Cost reduction and performance increase of PEM electrolysers

NOVEL: New materials & components

MEGASTACK: Manufacturing and upscale

Programme Review Days 2016
Brussels, 21-22 November
NOVEL

Novel materials and system designs for low cost, efficient and durable PEM electrolysers

Magnus Thomassen
SINTEF

www.novelhydrogen.eu
magnus.s.thomassen@sintef.no

Programme Review Days 2016
Brussels, 21-22 November
## Project Information

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<table>
<thead>
<tr>
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</thead>
<tbody>
<tr>
<td><strong>Call topic</strong></td>
<td>SP1-JTI-FCH.2011.2.7 - Innovative Materials and Components for PEM electrolysers</td>
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<tr>
<td><strong>Grant agreement number</strong></td>
<td>303484</td>
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<tr>
<td><strong>Application area (FP7) or Pillar (Horizon 2020)</strong></td>
<td>Hydrogen production and distribution</td>
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<td><strong>Start date</strong></td>
<td>01/09/2012</td>
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<tr>
<td><strong>End date</strong></td>
<td>30/11/2016</td>
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<td><strong>Total budget (€)</strong></td>
<td>5 743 445</td>
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<td><strong>FCH JU contribution (€)</strong></td>
<td>2 663 445</td>
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<td><strong>Other contribution</strong></td>
<td>310 683 (Norwegian Research Council)</td>
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<td><strong>Stage of implementation</strong></td>
<td>100% project months elapsed vs total project duration, at date of November 1, 2016</td>
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<td><strong>Partners</strong></td>
<td>SINTEF, Fraunhofer ISE, CEA Liten, AREVA H2Gen, Johnson Matthey Fuel Cells, Teer Coatings, PSI</td>
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</table>
Develop and demonstrate a PEM water electrolyser using beyond state of the art materials.

75% Efficiency (LHV), electrolyser stack cost < €2,500 / Nm$^3$h$^{-1}$, target lifetime of 40,000 h ( < 15 µVh$^{-1}$)
PROJECT SUMMARY - Partners

New Materials Development (Electrocatalysts & Membranes)

Component development and testing

Increased understanding of lifetime and degradation

Stack and system design

SINTEF

Johnson Matthey Fuel Cells

Fraunhofer ISE

Innovation in Motion

Miba

AREVA H₂Gen

(Teer Coatings Ltd)

United Kingdom
Johnson Matthey Fuel Cells
Teer Coatings

Germany
Fraunhofer ISE

France
CEA
AREVA H₂ Gen

Switzerland
PSI

Norway
SINTEF

Industry

R&D institution
PROJECT SUMMARY - Main achievements

- Highly active supported electrocatalysts
- Membranes with lower cost and H₂ crossover
- Advanced CCMs with higher performance
- Non-noble metal coatings for bipolar plates
- Low-cost stack design
- Degradation mechanisms and AST protocols
**PROJECT PROGRESS/ACTIONS - Cost**

### Achievement to-date

- **CAPEX (stack only)**: 8700€/Nm³h⁻¹
- **H₂ Cost**: 6 €/kg

### % stage of implement.

- 25%
- 50%
- 75%

### FCH JU Targets

- **Call topic**: 2016
- **2017**: 2500
- **2018**: 4000
- **2020**: 2100

### Future steps:

- **Further tests of stacks and novel materials to evaluate long term stability and causes for performance degradation.**
- **Improve manufacturability of new components**

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<table>
<thead>
<tr>
<th>Aspect addressed</th>
<th>Parameter (KPI)</th>
<th>Unit</th>
<th>SoA 2016</th>
<th>FCH JU Targets</th>
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<tbody>
<tr>
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<td>Call topic</td>
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<tr>
<td><strong>Cost</strong></td>
<td>CAPEX (stack only)</td>
<td>€/Nm³h⁻¹</td>
<td>8700</td>
<td>2500</td>
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<tr>
<td></td>
<td><strong>H₂ Cost</strong></td>
<td>€/kg</td>
<td>5-13</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>2017</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>2020</td>
</tr>
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</table>

|                  |                     |            |          | 5-9 |

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PROJECT PROGRESS/ACTIONS - Cost

Achievement to-date

% stage of implement.

8700€/Nm³h⁻¹
6 €/kg

4 €/kg
1500 €/Nm³h⁻¹

25% 50% 75%

2000€/Nm³h⁻¹
5 €/kg
![PROJECT PROGRESS/ACTIONS - Efficiency](image)

<table>
<thead>
<tr>
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<tbody>
<tr>
<td>Efficiency</td>
<td>Efficiency (HHV)</td>
<td>%</td>
<td>68</td>
<td>88 71 75</td>
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<tr>
<td></td>
<td>Energy use</td>
<td>kWh/kg</td>
<td>57</td>
<td>44 55 52</td>
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**Future steps:**

- *Further tests of stacks and novel materials to evaluate long term stability and causes for performance degradation.*
- *Improve manufacturability of new components*
PROJECT PROGRESS/ACTIONS - Efficiency

Achievement to-date
% stage of implement.

75% (HHV)

25% 50% 75%

84%

83% (HHV)

Cell Voltage

0 0.5 1 1.5 2 2.5 3 3.5

Current Density / A cm⁻²

NOVEL Targets
NOVEL STATUS
**Future steps:**

- *Further tests of stacks and novel materials to evaluate long term stability and causes for performance degradation.*
- *Improve manufacturability of new components*
## Synergies with Other Projects and Programmes

### Interactions with Projects Funded Under EU Programmes

<table>
<thead>
<tr>
<th>Project</th>
<th>Description</th>
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</thead>
<tbody>
<tr>
<td><strong>NEXPEL</strong></td>
<td>The NOVEL project is building upon the results generated in the FCH-JU NEXPEL project. Further development of the most promising technical solutions and introducing more novel materials and degradation mitigation strategies</td>
</tr>
<tr>
<td><strong>SMARTCAT</strong></td>
<td>Complementary activities on the fundamental understanding of electron mobility in oxides and methods for increasing the electronic conductivity of such materials</td>
</tr>
<tr>
<td><strong>MEGASTACK</strong></td>
<td>Collaboration on development of testing protocols for components and cells. AST development and dissemination events.</td>
</tr>
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### Interactions with National and International-Level Projects and Initiatives

<table>
<thead>
<tr>
<th>Project</th>
<th>Description</th>
</tr>
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<tbody>
<tr>
<td><strong>Moxilayer</strong></td>
<td>Development of oxide supported electrocatalysts for PEM electrolysers</td>
</tr>
<tr>
<td><strong>IEA-ANNEX 30</strong></td>
<td>Collaboration on development of standardized testing protocols for PEM electrolysers and cost reduction strategies.</td>
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DISSEMINATION ACTIVITIES

Public deliverables
- D6.2: condensed findings and conclusions from the organised international workshops on PEM electrolysis
- D6.3 Annual public progress reports

Conferences/Workshops
- 2 organised by the project
- >15 (with >20 presentations) in which the project has participated

Social media

Publications: 5
- M. Chandesris; Membrane degradation in PEM water electrolyzer: numerical modeling and experimental evidence of the influence of temperature and current density, Int.J. Hydrogen Energy, 1353-1366 (40) 2015

Patents:
MEGASTACK
Stack design for a megawatt scale PEM electrolyser

Magnus Thomassen
SINTEF

www.megastack.eu
magnus.s.thomassen@sintef.no

Programme Review Days 2016
Brussels, 21-22 November
**PROJECT OVERVIEW**

<table>
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<tr>
<th><strong>Project Information</strong></th>
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<tr>
<td><strong>Call topic</strong></td>
<td>SP1-JTI-FCH.2013.2.3 - Large capacity PEM electrolyser stack design</td>
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<td><strong>Total budget (€)</strong></td>
<td>3 451 654</td>
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<td><strong>FCH JU contribution (€)</strong></td>
<td>2 168 543</td>
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<td><strong>Other contribution</strong></td>
<td>363 375 (Norwegian Research Council)</td>
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<td><strong>Partners</strong></td>
<td>SINTEF, Fraunhofer ISE, CEA Liten, ITM Power</td>
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Megastack main objectives:
   Develop a cost efficient stack design for MW-sized PEM electrolysers.

Construct and demonstrate a prototype stack
75% Efficiency (LHV) @ 1.2 Acm⁻²;
stack cost < €2,500 / Nm³h⁻¹
target lifetime of 40,000 h ( < 15 µVh⁻¹)
• Go large & smart
  – Increase active area and current density, reduce waste (square design)
  – Reduce part count and improve manufacturability/assembly
  – Develop new and more cost efficient, large volume supply chains
• Multiscale/multiphysics design tools
  – Improved understanding of fundamental transport processes in PEM electrolyser components
  – Two phase flow model for optimisation of cell designs
  – Multiphysics stack model for stack design and control
### Future steps:

- Construct "short stack" demonstration unit
- Perform HAZOP study, complete documentation and ensure safe reliable operation
- Demonstrate electrolyser capabilities

### Achievement to-date

- **Cost:**
  - CAPEX: 8700€/Nm³h⁻¹
  - H₂ Cost: 6 €/kg
  - 8700€/Nm³h⁻¹
  - ~5 €/kg < 3000 €/Nm³h⁻¹
  - 2500€/Nm³h⁻¹

### % stage of implement.

<table>
<thead>
<tr>
<th>Aspect addressed</th>
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<th>JU Targets</th>
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<tr>
<td>Cost</td>
<td>CAPEX</td>
<td>Nm³h⁻¹</td>
<td>8700</td>
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<td>5-13</td>
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<td>5-11, 5-9</td>
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<tr>
<th></th>
<th>2017</th>
<th>2020</th>
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**PROJECT PROGRESS/ACTIONS - Efficiency**

**Aspect addressed**: Efficiency

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<td>kWh/kg</td>
<td>57</td>
<td>42</td>
<td>55</td>
<td>52</td>
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**Future steps:**
- **Further improvement of stack design by use of advanced modelling tools developed in the project**
- **Improved manufacturability, optimised components, higher current densities**
## Future steps:
- Evaluate long term durability of demonstrator stack
- Investigate possibility for increased current densities and alternative lower cost components without impact on durability
# Synergies with Other Projects and Programmes

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<td><strong>NOVEL</strong></td>
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<td><strong>PHAEDRUS</strong></td>
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<tr>
<td><strong>ELECTROHYPEM</strong></td>
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<td><strong>IEA-ANNEX 30</strong></td>
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<td><strong>JRC</strong></td>
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### Public Deliverables

- D1.1: Cost benefit analysis and cost and performance target for large scale PEM electrolyser stack
- D2.1: Cost benefit analysis and cost and performance target for large scale PEM electrolyser stack
- D3.2: Large scale MEA manufacture options and suppliers - testing of large scale MEAs

### Conferences/Workshops

- 1 organised by the project
- 3 in which the project has participated

### Social Media

- [YouTube](#)
- [LinkedIn](#)
- [Instagram](#)

### Publications: 0

- Publications on two phase flow modelling and transport processes in porous media in preparation

### Patents: 0

- Megastack design based on existing ITM patents
Thank You!

Coordinator: magnus.s.thomassen@sintef.no