Tubular proton ceramic electrolysers for pressurized hydrogen production

GAMER is a European research project co-financed by the European Union's Horizon 2020 research and innovation program and the Fuel Cells and Hydrogen Joint undertaking under grant 779486.

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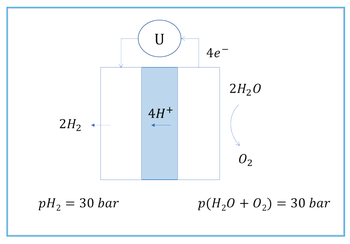
The GAMER project focuses on a novel cost-effective tubular Proton Ceramic Electrolyser (PCE) technology integrating proton conducting ceramic electrolyte materials.

The technology offers several advantages:

- Dry hydrogen is produced
- pH_2 is balanced with pH_2O+pO_2
- Electrochemical compression enables pressurized H_2
- Operation at intermediate operating temperature : 400 - 600 °C



Main objectives:

- To design an innovative electrolysis system integrated in industrial plants with efficient thermal coupling
- To develop a high volume cost-effective tubular cell technology
- To assemble the novel cells and necessary balance of plant equipment in a 10 kW prototype designed for pressurized operation
- To operate the 10kW prototype for 2000 hours in a relevant environment
- To establish techno-economic evaluation and life cycle analysis (LCA) of the integrated technology
- To ensure efficient exploitation and roll-out of the novel technologies in industry post 2025

GOAL: Demonstrate high temperature (400-600 °C) steam electrolysis with novel tubular cells integrated in a 10 kW module for dry pressurized hydrogen production (30 bar)

PCE design

Tubular cells:

- Simpler sealing technology, lower sealing area
- Better stress distribution during transient conditions
- High volume production at low cost

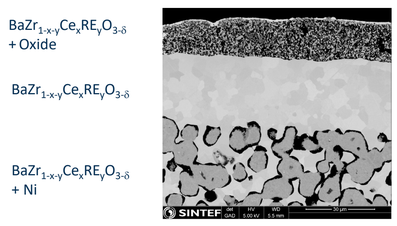


Figure 1: SEM micrograph in cross-section view (polished surface) of a tubular cell after testing at laboratory scale

10 kW prototype:

Design of novel system with required balance of plant (BoP) using advanced Modelling and simulation work to build a 10 kW electrolyser prototype delivering pure hydrogen at minimum 30 bar outlet pressure at 600 °C

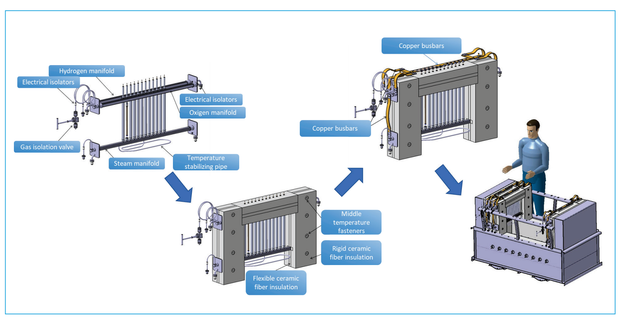


Figure 2: Schematic of conceptual design of GAMER electrolyser (no BoP included here)

PCE integration

The electrolyser system will be thermally coupled to renewable and/or heat sources in industrial plants and renewable electricity to achieve higher AC electric efficiency and efficient heat valorization of the integrated processes.

Various integration scenarios are under study
In collaboration with GAMER industrial advisory board:

- Methanol plants
- Refineries
- Fertilizer plants
- Etc.

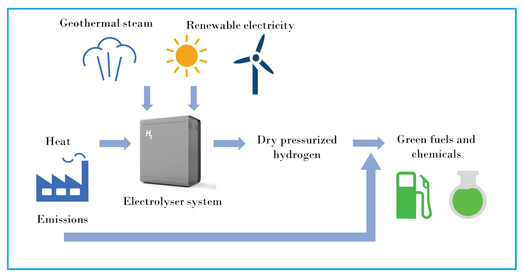


Figure 3: Process integration schematics in GAMER

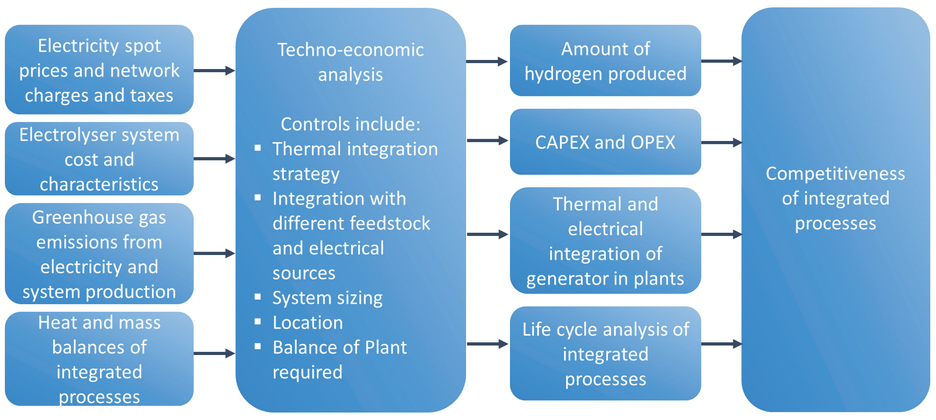


Figure 4: Methodology in GAMER for techno-economic and LCA analysis of integrated processes

PCE manufacturing

The project targets high volume production of the novel tubular proton conducting ceramic cells using solid state reactive sintering for reducing both sintering temperature and materials costs.

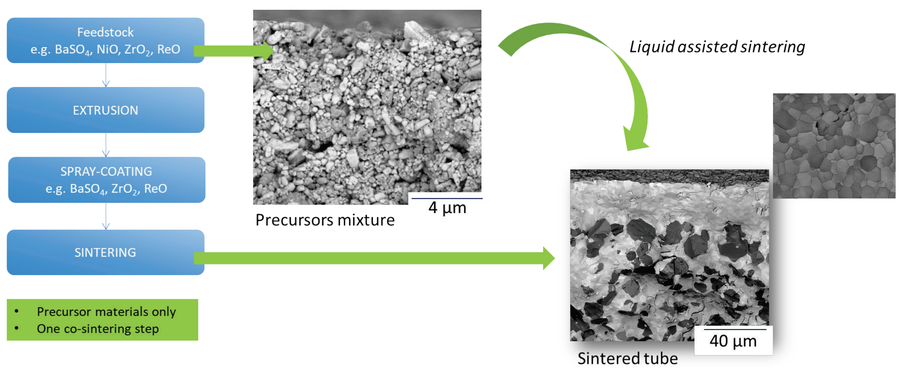


Figure 5: Illustration of solid state reactive sintering applied for the production of PCE functional layers

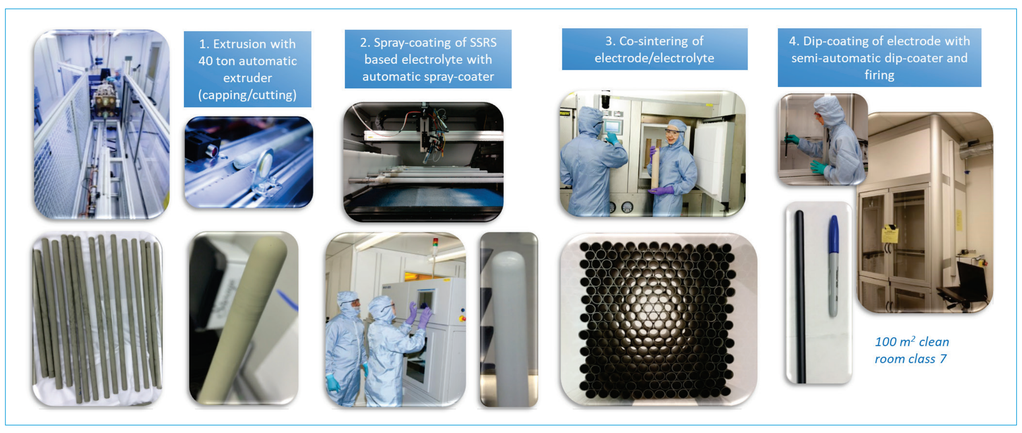


Figure 6: Manufacturing line for the production of tubular cells uses proven scaleable processes

FACTS

- GAMER is a European research project co-financed by the European Union's Horizon 2020 research and innovation program and the Fuel Cells and Hydrogen Joint undertaking under grant 779486.
- Starting date: 01/01/2018
- Duration: 3 years
- Overall budget: 2.998.951 €
- Industrial advisory board members:
  - YARA
  - Air Liquide

Partners	Country
SINTEF	Norway
Carbon Recycling International	Iceland
CSIC-ITQ	Spain
Coorstek Membrane Science AS	Norway
University of Oslo	Norway
MC2 Ingenieria y Sistemas SL	Spain
Shell Global Solutions International BV	Netherlands

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For more information visit our website:
www.sintef.no/projectweb/gamer/
See also our recent article: "*Mixed proton and electron conducting double perovskite anodes for stable and efficient tubular proton ceramic electrolysers*"
Nature Materials (2019);
https://www.nature.com/articles/s41563-019-0388-2