ComSos

Project n° 779481

"Commercial-scale SOFC systems"

Deliverable number 4.4

Verification plan of the installed systems

Work Package number and Title	WP4 - System validation and demonstration
Task	Task T4.2 Field measurements and monitoring
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Estimated Person Months	3
Due Date of Delivery	M12
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Author(s)	M. Gandiglio, M. Santarelli (POLITO), M. Münch (SUNFIRE), S. Modena, E. Varkaraki (SOLIDPOWER), T. Hakala, E. Fontell (CONVION), A. Nieminen, J. Kiviaho (VTT)
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Abstract:

From T 4.2 Field measurements and monitoring:

Field measurements for selected SOFC installations will be carried out at least for one year (no less than 9000 hours of data) to confirm the energy and environmental benefits of SOFC systems over conventional technology. These field-measurements will include CO_2, NO_x and particulate measurements. This task also carries out day-to-day monitoring of the whole demonstration fleet. The gathered data from the installed systems will be condensed into a monthly newsletter to partners informing them of the key parameters of the systems such as produced power, performance and availability.

Keyword list:

Data analysis, emission analysis, demonstration

Summary

1. Introduction

To verify and confirm the KPIs defined in ComSos-project and the environmental benefits of SOFC technology over conventional technologies, a comprehensive analysis of the installed units will be carried out. Performance data will be collected from all the installed SOFC units according to the document and Polito will analyse the collected data. For selected SOFC installations separate field measurements will be carried too. These field measurements will include CO_2, NO_x and particulate measurements and VTT is responsible for these measurements. Results of the analysis will be verified at the PMC meeting

Field measurements will be carried out for selected units. Primarily one unit or installation per each system integrator will be measured (Sunfire, SOLIDpower, Convion). The units that will be measured will be decided later when installation sites are known. Also, the schedule when these field measurements will be carried out will be decided later.

A more detailed description of data analysis, respect to this document, will be developed according to the following schedule:

- Deliverable D4.5: Performance and emissions of installed systems, 1 – POLITO, due at M23
- Deliverable D4.7: Performance and emissions of installed systems, 2 – POLITO, due at M41
- Milestone MS9: Installed systems are filling performance and emission targets – VTT, verified at M24 during PMC meeting

2. Comsos target KPI (from GA)

The table below shows the target KPIs for the COMSOS project, also compared with the ones of FCH-JU MAWP and SoA. These are the data which will be analysed for the selected demonstrators.

Table 1. COMSOS KPI from Grant Agreement.

KPI	UNIT	SOA	FCH-JU TARGETS			COMSOS TARGET
		2012	2017	2020	2023	2021
CAPEX	€/kW	6000-10000	5000-8500	4500-7500	3500-7500	<8000 @ < 20 units/y <6000 @ 20-100 units/y <4000 @ >100 units/y
Durability	Years of plant operation	2 – 20	6 – 20	8 – 20	8 – 20	10 yr (1 stack exchange during lifetime)
Availability	% of the plant	97	97	97	97	97
Electrical efficiency	% LHV	40 – 45	41 -50	42 – 55	42 – 55	> 50%
Thermal efficiency	% LHV	24 – 40	24 – 41	24 – 42	24 – 42	30 – 40 (total efficiency > 90%)
LCOE	c€/kWh	3 * grid parity	2.5 * grid parity	2 * grid parity	2 * grid parity	< 1.5 * grid parity
Emissions (NOx)	mg/kWh	< 40	< 40	< 40	< 40	< 40

3. Non-public data collection from the demonstrators

Data will be managed by POLITO personnel only in accordance with the Data Management Plan of the ComSos-project (D1.3). Sunfire, Convion and SOLIDpower will deliver the data to POLITO for analysis according to the D4.3 *(D4.3 - Description of the interfaces to the data storage).*

The goal of the non-public data analysis is to provide the funding agency (FCH-JU) and the entire consortium a detailed report on:

- System layout (inlet and outlet streams)
- Technical performance (electrical, thermal)
- Environmental performance (planned exhaust gas analysis)
- System availability
- Operation and control strategies (fixed operating point, variable operating point, etc.)
- Maintenance activities (types of ordinary maintenance, how is detected and organized)

Furthermore, by elaborating non-public data, generic figures on the system performance (e.g. efficiency range from the installations, average availability, etc.) could be produced – in agreement with the manufacturers – and used for the dissemination activities.

Details of the data collections and analysis procedure:

- Measurement interval is 15 minutes.
- Al the measurements and calculations related to technical performance will be developed – when possible – in accordance with the standard EN 62282-3-200 (Fuel cell technologies. Stationary fuel cell power systems. Performance test methods).
- A list of main events happened at the mini FC-CHP system during its operation will be shared by the manufacturers. This information is essential to determine the effective availability of the system and the reason for maintenance (planned or extraordinary), stops, partial load operation and other events. Operation strategies of the three SOFC units types will be discussed since they are part of T4.3.
- Auxiliaries consumption (auxiliaries = component required for the SOFC-CHP installation but placed outside the SOFC module, if happen) is necessary for evaluation. However, live data is not asked because it may not be available or measured. Therefore information of nominal/average auxiliary consumption is enough and can be provided for example when giving general information of the site and installation.
- Data on the end-users side are voluntary. Privacy of end user is acknowledged and therefore section ‘coverage of end-user loads’ can not be demanded. However, if the end-user is a public player that

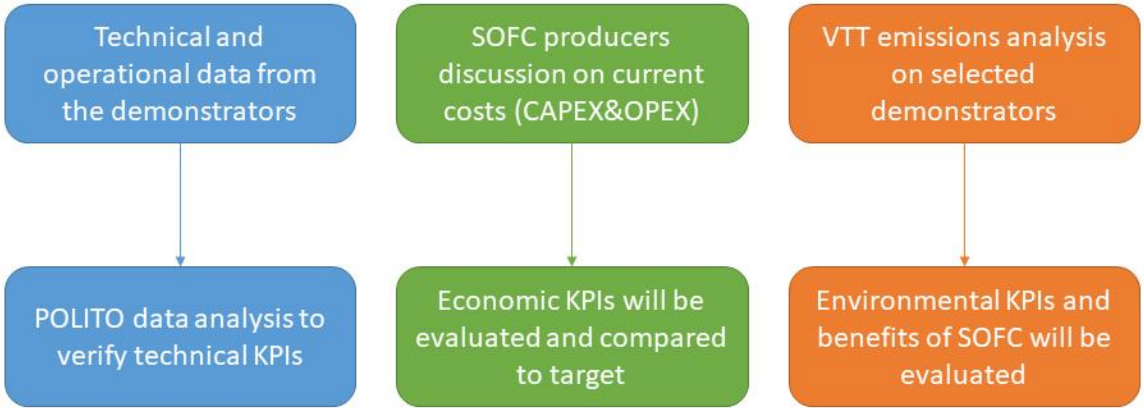
needs to share the information or if the end-user is willing to give the information then the information should be given.

Table 2. Data collected from the demonstrators.

	KPIs and other indicators for WP4 analysis	**Unit**
SOFC module performance	Electrical power production	kWe
	Electrical efficiency (**Comsos target**)	% LHV
	Cumulative electrical energy production	kWh
	Thermal power production	kWth
	Thermal efficiency (**Comsos target**)	% LHV
	Cumulative thermal energy production	kWh
	Total efficiency (**Comsos target**)	% LHV
	Cumulative hours of operation	h
	Inlet streams to the SOFC module: - Fuel consumption	kg/h
	Outlet streams from the SOFC module: - Exhaust	kg/h
	Hours in partial load operation - **or** graphical presentation of partial load operation	h
	Availability (**Comsos target**) - Defined as state of SOFC module being able to be used	%
	Durability (**Comsos target**) - If not available by the end of the project, Convion, Sunfire and SOLIDpower give estimates.	yrs
	List of events for the mini FC-CHP system, which includes: - Events (maintenance, stops, etc) - Hours with machine OFF	
	Emissions analysis (**Comsos target**) - Conducted by VTT (Task 4.2).	
Net perfor	Auxiliaries consumption	kWe
	Net electrical power production	kWe

	Net electrical efficiency (average in the covered period)	%
	Thermal losses from SOFC module to thermal user	kWth
	Net thermal power production	kWth
	Net thermal efficiency (average in the covered period)	%
	Net total plant efficiency (average in the covered period)	%
NG purification	NG purification management	Describe
	Lifetime of the adsorbents and maintenance period	Months
Maintenance	Maintenance activities performed.	Describe
Coverage of end user loads	% of electricity coverage	%
	Electricity bought from the grid	kWh
	Electricity sold to the grid	kWh
	% of thermal coverage	%
	NG bought from the grid	m^3
	Cost of electricity for the end-user	€/kWh
	Cost of NG for the end-users	€/kWh

4. Verification analysis procedure



5. Emission analysis

General

On-site emission measurements (field measurements) will be measured using a laboratory-in-a-van approach. All the measurement equipment, computers, calibration gases, etc. are installed into a van and the van will be driven to installation sites. This is a standard approach at VTT when measuring emissions from different power-production plants and it allows for dedicated and custom-made setups to be used on-site with relatively easily.

Figure 1 shows the simplified measurement setup. Process diagram has been drawn to depict measurement setup of field measurements done in DEMOSOFC-project for Convion SOFC-unit. Similar approach will be used in ComSos-project. A heated sampling line is placed inside exhaust chimney. The extracted gas is then fed through separate sampling line to FTIR (Fourier-transform infrared spectroscopy) for measuring gaseous species and to ELPI (Electrical low pressure impactor) for particulate measurement. The sample flow to ELPI is diluted with bottled air using ratio ~ of 1:7.

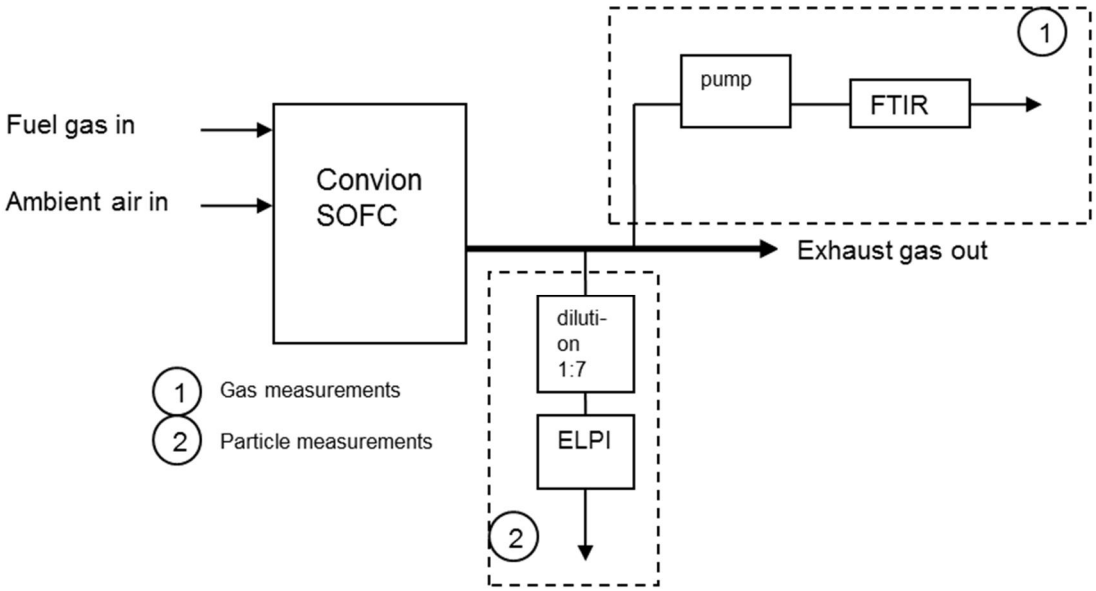


Figure 1. Process diagram of the emission measurement setup.

Particulate measurement

Particle number size distributions will be measured with the ELPI instrument. The main parts of the ELPI are charger and low pressure impactor. Inside the charger the particles are charged and the aerodynamic size classification is done inside the impactor (see Figure 2). The current values are measured from each stage of

the impactor and transformed to number of particles using calculations. ELPI measures particle size distribution and concentration in real-time of particle size range from 8 nm to 10 µm. Sampling flow from exhaust pipe is diluted to approx. 1:7 with purified compressed air before ELPI. Background levels (zero) are measured for a reference by using HEPA-filtered air (High Efficiency Particulate Air filter).

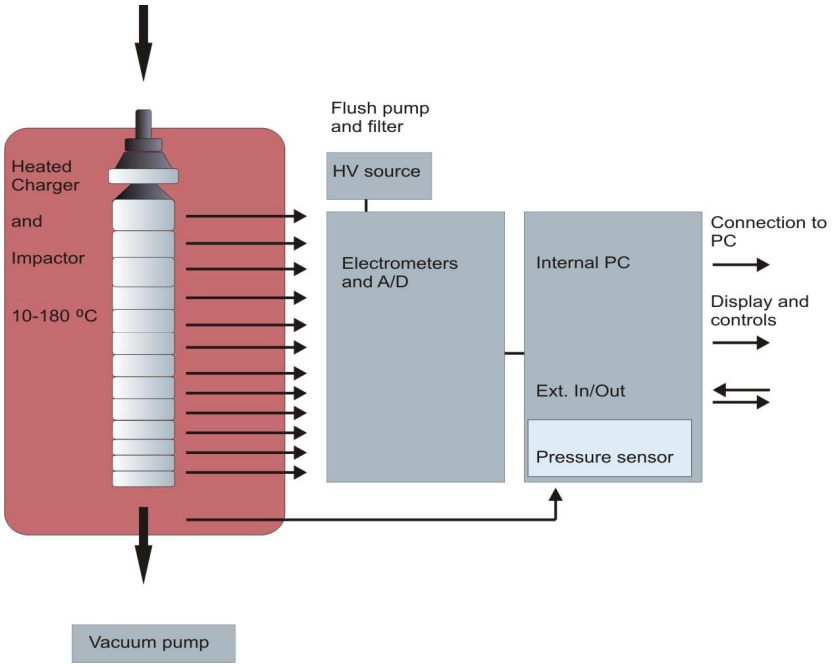


Figure 2. Measurement principle of the electronic low-pressure impactor (ELPI).

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