M-PP-0113

Power Pack Operating Manual

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Forward

Thank you for purchasing Ensol System's Power Pack.

Please read through this reference guide before operating the unit as it contains particular start up, shut down and disconnection procedures.

If you have any questions or concerns, contact Ensol at:

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Section 1 – Transportation and Storage

Since the EFOY Pro fuel cells contain water, they must be protected from freezing. IF A FUEL CELL FREEZES, IT MAY BECOME DAMAGED AND MAY NOT BE COVERED UNDER WARRANTY. When installed in Ensol's Power Pack, the fuel cell will keep itself warm, but only if this system is turned on, connected to a fuel cartridge and to batteries over 9 VDC. If the Power Pack did not come with batteries, the fuel cell will not be able to run the Anti-Freeze Mode, and therefore must be stored or transported in a heated atmosphere.
For more information on the Anti-Freeze capabilities of the fuel cell, see section 4.7 Anti-Freeze Protection Mode.

Before transporting or storing the fuel cell, complete the following steps:

1. Ensure all fuses and/or circuit breakers are closed or set to 'On'.
2. Check that the fan is operational by dropping the thermostat setting all the way down. Once the check is completed, set the thermostat to 30°C or 90°F.
3. Confirm that the fuel line is tightly connected to an adequately filled fuel cartridge. Without fuel the Anti-Freeze Mode will not be able to function.
4. Connect the exhaust/vent lines to the water collection tank.
5. Set the fuel cell to Auto, by pressing the power button on the remote, until the remote reads 'Auto'.
6. Closed the Power Pack lid and ensure that it is properly sealed shut.

By following these steps, the EFOY Pro should never freeze, provided there is fuel in the cartridge.

If the system is to be stored for a long period of time, periodically check the fuel cartridge level. We recommend you check it once a month, even though the fuel will last much longer.

Section 2 – Quick Startup Procedure

1. Ensure all fuses and/or circuit breakers are open or set to ‘Off’
2. Connect the battery leads to the batteries if required.
3. Plug the remote into the RJ45 port labeled ‘Remote’ on the fuel cell.
4. Connect fuel line to methanol cartridge.
5. Ensure all fuses and/or circuit breakers are open or set to ‘Off’
6. Connect the battery leads to the batteries if required.
7. Plug the remote into the RJ45 port labeled ‘Remote’ on the fuel cell.
8. Connect fuel line to methanol cartridge.
9. Insert the exhaust tube from the fuel cell, to the water collection tank port.
10. Ensure the 2” exhaust port from the water collection tank is connected.
11. Plug the power connector into the fuel cell.
12. Close all fuses and/or circuits breakers.
13. Turn the system on using the power button on the remote, or the button on the fuel cell.
14. If the display of the remote control shows “Automatic“ – device is ready
15. Functionality check: Switch on device manually – check if charging starts (this is only possible if battery voltage < 13.2 V)
16. Ensure the thermostat is set at an appropriate temperature for cooling the unit (less than 45^{o}C).
17. Remove any tools from the enclosure, store service fluid and user manual.
18. Close the enclosure and ensure that it is properly latched and sealed.

Section 3 – General Information

3.1 Product Introduction

The Ensol Systems Power Pack can be used to provide reliable power for measurement and control equipment, air compressors, chemical injection, communications, surveillance and a broad range of other applications.

Powered by a DMFC (Direct Methanol Fuel Cell), these packages are reliable even in the most remote and harsh environments.

These systems can be used in conjunction with other power systems. Typically Ensol ties the fuel cell packages into existing solar systems. The design philosophy then is to use solar energy when you have it, with a methanol fuel cell as a back-up when you don't. This will provide you with 100% reliable power even in the darker months of winter.

3.2 Product Specifications

	EFOY Pro 600	EFOY Pro 1600	EFOY Pro 2200
Max. Energy Output	**600 Wh/day**	**1,560 Wh/day**	**2,160 Wh/day**
Nominal Power	**25 W**	**65 W**	**90 W**
Hybrid Power Solutions	**Cascading multiple EFOY Pro units and integrating them into hybrid solar or wind packages provide significantly higher power**		
Nominal Current @12 V / 24 V	**2.1 A / 1.05 A**	**5.4 A / 2.7 A**	**7.5 A / 3.75 A**
Operating Temperature	**-40 to +45 °C (Storage Temperature 1 to 45°C)**		
Methanol Consumption	**0.9 L/kWh (0.24 US gal/kWh)**		
Package Dimensions (L x W x H)	**960 x690 x660 mm (37.75x27x26 in)**		
Enclosure Weight	**130 kg (285 lbs)**		

Section 4 System Installation

4.1 Installation Overview

The Fuel Cell Power System's electrical rating is General Purpose and shall therefore be installed outside the Hazardous location. Typically the system will be mounted 3 meters away from any source of gas and 0.6 meters off the ground.

The Power Pack also has an exhaust port located on the bottom of the unit. In order for the unit to operate, this port shall not be blocked and needs at least a 30cm space left open below it.

4.2 Batteries

Sealed Lead-Acid batteries may be provided to store the fuel cell energy. Battery cables provide the link between the batteries, equipment and charging system. Faulty connections can lead to poor performance, terminal damage, meltdown or fire.

Batteries Inspection

- Examine the outside appearance of the battery. The tops of the batteries and terminal connections should be clean, free of dirt and corrosion, and dry.
- If fluid is on the top of a gel or AGM battery this means that the battery is being overcharged and the performance and life will be reduced
- Check battery cables and connections. Replace any damaged cables with a min. #12 AWG. Tighten any loose connections.

Changing or Disconnecting Batteries

- Use extreme caution while working on the batteries and ensure appropriate PPE is utilized.
- First isolate the batteries from the electrical system by disconnecting all fuses and/or circuit breakers.
- Disconnect the leads from the batteries, first beginning with the positive leads, then continue to disconnect the remaining batteries from one another
- When reconnecting the batteries, please ensure that they are wired appropriately for 12 or 24VDC as your electrical system requires. Wiring the batteries incorrectly can result in an over voltage condition and damage process equipment wired to the Power Package.
- Once the battery bank is connected, check that the voltage going to the system is within the range (dependent upon a 12 or 24VDC electrical system). If the wiring is correct and the voltage is still not within the correct range test each battery individually to see if any are defective or damaged.
- If the voltage is within the range reconnect all the loads via the fuses and/or circuit breakers.

4.3 Methanol Fuel Cell

The EFOY Pro Fuel Cell will already be mounted, but all its accessories still may need to be connected.

Connect all accessories in the following order:

- First, connect the methanol fuel cartridge. Screw the M28 cartridge adapter to the cartridge if not already done so. Then connect the fuel line to the cartridge. If there is only one cartridge in the system, screw the fuel line from the fuel cell to the top of the M28 adapter.
- Second, connect the exhaust tubing line to the EFOY Pro fuel cell's exhaust port. This is a small tube stub protruding just next to the fuel line. Push the other end of the tube into the water collection tank. Then connect the 2" exhaust pipe through the bottom of the enclosure.
- Third, connect the wiring harness and remote to their respective ports. Ensure that the remote is plugged into the 'Remote' RJ45 port and not the 'Data' port.

Section 5 System Operation

5.1 General System Operation

The Power Pack is a simple system consisting of a methanol fuel cell to charge a bank of sealed lead-acid batteries. This stored electrical power is then used to run measurement and control equipment and whatever other loads may be involved. A typical hybrid application where the fuel cell is connected in parallel with a solar system is illustrated in Figure 1.

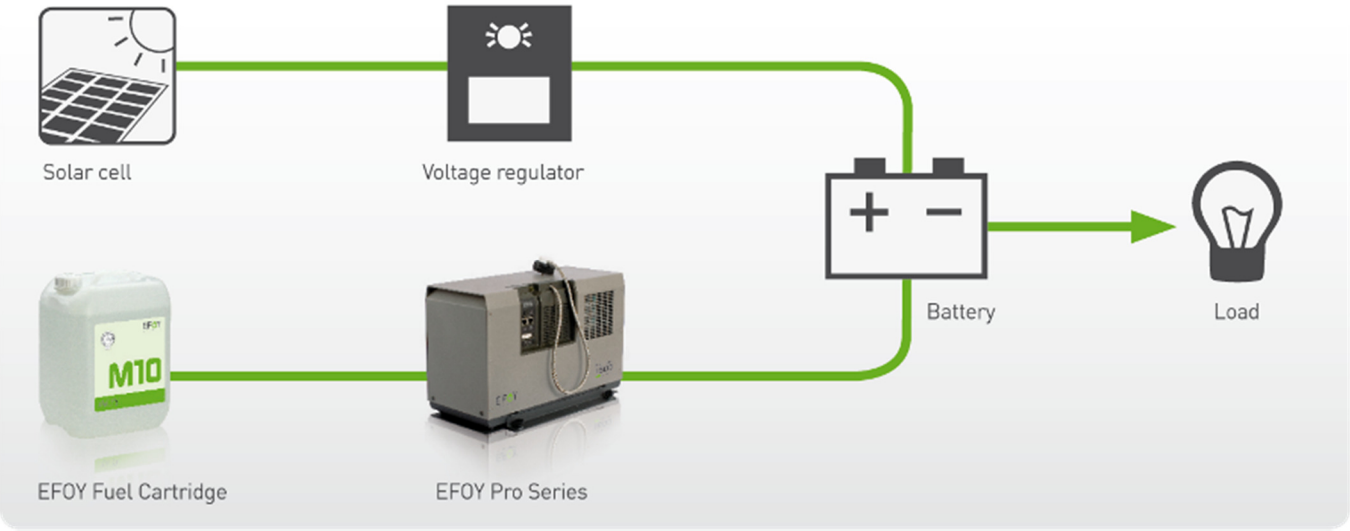
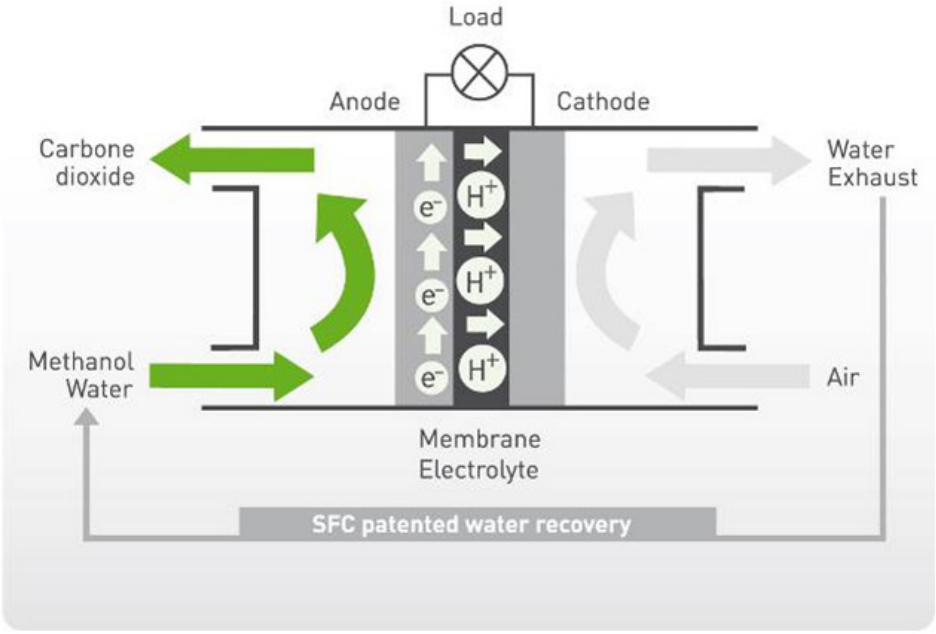


Figure 1 – Hybrid System

5.2 Fuel Cell Operation

The EFOY Pro fuel cell uses a catalytic process to directly convert methanol into electricity (see Figure 2). The byproduct of this reaction is water, small amounts of CO_2 and heat. To eliminate freezing, the water must be collected internally. The collected water should be changed out at the point in time that the fuel cartridge is replaced.



Methanol + Oxygen → Carbon dioxide + Water vapor

$2\ CH_3OH + 3\ O_2 \rightarrow 2\ CO_2 + 4\ H_2O$

Figure 2

Since the EFOY Pro fuel cell is a 'smart' fuel cell, charging and monitoring to the batteries is handled automatically (example in Figure 3). With the remote, which is included, the user can view the charging mode, battery voltage, charging current, system operating hours and firmware version, and can also change the charging mode. By pressing the power button on the remote, the user can turn the system off, put it in automatic or turn the system on for one charge cycle.

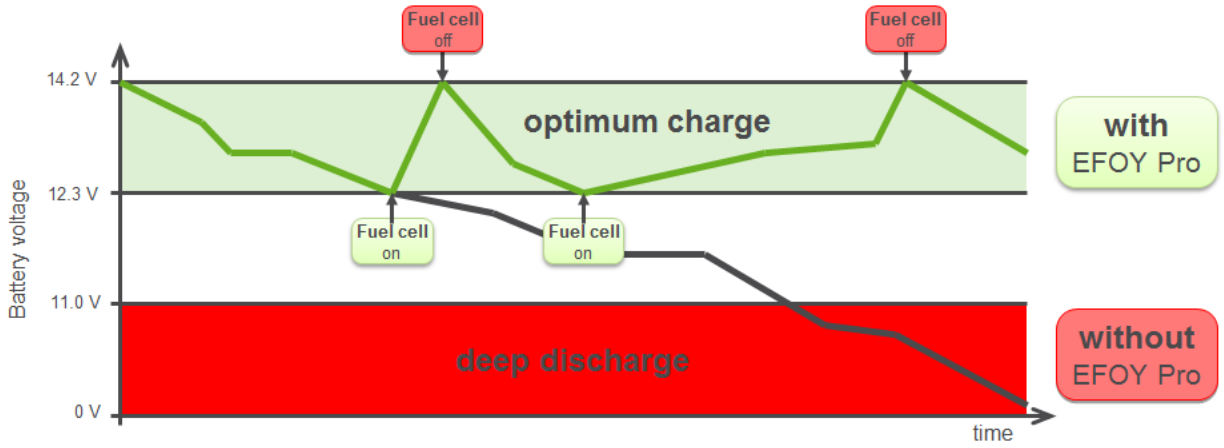


Figure 3

Ensol Systems has pre-programmed the fuel cell's parameters for the installation location. If charging voltage set points need to be altered, please contact Ensol Systems.

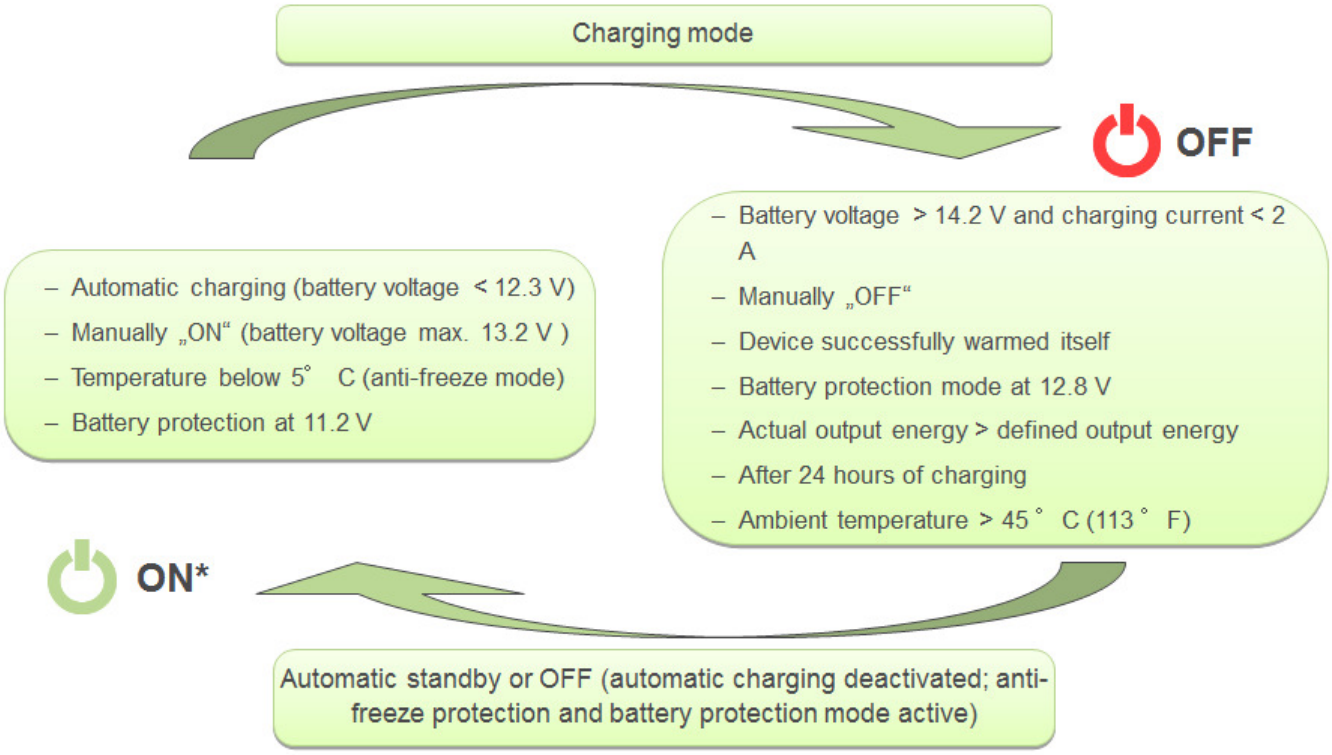
For a full description of the EFOY Pro fuel cell's operation, please see the manual provided by SFC's document 101123_UM_EFOY_Pro_GB_v02.

5.3 UN Certified Methanol Fuel Cartridges

The EFOY Pro uses special plastic fuel cartridges to facilitate ease of use and transport:

- The methanol fuel cartridges are UN certified containers certified for transport on cargo planes.
- The containers are spill resistant and designed to withstand significant impact force.
- Ensol Systems will recycle empty plastic cartridges and dispose of any residual methanol if necessary.
- 28L cartridges are the largest available size and a cartridge adapter is required to use this cartridge with the EFOY Pro fuel cell. DO NOT THROW AWAY THE CARTRIDGE ADAPTER!
- The fuel cell methanol is ultrapure. Do not puncture the cartridge. To avoid contamination, do not transfer residual methanol from an old cartridge to a new cartridge. DO NOT USE ANY OTHER METHANOL SOURCE TO FUEL THE EFOY PRO! Impure/contaminated methanol will severely degrade the performance and life of the EFOY and will **VOID WARRANTY**.

5.4 Operational States

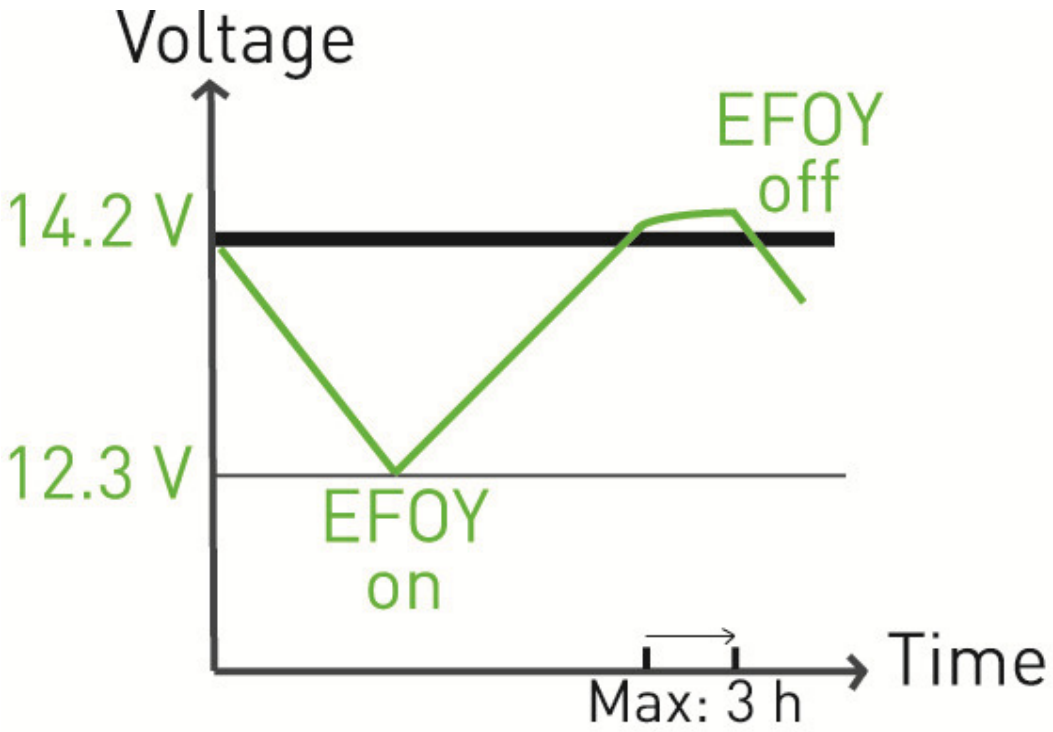


- Note that a minimal battery voltage of 9.0V or 18.5 V is required for the EFOY Pro to start.

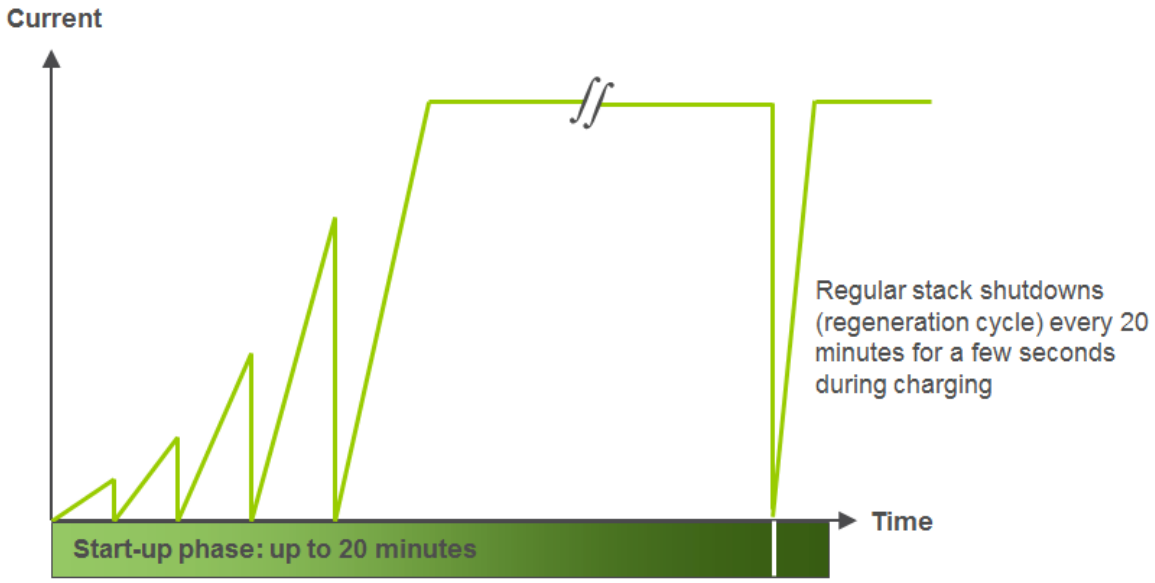
5.5 Default Parameters of cutoff threshold

New charging strategy (firmware 9.20 since mid of August 2010):

- Switch on voltage: 12.3 V (11.0 - 13.0 V), or 24.6 V (22.0 – 26.0 V)
- Switch off voltage: 14.2 V (13.5 - 14.7), or 28.4 V (27.0 – 29.4V)
- Switch off current: 2 A / 4 A @ EFOY Pro 2200 (0.5 - 10 A)
- Switch off time: 3 hours (0 - 5 hours)
- This ensures full battery charging and maximizes battery life

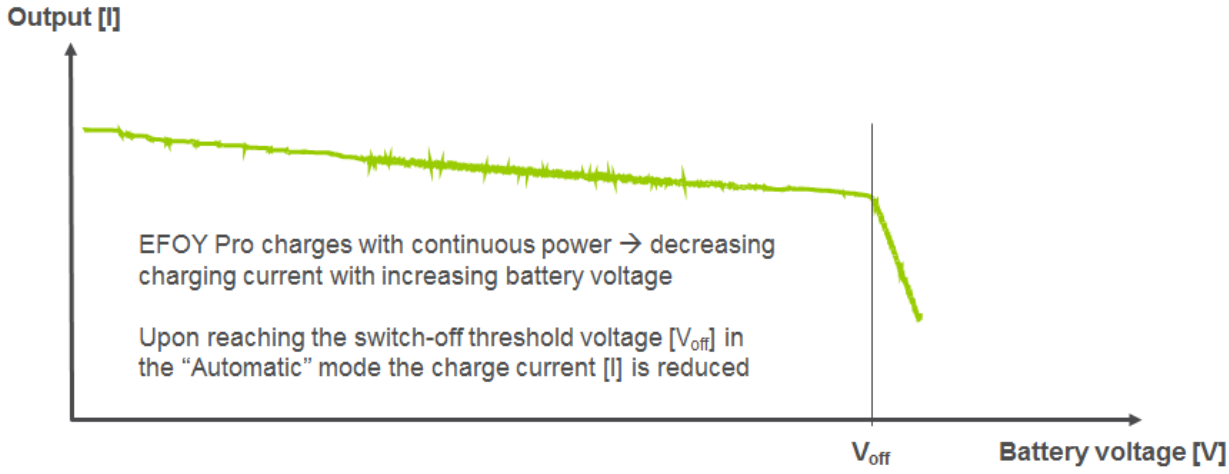


5.6 Startup and Shutdown Phases



Note:

- Device needs a start-up phase of 10 -20 min to achieve full power
- During start-up phase several starts until full power is achieved



End of charging

- The switch-off process allows a controlled disconnection of the EFOY Pro Fuel Cell
- The switch-off process may take up to 30 minutes
- Avoid interrupting the switch-off process!

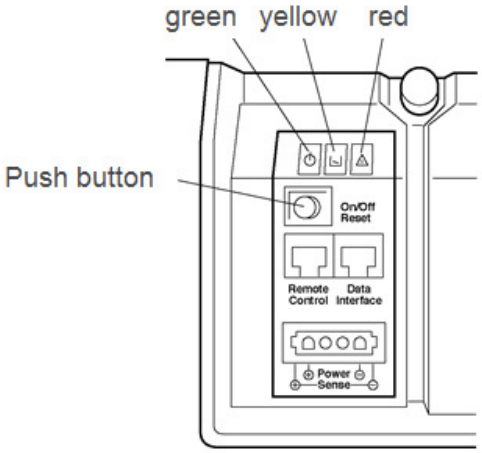
5.7 Anti–Freeze Protection Mode

- Note that the standard Ensol Systems Power Packs are rated to -40°C operation.
- THE ANTI-FREEZE PROTECTION MODE WILL NOT WORK WITHOUT FUEL! Please ensure that the fuel cell does not run out of methanol in freezing temperatures. If the fuel cell freezes, 24 hours will be required for the fuel cell to warm back up and be returned to service. Please note that freezing the fuel cell may cause irreversible damage to the fuel cell. If this is the case, the fuel cell will need to be sent to Ensol for a service.
- The Anti-Freeze Mode will keep the EFOY Pro warm while the temperature is below 5^{o}C (This will work even when the unit is “OFF”).
- Anti-Freeze Mode requires the connection to a faultless, adequately charged battery and fuel cartridge.
- Fuel consumption will be dependent upon external temperature differential. Weather, insufficient insulation, ambient temperature and operating mode can have an impact on fuel consumption. An approximate fuel consumption estimation is 5-10L for a 5 month winter period, in Anti-Freeze Mode only.
- The EFOY Pro does not give the produced energy to a fully charged battery in Anti-Freeze Mode. Rather, the stack “burns” methanol and supplies the peripheries (pumps, etc…) to heat up the system. The batteries will not be overcharged.
- The EFOY Pro can operate in -20 ^{o}C temperature. Proper heat management and insulation is required to ensure reliable operation at -40 ^{o}C.
- Startup temperature (when the Anti-Freeze Mode has not been activated) is 5 ^{o}C.

5.8 Operation at the Device

Push button

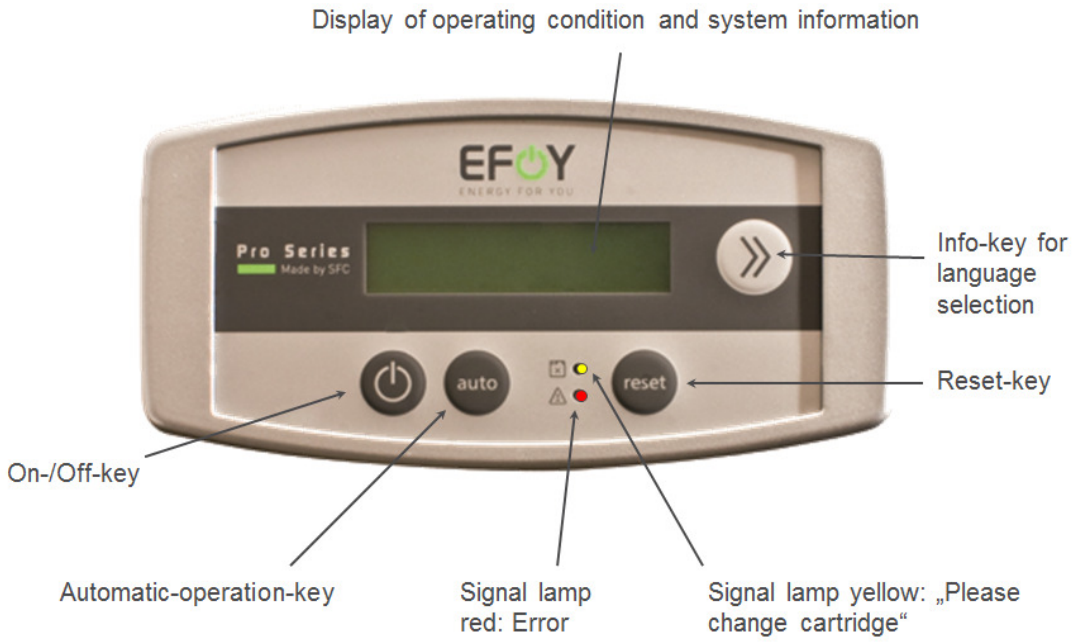
	Result
Push shortly (< 0.5 s)	Reset
Push longer (> 3 s)	On/Off



LED state

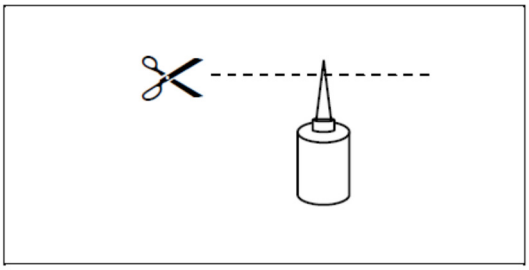
	Green	Yellow	Red
On	Ready	Add service fluid	Error
Blinking	Shutting down	Cartridge empty	Interruption
Off	Off or error	No error	

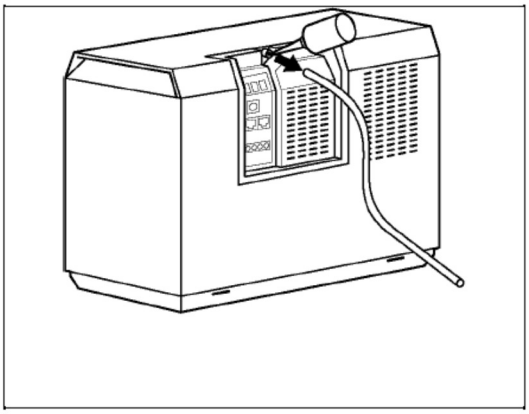
Remote Control:



5.9 Service Fluid

- If service fluid is low the yellow light will turn on at the EFOY Pro and the message “Please refill service fluid” will appear at the control panel display.
- Normally, there is no need to add service fluid prior to the initial start-up, but if the fuel cell has been stored for a longer period of time, this may need to be done.
- Note that the fuel cell produces its own service fluid during operation. This is critical to the function of the device. If the EFOY Pro is operated continuously at temperatures above the acceptable operating range (45 °C), the service fluid will be expelled faster than it can be regenerated and cause a failure. For this reason, it is critical that the thermostat and fan provided with the Power Packs are maintained in working order and set at an appropriate temperature.
- Service fluid can be added by removing the exhaust line as pictured below.





Section 6 Error Messages

6.1 Error Classifications Ranges

- 10 Internal hardware or firmware issue - Contact Ensol Systems.
- 20 Fuel - Change the cartridge and reset.
- 30 Service Fluid - Add service fluid and reset. Check thermostat and fan function.
- 40 Environmental Issue – Temperature too high or too low to maintain function.
- 50 Battery - Battery voltage too high or low. Check connections. Check solar charge controller.
- 70 Reservoir - Internal fuel problem. Check fuel connections and reset.
- 80 System - Internal voltage or system error. Reset.

6.2 Error Types

- A = Automatic reset (after error cause is remedied)
- M = Manual user intervention required
- F = Anti-freeze protection is possible from this error, if the error cause currently no longer exists
- P = Permanent error (not resettable)
- R = Reset required to restart system
- W = Warning

6.3 Most Common Error Messages

- 12, 13, 14 - Failure due to blocking of exhaust or circulation pump defect.
- 32, 31, 30, 41 - Failure due to high surrounding temperature. Check installation and ensure air circulation is adequate.
- 52-54 - Check battery (voltage too low) and/or battery connection problem
- 72, 76 - Failure in Methanol dosing or internal sensors. Possible issues in Methanol cartridge because of fuel line.

text message	error Nr.	type of error	error description	possible cause of error	action	note
Please contact Service!	1	P	System configuration incomplete	Firmware update failed	Repair required	
	10	P	Stack defect	Defect component	Repair required	Update current firmware version
	13	A (1x30s) R/B F P	System delivers no stack power	Defect component	Press RESET If error should remain, repair required	
				Different switching on and off thresholds in cluster operation	Adjust switching on and off threshold (via Hyperterminal)	
	14	A (1x30s) R F P	Circulation pump defect	Defect component	Repair required	
	15	P	System error	Error 10 occurred before, internal problem	Repair required	
	17	R F P	Illogical state	Defect component	Repair required	
Please check exhaust hose	11	A (1x30s) B R F P	Stack power to low or voltage trip	Exhaust hose blocked	Take off exhaust hose and press "reset", if the system runs without any problems, the exhaust tube is blocked. If error should remain, repair required	Update current firmware version
				Lack of additional air	Please check installation situation, make sure that there is enough cooling air (port diameter should be 10 cm)	
				Exhaust tube blocked	Repair required	
				Defect component	Repair required	
	18	A (1x30s) B R F P	open circuit voltage to low	Exhaust tube or heat exchanger is blocked / frozen	Take off exhaust tube and press "reset" If error should remain, repair required	
				Failure in open circuit voltage	Repeat start up 3 times to reheat the stack	
				Defect component	Repair required	

text message	error Nr.	type of error	error description	possible cause of error	action	note
Please change fuel cartridge	20	B R F	Empty fuel cartridge	Empty or no cartridge	Connect a new fuel cartridge	In isolated cases the valve of the EFOY M5 and M10 fuel cartridges may not work. Please contact the SFC service.
				Tank connector defect	Check if tank connection is defiled or cracked	
				Filled or partly filled cartridge	Connect new cartridge. If fuel cartridge is not completely empty, please shake it, that the intake hose is free again	
	22	B R F P	No methanol in the system (at the beginning of operation)	Fuel cartridge sucks ambient air / fuel connector inappropriate connected	- Back off fuel connector and remove foreign material. - Connect fuel connector tightly	
				Dosing pump blocked or defect	- Maybe you have to compress the fuel cartridge firmly while connected so a deadlock has the chance to declamp - If not --> repair required	

Please refill Service Fluid	30	B R F P	Intermediate reservoir filling level: < 30%	Caused by operation at too high ambient temperatures; lack of cooling air	Please refill Service Fluid and make sure that there is enough cooling air	If you have to refill service fluid to many times you should please check installation as well as the air in- and outlet
				Subsequent damage of frozen stack	Repair required	
				Defect components		
				Inner tubes are leaky	Mainly concerns systems produced before end of 2010	
				30-60 min after initial start-up --> absence of enough cooling air	- Make sure that there is enough incoming air - Press "reset", so the system has to do the start-up again	
	31	B P	Intermediate reservoir filling level: < 5%	Leakage or defect component	Repair required	Result of error 30

text message	error Nr.	type of error	error description	possible cause of error	action	note
Interruption : Surroundings to warm	32	A B F	Intermediate reservoir filling level < 55 % and ambient conditions cause negative water balance	System temperature is too high	- Bring down ambient temperature - possibly fan blocked - inappropriate inlet air installation - incoming air blocked by fuel cartridge or wall	Please check installation regarding off-heat
	41	A B F	Error caused by ambient temperature	Ambient temperature over 45 °C	System starts up automatically, if temperature is under 38 °C: Lower ambient temperature	

Interruption : Please defrost device slowly	40	A B P	Error caused by ambient temperature	Stack temperature below 3 °C (possibly frozen)	Defrost system at room temperature (approximately 24 h), afterwards install the system again and start running	
				Defect component	Repair required	

Please insert filter	38	B	EFOY Pro 2200 XT only: Filter not detected	Filter was removed or not changed correct	Insert filter or repeat exchange	

Please check battery voltage	50	A B	Battery voltage is too low (sense line)	Voltage metering not in order (e.g. sense lines not or not approximately connected or cut-outs of the sense line defect	- Take comparative measurement with circuit analyser at EFOY-power plug (two outer pins) and battery - check cut-outs of the connecting cables	
				Battery voltage under 9V respectively 18.5 V	Recharge battery with battery charger, please change if battery is defect	
	52	A B	Output voltage too low (power line)	Voltage metering not in order (e.g. power lines not or not approximately connected or cut-outs of the power line defect)	- Take comparative measurement with circuit analyser at EFOY-power plug (two outer pins) and battery - check cut-outs of the connecting cables	
				Battery voltage between 16 V and 18.5V --> no detection if 12 V or 24 V application is connected	Recharge battery with battery charger, please change if battery is defect	
				Battery voltage under 9V respectively 18.5 V	Recharge battery with battery charger, please change if battery is defect	

text message	error Nr.	type of error	error description	possible cause of error	action	note
	51	A B	Battery voltage too high (sense line)	Voltage metering of the battery is not in order (e.g. sense line not or not correctly connected or cut-out of sense line defect)	- Take comparative measurements with a multimeter at the EFOY power pins (two outer pins) and the battery - check cut-outs of the connecting cables	
				Parallel connected charge controller hoist battery voltage too high or reacts to slowly	- Check external charge controller - Possibly caused by alternator (inside of the vehicle)	
				Battery voltage over 16 respectively 30.5 V	Check external charge controller, if necessary disconnect to avoid damage	
	53	A B	Output voltage too high (power line)	Output voltage metering is not in order	Take comparative measurements with a multimeter at the EFOY power pins (two outer pins) and the battery	
				Parallel connected charge controller hoist battery voltage too high or reacts to slowly	- Check external charge controller - Possibly caused by alternator (inside of the vehicle)	
				Battery voltage over 16 V	Check external charge controller, if necessary disconnect to avoid damage	
Please contact service	54	P	Faulty measurement of battery voltage	In operation with several charging sources	Update to firmware 9.16	Solved with firmware 9.16

text message	error Nr.	type of error	error description	possible cause of error	action	note
Please contact Service	70	R P	Reservoir sensors alert illegitimate condition -> 3 resets maximum, then error 76 permanently	Defect component	Shake system and press RESET If error should remain, repair required	Update current firmware version
	73	P	Reservoir sensor defect	Tube sensor defect	Repair required	
				Sensor sees no methanol		
	75	P	Illogical state	Condensate at optical sensor	Repair required	Solved with firmware 11.09
	76	P	Cumulative occurrence of error 70 and 72	Incorrect refilling of the reservoir	Repair required	
	80	R	Defect circuit board	Defect component	Press RESET If error should remain, repair required	
			Unit self-test failed	Defect component		
	83	R	Defect dc/dc converter	Defect component Maybe unfounded error caused by firmware bug in firmware 11.08 and 11.09	- Update current firmware version - Press RESET If error should remain, repair required	Maybe unfounded error caused by wrong system settings. Firmware-bug in 11.08 and 11.09, resettable with update Update current firmware version
	84	A R	Unit self-test failed	Defect component	Press RESET If error should remain, repair required	
	85	A R	EFOY Pro 2200 XT only: System error	Defect component	Press RESET If error should remain, repair required	

text message	error Nr.	type of error	error description	possible cause of error	action	note
Check connection	72	A B F R P	Filling of the reservoir -> timeout -> 3 restart trials at most, then error 76 permanently	Tube inside the fuel cartridge adhered to the cartridge wall	Shake cartridge firmly --> press RESET	Please also test the actions regarding error 20 / 22 Update current firmware version
				Tank connection not fixed	Screw tank connection tightly --> press RESET	
				Defect component	Repair required	

UPDATE: DO NOT UNPLUG BATTERY	99	A	Firmware update is running			Do not disconnect system and battery, do not cut data interface connection

None Only displayed in ERROR-LOG	137	A	EFOY Pro 2200 XT only: Filter exchange XT confirmed		No activity necessary	
	139	A	EFOY Pro 2200 XT only: Necessary filter exchange is displayed	Note for filter exchange after 2.200 operating hours	Change filter according to user manual	
	140	A	Anti freeze protection not possible	Anti freeze mode is blocked by previous error	Fix previous error	
	172	A	Error 72 was ignored once		No activity necessary	
	184	A	Successful self-test		No activity necessary	

Firmware corrupt update required	none	A B	An error occurred during the firmware update		Update the firmware via EFOY update tool (EUT) or updater	

text message	error Nr.	type of error	error description	possible cause of error	action	note
"check battery" or "check connection "	none	A B	Remote control is not communicating with the fuel cell	Remote control is connected to the wrong socket (Data interface)	check connection between fuel cell and remote control, possibly charge the battery, check cable	Maybe unfounded error caused by firmware 9.23 and 11.08 Update current firmware version
				Battery voltage lower than 8 V		
				Defect remote control	Connect another remote control.If error should remain, repair required	

Hybrid or R or RC in Display	none	B P	Hybrid or Remote mode although not activated or not controlled	Unintentional activation	Deactivate: - via hyperterminal "remote off" - key combination "auto" + ">>" deactivates remote control (a lock appears top right)	
				Humidity at cable or board --> oxidised cable or oxidised board connections	- Check if the system was or is in contact with humidity --> dry - If external cable is oxidised --> change cable - System defect --> Repair required	
				Socket "Data Interface" receives signal on Pin 7 / 8	Check cable in socket "Data Interface", if Pin 7 / 8 receives a signal. Check cable.	