STAGE-SOFC
Innovative SOFC system layout for stationary power and CHP

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Programme Review Days 2017
Brussels, 23-24 November
PROJECT OVERVIEW

- Call year: 2013
- Call topic: SP1-JTI-FCH.2013.3.4 - Proof of concept and validation of whole fuel cell systems for stationary power and CHP applications at a representative scale

- Project dates: 01/04/2014 - 30/04/2018
- % stage of implementation 01/11/2017: 95%
- Total project budget: 3,970,268.20 €
- FCH JU max. contribution: 2,165,724.60 €
- Other financial contribution: - €
- Partners: VTT TECHNICAL RESEARCH CENTRE OF FINLAND (VTT), Sunfire GmbH (SF), ICI Caldaie S.p.A. (ICI), Lappeenranta University of Technology (LUT), West Pomeranian University of Technology, Szczecin (ZUT)
PROJECT OVERVIEW

Project objectives

- Development of a 5 kWel PoC prototype of a new SOFC concept with a serial connection of one CPOX stage and one steam reforming stages.
- Combination the benefits of the simple and robust CPOX layout with the high efficiencies obtained by the steam reforming process.
- The system should achieve an electrical efficiency of 45% and an overall efficiency of 80%

Applications

- Small-scale CHP or CCP for apartment houses or commercial sector
- Off-grid power generator for pipeline, telecommunication or remote measurement applications
- Back-up power for data centers
## PROJECT OVERVIEW

<table>
<thead>
<tr>
<th>2014</th>
<th>2015</th>
<th>2016</th>
<th>2017</th>
<th>2018</th>
</tr>
</thead>
<tbody>
<tr>
<td>Q2</td>
<td>Q1</td>
<td>Q1</td>
<td>Q1</td>
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<tr>
<td>Q3</td>
<td>Q2</td>
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<tr>
<td>Q4</td>
<td>Q3</td>
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</tbody>
</table>

**WP1: Coordination & project management**

**WP2: Conceptual design, system specification and simulation**
- Feasibility of efficiency targets

**WP3: Dev.and testing of 1st prototype**
- Efficiency and power targets achieved

**WP4: Hotbox design and development of key components**
- Reforme development & characterisation
  - PoC system

**WP5: BoP components, control and safety system, certification**

**WP6: Prototype integration and testing**
- 3000 h testing

**WP7: Market, techno-economic and environmental studies**

**WP8: Dissemination, exploitation plan and IPR management**
Global positioning vs international state-of-the-art

<table>
<thead>
<tr>
<th>Key performance indicator (KPI)</th>
<th>Unit</th>
<th>International SoA (2012)</th>
<th>Global positioning (FCH-JU target)</th>
</tr>
</thead>
<tbody>
<tr>
<td>CAPEX</td>
<td>€/kW</td>
<td>16,000</td>
<td>2017 14,000 12,000 10,000</td>
</tr>
<tr>
<td>Durability</td>
<td>Years of operation</td>
<td>10</td>
<td>2020 12 13 14</td>
</tr>
<tr>
<td>Availability</td>
<td>% of the plant</td>
<td>97</td>
<td>2023 97 97 97</td>
</tr>
<tr>
<td>Electrical efficiency</td>
<td>%_{\text{LHV}}</td>
<td>30-60</td>
<td>2017 33-60 35-60 35-60</td>
</tr>
<tr>
<td>LCOE</td>
<td>€ Ct/kWh</td>
<td>3*grid parity</td>
<td>2017 2.5<em>grid parity 2</em>grid parity &lt;2*grid parity</td>
</tr>
<tr>
<td>Emissions</td>
<td>mg/kWh</td>
<td>NO\textsubscript{x}&lt;2 ppm, no SO\textsubscript{x}</td>
<td>2020 NO\textsubscript{x}&lt;2 ppm, no SO\textsubscript{x} NO\textsubscript{x}&lt;2 ppm, no SO\textsubscript{x}</td>
</tr>
</tbody>
</table>

*Values in red indicate targets not met.*
## PROJECT PROGRESS/ACTIONS - Efficiency

### Achievements:
- Confirmation of feasibility of efficiency targets by detailed multi-parameter simulations
- Electrical efficiency proven in initial lab prototype

### Future steps:
- Evaluation of the efficiency curves for the Proof-of-Concept system

*) The overall efficiency is derived form the MAIP 2014-2020 instead of the thermal efficiency

### Parameters and Targets

<table>
<thead>
<tr>
<th>Aspect addressed</th>
<th>Parameter (KPI)</th>
<th>Unit</th>
<th>SoA 2017</th>
<th>FCH Call topic</th>
<th>JU Targets</th>
</tr>
</thead>
<tbody>
<tr>
<td>Efficiency*)</td>
<td>Electrical efficiency</td>
<td>%$_{LHV}$</td>
<td>30-60</td>
<td>45</td>
<td>33-60</td>
</tr>
<tr>
<td></td>
<td>Overall efficiency</td>
<td>%$_{LHV}$</td>
<td>85</td>
<td>80</td>
<td>85</td>
</tr>
</tbody>
</table>

### Achievements:
- Confirmation of feasibility of efficiency targets by detailed multi-parameter simulations
- Electrical efficiency proven in initial lab prototype

### Future steps:
- Evaluation of the efficiency curves for the Proof-of-Concept system

*) The overall efficiency is derived form the MAIP 2014-2020 instead of the thermal efficiency
Example of parameter variations in the simulation showing the potentials in electrical (left) and overall (right) efficiencies.
Relationship between electrical efficiency and electrical power output measured in the first lab prototype system
### Total Cost of Ownership

- **CAPEX feasibility by detailed cost analysis (+1000 pieces)**
- **Lifetime proven in µCHP application (with partner Vaillant)**

#### Parameter (KPI) | Unit | SoA 2017 | FCH Call topic | JU Targets
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<tbody>
<tr>
<td><strong>CAPEX</strong></td>
<td>€/kW</td>
<td>16,000 (6,000-10,000)</td>
<td>-</td>
<td>14,000 (5,000-8,500)</td>
</tr>
<tr>
<td><strong>Lifetime</strong></td>
<td>h</td>
<td>30,000</td>
<td>40,000</td>
<td>30,000</td>
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</table>

*) Cost targets from MAIP 2014-2020, lifetime from MAIP 2008-2013*
Cost analysis of a 5 kW Stage-SOFC based system. Note: increase of power density isn’t included.
Stack degradation

- Average degradation rate: 30 mΩcm²/kh (sufficient for > 30,000 h)
- Mid-term target: 15 mΩcm²/kh

Stack lifetime

- Proven lifetime: 30,000 h

System lifetime

- Proof-of-Concept system will be tested for at least 3000 h in simulated application environment (ICI lab)
SYNERGIES WITH OTHER PROJECTS AND PROGRAMMES

• Interactions with projects funded under EU programmes
  – SOFCOM: Techno-economic evaluation of small-scale CHP cases in various EU countries
  – GrInHy: Development of reformer unit, investigation of carbon formation in reformate
  – CoACH: Mechanical analysis of SOC stack, development of glass ceramics for SOC stack

• Interactions with national and international-level projects and initiatives
  – FOSUS (GER): Stack improvement in terms of cost per power and durability, SOEC scale up 5 to 10 times from 5 kW and cost optimization of stack modules
DISSEMINATION ACTIVITIES

Public deliverables
- D1.1: Project Management Guidelines
- D3.1: Report on design and testing of 1st lab prototype
- D7.3: Technical analysis of the various system configurations
- D7.5: Report on potential CO₂ mitigation including streamlined LCA

Conferences/Workshops
- 1 organised by the project
- 12 oral presentations at conferences
- 15 exhibition stgands Number in which the project has participated (but not organised)

Project Website: http://www.stage-sofc-project.eu

Publications (15 scientific papers):

Patents: 0
Thank You!

Speaker: Oliver.Posdziech@sunfire.de