30-03-2019, VERSION 1.

D7.1 – Plan for the exploitation and dissemination of results (PEDR)

PROJECT INFORMATION

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PROJECT ACRONYM	LOWCOST-IC
FUNDING SCHEME	FCH-JU2
START DATE OF THE PROJECT	1/1-2019
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PROJECT WEBSITE	www.lowcost-ic.eu

DELIVERABLE INFORMATION

DELIVERABLE N°	D7.1
WP LEADER	Belma Talic
CONTRIBUTING PARTNERS	All
NATURE	Report
AUTHORS	Belma Talic, Karin Vels Hansen
CONTRIBUTORS	Jan Froitzheim, Dino Boccaccini, Christian Walter, Richard Schauperl, Jörgen Westlinder, Gert Nilissen, Pierre Olivier Santacreu
CONTRACTUAL DEADLINE	31.03.2019
DELIVERY DATE TO EC	

VERSION HISTORY

30-03-2019	Version 1, accepted by all partners

DISSEMINATION LEVEL

PU	Public	x
PP	Restricted to other programme participants (incl. Commission Services)	
RE	Restricted to a group specified by the consortium (incl. Commission Services)	
CO	Confidential, only for the members of the consortium (incl. Commission Services)	

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1 Introduction

1.1 Scope and objectives of this deliverable

The Plan for the Exploitation and Dissemination of Results (PEDR) outlines the strategy and concrete actions to ensure effective dissemination and maximum exploitation of the results generated by LOWCOST-IC. The PEDR includes descriptions of the project objectives, key messages, target audiences, dissemination methods, and a detailed plan and timeline for the dissemination activities. The PEDR also includes a communication tool-box.

This deliverable presents the first version of the PEDR and concentrates on the dissemination and exploitation activities planned in the project. The PEDR will be updated in M12, M18 and M36 with a more detailed plan for the second and third year of the project. The updated PEDR will include an overview of the dissemination and exploitation activities carried out in the first year.

The PEDR is a public deliverable and will be made available for download on the project website.

1.2 Scope and objectives of the LOWCOST-IC project

Increasing the capacity for energy conversion and storage is essential for enabling the EU to develop a low carbon electricity system. Solid oxide cells (SOC) are an attractive technology for this purpose, but lower costs and a better long-term stability are needed for this technology to become commercially interesting at large scales. Among the enduring challenges is degradation related to the steel interconnect material and insufficient robustness of the contact between the interconnect and the cell.

LOWCOST-IC will tackle these issues by developing, fabricating and demonstrating low-cost interconnects and exceptionally tough contact layers for use in SOC stacks.

The cost of SOC interconnects will be reduced by combining cost-effective high volume steel grades with highly protective coatings. Large-scale mass manufacturing methods will be demonstrated for application of the coating by physical vapour deposition (PVD), subsequently shaping of the interconnects by hydroforming and finally fast printing of contact layers by a drop-on-demand process. Novel robust contact layers, utilizing the concept of reactive oxidative bonding will substantially improve the mechanical contact between the cell and the interconnect, while ensuring a low and stable area specific resistance (ASR).

To accelerate the development of interconnects, new computationally efficient SOC stack models will be customized to the purpose, and the cost of prototyping will be brought significantly down by hydroforming with far more affordable tools. The new interconnect steels, coatings and contact layers will be implemented in the SOC stacks of two commercial manufacturers and undergo extensive testing in an industrially relevant environment, including thermal cycling and long-term operation. The stack test results will be analysed for further optimization of the individual components and the solution as a whole. Finally, the cost-effectiveness of the proposed production route will be assessed and compared with existing production routes as background knowledge for the SOC industry and to facilitate a fast market entry of the project innovations.

Compared to state-of-the art technology used today in most SOC stacks, ICs developed in LOWCOST-IC will have the following main advantages/improvements:

- Reduced raw material cost
- Lower fabrication and investment costs
- Improved mechanical strength of contact points between cell and IC and a lower ohmic resistance
- Novel IC designs with high gas permeability and a low-pressure drop

The project consortium covers the entire value chain for interconnects, coatings and contact layers, as illustrated in Figure 1.

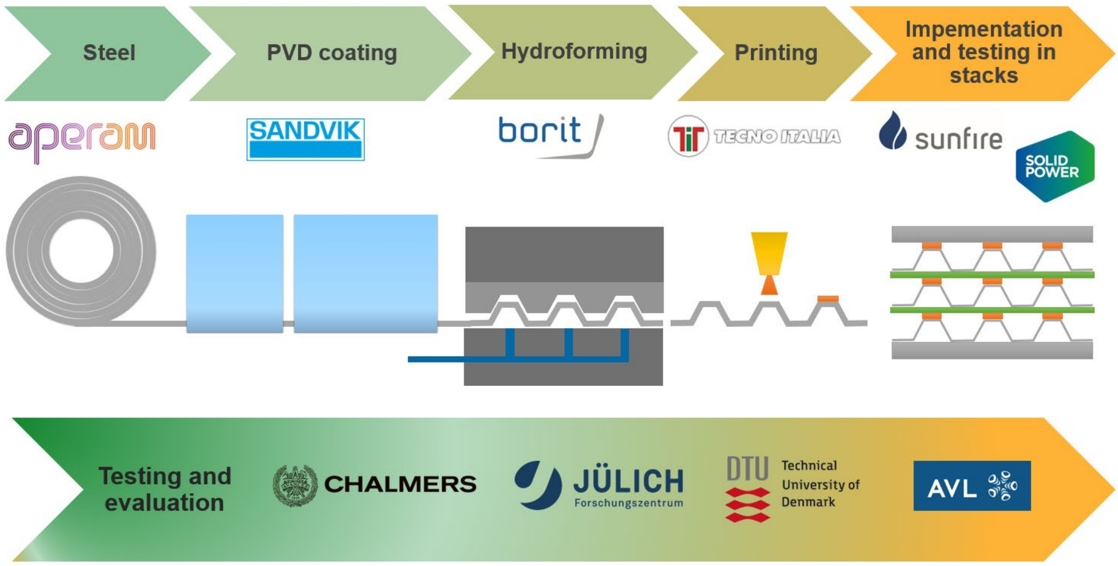

Figure 1. LOWCOST-IC value chain and consortium partners

2 Dissemination plan

2.1 Dissemination strategy

The overall objective behind the dissemination strategy is to maximize the project's impact and promote exploitation of the results. In order to do so, the subjects for dissemination and the target audiences for the different dissemination subjects have been identified. A detailed dissemination plan is constructed in order to reach each of the target audiences in the most effective way. The dissemination plan will be revised and updated throughout the project.

2.1.1 Subjects for dissemination

The following topics have been identified as key subjects for dissemination:

1. **The LOWCOST-IC project itself**. The overall scope and objectives of the project, as described in Section 1.2.
2. **Scientific results**. The project will generate results on ASR, mechanical properties, stack performance, corrosion resistance, stack model etc.
3. **Technologies**. Roll-to-roll PVD of protective coatings, hydroforming of interconnects, DoD printing of contact layers, etc.
4. **Economical assessment.** The overall cost-effectiveness of the proposed route for interconnect manufacturing will be assesses and compared to existing production routes.

2.1.2 Target audiences

The audiences targeted in the dissemination of the project's results are:
1. **The project partners.** Several of the partners in the consortium are potential end-users of the project's results. Furthermore, they are important players in the SOFC/SOEC industry and may therefore be viewed as "influencers".
2. **Scientific community, including students**. The results from the project should be of particular interest to researchers working in the fields of SOC technology, high temperature corrosion, multiphysics modelling and fracture mechanics.
3. **H_2 and fuel cell industry.** In particular, other stack manufacturers.
4. **EU projects working in a similar domain.**
5. **Policy makers and organizations.**

2.2 Dissemination methods

An outline of the dissemination methods and the target audiences is given in Table 1. Where possible, a quantitative target has been formulated. The targets already fulfilled are highlighted by green font. Some of the individual dissemination activities are outlined in more detail in the following. Other activities such as the website, newsletter and poster/flyer are part of the communication tool-box, presented in Section 2.4.

Table 1: Overview of dissemination methods

Platform	Dissemination method	Target audience(s)	Target goal
Scientific journals	Publish papers under gold open access in peer-reviewed journals. **Responsible partners:** DTU, CU, FZJ	Scientific community	> 15 papers
Conferences	Attend conferences with oral and poster contributions. Target conferences: ECS meetings, the European SOFC & SOE Forum, the European Fuel Cell Technology & Applications "Piero Lunghi" Conference (EFC), the ASME Fuel Cell Science. **Responsible partners:** DTU, CU, FZJ, AVL	Scientific community	>3 oral presentations per year

Technology fairs	Be present with a booth promoting products and processes developed in the project (e.g. Hannover Messe, F-cell Stuttgart, Fuel Cell Expo etc). **Responsible partners:** APE, SMT, BOR, SUN, SOL, TI, AVL	H_2 and FC industry	1 fair per year
Other events	Participate in FCH2-JU review days and events within National Hydrogen Associations (e.g. Danish Partnership for Hydrogen and Fuel Cells and Swedish Hydrogen Association). Take active participation in networking events with stake-holders and policy makers, e.g. meeting hosted by EERA. **All Responsible partners:** All	H_2 and FC industry, Policy makers	> 1 meeting per year
Technical datasheet	Collect relevant results for each product (e.g. alloy, coating, contact layer) in a technical datasheet, to be published on the LOWCOST-IC website and the websites of the relevant project partners **Responsible partners:** APE, SMT, TI	H_2 and FC industry	Technical datasheet published M30
Workshops	Organize 2 workshops during project: 1) Workshop on mechanical properties (to be held in connection with the European Fuel Cell Forum 2020). **Responsible partner:** DTU 2) Workshop on corrosion and protection of interconnects (to be held in connection with SOFC XVII in 2021). **Responsible partner:** CU	Scientific community, Students, H_2 and FC industry	Both workshops attended by > 25 participants
Summer school	Lecture on issues related to SOC interconnects during the Joint European Summer School (JESS) on Fuel Cell, Electrolyser and Battery Technology. **Responsible partner:** DTU, CU	Students	1 lecture given during JESS
Website	Provide information about the project objectives and partners, result highlights, overview of publications etc. **Responsible partner:** DTU	Scientific community, H2 and FC industry	Launched 12.03.2019
Social media	Project profiles on ResearchGate, Mendeley etc.	Scientific community	Profiles created
Newsletter	Send out to subscribers with updates on result highlights and technological breakthroughs. **Responsible partner:** DTU	Scientific community, H2 and FC industry	2 newsletters per year
Poster/flyers	Information about project scope and objectives. The posters will be displayed at partner locations and flyers distributed during various networking events. **All**	Policy makers	2 versions made

2.2.1 Publication in scientific journals

Based on the expected scientific results from the project, several target journals have been identified. An overview with expected review times and costs for gold open access is presented in Table 2. As the project progresses and the first results are achieved, the PEDR will be updated to include a more detailed plan for which results to be published where and a timeline for writing the manuscripts.

Table 2: Overview of target journals

Journal	Review time (weeks)	Embargo period (months)	Gold open access fee (EUR)
Journal of Power Sources	5	24	3600
Applied Energy	6	24	3100
Journal of Hydrogen Energy	9	24	2400
Fuel Cells		12	2500
Oxidation of Metals	12		2500
Journal of the Electrochemical Society	4		900
Corrosion Science	18		2900
Journal of the European Ceramic Society	8	24	3500

The partners within LOWCOST-IC recognize the importance of making our research output widely accessible and will take an active approach to the open access policy of Horizon 2020. All publications generated by the project will therefore be made freely accessible by publishing either in gold open access journals if they are on the same or higher level than the best journals in their field, or by making the publication available in green open access six months after publication. All of the targeted high-impact journals listed above have an option to publish in gold open access mode and appropriate funds for gold open access have been allocated in the budget.

To ensure long-term preservation, all articles will additionally be deposited in an OpenAIRE compliant depository (such as DTU Orbit and Chalmers Research). This approach contributes to support "optimal circulation, access to and transfer of scientific knowledge" and "facilitate effective collaborative research and knowledge transfer within the research Framework Programs and beyond", as defined in the EC Communication.

2.2.2 Conferences and events

To maximize the coverage of different conferences and events, the project partners will as far as possible distribute themselves among the target events. At the present stage of the project it is too early to plan for the conferences. This table will be expanded in the next version of the PEDR.

Table 3: Target conferences and events

Type	Date	Event	Main topic to disseminate	Partner
Conference	July 2020	European SOFC and SOE Forum, Luzerne		

	December 2019	European Fuel Cell Technology & Applications "Piero Lunghi" Conference (EFC), Naples		
	September 2019	SOFC XVI, Kyoto		
Fair/Expo	April 2019	Hannover Messe	Overall plans objectives of the project	DTU
	April 2020	Hannover Messe		
	September 2019	F-cell Stuttgart		
	February 2020	Fuel Cell Expo, Tokyo		
Networking events		FCH2-JU review days		
		Danish Partnership for Hydrogen and Fuel Cells		
		Swedish Hydrogen Association		
		EERA stake-holder meeting		

2.2.3 Workshops

A workshop on **mechanical integrity of SOFC stacks** will be held in connection with 14th European SOFC & SOE Forum 2020. The focus of this workshop will be interfaces in SOFC stacks, enhancing their properties, characterization and modelling thereof. The objective of the workshop is both dissemination of project knowledge and retrieval of knowledge to the project from other stakeholders in the field. The workshop will therefore target both academia and industry. To maximize interaction between participants the workshop will contain discussion forums and informal short presentations inspiring dialogue.

A workshop on **corrosion and corrosion protection of interconnect materials** will be held in connection with the SOFC XVII conference in 2021. The workshop will comprise lectures on all issues related to using stainless steel interconnect materials, and will be targeted towards doctoral students, researchers and representatives from the SOC industry. Relevant lecture topics include oxidation kinetics, Cr vaporization, area specific resistance, development of protective coatings, etc. In addition to serving as a platform for dissemination of project results, the workshop will facilitate knowledge exchange with other projects and researchers working on the same issues.

2.2.4 Other activities

Project profiles on ResearchGate and Mendeley have been created. These profiles allow interested researchers to follow news about the project, get notified about new publications and ask questions. A screen dump of the profile on ResearchGate is shown in Figure 2.

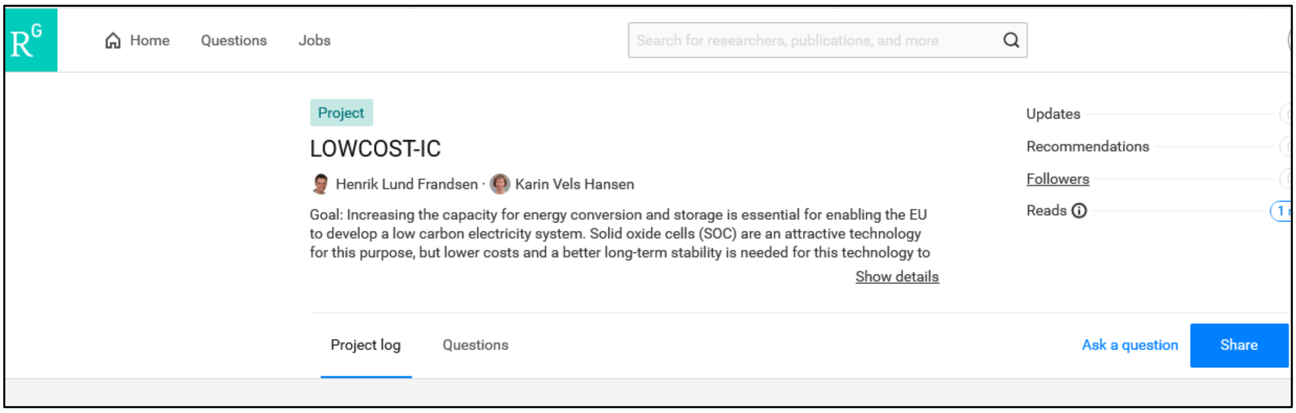

Figure 2: Screen dump of ResearchGate profile

2.3 Dissemination management

2.3.1 Distribution of responsibility

According to the Article 29.1 of the EC-GA "Each beneficiary must – as soon as possible – 'disseminate' its results by disclosing them to the public by appropriate means (other than those resulting from protecting or exploiting the results), including in scientific publications (in any medium)." Thus, all of the individual partners must contribute in dissemination of the project's results.

Belma Talic (DTU) has been appointed the Dissemination Manager and will oversee and keep track of the dissemination activities. The dissemination manager will act as the central contact point for external communication about the project.

Contact information:
Email: beltal@dtu.dk
Phone: +45 61 41 84 52

2.3.2 Dissemination policy and rules

The general rules for dissemination are detailed in Article 29 of the Grant Agreement. In the following, some of the main guidelines are summarized.

2.3.2.1 General policy

Special care will be taken to ensure that disseminating Foreground IP (produced through the partners' research) does not lead to the unintentional disclosure of confidential/secret information that was made available as Background IP by a partner at the start of the project. Before a partner can disseminate its results, a notice about the activity must be given to the other partners at least 14 days in advance. Any other beneficiary may object within 7 days of receiving the notification, if it can show that its legitimate interests in relation to the results or background would be significantly harmed. In such cases, the dissemination may not take place unless appropriate steps are taken to safeguard these legitimate interests.

In case of a major public event or press conference, the dissemination manager will formally notify the FCH JU prior to the event.

The policy and rules for handling data generated by the project is described in the Data Management Plan, which is a separate deliverable (D1.2).

2.3.2.2 Monitoring, reporting and evaluation

All dissemination and communication activities should be reported to the Dissemination Manager. A spread-sheet for reporting has been uploaded to the internal website.

An overview of the dissemination and communication activities will be reported in the updated PEDR (M12). An overview of news stories, published papers, and conference/fair attendance by the consortium partners will be published on the external website.

An evaluation of the dissemination will be made based on the numerical targets set for the different activities, as outlined in Table 1. The targets will be periodically reviewed by the Dissemination Manager, in collaboration with the steering board.

2.4 Communication tool-box

2.4.1 Graphical identity

The logo is presented in Figure 3. The logo consists of the project acronym and a graphic illustrating the main objective of the project: to bring down the cost (down-pointing arrow) of interconnect materials (the wavy line, symbolizing a corrugated steel sheet). The coloured version of the logo should preferably be used.

The logo will be used on all reports, deliverables etc. both when communicating externally and internally within the project.

In addition to the logo, power-point and word templates have been created to ensure a common visual identity for all dissemination material in the project. These templates will be used as basis for making the deliverable reports, conference presentations etc. and are available to the project partners through the internal website.

Figure 3 Project logo in colours, and in grayscale.

2.4.2 Public website

A website (www.lowcost-ic.eu) has been established for communication to the public. A screen dump is shown in Figure 4. At this time (M3), the website includes information about the project objectives, work packages and consortium partners. As the project progresses, the website will be updated to include result highlights and links to publications. Public deliverables will also be made available for download through the website. To maximize the visibility, all consortium partners will link to the site from their respective webpages.

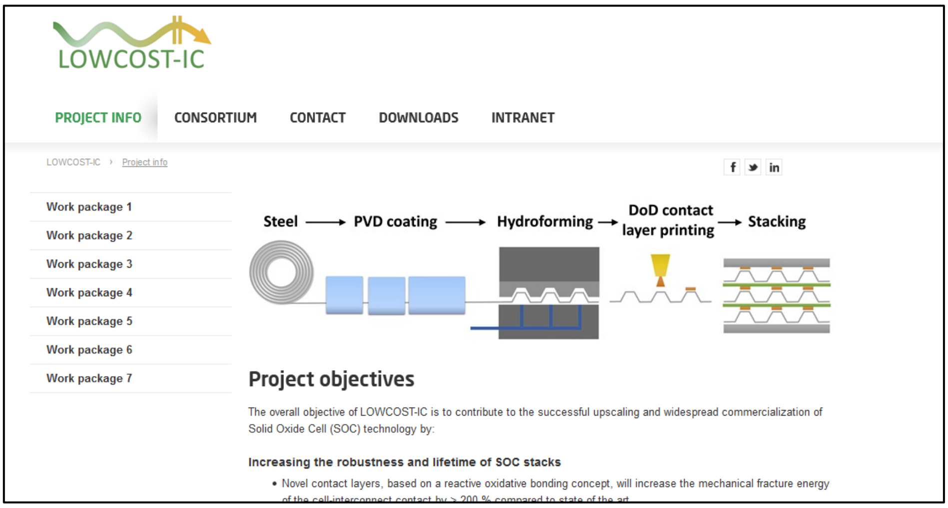

Figure 4: Screen dump from LOWCOST-IC website

2.4.3 Information poster

A poster describing the project objectives and consortium has been created and is attached at the end of the PEDR. The poster will be used at networking events, in the offices and labs of the partners. The poster will be updated midway through the project to include result highlights.

2.4.4 Electronic newsletter

News about the project, such as major technological break-troughs, recently published results and upcoming conferences/events where the partners will be present will be reported in an electronic newsletter. The newsletter will be sent out to the project partners and other newsletter subscribers on a biannual basis. A template for the electronic newsletter has been created and uploaded to the internal website.

3 Exploitation plan

The ambition of LOWCOST-IC is to ensure that the created results not only are available to the consortium partners, but that they are also accessible to all stakeholders interested in SOC technology, both in the industry and the scientific community.

3.1 Exploitation strategy

Based on the expected outcome of the LOWCOST-IC project, we have identified several "exploitable items", listed in Table 3. For each of these exploitable items, we have identified the potential markets and suitable methods for exploitation, as detailed below.

Table 4: Identification of exploitable results

Exploitable item	Expected project result
Cost-effective alloy for SOC interconnects	Extensive testing carried out in WP2 will identify the most suitable alloy for SOFC interconnects based on combined consideration of cost and performance. Long-term demonstration in a real-life stack will create the relevant credibility required by potential customers. Techno-economic analysis in WP6 will demonstrate the potential cost-savings using the new interconnect material.
Improved interconnect coatings with proven performance	Corrosion testing and coating development in WP2 will target an improved coating solution. Long-term demonstration in a real-life stack will create the relevant credibility required by potential customers. Techno-economic analysis in WP6 will demonstrate the potential cost-savings using the roll-to-roll PVD process for coating interconnects steel.
Guidelines for IC (+coating) shaping with hydroforming	The possibilities, design limitations and cost of using hydroforming investigated in WP3 and WP6 will be summarized in the final project report. This report will enable SOFC manufacturers and companies interested in starting activities in this field to ensure that their interconnect design can be realized without technical difficulties. The results of the LOWCOST-IC project with prove that the hydroforming technology is compatible with pre-coated materials in order to create functioning interconnects.
A novel contact material based on	

reactive oxidative bonding.	Testing the novel contact solution in a prototype stack (WP 5) will allow acquisition of novel know-how, and after one year constitute a new product ("contact paste for screen and inkjet printing") to serve clients (SOFC/SOFC stack producers).
DoD printing for SOC components	The process of depositing advanced ceramic pastes onto stainless steel substrates by DoD printing will be demonstrated in the project.
Techno-economic analysis report	The economic benefit of the high-volume processing methods combined in LOWCOST-IC are assessed by AVL, through a thorough cost-benefit analysis of the different production methods available. The SOC stack companies will benefit from the analysis in considerations about further upscaling, and the analysis can serve as guidance for designing the plants. The sub-suppliers will also gain by this direct comparison, as it will highlight the advantages of their production method, and promote the deployment of their respective technologies.
Novel interconnect design	The interconnect designs will be made publicly available (without revealing Sunfire IPR). Even more importantly, the developed approach for optimizing the interconnect design will be made available, so that also other stack manufacturers can benefit from the results.
Improved SOFC modelling software	The know-how created within the project will lead to an improved SOC stack model, which readily can predict failures in SOC stacks. Credibility towards customers will be created by demonstrating the approach (model → implementation).
Academic exploitation items	Scientific questions from the project will form the base for several MSc and PhD theses at Chalmers and DTU. In this way the project contributes to the education of European engineering students in general and with skills in fuel cells in particular.

3.1.1 Exploitation strategies for each exploitable item

Cost-effective alloy

Main beneficiary: Aperam
Potential market: All SOC stack industry

Exploitation strategy. The identified alloy will be advertised on Aperam's web page, and a technical data sheet for download and distribution at conferences and fairs will be made available. The results from the project will be used in technical meetings with potential customers (producers of SOC or CHP systems).

Interconnect coating

Main beneficiary: Sandvik

Potential market: SOC stack industry relying on thin plate IC. Parts of chemical/energy industry requiring corrosion protection of steel

Exploitation strategy. The developed solution will be added to Sandvik's existing portfolio on SOFC coatings. The improved version will be presented at conferences and exhibitions, as well as advertised on Sandvik's web page.

Shaping with hydroforming

Main beneficiary: Borit

Potential market: SOC stack industry relaying on thin plate IC. Automotive industry.

Exploitation strategy. The knowledge gain from LOWCOST-IC will be added to Borit's existing competences. The design guidelines for shaping, in combination with the developed pre-coated materials will be used in marketing and in prototype production projects to ensure proper design for manufacturability. The results from the project indicating the technical performance of the interconnect formed from pre-coated material will show that pre-coated materials combined with hydroforming is a viable way to produce high quality parts on an industrial scale.

Contact solution

Main beneficiary: DTU

Potential market: All SOC stack industry. Suppliers of slurries/inks.

Exploitation strategy. DTU will contact four potential European suppliers (ESL ElectroScience, Schott glass, Fuel Cell Today, Kerafoil) for licensing the product (WP7, D7.3), which also will be presented to relevant customers at the Hannover Fair 2022 and at the EFCF2020 and SOFC XVII conferences.

DoD printing for SOC components

Main beneficiary: Tecno Italia

Potential market: SOC stack industry is the primary market. Other markets could be electronic boards printing, automotive, avionics and other advanced sectors

Exploitation strategy. Targeted countries in EU for commercializing must be defined. In a first stage, the target countries could be: Year 1 Italy and Germany; Year 2 Rest of Europe and Year 3 Global. The commercial distribution and service network of Tecno Italia takes care of the training of final costumers and the service for both the mechanical and electronic parts of the machines. It includes: Polab (Poland), TecnoPrecision (China), Sempa (Turkey), Italab (Thailand), Tecno Italia (Spain), Tecno Italia (Italy), PT Techno Cher. (Indonesia), Italcer (Mexico), Euromec (Brasil), Eurolaser (Argentina).

Tecno Italia will seek initial market entry in Italy and Germany because SOLIDpower and Sunfire, from Italy and Germany respectively, are partners in the project. After successful launch, we will seek global entry starting with the rest of the EU, then North and South America and finally Asia. We will make use of our existing distribution channels and seek to engage new distributers in other regions.

To achieve the commercial and expansion goals, dissemination activities will be carried out. We have planned activities for increasing visibility at international trade fairs of SOCs and SOFCs. We will (1) participate in international fairs, (2) propose technical papers in recognised technological and scientific journals and (3) create videos, posters, presentations of our solution. We will also conduct demo on site experiences of DigiGraphic printer for potential customers and hold training courses on its correct use for newly installed systems and for the installation service teams of our distributors. DigiGraphic printer testing could be running at Sunfire (Germany) and at SOLIDpower (Italy).

Techno-economic analysis report

Main beneficiary: AVL
Potential market: All SOC stack industry.

Exploitation strategy. The SOC stack companies will benefit from the analysis in considerations about further upscaling, and the analysis can serve as guidance for designing the plants.
The sub-suppliers will also gain by this direct comparison, as it will highlight the advantages of their production method, and promote the deployment of their respective technologies.

Interconnect design

Main beneficiary: DTU/FZ Jülich
Potential market: All SOC stack industry

Exploitation strategy. The interconnect designs and the developed approach for optimizing the design will be made publicly available (without revealing Sunfire IPR). The design guidelines will be marketed towards other stack manufacturers that can benefit from the results.

SOFC modelling software

Main beneficiary: DTU
Potential market: All SOC stack industry.

Exploitation strategy. DTU will apply the model in future projects, and will promote consultancy to relevant stakeholders at conferences and fairs.

3.2 Market analysis

SOC technology is on the brink of true commercialization. The global market for solid oxide fuel cells was valued at 230 M€ in 2016 and is expected to grow at a CAGR of 13.88% from 2017 to 2025, reaching a market size of 1,040 M€ by 2025[1]. IEA's global scenario in 2050[2] assumes an installed capacity of 200-300 GW of SOFC is needed to meet the demand for combined heat and power in buildings.

To quantify the impact and market potential already at this low TRL level, the following scenarios and assumptions have been made:

- ***Scenario A***: Near future scenario (2022) with SOFC power of 50 MW/year installed. This scenario requires 400,000 interconnects assuming a conservative stack footprint of 20*20 cm^2 and an average stack current density of 0.33 A/cm^2.
- ***Scenario B***: Global scenario (2050) based on assumptions from the international energy agency (IEA)[3]. In this scenario, SOFCs primarily fueled by natural gas, are expected to respond to the demand for combined heat and power in buildings, reaching 200-300 GW of installed capacity by 2050 (or 5% of global capacity). In this scenario, 200 GW correspond to 1,600,000,000 interconnects.

Based on the above scenarios, the expected long-term impact of this project on innovation and industrial growth of each of the commercial partners is outlined in Table 5.

Table 5: Expected long-term impact on innovation capacity, new markets and growth

Industrial Partner	Expected impact on innovation capacity, new market opportunities and growth*
Aperam	Aperam is already a global player in the stainless steel market, with 2.5 megatons of flat stainless steel capacity in Europe and Brazil. LOWCOST-IC represents an excellent opportunity for Aperam to introduce their steels to a new market. In case of Scenario A ca. 100 tons of stainless steel is needed to produce the interconnect material[4], corresponding to a niche market for Aperam. For an annual production of 200-300 GW SOFC/SOEC (Scenario B), ca. 400,000 tons of stainless steel is needed to produce the interconnect material[4]. Scenario B corresponds to a market size of 1,500 M€.
Sandvik	The results from LOWCOST-IC can facilitate broader market share of the Sandvik pre-coated solution for fuel cells by offering several products for the

[1] Solid Oxide Fuel Cell Market by Type (Planar and Tubular), Application (Power Generation, Combined Heat & Power, and Military), End-Use (Data Centers, Commercial & Retail, and APU), Region (North America, Asia Pacific, and Europe) - Global Forecast to 2025 (link)
[2] IEA Energy Technology Essentials, IEA (2017) (link)
[3] [https://www.iea.org/publications/freepublications/publication/essentials6.pdf]
[4] Assuming an interconnect made from a 0.2 mm thick sheet and disregarding any scraps.

	different SOC technologies. Higher performance with long lifetimes will potentially also contribute to faster market expansion. Sandvik has capacity to cover the need for PVD coated interconnects for Scenario A in 2022. The revenue in this time frame is expected to be in the level of 1 M€. For Scenario B, Sandvik is committed to any additional investment in capacity that is justified from the market development scenario. The product and process will require continuous development over time and hence revenue estimations for the 2050 time-frame are still uncertain. However, in the longer time-frame (scenario B) Sandvik expects revenues from the SOFC market well above 100 M€.
Borit	Currently, Borit has the production capacity for interconnect production in the scale of 50 MW/per year (400,000 interconnects). Such a production would increase the revenue around 0.5 M€. A scaling up to meet increased demands in case of larger market penetration towards 2050 (Scenario B) can easily be realized and would further increase the revenue by 1.5 M€ per 10 million produced interconnects.
Tecno Italia	Successful demonstration of DoD printing on SOFC interconnects will open new market opportunities in this segment. Assuming, i) an annual production of 50 MW SOFC/SOEC corresponding to 400,000 interconnects by 2022 and ii) that 25 % of the needed interconnects are coated by DoD, an additional revenue of 1.3 M€, corresponding to 4 new jobs, is expected[5]. Furthermore, novel capabilities developed in this project (printing of metallic particles, printing on pre-shaped 3D structures) can be applied in flexible electronics and the automotive industry.
SOLIDpower	SOLIDpower is currently up-scaling their production capacity to be able to manufacture up to 33,000 1.5 kWe systems per year. This represents an investment in the order of 22 M€, and is expected to employ up to 210 workers and staff. With a successful integration of new steels and novel robust contact layers, 30 % longer life-time is estimated. This will influence the OPEX of the SOC stack systems, as replacement of stacks is minimized. With a yearly production of 50 MW, this results in an increase of the gross margin of 8 M€, on a yearly basis.
Sunfire	In addition to the expected increased life-time of materials, introduction of cost-effective interconnect steel and cheaper deposition of contact materials will decrease the CAPEX of the SOC stacks by ~20%. With the extended life-

[5] The number of created jobs is calculated from the expected turnover increase (factor 0.2)

	time and cheaper production methods, Sunfire estimates an expected gain in revenue by 30-50 M€, under the assumption of a yearly production of 50 MW.

It should be emphasized that this initial analysis was made based on different publicly available sources. An updated and more accurate market analysis will be included in the later versions of the PEDR. The updated market analysis will be made on the basis of the techno-economic analysis, which is made in WP6.

3.3 Exploitation management

3.3.1 IPR management

The industrial partners of the project are already operating with their current technologies on the market. In LOWCOST-IC, the industrial partners will optimize their current technology to increase the life time or decrease the cost of the SOC technology. These modifications are not foreseen to be hindered by any current IPR.

In LOWCOST-IC, the contact layer for the oxygen electrode utilizes the concept of reactive oxidative bonding, resulting in conductive spinel oxides. For work related to the novel contact layer, a preliminary patent search has been performed, with the purpose of identifying existing patents that might eventually hinder commercialization of the project's technological results. This preliminary patent search was done using EPODOC and WPIAP.

Searching for contact materials comprising metals, many patents were found related to the contacting on the *fuel* side[6,7,8,9]. One patent utilized the concept of phase (reduction) change during assembly going from NiO to Ni[9]. In patents describing contacting on the *air* side, the state of the art well-conductive perovskites are suggested in multiple patents[10,11,12]. One patent suggests the use of noble metals [9]. One patent suggests the use of spinels[13] but without introducing the essential step to achieve high toughness; namely the reactive oxidative bonding which occurs when the spinels are formed due to oxidation of a *metallic* contact layer. Thus, no current patents were found that would hinder commercialization of possible technological results with regards to the reactive contact layers.

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[6] I. Becker and C. Schillig, Aid for Electrical Contacting of High-Temperature Fuel Cells and Method for Production Thereof; US12680238, 2008.

[7] A. Selcuk, Metal substrate for fuel cells; US9243335B2, 2007.

[8] H. Simpkins, K. Haltiner, and S. Mukerjee, Compliant current collector for fuel cell anode and cathode; US8048587B2, 2002.

[9] J.M. Keller, G.F. Reisdorf, K.J.H. Jr., S.L. Cooper, S. Mukerjee, W.E. Vilders, and D. M., Method and apparatus for forming electrode interconnect contacts for a solid-oxyde fuel cell stack; EP1732157 A1, 2006.

[10] T.J. Rehg, J. Guan, K.C. Montgomery, A.K. Verma, and G.R. Lear, Method and materials for bonding electrodes to interconnect layers in solid oxide fuel cell stacks; EP1786056A1.

[11] J. Bae and C. Lee, Combination Structure Between Single Cell and Interconnect of Solid Oxide Fuel Cell; US11942481, 2007.

[12] X. Zhang, Electrically conductive fuel cell contact material; US7892698B2, 2004.

[13] M. Ohmori, T. Nakamura, and T. Ryu, Electrochemical device; US12645528, 2009.

LOWCOST-IC

Attachment A: Information poster (part of the communication tool-box)

Low cost interconnects with highly improved contact strength for SOC applications

Project objectives

LOWCOST-IC will decrease the cost and increase the robustness of SOC stacks by developing, fabricating and demonstrating low-cost interconnects and exceptionally tough contact layers

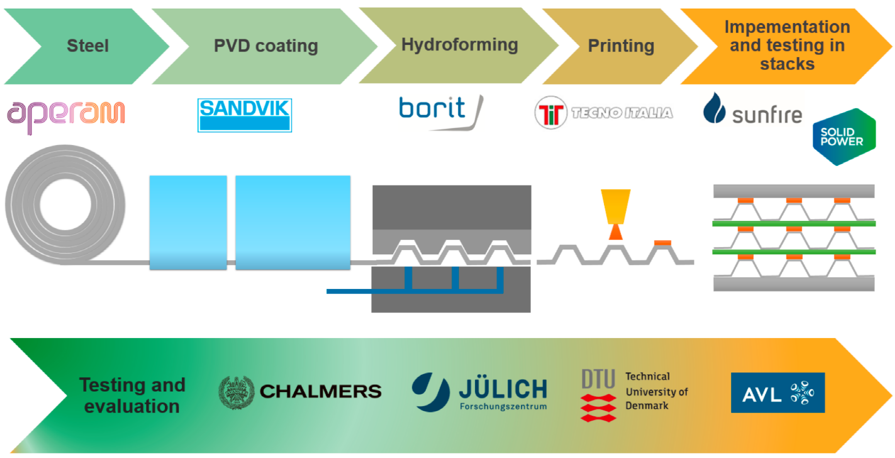
Increased robustness and lifetime of SOC stacks

- Highly protective interconnect coatings to ensure a low ohmic resistance and excellent protection against Cr vaporization
- Novel interconnect designs that reduce the maximum stress by > 30 % in the cell-interconnect interface, while maintaining a low pressure drop (< 30 mbar)
- More robust contact layers based on a reactive oxidative bonding concept - increasing the interface robustness with > 200 %

Decreased development and production costs

- Cheaper, high-volume steels will reduce raw material cost by > 80 %
- A cheaper and more stream-lined high volume production by combining roll-to-roll processes for coating and shaping the interconnect and for depositing the contact layer
- A flexible and cost-effective interconnect development route by applying hydroforming and computationally highly efficient SOC stack models

Partners and value chain



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Contact:
Project coordinator:
Henrik Lund Frandsen
email: hlfr@dtu.dk

www.lowcost-ic.eu

LOWCOST-IC

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