





# DEMOSOFC

## Project nº 671470

# "DEMOnstration of large SOFC system fed with biogas from WWTP"

## **Deliverable number 3.3**

## D3.3 Connection of the SOFC system to the DEMO (fuel supply, electrical connection, thermal recovery)

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#### Abstract:

The document includes details about the works for the installation of the DEMOSOFC plant. In particular, the document provides information on the 2 SOFC modules connection to the DEMO plant: mechanical, electrical and automation connections are described.

Keyword list: biogas, SOFC, WWTP, connections, piping, cables



D3.3 - Connection of the SOFC system to the DEMO

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## **1. SOFC modules**

The following section is related to the connections between the CONVION supply (first and second SOFC modules) and the DEMOSOFC system. These connections are divided into:

- Mechanical connections
- Electrical connections

### **1.1 SOFC 1 – October 2017**

The supplied equipment from CONVION LTD included:

- 1 SOFC Module C50 (Figure 1)
- 1 transformer (Figure 3)
- 1 DC/AC inverter cabinet (Figure 4)
- 1 grid interface cabinet, used for connection of the SOFC units to the DEMOSOFC system (Figure 5).

Cables and connections between the SOFC module and the other parts supplied by CONVION were done by SMAT personnel in accordance to CONVION instructions and supervisions.

In particular:

- 6 current cables (DC) connect the SOFC unit to the inverter cabinet (Figure 6)
- One power cable (AC, for startup) connect the SOFC unit to the inverter cabinet (Figure 7)
- Three cables connect the inverter cabinet to the transformer
- Different cables connect the grid interface cabinet to the inverter cabiner
- One Ethernet and one Ethercat cable connect the SOFC module to the grid interface cabinet (Figure 8)

Detailed instruction on these electrical connections were available in the detailed "*Field cable connection and supervision instructions*" document supplied by CONVION.

#### **1.2 SOFC 2 – October 2018**

The equipment supplied by Convion for the SOFC module 2 (Figure 2) was the same described above with the only exception that the second unit did not require a transformer and so power cables were directly connected to the inverter. Furthermore, the grid interface cabinet was unique for both the SOFC modules, so the power and signals connection were performed by reaching the same cabinet (shown in Figure 5).





Figure 1. Convion supply #1 – C50 SOFC module.



Figure 2. Convion supply of SOFC module 2.



*Figure 3. Convion supply #2 – transformer.* 





Figure 4. Convion supply #3 – inverter cabinet.



*Figure 5. Convion supply #4 – grid interface cabinet.* 





Figure 6. Six current DC cables from SOFC unit.



Figure 7. Two AC cables connection from SOFC unit.



Figure 8. Ethernet and Ethercat cables outlet from SOFC unit.



## 2. Mechanical connections

The mechanical connections to the SOFC modules were identical between SOFC 1 and 2.

Mechanical connections to the SOFC include cold and hot side connections. Cold side connections (Figure 10) are biogas, purge gas (NH mix, 95% N2 and 5% H2, from cylinders) and compressed air (from the SMAT compressed air circuit). Hot side connections (Figure 12) include inlet and outlet water lines from the Heat Recovery Unit (HRU). Furthermore, connections to drain are also available.



Figure 9. SOFC module interfaces on cold (on the left) and hot (on the right) side.

### 2.1 Cold side

Cold side connections are done with Swagelock fittings, 12 mm diameter.



Figure 10. Cold side connections. From the left: purge gas, fuel and compressed air.





*Figure 11. Cold side connections with view on the internal connection box. From the left: purge gas, fuel and compressed air.* 

## 2.2 Hot side

Hot side connections are done with Swagelock fittings, 25 mm diameter.



Figure 12. Hot side connections: cold water inlet, hot water outlet and drain.



## 3. Electrical and automation connections

Electrical connections included:

- Electrical cables (power supply/power out)
- Automation connections (wired signals, Profinet communication)

#### 3.1 AC cables

For the system start up, AC power is supplied from the grid to the SOFC through the grid interface cabinet (3 phases AC cable, Figure 7). This line can be used also in reverse mode during power production when AC power is supplied by the SOFC to the grid. This line is also connected, through a series of switches, to the auxiliary services of the DEMOSOFC site (biogas processing unit, heat recovery system, technical building electrical supply, etc) and, during island mode, AC power produced from the SOFC can also go to supply services when grid is not available.



Figure 13. AC power supply to the grid interface cabinet.





Figure 14. Electrical connections layout.

### 3.2 Automation wired signals

The CONVION PLC (Figure 15) has also been connected to the DEMOSOFC main PLC (described in Deliverable D3.1). Even if the plant includes only 2 SOFC modules, the complete control system and the grid interface cabinet were designed for 3 units, and this is the reason why wired signals (listed below) are related to 3 units.

Wired signals (which includes 4-20 mA analogic signals input/output and digital signals input/output) include:

- RUN command for the 3 SOFC units (3 digital)
- FORCED STOP command for the 3 SOFC units (3 digital)
- HOT STANDBY command, one for all the units (1 digital)
- Info on RUN active status for the 3 units (3 digital)
- Info un FAILURE active status for the 3 units (3 digital)
- Info on ISLAND mode status, one for all the units (1 digital)
- Info on HOT STANDBY mode status, one for all the units (1 digital)
- Set point for the 3 SOFC units (3 analogic)
- ISLAND MODE command from PLC (to simulate a grid failure) (1 digital)



- Info on the 2 emergencies stop buttons (2 digital)
- Interlocking signals for grid re-connection after a failure (1 digital)
- Data on ambient pressure, temperature and humidity (3 analogic)
- Measurements signals from Qualvista analyser (4+2 analogic)

All these connections have been performed by SMAT/POLITO together with CONVION and allow the communication between the Convion unit and the main DEMOSOFC PLC system.

More details on the control system hardware and software connections are provided in Deliverable D3.4.



Figure 15. CONVION PLC.

## 3.3 Profinet communication

In order to avoid a too high number of wired signals, data on the SOFC modules operation will be provided by a Profinet cable, installed between the Convion PLC and the DEMOSOFC main PLC. The communication was initially difficult to be established because of the different type of PLC installed (Beckhoff in CONVION system and Siemens in SMAT system). Anyway, the connection was then performed and data are available in the main operation panel.





Figure 16. Information available from the Profinet communication cable. The same page was developed also for SOFC2 and 3.

#### 3.4 Ethernet cable for internet connection

In order to allow CONVION to have remote access at the plant site, a DEMOSOFC dedicated internet grid has been developed. SMAT internet line is very slow (2 MBs) and remote access cannot be guaranteed since the control system of Collegno is linked to the overall SMAT control system, and remote access could increase risks for external accesses. For this reason, a dedicated DEMOSOFC 4G LTE Router (TP-Link) has been installed, with a 4G SIM card (from TIM) to provide both ethernet and wi-fi internet access. This router currently provides internet access to:

- Qualvista team who is remotely checking the analyser
- CONVION who is also remotely accessing the system and the internal control system
- POLITO/SMAT team who will control the system even when not present at the site.
- All the operators onsite who are using a personal laptop or electronic device.

CONVION was thus able to remotely access their operator panel and their control system and to perform tests on the system or software modifications, if required.





Figure 17. TP-link router for the DEMOSOFC internet connection.



Figure 18. Operator panels, Convion (left) and SMAT/DEMOSOFC (right).

# 3.5 SIM card for safety remote connection and SMS alarms

Furthermore, for safety reason, CONVION has installed two extra SIM cards in their system for the following purposes:

- One SIM card is connected to the CONVION operator control panel through a Modbus connection and it's sending SMS to CONVION personnel in case of alarms or emergencies.



- Another SIM card is connected into the grid interface cabinet and it's used as backup system for data connection in case the DEMOSOFC internet line shows a failure.



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