installation. In all, an installed 2kw diesel gen set costs an absolute minimum of 6500 €. Not to mention the fact that when its running it will produce a loud rattle & clouds of black smoke!

**How about a free standing petrol generator @ 1000€ !** These are invariably air cooled & with free exhausts. They therefore need to be free standing on deck. The noise, smell & nuance factor is 10 x that of even a diesel type . Not to mention the dangers linked to transferring petrol from a jerrican to a small fuel tank on deck at sea.

**But 100A per day isn't 2kw !!** Your right is not, it's 50 W, but your 2 kW genset is only running for 2h per 24h at the most. So that's already only 166w in 24h terms. Then add to that the 220v to 12v battery charger efficiency (about 50%) Reduces that to 83w in 12v fuel cell terms. Then you have the charge efficiency to include in your calculation.





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**Charge efficiency ?** Yes deep cycle batteries can only accept a charge of a maximum of 20% of their capacity per h (without damage) 10% is therefore considered a normal charge. At this charge rating the batteries only hold 85 % of the power pushed into them. So when charging a 100 Ah battery bank @ a rate of 10 A only about 8.5 A is really held inside the battery. However when slow charging (less than 5% of capacity) this figure can go up to 95% ! Again this weighs in favour of the Fuel cell.

**Direct channel; Fuel cell to power consumer.** Once this is understood, you can then assimilate another important factor. A fuel cell is producing power constantly 24 h/day & the yacht is consuming power 24 h a day. This means that your battery bank is only there to supply, momentary surges in power consumption & stock excess fuel cell power for future momentary surges. In a word you never really discharge your batteries, they are constantly held at between 70 & 85 % of their full charge. Most of the time equipment such as the fridge & electronics or auto pilot are in effect being powered directly through the fuel cell.

**Can I use a smaller battery bank if I fit an MFC ?** Yes yachts use large battery banks to store electricity produced during one or two hours of engine run time. This power is then used over the remaining 22 h of the day. If you are producing power constantly during the full 24h then you no longer need all that storage capacity.

**How big should my battery bank be ?** You remember we said charging @ only 20% of total capacity is already considered as a "fast charge" ? Well if you need to consume 100 A per day & you want to replace that power in 2 h, then you need to charge at 50 Ah or 60 A counting efficiency: 20% of 300Ah = 60A . In a word if you respect the rules, you need a minimum 300 Ah battery bank to consume 100 Ah per day & recharge in 2 h! Even with this you will be fast charging & heavily cycling your batteries. This is why yachts give their batteries such a hard time. With an MFC running all the time your battery bank could be as small as 100 Ah & still be capable of supplying your on board functions.

**Will an MFC prolong battery bank life ?** Yes very much so ! Battery's on yachts suffer from two main aggressions: The first is deep discharging (or deep cycling ) The second is over fast charging (faster than 10 % of total capacity) Both of these factors create premature battery death. Both of these problems are solved using a constant charge as with an MFC.

**How often will I need to change the fuel cartridge ?** One 4.4 kg fuel cartridge will last over 3 days on full power, or will produce 340 Ah of 12 V dc power over a much longer period if running intermittently.

**Isn't this totally new, & untested technology ?** Not really, NASA first used fuel cells on space craft over 40 years ago & have been doing so ever since. Cost & fuel storage have been the main problem not the actual Principe of using fuel cells in this sort of application. The new part comes with the relative simplicity of using DMFC's (direct methanol fuel cells ). Replacing Hydrogen by methanol has allowed the Max Power Marine fuel cell to be brought to market.





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**Can I use an MFC to automatically charge the batteries of a yacht kept on a swinging mooring?** Yes the MFC 100 AHD will automatically monitor your batteries, switch on to charge when needed & shut down when no longer needed. This will guarantee power is always available for critical equipment such as bilge pumps & automatic anchor lights.

**So what kind of equipment can be run from the MFC 100 AHD?** This unit was originally designed to run the "house & sailing system's" of a 35' to 45' sailing yacht . This would typically include a fridge, interior lighting, navigation lights, electronics, pumps, auto pilot etc.

**What happens if you use more than 100 amps per day?** You return to the configuration you had before the MFC existed. In other words some engine run time will be needed to top up the extra power. That said even in perfect sailing conditions your engine will always be needed at least for entering & leaving your anchorage.

**Do I need to switch the MFC off when motoring?** No the MFC will automatically switch off when the engines alternator takes over the job of charging your batteries.

**Can I use an MFC to power a water maker.** Yes, the MFC 100 AHD produces 100 A per day & modern low pressures water makers use 8 amps for 30 l of fresh water. Using this type of water maker you could produce over 350 l of water per day from the MFC's power. If you look at the question from another view point a single 4.4 kg fuel cartridge represents 1150 L of fresh water !

**How do I get new Fuel cartridges ?** Max Power is part of the Navimo group (Plastimo) & will therefore be using Navimo's distribution network to make fuel cartridges available, this will initially be through ship-chandlers but will rapidly include fuel stations.

**Can two MFC's be connected in parallel to make 200 A per day ?** Yes, Fuel cells behave like batteries they can therefore be connected in parallel.

**Can a MFC be run in confined spaces ?** Yes, but ventilation will be needed. The by-product of an MFC is a small quantity of Carbon dioxide, a bit of pure water & some heat. The carbon dioxide proportion is about same quantity as in the breath of a small child.

**Will an MFC need servicing ?** Ultimately yes. A Fuel cell is by definition infinitely more reliable than an internal combustion engine as it has few moving parts. That said it's heart (the cell stack) will eventually start to degrade much in the same way as a battery & performance will slowly drop. The life of the stack will vary widely depending on usage, however, the absolute minimum life of a stack is of 1500 h & can easily exceed 5000h. In all cases replacing a stack is a simple exercise & Max Power can service the unit with minimum delay.

**How do I get my MFC serviced ?** Your MFC 100 weighs only 7kg & therefore can, unlike a 120kg generator, be returned to a service center with the ease of a laptop computer. In this way your fuel cell always gets serviced by experts & not by a local "odd job man ".





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## POWER CONSUMPTION

### CONSUMPTION OVER 24 HOUR PERIOD WHEN SAILING

Consumers	Consumption		Time	%on	Consumption 24hrs	
	Watt	Amp	24hrs		kWh	Ah(12V)
C Navigation instruments		0.2	24			5
C GPS		0.2	24			5
C VHF standby		0.1	24			2
transmitting		5	0.2			1
C Refrigerator, air-cooled heat exchanger	50	4.2	24	50		50
L Tricolour navigation light or anchor light	25	2.1	8			17
L Autopilot		5	20	30		30
L Radio		1	3			3
S Cabin Lighting	200		0.6			10
S Other						5

Total consumption per 24 hour period					1.5	128
Average consumption per 24 hour period	64	5.3				

Minimum battery capacity required, assuming 2 recharges per day						256
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### CONSUMPTION OVER 24 HOUR AT ANCHOR WITHOUT 230 V SHORE POWER PICK UP

Consumers	Consumption		Time	%on	Consumption 24hrs	
	Watt	Amp	Hours		kWh	Ah(12V)
C Refrigerator, air-cooled heat exchanger	50	4.2	24	50		50
L Masthead Light	25		8		0.2	17
L Radio		0.1	3			3
S Cabin lighting, ten 20 W lighting points	200		0.6			10
C Other						5

Total consumption per 24 hour period					1	85
Average consumption per 24 hour period	42	5.3				

Minimum battery capacity required, assuming 2 recharges per day						170
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