User Manual

EFOY H_2Cabinet N-Series

Indoor Hydrogen Energy Solutions

N2.5

N5.0

N7.5

N10.0

Thank you!

Congratulations on choosing an EFOY Hydrogen Energy Solution from SFC Energy AG.
We hope you enjoy your new power supply. If you have any questions about installation or operation, please contact your sales partner or the EFOY hotline.

Specifications may change without prior notice. Revision from January 2023.

Notes on safe operation

Before using the H_2Cabinet Energy Solution, read all instructions, cautionary markings, and safety information for the H_2Cabinet, the EFOY Hydrogen Fuel Cell 2.5, and the EFOY Hydrogen Controller as well as for associated components in the respective user manuals of the components. Any deviation from the instructions in this manual will result in cancelation of the system warranty.
Read the operating instructions before commissioning the system. Store the user manual near the H_2Cabinet Energy Solution.

Do not open the components of the H_2Cabinet Energy Solution.

Transport in an upright position only.

Store the H_2Cabinet Energy Solution in a place protected from frost.

Keep all combustible material and ignition sources clear of the H_2Cabinet Energy Solution and all ancillary equipment at all times. Never smoke or allow sparks or flames around the system.

Only qualified professionals may perform the installation, commissioning, and maintenance of the H_2Cabinet System.

Service and contact

SFC Energy AG
Eugen-Saenger-Ring 7
85649 Brunnthal
Germany

Hotline: +49 (0) 89 673 592 555
Toll-free number*: 00800 732 762 78
E-mail: service@sfc.com
Web: www.efoy.com

**The toll-free number can be called free of charge from a landline telephone in the following countries: Germany, Belgium, Denmark, France, Great Britain, Italy, the Netherlands, Norway, Austria, Sweden, Switzerland and Spain.*

Content

1 Safety

1.1 Explanation of signal words

DANGER

Indicates a hazard with a high degree of risk which, if not avoided, will result in death or serious injury.

- Pay attention to the danger warning.

WARNING

Indicates a hazard with a medium degree of risk which, if not avoided, can result in death or serious injury.

- Pay attention to the danger warning.

CAUTION

Indicates a hazard with a low degree of risk which, if not avoided, can result in minor or moderate injury.

- Pay attention to the danger warning.

INFO

Indicates an action which can result in damage.

- Pay attention to the information.

Includes further information and tips on using the EFOY fuel cell in an optimal way.

1.2 Safety instructions

1.2.1 Safety instructions H_2Cabinet Energy Solution

DANGER

Danger to life due to unauthorized modifications!
Modifications and changes to the system can lead to general hazards (injury from escaping hydrogen, risk of injury from heavy parts, risk of death from electric shock).

- Do not carry out any modifications or changes to the product or individual components.

DANGER

Impermissible use!
The EFOY H_2Cabinet must not be used for the following applications:

- Medical, life support and agricultural equipment.
- Operation outside the stated technical specifications
- Operation outside the permissible operating environment
- Feeding recovered energy into the power grid
- Operation in potentially explosive atmospheres
- Operation with damaged or missing components

WARNING

Observe the correct installation location
Only install and operate the H_2Cabinet in locations that comply with the conditions for installation locations.

- Observe the conditions for the installation site

CAUTION

Danger of burns
Danger of burns on the radiators during operation and shortly after switching off.

- Do not touch.

CAUTION

Injury from rotating parts
Risk of injury from rotating parts in the cabinet fans.

- Do not touch.

INFO

Expiry of warranty
Any of the following may render the system warranty invalid:

- Use of any fuel other than Hydrogen Grade 3.0
- Installation, replacement or removal of any components or materials other than those approved by SFC Energy
- Installation, replacement or removal of any components or materials by unqualified personnel
- Installation or operation inconsistent with the intended use of the product as described in system or service manuals and marketing materials

1.2.3 Safety instructions electrical installation

DANGER

Risk of electric shock!

High voltages can occur in the system even when the system is switched off or disconnected from the mains. Components within the system are connected to electrical energy storage (batteries) and are live.

- The EFOY H_2Cabinet must be grounded.
- Before servicing, disconnect the energy storage devices and check that the system is de-energized.

Components inside the H_2Cabinet are not waterproof. There is a risk of injury from water penetration in combination with electricity.

- Make sure that no water enters the H_2Cabinet.
- Do not operate the system if any component of it has been immersed in water.
- Using the system in water may cause a fire or explosion. Immediately notify SFC Energy or your service partner to have the system inspected and the functional parts that are affected replaced.

DANGER

Risk of electric shock!

Batteries have no protection against short circuits.

- Only use specified battery types
- Have work on the electrical system carried out by qualified personnel only.

1.2.4 Safety instructions Hydrogen

DANGER

Explosion!

Escaping hydrogen can ignite and burn the skin. Hydrogen is a colorless, odorless and flammable gas. Hydrogen is highly flammable and burns with a colorless flame.

- Avoid heat around the system and the hydrogen source.
- Do not smoke, no naked flames allowed.
- Observe guidelines for handling pressurized hydrogen gas cylinders.
- If gas is emitted, keep your distance and keep flammable materials away.
- Prevent electrostatic charging.
- Ensure proper and intended installation of the hydrogen supply.
- Regularly check hydrogen lines and connectors for leaks.

The EFOY Hydrogen Fuel Cell regularly checks its internal lines and connectors for leaks with a self-test. If a leak is detected, the system shuts down and can no longer be started.

- Ensure that the fittings and gas lines of the system are leak-proof.
- The EFOY Hydrogen Fuel Cell and the EFOY H_2Cabinet **must not be operated** if a leak in the hydrogen-carrying lines or an increased hydrogen concentration has been detected.
- Observe local regulations for handling pressurized gas cylinders.
- Carefully follow the installation instructions, warnings and safety regulations of the hydrogen supplier when handling compressed hydrogen.

DANGER

Oxygen deficiency!
Escaping hydrogen can reduce the oxygen content and lead to breathing difficulties.

- Do not inhale hydrogen

The EFOY Hydrogen Fuel Cell consumes oxygen during operation.

- The EFOY Hydrogen Fuel Cell and the EFOY H_2Cabinet must not be installed and operated in an unventilated room where an adequate supply of fresh air cannot be guaranteed.
- Ensure that the openings for the supply and exhaust air are not blocked by objects.

Always pay attention to the material safety datasheet of your hydrogen supplier.

1.3 Transportation and disposal

Information on transportation can be obtained by calling the EFOY hotline.

WARNING

Risk of suffocation through foils and folding carton.

- Keep packaging and its parts away from children.

Old devices: Old electronic devices must not be disposed of with household garbage. Information on returning old devices can be obtained by calling the EFOY hotline.
Please note the instructions for the individual components.

2 System Description

EFOY H_2Cabinet Energy Solutions by SFC Energy are electric power generators that use hydrogen as fuel. Built-in fuel cell technology provides the output power.

2.1 Overall system function and proper use

The energy solutions of the EFOY H_2Cabinet N-Series are designed for indoor application sites. They come as fully integrated cabinet solutions, with a maximum fuel cell power output of 2.5, 5.0, 7.5 or 10.0 kW DC. Values for output power depend on the configuration of the system. Hydrogen piping must be connected to the coupling on top of the cabinet. According to its configuration the system can be used as a stand-alone system, as a back-up power supply, as an uninterruptible power supply (UPS), or as a hybrid system with other energy sources (e.g. solar). The standard output voltage is 48V DC, but other DC voltage levels or AC outputs are also available: Depending on the application, the Energy Solution can be configured with such additional components. EFOY H_2Cabinet solutions are suitable for the following applications, for example:

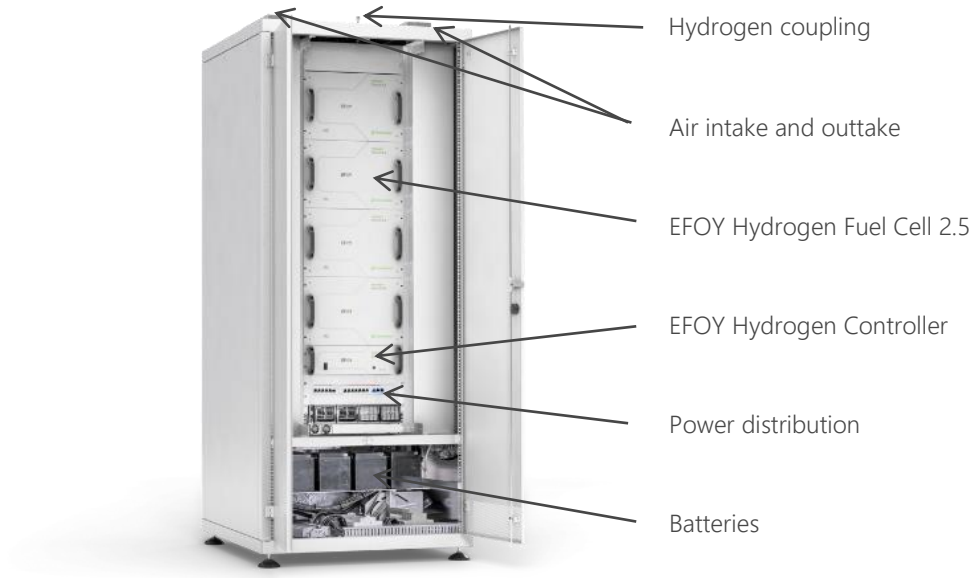
- Simple transceiver stations for mobile communications
- Professional mobile radio
- Network nodes in telecommunications networks
- Emergency power supply for industrial applications (gas detectors, servers, etc.)

The energy solution was developed as an indoor system and consists of a cabinet in which up to four EFOY Hydrogen Fuel Cell 2.5 modules, an EFOY Hydrogen controller and peripheral components such as fans, heaters and sensors are installed. This provides an electrical output of up to 10 kW DC per cabinet, and a modular combination of several such cabinets is possible to achieve higher outputs. The cabinet is fully equipped to supply the air-cooled fuel cell modules with fresh supply air and the necessary oxygen and to conduct the waste heat and humid air as well as hydrogen particles out of the installation space via the exhaust air duct. The installation site may only be accessed by trained and authorized personnel.

The EFOY Hydrogen Fuel Cell(s) 2.5 with a maximum electrical output of up to 2.5 kW DC per fuel cell are connected to a 48 V battery storage. This battery storage acts as a buffer to supply the fuel cells with starting power and to bridge the start-up time of the fuel cells, which provide full output power in less than 2 minutes. Depending on the configuration of the energy solution, an inverter system can be connected to the battery storage unit. According to the configuration single phase or three-phase alternating current for different output power ranges (in kV AC) are possible. E.g. the inverter can be switched on and off via an external signal. When the system is not in operation, it is supplied with energy from the mains via a rectifier in order to charge the batteries and operate the system peripherals. A multi-converter combines these two functions in one device. More information on those components can be found in the documentation of the manufacturer of those devices.
The internal control and monitoring of the system is handled by the built-in EFOY Hydrogen Controller. The cabinet has its own control system with pressure and hydrogen sensors as well as solenoid valves for safety-related monitoring and shutdown. Furthermore, several environmental parameters such as temperature and hydrogen concentration are measured and evaluated.

2.3 Dimensions and Layout of the system

The illustration shows an example configuration for an H_2Cabinet N-Series: the system can be equipped with a total of four EFOY Hydrogen Fuel Cells 2.5, one EFOY Hydrogen Controller and batteries.



Please note: For N-Series cabinets with a limitation in height of 40 rack units (-40U), batteries need to be placed outside the cabinet.

Dimensions of the Cabinet (-50U):
Height: 2.600 mm
Width: 1.000 mm
Depth: 1.000 mm

Dimensions of the Cabinet (-40U):
Height: 2.000 mm
Width: 1.000 mm
Depth: 1.000 mm

The cabinet is equipped with the following warning notices:

- Access to the installation prohibited for unauthorized persons
- Smoking is prohibited
- Electrical operating room: Risk of electric shock

Explosion protection and safety concept:

The EFOY H_2Cabinet must not be installed in an explosion protection zone.

During normal operation however, the EFOY H_2Cabinet does not create an explosion protection zone:

- All pipings of the H_2Cabinet are technically tight in the long run . Pay attention to maintenance intervals for checking the piping on tightness.

- Two solenoid valves (normally closed) are installed: one at the system border on top of the H_2Cabinet, one at the pressure reducer inside the H_2Cabinet.
- A Hydrogen sensor beneath to roof of the H_2Cabinet detects any hydrogen leakage inside the H_2Cabinet. In case of a leakage the fuel cells and controller are immediately set to standby, the solenoid valves are closed and avoid any further hydrogen supply to the H_2Cabinet. Any other AC power components (according to the configuration of the H_2Cabinet) are not affected by this.
- The customer needs to install a separate gas detection system at the installation site.

2.4 Technical data

The configuration of the N-Series Cabinet Solution depends on the customer's output power needs. Each EFOY Hydrogen Fuel Cell delivers – depending on the voltage level of the connected batteries – a maximum of 2.5 kW. The EFOY Hydrogen Controller controls up to four fuel cells. Further sub-systems of the energy solution are the power distribution and the battery installation. Your solution can be optionally configured with a range of additional components, e.g. a remote monitoring system or a rectifier/ inverter unit for AC power output.

Configuration	EFOY H_2Cabinet N2.5	EFOY H_2Cabinet N5.0	EFOY H_2Cabinet N7.5	EFOY H_2Cabinet N10.0
Nominal fuel cell output power	2.5 kW	5.0 kW	7.5 kW	10.0 kW
Fuel Cell(s)	EFOY Hydrogen Fuel Cell 2.5 (1 unit)	EFOY Hydrogen Fuel Cell 2.5 (2 units)	EFOY Hydrogen Fuel Cell 2.5 (3 units)	EFOY Hydrogen Fuel Cell 2.5 (4 units)
Controller	EFOY Hydrogen Controller Monitoring and control of EFOY Hydrogen Fuel Cell(s)			
Power Distribution	Power distribution and protection of all components inside the cabinet			
System voltage	48 V DC			
Output voltage	41 - 57 V DC			
Compatible H_2 source	External hydrogen pipe connection, 10 – 18 bar, hydrogen 3.0 or higher			
Battery installation	48 V / 30 Ah (4 batteries of 12 V and 30 Ah in series)	48 V / 60 Ah (4 batteries of 12 V and 60 Ah in series)	48 V / 90 Ah (4 batteries of 12 V and 90 Ah in series)	48 V / 120 Ah (4 batteries of 12 V and 120 Ah in series)
Housing	H_2Cabinet P14-50U or H2Cabinet P14-40U			
Optional Configuration	- Remote Monitoring System - Rectifier and/or Inverter for AC power output - DC/DC module for constant DC power output - Charge controller for integration of PV-modules - Uninterruptible power supply module - Flexible hydrogen connection to various hydrogen storage solutions			

2.5 Sub-System Overview

This chapter provides an overview on the major system components that are part of your EFOY H_2Cabinet N-Series Energy Solution:

- Cabinet housing
- EFOY Hydrogen Fuel Cell 2.5
- EFOY Hydrogen Controller
- Battery system
- Rectifier and inverter (in AC-configuration of the H_2Cabinet only)
- Hydrogen supply
- External room surveillance

2.5.2 Cabinet design

Housing

The housing of the EFOY H_2Cabinet N-Series consists of a powder coated aluminum cabinet, that fulfills protection class IP20 and is made for operating temperatures from +5 °C to +45 °C. The dimensions of the cabinet are 2.650 x 1.000 x 1.000 mm, total weight of the empty cabinet (without EFOY Hydrogen Fuel Cell(s)) is 300 kg. External hydrogen supply for the system will be connected via a H_2 pipe coupling on top of the cabinet.

The cabinet has a built-in 19'' rack construction. There, the fuel cell unit(s), the EFOY Hydrogen Controller, the power distribution and further components are installed. The bottom of the cabinets provides installations space for the battery unit. The cabinet contains necessary components and connections for grounding and emergency stop as well as a main switch.

The cabinet is prepared for up to four units of the EFOY Hydrogen Fuel Cell 2.5, depending on the configuration. For a quick and safe installation and commissioning, the racks are equipped with quick couplings for the hydrogen supply and an electrical socket for power and communication.

In the cabinet, the air ducting of the electrical components and the supply and exhaust air ducting of the fuel cells are isolated and supplied via separate air openings. The air supply duct on the right hand side of the cabinet provides fresh air for the chemical reaction in the Fuel Cell Unit(s), the exhaust heat duct on the left hand side of the cabinet dissipates the waste heat. The 19" racks of the fuel cells are prepared with appropriate F6 filters for the supply air and exhaust air ducting.

Built-in fans and heating elements assure active ventilation and heating of the cabinet.

EFOY H_2Cabinet housing	H_2Cabinet P14-50U	
Coupling for Fuel Cell Unit	4	4
Number of available height units in the rack	50	40
Dimensions (H x W x D)	approx. 2600 x 1000 x 1000 mm	approx. 2000 x 1000 x 1000 mm
Weight	300 kg (empty cabinet) Up to 500 kg (fully equipped)	250 kg (empty cabinet) Up to 450 kg (fully equipped)
Housing	Single wall aluminium cabinet, powder coated	
Connection of the H_2 pipe connection	1 x on the roof of the cabinet 10 – 18 bar, thread: 3/8 NPT (female)	
Temperature range	+5 °C to + 45°C	
IP class	IP20	
Features	- Active ventilation and heating of the cabinet - Air supply and waste heat duct - Pressure sensors and blowers - Pressure reducer with pressure sensors and solenoid valve - Documentation and maintenance plan - Built-in 19'' rack: installation space for Fuel Cell Unit(s), Master Control Unit, Power Distribution Unit, Power Converting Unit and further electronics	
Installation of batteries	Inside the H_2Cabinet	Outside the H_2Cabinet

The hydrogen storage is provided externally by the customer. The hydrogen needs to be provided with a pressure of 10 – 18 bar. On that pressure level, a pip is led inwards at the top of the cabinet. A pressure reducer is installed inside the cabinet, which reduces the pressure to the required low pressure of 0.45 bar. Pressure sensors are installed on both sides of the pressure reducer and a solenoid valve is installed on the medium-pressure line to switch off the hydrogen line if necessary. The fuel cell modules (respectively 1 to 4, according to the number of Fuel Cell Units installed) are connected to the low-pressure line via a coupling. From there the hydrogen enters the stacks of the Fuel Cell Units.
The hydrogen piping structure has a built-in, fail safe solenoid valve that closes without current in the event of a fault.

2.5.3 EFOY Hydrogen Fuel Cell

The EFOY Hydrogen Fuel Cell is the center of your energy solution: here the chemical reaction takes places and electrical energy is produced. You can equip your solution with up to four fuel cells, according to your power demand. Each fuel cell delivers a maximum of 2.5 kW output power at a voltage of 48 V.

The EFOY Hydrogen Fuel Cells are mounted in the 19'' of the cabinet. The backplane connectors provide hydrogen supply and electrical connection. You can find detailed information on the fuel cells in the separate EFOY Hydrogen Fuel Cell user manual.

EFOY Hydrogen Fuel Cell 2.5	
Power output	2.500 W
Nominal voltage	48 V
Weight	28.5 kg
Nominal consumption	0.06 kg/kWh
Dimensions (L x W x H)	536 x 483 x 311 mm

2.5.4 EFOY Hydrogen Controller

The EFOY Hydrogen Fuel Cell 2.5 requires an EFOY Hydrogen Controller, which is pre-wired at delivery. The EFOY Hydrogen Controller is necessary for monitoring and controlling the fuel cell modules and the pressure sensors of the hydrogen lines.
The EFOY Hydrogen Controller is the control center of your energy solution: it controls up to four fuel cells and provides interfaces for external signal transmission.
Solenoid valves and pressure sensors are connected and read out or switched via the Controller. For safe operation, the Controller can switch off the hydrogen lines if necessary, thus ensuring safety-relevant functions. Parameters and values of the control system can be read out via the MODBUS RTU protocol. A variant with integrated remote monitoring module is available as an option.

You can find detailed information on the EFOY Hydrogen Controller in the separate EFOY Hydrogen Fuel Cell 2.5 and EFOY Hydrogen Controller user manual.

EFOY Hydrogen Controller

Dimensions (L x W x H)	446 x 483 x 133 mm
Weight	7.6 kg
Supply voltage	36 – 57 V DC
Current consumption	Max. 2 A @ 48 V basic structure
Connectors / external Interfaces	- RS 485 Interface - Ethernet - Alarm contacts - Stop signal - Rectifier voltage reduction - Heating / cooling - 24 V power supply
Communication / Protocols	- MODBUS RTU (RS 485) - Web Interface (Ethernet: Firefox 44.0 and Java SE 8)

2.5.5 Battery system

INFO

Important notice:

- Only use specified battery types
- Batteries have no protection against short circuit
- Batteries have no protection against overheating
- Batteries have no protection against deep discharge

Batteries are required to buffer the peak load and to supply the fuel cell modules with energy during the start-up phase. The standard version of the N-Series H_2Cabinet Solution will work with a 48 VDC battery bank, four batteries of 12 VDC each connected in series. The capacity depends on the configuration of the cabinet (number of installed fuel cells), recommendation is:

- 30 Ah for the H_2Cabinet with one EFOY Hydrogen Fuel Cell installed
- 30 Ah for the H_2Cabinet with two EFOY Hydrogen Fuel Cells installed
- 100 Ah for the H_2Cabinet with three EFOY Hydrogen Fuel Cells installed
- 100 Ah for the H_2Cabinet with four EFOY Hydrogen Fuel Cells installed

The batteries are not installed at the delivery of the system but are delivered separately.

Battery bank for EFOY Hydrogen Energy solution

Type	AGM			
Rated voltage per battery	12 V DC			
Rated capacity	30 Ah	30 Ah	100 Ah	100 Ah
Weight	10.8 kg	10.8 kg	31.0 kg	31.0 kg
Dimensions (LxWxH)	280 x 97 x 159 mm	280 x 97 x 159 mm	395 x 108 x 287 mm	395 x 108 x 287 mm

Quantity in system	4	4	4	4
Total capacity of battery bank	30 Ah (@ 48 V DC)	30 Ah (@48 V DC)	100 Ah (@ 48 V DC)	100 Ah (@48 V DC)

Please find further information on the separate battery data sheet.

2.5.6 Rectifier and inverter (in AC-configuration of the H_2Cabinet only)

Depending on the technical configuration, various electrical AC components are installed in your H_2Cabinet. For the documentation of these components, please refer to the original documents of the manufacturer. Examples of such components are:

- Rectifier
- Inverter
- Multi-converter

These components ensure that your H_2Cabinet can also provide 230 VAC or 400 VAC output power, or is supplied via a mains input in standby mode.

2.5.7 Hydrogen Supply (external)

The coupling for hydrogen connection is located on top of the cabinet. This valve connection is a 3/8 NPT (female) standard coupling. The hydrogen supply for your N-Series energy solution needs to be provided at a pressure of 10 – 18 bar. The system can be delivered with an additional pressure regulator that reduces high hydrogen pressures to 10 – 18 bar. The lengths of the necessary pipes depends on the installation side.

Hydrogen 3.0 (purity of 99.9%) must be used. The hydrogen is not delivered by SFC Energy and is never part of the delivery content.

Inside the H_2Cabinet the hydrogen pressure is reduced from the incoming pressure (10 – 18 bar) to the pressure level for the fuel cells (0.36 – 0.55 bar, 0.45 bar optimum). For optimal operation, please make sure that the outlet pressure of this pressure reducer is set to 0.45 bar.

Further technical specifications of the pressure reducer can be found in the following overview.

Pressure reducer

Medium	Hydrogen
Inlet pressure	10 -18 bar
Outlet pressure (pre-set)	0,45 bar (+/-50 mbar)
Maximum volume flow rate	600 Nl/min
Temperature of the medium	-25° C to + 110° C
Ambient temperature	-25° C to + 50° C

Protection class	IP 65
Connections	Connection "P": connection thread NPT ¼ Connection "A": connection thread NPT ¼ Connection "PT (A) und PT (P)": connection thread NPT 1/8 and M12 x 1,5
Installation position	Solenoid body vertically upwards, ±90°
Flow direction	defined, "P" → "A"
Mounting	4 x M5 thread
Switching function	Normally closed (NC)
Supply voltage	24 V DC ±10%
Electrical power	18 W
Electrical connection	Cable plug according to DIN EN 175301-803

For further information, please refer to the hydrogen specification sheet provided by SFC. Only hydrogen, that fulfills those requirements, may be used for the H_2Cabinet and the EFOY Hydrogen fuel cells.

2.5.8 Room surveillance (external)

When operating a hydrogen fuel cell solution safety is always a major topic. The EFOY H_2Cabinet N-Series solutions already come equipped with several safety features as pressure sensors or solenoid valves. Nevertheless, each installation site is unique and therefore needs a suitable room surveillance concept that fits best for the chosen site. An external gas warning system must be installed at the installation site of the H_2Cabinet.

3 Installation, start-up and operation

3.1 Installation

The system must be set up by qualified personnel and then undergo final acceptance testing.

3.1.1 Installation site requirements

The following requirements must be met by the planned installation site for the N series H_2Cabinet:

- Dry installation site, protected from moisture and water penetration (also protected from leakage at water pipes etc.)
- Clean supply air (no dust / exhaust fumes)
- Air supply: The installation room must guarantee an air volume flow of max. 700 m³ / h per EFOY Hydrogen 2.5 fuel cell. If the room does not have an opening to the outside that covers this air volume flow, it must either be provided directly to the cabinet via ventilation pipes or a corresponding opening must be provided in the room.
- The entire section, from the air inlet to the air outlet of the system housing, must be designed in such a way that a pressure drop of 200 Pa is not exceeded at a maximum air delivery of 700 m³/h per fuel cell.
- Supply air temperature: +3 °C – 50 °C
- Exhaust air ducting: The exhaust air must be ducted directly out of the installation room into the open. Air volume flow: max. 700 m³ / h per EFOY Hydrogen 2.5 fuel cell.
- No clogging or blocking of the exhaust air ducting.
- Marking of the cabinet installation location with "Access for unauthorized persons prohibited".
- Protect the cabinet with collision protection / impact protection if transport vehicles or other vehicles are in use at the installation site.
- Electrical grounding is required
- Install an H_2 monitoring system (gas warning system) independent of the H_2Cabinet with separate alarm in case of hydrogen leakage.
- Select an installation site where overheating of the system cannot occur.
- Make sure that any local regulations regarding installation and use of hydrogen are met

3.1.2 Pre-installation tasks

Before the H_2Cabinet can be installed there are a couple of tasks that need to be finished.

- Supply air duct preparation: If provided, it must be prepared until commissioning.
- Exhaust air duct preparation: it must be prepared until commissioning.
- Connection H_2: To be connected before commissioning. The duct must be checked for leaks before commissioning. The external gas warning system must be in operation.
- Depending on the configuration of the H_2Cabinet solution: prepare and check all incoming and outgoing power cables
- Prepare and check electrical grounding
- De-energize the cables until commissioning.

3.1.4 Commissioning of the H_2Cabinet

DANGER

Risk of electric shock!

Batteries have no protection against short circuits.

- Only use specified battery types
- Have work on the electrical system carried out by qualified personnel only.

The Installation includes the following steps:

1) Placing the H_2Cabinet on its installation site.
2) Mounting of the feet of the Cabinet and adjustment of the feet so that the cabinet is stable and aligned.
3) Open the front door; make sure that the main DC circuit breaker is open to separate the system from all DC power input.
4) Check that RCD circuit breaker and all DC fuses are also open!
5) Electrical grounding: Earth cable must be connected
6) Connect the batteries to the prepared cable harness at the bottom of the H_2Cabinet: batteries must be fully charged! For the N-Series 40U cabinet, place batteries next to the cabinet and connect via the opening in the bottom of the cabinet.
7) Connect the Hydrogen supply: The hydrogen supply must be connected to the EFOY H_2Cabinet via the defined piping and tested for leaks in accordance with applicable guidelines. All hydrogen pipes must be evacuated before put into operation. Hydrogen pressure is 10 – 18 bar. All hydrogen pipes must be connected and tested in accordance with applicable guidelines and standards.
8) Assure that hydrogen supply is correctly connected to the coupling on top of the cabinet
9) Switching on the system (close the DC circuit breaker and other fuses for the DC side)
10) Switch on EFOY Hydrogen Controller
11) Test of functionality test of the H_2 sensor (with test gas)
12) Leak test (incl. protocol) for all the piping inside the H_2Cabinet.
13) Flushing the H_2 Backplane Connections (service mode EFOY Hydrogen Controller)
14) Testing the entire system (electrical connection, signal connections, single components like heaters and fans)
15) Plausibility check of all components (solenoid valve, heating, fan, temperature sensors)
16) Mains connection: Electrical connection including power supply must be connected (if H_2Cabinet is configured for a grid-connection): use the cable feed-through in the bottom of the cabinet
17) Load connection: Electrical connection of the load must be connected if required (use the cable feed-through in the bottom of the cabinet)
18) Closing of the cable feed trough in the bottom of the cabinet
19) Installation of the internal plug-in fuel cell module(s): connection via the backplane-connectors
20) Cold start: Restart controller
21) Switch FI circuit breaker active
22) System test and optimization of the system configuration: All electrical connections must be connected and tested in accordance with applicable directives and standards.

Detailed information on the wiring of the H_2Cabinet can be found in the circuit diagram of the system.

3.2 Self-test fuel cell power

Start DC fuel cell self-test
(For explanation see next chapter).

3.3 Operation modes

Fuel cell in standby

During standby operation, the system permanently monitors the voltage of the internal 48V DC rail. Standby power consumption is around 100 W and power is supplied from the 48V DC rail. Under very cold or warm conditions, the internal heaters or fans will heat or cool the inside of the cabinet.
H_2Cabinets that are configured with a power input from the power grid (rectifier) will use power from the grid to cover standby power consumption of the H_2Cabinet.

Fuel Cell in normal operation

If the voltage of the connected batteries drops below a certain voltage level (switch-on voltage: configurable) is reached, the fuel cell system automatically switches on and starts to charge the batteries. The hydrogen supply pressure is continuously monitored. When the hydrogen pressure drops below a predefined value (configurable), the system sends a status signal "Fuel tank at minimum" to initiate refilling. The switch-on voltage level can be configured, please find detailed information in the separate user manual of the EFOY Hydrogen Controller.

Fuel cell switch off

When the voltage of the connected batteries exceeds a certain voltage level the system is switched off and the system returns to standby mode. The switch-off voltage level can be configured, please find detailed information in the separate user manual of the EFOY Hydrogen Controller.

Fuel cell self-test

If the system is in standby mode for a longer time, a self-test is automatically started. The time range for this self-test can be configured from 30 – 90 days, pre-set parameter is 30 days. During the self-test, each Fuel Cell Unit is started and supplies power for a short time. During the test, all system components are checked for faults. After a successful self-test, the system switches back to standby mode.

The Hydrogen consumption during the fuel cell self-test can be calculated to 0.02 kg H_2 / fuel cell module / self-test which leads to a annual consumption of 0,24 kg H_2 / fuel cell module / year.
For a H_2Cabinet fully equipped with four EFOY Hydrogen Fuel Cell 2.5 that results in 0.96 kg H_2 / year for the self-test.

3.4 Operation

General notes on operation

- Always keep the doors of the cabinet closed during normal operation.
- Ensure that unauthorized persons do not have access to the interior of the cabinet.
- Observe the specified maintenance intervals for the H_2Cabinet.

A detailed description on the operation of the EFOY Hydrogen fuel cell(s) and the EFOY Hydrogen Controller can be found in the respective user manual for those components.

3.5 Troubleshooting

The EFOY Hydrogen Controller constantly monitors all operation parameters and guarantees a save operation. Pressure sensors, Hydrogen detection sensors and temperature sensors constantly track measurement data. If measured values are outside the tolerances, operation is stopped and the fuel cell and the controller are set to standby. If the hydrogen sensor detects a leak, solenoid valves are automatically closed.

Please refer to the user manual of the EFOY Hydrogen fuel cell and EFOY Hydrogen Controller for further information on troubleshooting, warnings and error codes.

4 Service and maintenance

The Hydrogen Energy Solution system requires only minor maintenance. Unless otherwise agreed, a full preventive maintenance service must be carried out every 12 months. The content of this service is described below. This work must be carried out by qualified service personnel only.

The Hydrogen piping must be checked for tightness every 12 months. Furthermore checking the piping is always mandatory after changing the position of the H_2Cabinet.

Defined deadlines for individual checks can be taken from the separate maintenance plan.

CAUTION

Danger of burns
Danger of burns on the radiators during operation and shortly after switching off.
- ▶ Do not touch.

CAUTION

Injury from rotating parts
Risk of injury from rotating parts in the cabinet fans.
- ▶ Do not touch.

4.1 Regular service

Single components

Check Hydrogen piping and solenoid valves
Check every 12 months
- Check for tightness of the hydrogen piping
- Check for correct function

Check for function of the H_2 sensor
- Check according to manufacturer's instructions
- Replacement if necessary according to manufacturer's instructions

Change of the air filters inside the H_2Cabinet
- Normally not necessary
- If necessary: Ensure that the filter cassette is locked again after replacing a filter

General inspection

The following work must be carried out once a year:
Visual inspection of the system including the following components:

- Cabinet
- Wiring
- Plugs / connections
- Fans / heaters
- Air ducts
- Solenoid valves
- Batteries

The components must be checked for:

- Damage
- Ageing
- Faulty paint
- Cleanliness

Individual work to be carried out:

- Checking the complete enclosure and system configuration
- Checking the electrical grounding
- Cleaning (dust removal)
- Visual inspection of the air filters and replacement if dirty
- Checking the measured voltages and currents of all system components for plausibility.
- Checking all accumulator and rectifier connections
- Checking the log files of the EFOY Hydrogen Controller for warnings

Please find more information on the separate maintenance schedule.

4.2 Hydrogen piping maintenance

For the hydrogen piping maintenance, the following checks must be carried out by service personnel:

- Visual inspection of the piping and switching equipment for damage or ageing.
- Checking valves on correct function
- Checking hydrogen sensor
- Leak test (minimum once a year)

The leak test must be carried out in accordance with applicable directives and standards.

4.3 Removing EFOY Hydrogen Fuel Cell and EFOY Hydrogen Controller

CAUTION

Heavy weight
The EFOY Hydrogen Fuel Cell 2.5 weights around 30 kg.

- ▶ Only work in pairs to better handle the modules

In the event that the EFOY Hydrogen Controller or a module of the EFOY Hydrogen Fuel Cell 2.5 must be removed from the H_2Cabinet, please observe the following procedure

For the EFOY Hydrogen Fuel Cell 2.5:

- Disconnect the DC side by opening the DC circuit breaker
- Loosen the screw connection at the front
- Slowly pull out the module

For the EFOY Hydrogen Controller:

- First, remove the fuel cell module directly above the EFOY Hydrogen Controller (see above for instructions). That will assure that you have enough free space for removing the EFOY Hydrogen Controller.
- Loosen the screw connection on the front of the controller.
- Pull the controller out a little (around 20 cm)
- Disconnect the wiring harness from the EFOY Hydrogen Controller
- Pull out the controller completely

4.4 Function test on the Hydrogen Energy Solution (self-test)

To test the proper functionality of the fuel cell system, a self-test is triggered by disconnecting the mains supply. During the test, the voltage of the DC bus bar is monitored. When the start-up voltage is reached, the fuel cell begins to generate current for the load. This test is not required if the customer is already operating the system regularly. In this case, all alarm logs must be analysed for abnormal values.

5 Decommissioning and transport

To prepare the H_2Cabinet for transport, please proceed as follows:

- Open DC circuit breaker to disconnect the DC side
- Disconnect load
- Disconnect the mains connection (if applicable, according to H_2Cabinet configuration)
- Remove the H_2 supply to the H_2Cabinet
- Disconnect and remove the batteries
- Remove fuel cell module(s)
- Remove controller

Notes on transport:

- Only allow the H_2Cabinet to be moved by professional personnel.
- Pay attention to the weight and to the securing of the cabinet during transport.
- Only transport the cabinet upright

6 Appendix

Overview on further documentation:

- User manual of EFOY Hydrogen Fuel Cell 2.5 and EFOY Hydrogen Controller
- Datasheet H_2Cabinet Energy Solution
- Datasheet EFOY Hydrogen Fuel Cell 2.5
- Datasheet EFOY Hydrogen Controller
- Datasheet of single components inside the H_2Cabinet
    - Datasheet Hydrogen pressure reducer
    - Datasheet DC circuit breaker
    - Datasheet fans
    - Datasheet H_2 sensor
    - Datasheet heater
    - Datasheet audio-visual alarm
    - Datasheet solenoid valve
    - Datasheet hydrogen piping
    - Datasheet current measurement sensor
- Specification datasheet hydrogen
- Circuit diagram