Solid Oxide Cell and Stack Testing, Safety and Quality Assurance

Collaborative Project - *FCH JU GRANT AGREEMENT N° 621245*

THEME [SP1-JTI-FCH.2013.5.4]

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***Project Coordinator**: M. Lang – DLR*

DELIVERABLE REPORT

D.7.3 – FINAL REPORT ON LIAISON AND DISSEMINATION ACTIVITIES	
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Main Author	S. McPhail (ENEA)
Co-Author(s)	M. Lang (DLR)
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DISSEMINATION LEVEL		
PU	*Public*	*X*
PP	*Restricted to other programme participants (including the Commission Services)*	
RE	*Restricted to a group specified by the consortium (including the Commission Services)*	
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NATURE OF THE DELIVERABLE		
R	*Report*	*X*
P	*Prototype*	
D	*Demonstrator*	
O	*Other*	

SUMMARY	
Keywords	*Liaison, standards, industry needs, dissemination*
Abstract	Combining continuous promotion with high-level liaison, "SOCTESQA" has generated widespread awareness and impact. The project initiated a dedicated working group within IEC in order to incorporate "SOCTESQA" test modules in a new standard for solid oxide cells operating in reversing mode. Several dissemination activities were carried out by the "SOCTESQA" partners, e.g. project website, posters presentations at European and international conferences, presentations at other European funded projects, newsletters, project flyers, fair exhibition, promotional articles and presentations at key international events.

D.7.3 – FINAL REPORT ON LIAISON AND DISSEMINATION ACTIVITIES

1 Objectives of liaison and dissemination in "SOCTESQA"

Work package 7 was dedicated to dissemination of the project results and to interaction with standards developing organizations (SDO) and with relevant industrial stakeholders. The ultimate objective of the project was to come up at the end of the project with procedures that are not only validated inside the laboratory, but are already shaped towards the requirements of regulations codes and standards as well as industrial productivity and reliability. The test procedures have incorporated the inputs from both entities and should foster worldwide discussion and awareness of the topic, especially thanks to the take-up of the procedures within the international standardization body "International Electrotechnical Commission" (IEC). In this way the maximum exploitation of the project outcome was achieved.

2 The Industrial Advisory Board

Table 1 shows the members of the industrial advisory board of the SOCTESQA project.

Table 1: Industrial advisory board of the SOCTESQA project

Industry		Contact
BOSCH	Bosch – Germany	Raphaëlle Satet
CeramTec	CeramTec – Germany	Michael Scharrer
CeresPower	Ceres Power – UK	Chris Evans
elcogen	Elcogen – Finland	Matti Noponen
elringklinger	ElringKlinger – Germany	Thomas Kiefer
FuelCon	FuelCon – Germany	Mathias Rachau
H.C.Starck	H.C. Starck – Germany	Michael Fooken
HYGEAR	HyGear – Netherlands	Robert Makkus
ICI CALDAIE	ICI Caldaie – Italy	Carlo Tregambe
KERAFOL	Kerafol – Germany	Andreas Glauche
HEXIS	Hexis – Switzerland	Andreas Schuler
SAINT-GOBAIN	Saint Gobain – France	Nathalie Petigny
SCHOTT	Schott – Germany	Jens Suffner
SOLID POWER	Solid Power – Italy	Stefano Modena
sunfire	Sunfire – Germany	Mario Heinrich
ZAHNER	Zahner – Germany	Carl Albrecht Schiller

Interaction with industry has been part of “SOCTESQA” since the time of writing the project proposal: a number of letters were gained at that time where key industrial players manifested their interest in following the project’s activities and achievements. These industries were chosen to constitute the project’s industrial advisory board (IAB) - see Table 1.

In the beginning of operations, fact sheets [1] were compiled by “SOCTESQA” partners to send out to the IAB for gaining technical input as to the operating conditions of SOC systems in the applications targeted: systems for combined heat and power generation (µ-CHP), auxiliary power units (APU) and electrolysis systems mainly. Feedback and filled in fact sheets were obtained from several IAB partners, e.g. ElringKlinger, SOLIDpower, Elcogen, HyGear and ICI Caldaie. This provided sufficient information to decide on the stack size to be tested within the project and to assess the involvement of industry [2].

3 Liaisons with Standards Developing Organizations

“SOCTESQA” has carried out a comprehensive survey of ongoing standardization activities in the field [3] and has entered into contact and liaison with the main bodies currently working on regulations for hydrogen and fuel cell technologies. Essentially, these are grouped under the international bodies of the ISO Technical Committee 197 on hydrogen technologies – which looks mainly at safety issues of electrolyzers and hydrogen handling – and the IEC TC105 on fuel cell technologies. The latter is much more focused on the technology and the definition of practical guidelines in terms of system performance, installation and characterization.

3.1 Liaisons with IEC and ISO

The work in “SOCTESQA” is considered more in line with IEC, and in fact the Technical Specification on Solid oxide fuel cell and stack test procedures issued in 2014 as IEC TS 62282-7-2 [4] has been a fundamental seed document for further elaboration. However, “SOCTESQA” explored new terrain in the assessment of test procedures for the recently emerging applications of high-temperature electrolysis. Solid oxide cells show tremendous potential as reversing power generator-storage devices, since the materials of the stack can remain unvaried when switching polarity and the high operating temperature is beneficial for electric efficiency in both modalities.

In fact, compared to PEM and Alkaline electrolysers producing hydrogen at around 40-60 kWh/kg H_2, the solid oxide technology effectively turns part of the heat into hydrogen, allowing it to reach hydrogen yields of 30-40 kWh/kg H_2. This is particularly interesting in view of the increasing penetration of renewables in the electric grid, which already leads to frequent curtailment of renewable power. SOC electrolysis can thus store excess power more efficiently, and the potential for re-electrification is enhanced as well, thanks to the high power generation efficiency and the capability to dimension systems to localized needs. Note that this has been fully addressed in test programmes 03 and 04.

Thus, it is considered a crucial task within “SOCTESQA” to lead international activities in standardization of solid oxide cells used in this way by example. To this effect, “SOCTESQA” was presented at the IEC TC105 plenary meeting in Tokyo in October 2014, and the proposal was submitted to initiate a dedicated working group on procedures for testing fuel cells in reversing mode (including PEM and Alkaline to be technology neutral). This was preliminarily accepted by the IEC, after which a technical meeting followed hosted by ENEA in Rome, and the drafting of a New Work Item Proposal (NWIP) for the production of 3 international standards by 2019:

- 62282-8-101: Solid oxide single cell and stack performance including reversing operation
- 62282-8-102: PEM single cell and stack performance including reversing operation
- 62282-8-201: Power-to-power systems performance

This activity was approved by the IEC and is currently undertaken by working group 13 in the TC105, and Stephen McPhail, leader of this Work Package 7 in "SOCTESQA", will act as project leader for the first standard, and as convener for the entire WG13. Thus, first-hand involvement is guaranteed (and formalized on 21/10/2016 in the form of a so-called *Category D Liaison* with the IEC TC105, allowing all "SOCTESQA" members to participate in the WG13 meetings) and the best possible output pathway for "SOCTESQA" activities is enabled and on-going. In fact, the test modules developed in "SOCTESQA" constitute the bulk of the 62282-8-101 standard that is currently in the stage of preparation of the "Committee Draft", i.e. the first complete draft that will be circulated to all National Committees that are member of TC105 for comments. These will then be taken into consideration and resolved at the final technical meeting of WG13 before voting for publication of the standard.

Through the IEC TC105 committee, liaison is also ensured with ISO's TC197 on hydrogen technologies, which will be monitored through the former activity.

3.2 Liaisons with CEN-CENELEC and JRC

Simultaneously, CENELEC, the European technical standardization body, has also initiated a new working group on Hydrogen. The scope of the working group covers the production of hydrogen through electrolysis and the transportation, distribution and usage of hydrogen in pure form or as a natural gas dominant mixture (H2NG). In addition, actions in cross-cutting fields such as safety and training of personnel are identified. The final objective of this working group is to set a long term collaborative framework (liaison) with major bodies for strengthening cooperation between regulatory work, standardization work and research & development programs (e.g. European Commission, JRC, FCH2 JU, IEA, ISO, IEC). DLR has joined this working group, namely task force 2: electrolysers, and participated at several meetings with the background of transferring the results and experience so far achieved in "SOCTESQA". Moreover, DLR has entered into a formal liaison with CENELEC to monitor the progress in this working group on behalf of the "SOCTESQA" consortium. The corresponding liaison agreement between DLR and CENELEC was signed in Sept. 2015.

Finally, JRC has launched a Europe-wide harmonization exercise for testing protocols for stationary (fuel cell) applications (for which a workshop was held in November 2016, in Brussels), which will rely heavily on the activities carried out in "SOCTESQA". Through the collaboration engendered with JRC in "SOCTESQA", the contribution of the "SOCTESQA" partners to this industry-facilitating task is ensured well beyond the end of the project.

4 Dissemination Activities

The basic tool for dissemination, namely the project website with a "corporate" identity, was developed early in the project and went on line as planned [5]. In addition to this, a project flyer was developed, for distribution at exhibitions and conferences [2].

The "SOCTESQA" project was intensively promoted, with 3 news items disseminated to the general public, 9 posters at high-profile conferences/workshops, 3 newsletters and 14 presentations at key international events including assemblies of the IEC. Especially the latter events have generated the

highest impact, since thanks to this engagement (formalized in the liaison mentioned in section 3.1) the project has provided the procedures for solid oxide cell and stack testing that are to become internationally applicable standards, for the benefit of industrial production all round.

A crucial dissemination event that catalysed the interaction with industry and standardization, an important milestone within “SOCTESQA”, was the workshop organized on 15.12.2015 in the frame of the 2015 European Fuel Cell “Piero Lunghi” conference in Naples/Italy. Keynote speakers from standardization bodies (JRC, IEC, Japanese electrical manufacturers’ association – JEMA) and collaborating projects such as “STACKTEST” (FCH-JU) interacted with industry (CERES Power, Elcogen) and academia to demonstrate achievements, identifying gaps and bottlenecks and ways forward in a lively debate.

The experimental results and knowledge generated by the project have been presented at important scientific and topical events around the world, under the firm conviction that a straightforward and open approach is the key to the universal adoption of harmonized, quality-assuring procedures, for the benefit of technological progress and the entire industry.

A list of dissemination activities carried out by “SOCTESQA” partners is given in the table 2 below, with details regarding dates, presentation types and titles, and outcome where relevant.

Table 2: Dissemination activities within SOCTESQA

Date	Event	Location	Presentation type	Title	Presented by (partner)	Audience (number)	Comments
12.12.2013	EFC13	Rome, Italy	Poster	Solid Oxide Cell & Stack Testing, Safety and Quality Assurance (SOCTESQA)	ENEA, DLR	scientific (>200)	
15.04.2014	Kick-off meeting EU-project "ENDURANCE"	Genova, Italy	Presentation	FCH-JU project "SOCTESQA" (Solid Oxide Cell & Stack Testing, Safety and Quality Assurance)	DLR	scientific (>30)	
29.04.2014	n.a.	ENEA website	News item	L'ENEA nei progetti europei per le celle a combustibile	ENEA	generic (>1000)	http://www.enea.it/it/comunicare-la-ricerca/news/enea-nei-progetti-europei-per-le-celle-a-combustibile
03.06.2014	Workshop EU-project "STACKTEST"	Stuttgart, Germany	Poster	Collaborative project: Solid Oxide Cell & Stack Testing, Safety and Quality Assurance (SOCTESQA)	DLR	scientific (>30)	
15.06.2014	WHEC 2014	Gwangju, S. Korea	Poster	Solid Oxide Cell & Stack Testing, Safety and Quality Assurance (SOCTESQA)	ENEA	scientific (>500)	
01.07.2014	EFCF 2014	Luzern, Switzer-land	Poster	SOCTESQA - Solid Oxide Cell and Stack Testing, Safety and Quality Assurance	DLR	scientific (>300)	
31.07.2014	n.a.	Internet	Project website	www.SOCTESQA.eu	ENEA	generic (>1000)	www.SOCTESQA.eu
02.10.2014	Technical meeting SUNFIRE	Dresden, Germany	Presentation	Introduction to FCH-JU project „SOCTESQA"	DLR	stack supplier	

02.10.2014	n.a.	DTU website	News item	Research in hydrogen and fuel cell energy systems to be accelerated through standardization	DTU	generic (>1000)	http://www.dtu.dk/english/News/2014/10/Research-in-hydrogen-and-fuel-cell-energy-systems-to-be-accelerated-through-standardization
21.10.2014	Putting science into standards workshop	Petten, Nether-lands	Participation	n.a.	DLR, DTU	SDO (>30)	initiated liaison procedure with CENELEC
28.10.2014	Technical meeting SOLIDPOWER	Trento, Italy	Presentation	Introduction to FCH-JU project „SOCTESQA“	DLR	stack supplier	
28.10.2014	Asia Clean Energy Summit	Singapore	Presentation	Electrolyzer/Fuel Cell --- A bridge towards a more sustainable future	NTU	stakeholders (>100)	
01.11.2014	n.a.	Denmark	Newsletter	DTU skal være med til atstandardisere brændselsceller	DTU	generic (>1000)	
08.11.2014	TC105 General Assembly	Tokyo, Japan	Presentation	Future perspectives of SOFC/SOEC applications and the role of standardization	ENEA	SDO (>30)	initiated ad-hoc group (AHG6) for International Standard on regenerative FC within IEC
10.11.2014	FCH JU Programme Review Days	Brussels, Belgium	Poster	SOCTESQA - Solid Oxide Cell and Stack Testing, Safety and Quality Assurance	DLR	Stake-holders (>100)	
07.01.2015	2nd International Conference on Sustainable Urbanization (ICSU 2015)	Hongkong, China	Presentation	Fuel Cell and Electrolyzer – towards Power to Gas Application	NTU	Scientific (>200)	

05.02.2015	n.a.	Internet	Newsletter	#1	ENEA	generic (>1000)	
13.04.2015	Hannover Messe	Hannover, Germany	Flyer	SOCTESQA - Solid Oxide Cell and Stack Testing, Safety and Quality Assurance	ENEA, DTU, DLR	generic (>1000)	
22.05.2015	ENERGY, SCIENCE & TECHNOLOGY – International Conference and Exhibition, EST 2015	Karlsruhe, Germany	Flyer	Project "SOCTESQA"	EIFER	scientific (>100)	
22.07.2015	IEC TC105 AHG meeting	Rome, Italy	Participation	n.a.	ENEA, JRC	SDO (>30)	plan for AHG6 activity
27.07.2015	SOFC XIV	Glasgow, Scotland	Poster	SOCTESQA - Solid Oxide Cell and Stack Testing, Safety and Quality Assurance	DLR	scientific (>400)	
11.08.2015	n.a.	Internet	Newsletter	#2	ENEA	generic (>1000)	
22-23/09/2015	IEC TC105 International FC Conference	Beijing, China	presentation	"Test procedures for a quality-assured supply chain – SOCTESQA"	ENEA	SDO, scientific (>100)	
21,24-25/09/2015	IEC TC105 AHG and Plenary meeting	Beijing, China	participation	"Energy storage systems using fuel cell modules in reverse mode"	ENEA	SDO (>30)	New Work Item Proposal for International Standard on Fuel cells operated in regenerative mode
19/10/2015	Mid-Term-Review of Spurc project	Singapore	Presentation	Solid Oxide Cell Stack Test Station	NTU	Review panel members (10)	

27.10.2015	Asia Clean Energy Summit	Singapore	Presentation	Power to Gas by High Temperature Solid Oxide Electrolysis Cell (SOEC)	DLR	Stake-holders (>100)	
17.11.2015	FCH JU Programme Review Days	Brussels, Belgium	Poster	SOCTESQA - Solid Oxide Cell and Stack Testing, Safety and Quality Assurance	DLR	Stake-holders (>100)	
15-18/12/2015	EFC15	Naples, Italy	Presentation	SOCTESQA - Solid Oxide Cell and Stack Testing, Safety and Quality Assurance	DLR	scientific (>200)	
15.12.2015	SOCTESQA Workshop	Naples, Italy	Workshop	Fuel Cell Deployment and Standardization: formulating univocal procedures relevant for industry	ENEA, All	scientific (>30)	
09.02.2016	VDMA working group "Hochtemperatur brennstoffzelle" meeting	Weinheim, Germany	Presentation	Project „SOCTESQA“ (Solid Oxide Cell and Stack Testing, Safety and Quality Assurance)	DLR	German SDO	
25-29/04/2016	Hannover Messe	Hannover, Germany	Poster	Solid Oxide Cell and Stack Testing, Safety and Quality Assurance - SOCTESQA	DTU	Stake-holders (>1000)	
19.04.2016	IEC e-tech magazine, March '16 edition	IEC e-tech website	News item	Reverse mode fuel cells for energy storage	ENEA	SDO, scientific, general (>1000)	http://iecetech.org/issue/2016-03/Reverse-mode-fuel-cells-for-energy-storage
05-08/07/2016	12th European SOFC & SOEC Forum 2016	Lucerne, Switzer-land	Poster	Increase of Quality Assurance	DLR	scientific (>300)	

05.10.2016	ECS PRIME Conference	Honolulu, USA	Presentation	Towards Quality Assurance in SOC testing: Effects of Test Bench Architecture and the role of International Standards	ENEA	scientific (>1000)	
21.11.2016	FCH JU Programme Review Days	Brussels, Belgium	Poster	SOCTESQA - Solid Oxide Cell and Stack Testing, Safety and Quality Assurance	DLR	Stake-holders (>100)	
23.11.2016	First EERA Annual Conference	Birming-ham, England	Presentation	Quality assurance of solid oxide fuel (SOFC) and electrolysis (SOEC) cells and stacks	DLR	scientific (>30)	
17.02.2017	Workshop on Degradation Mechanisms in Solid Oxide Cells and Systems	Barcelona, Spain	Presentation	Project SOCTESQA : Solid Oxide Cell and Stack Testing, Safety and Quality Assurance	DLR	scientific (>30)	
17.02.2017	Workshop on Degradation Mechanisms in Solid Oxide Cells and Systems	Barcelona, Spain	Presentation	Quality Assurance of SOC stacks with focus on degradation	DLR	scientific (>30)	
17.02.2017	Workshop on Degradation Mechanisms in Solid Oxide Cells and Systems	Barcelona, Spain	Poster	Degradation of SOC stack tested in SOFC mode operation	ENEA, DLR	scientific (>30)	
17.02.2017	Workshop on Degradation Mechanisms in Solid Oxide Cells and Systems	Barcelona, Spain	Poster	Testing of SOC stacks in steam electrolysis mode	EIFER	scientific (>30)	
17.02.2017	Workshop on Degradation Mechanisms in	Barcelona, Spain	Poster	Degradation of SOC stack tested in SOFC-SOEC combined mode operation	DTU	scientific (>30)	

	Solid Oxide Cells and Systems						
24-28/04/2017	Final SOCTESQA Workshop and promotional event	Hannover Messe, Germany	Exhibition booth	SOCTESQA booth	All	industry, end-users, general (>1000)	in conjunction with DLR booth and with promotional material from IEC
26.04.2017	Final SOCTESQA Workshop and promotional event	Hannover Messe, Germany	Presentation	SOCTESQA: Test procedures for SOFC/SOEC - implementation in international standards	ENEA	industry, end-users, general (>30)	https://youtu.be/R0dOIZo10iY
27.04.2017	Final SOCTESQA Workshop and promotional event	Hannover Messe, Germany	Presentation	SOCTESQA: Test procedures standardization for the industrialization of SOFC/SOEC	DTU	industry, end-users, general (>30)	https://youtu.be/eDiFcqGpdII

5 Plan for beyond the Project

After SOCTESQA has ended, the liaisons with CENELEC and IEC will continue, since these bodies are currently active in defining regulations that are in line with what SOCTESQA carried out in practice. The developed and validated test modules and test programs will be made available on the ongoing project website, www.soctesqa.eu, for free download by all interested. An application to collect feedback from potential users will be implemented on the same website to make sure the procedures remain topical and up-to-date. The procedures are expected to be adopted by all FCH JU projects that are concerned with SOFC/SOEC/Re-SOC testing and qualification. A stronger uptake by European industry is therefore also envisaged: this has already been realized by the recent joining of Sunfire GmbH to the activites of WG13 of the TC105, the first European industry to join this SDO otherwise traditionally led by Japanese and US industries and industry associations, where Europe generally provides experts from research and academic background. In any case the leading positions of SOCTESQA partners in the standardization process will be maintained, also through the JRC, to balance the definition of international benchmarks.

6 References

[1] G. de Marco, „D.2.1 – LIST OF SOC SPECIFICATIONS (REVISED VERSION),“ 2016.

[2] S. MC Phail and M. Lang, „D7.2 Interim report on liaison and dissemination activities,“ 2015.

[3] T. Malkow, M. Lang and C. Auer, „D.2.2 – LIST OF SOC TEST PROCEDURES,“ 2014.

[4] Intern. Electrotech. Comm., „IEC 62282-7-2: Single cell and stack test methods –Single cell and stack performance tests for solid oxide fuel cells (SOFC),“ 2014.

[5] S. McPhail, C. Mungiguerra and M. Castillo-Jaramillo, „D.7.1 – PROJECT WEBSITE,“ 2014.