Green Industrial Hydrogen
via reversible high-temperature electrolysis

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The GrInHy consortium consists of 8 partners from 5 different EU countries and is characterized by its interdisciplinary expertise.

These include a technology specialized SME, large industries, university and non-university research organizations.

This project has received funding from the Fuel Cells and Hydrogen 2 Joint Undertaking under grant agreement No 700300.

This Joint Undertaking receives support from the European Union’s Horizon 2020 research and innovation programme and Hydrogen Europe and N.ERGHY.

www.green-industrial-hydrogen.com
GrInHy: Motivation

Decarbonisation of Europe’s economy
e.g. transport, energy and process industry sector

Higher shares of renewable energy require highly flexible units for
• energy production,
• load management and
• storages.

SOLUTION

Reversible high-temperature electrolyzer providing green hydrogen as a cross-sectional technology while also enabling higher shares of renewable energy
**GrInHy: Mission**

- **First-time implementation** of a reversible SOC generator implemented in an integrated iron and steel works
- **Proof of concept** of the green hydrogen production from renewable energy sources
- **Assessment** of further business cases (e.g. internal load management, grid services) or hydrogen applications (e.g. Carbon Direct Avoidance) to generate additional economical benefits
- **Enhancements** of the most powerful reversible high-temperature electrolyzer towards a marketable product
GrInHy: Technology

Reversible Solid Oxide Cell (here electrolysis mode)

\[ \text{H}_2\text{O} (\text{g}, 850 \, ^\circ\text{C}) \]

\[ \text{H}_2\text{O} (\text{g}) + 2 \, \text{e}^- \leftrightarrow 2 \, \text{H}_2 + \text{O}^{2-} \]

\[ \frac{1}{2} \text{O}_2 \]

\[ \text{O}^{2-} \leftrightarrow \frac{1}{2} \text{O}_2 + 2 \, \text{e}^- \]

Catalyst
*nickel foam*

Hydrogen Electrode
*NiO/GDC*  
*nickel oxide / gadolinium doped ceria*

Solid Oxide Electrolyte
*YSZ*  
yttria-stabilized zirconia

Oxygen Electrode
*LSCF*  
lanthanum strontium cobalt ferrite

Bipolar Plate
*Crofer 22APU*
GrInHy: Energy balances

Electrolysis (SOEC mode)

- ca. 80% electricity
- ca. 20% (waste) heat @ 150 °C

\[ \eta_{\text{el,LHV}} = 85\% \]

Fuel Cell (SOFC mode)

- H₂/NG
- SOFC
- electricity
- heat @ 60 °C

\[ \eta_{\text{el,LHV}} = 50\% \]
\[ \eta_{\text{th,LHV}} = 30\% \]
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Work Plan & Milestones

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- WP 1: Coordination and Management
- WP 2: System Layout and Basic Engineering
- WP 3: Market Readiness of rSOC Stack Modules
- WP 4: System Design & Optimization
- WP 5: System Integration & Operation
- WP 6: Market, Techno-economic and environmental studies
- WP 7: Dissemination, Exploitation Plan and IPR Management

**Key Milestones:**
- System layout frozen
- Construction of stack module finalized
- Construction and fabrication of system finalized
- System operation in industrial environment started
- 10,000 h stack test reached
- 7,000 h system test reached

February 2017
GrInHy: System (I)

Highly integrated 20’ container solution with all BoP components including e.g.

- reversible Solid Oxide Cells (6 ICM total)
- hot components (reformers and heat exchangers…)
- gas controls
- cooling system
- power electronics

Electrolysis (SOEC mode)

- Power input: $150 \text{ kW}_{\text{AC}}$; $> 80\%_{\text{LHV}}$
- Steam input: 50 kg/h
- H2 output: $40 \text{ Nm}^3_{\text{H}_2}/h$
- peak load: $200 \text{ kW}_{\text{AC}}$; $50 \text{ Nm}^3_{\text{H}_2}/h$
Highly integrated 20’ container solution with all BoP components including e.g.

- reversible Solid Oxide Cells (6 ICM total)
- hot components (reformers and heat exchangers…)
- gas controls
- cooling system
- power electronics

**Fuel Cell (SOFC mode)**

- Power output: 30 kW\(_{\text{AC}}\); > 45 %\(_{\text{LHV}}\)
  - with up to 95 % fuel utilization (by recirculation)

- Power output: 25 kW\(_{\text{AC}}\); > 50 %\(_{\text{LHV}}\)
  - with no need for external water supply due to internal recirculation of steam and up to 90 % fuel utilization
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