Large Scale PEM Electrolysis for Industrial Applications

Hydrogen Solutions
ECCM Conference 2019 – Innovative electrochemistry

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Hydrogen from renewables enables large scale long term storage and sector coupling

- Photovoltaic
- Wind power
- Grid stabilization
- PEM electrolysis
- H₂ generation
- H₂ conversion/storage

Exports for different applications:

- **Industry**: Hydrogen for ammonia production, petroleum refinement, metal production, flat glass, etc.
- **Mobility**: Hydrogen as alternative fuel or as feedstock for green fuels
- **Energy**: Hydrogen blending (gas grid), Remote energy supply/Off-grid
Silyzer portfolio scales up by factor 10 every 4-5 years driven by market demand and co-developed with our customers

Silyzer portfolio roadmap

- **2011**
  - **Silyzer 100**
    - Lab-scale demo
    - ~4,500 op.h
    - ~150k Nm³ of H₂

- **2015**
  - **Silyzer 200**
    - ~86,500 op.h
    - ~7.3 mio Nm³ of H₂
    - World’s largest Power-to-Gas plants with PEM electrolyzers in 2015 and 2017 built by Siemens!

- **2018**
  - **Silyzer 300**
    - Biggest PEM cell in the world built by Siemens!

- **2023+**
  - Next generation
  - Under development

- **2030+**
  - First investigations in cooperation with chemical industry

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1 op.h.: operating hours; Data op.h & Nm³ as of Jan. 2019
<table>
<thead>
<tr>
<th><strong>Silyzer 300</strong> – the next paradigm in PEM electrolysis</th>
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</table>
| **17.5 MW**  
  Power demand per full Module Array (24 modules) |
| **75%**  
  System efficiency (higher heating value) |
| **24 modules**  
  to build a full Module Array |
| **340 kg**  
  hydrogen per hour per full Module Array (24 modules) |

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**Silyzer 300 – Module Array (24 modules)**
The Silyzer 300 enables primary reserve services with efficient hydrogen yield and maximum dynamics

<table>
<thead>
<tr>
<th>Start 0-100% H₂</th>
<th>&lt;1min, enabled for PFRS¹</th>
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<tbody>
<tr>
<td>Dynamics in range</td>
<td>≥ 10%/s in range 0-100%</td>
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![Graph showing hydrogen dynamics and operation phases](Image)

1. PFRS: Primary Frequency Reserve Service

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Page 5       June 2019

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Five main drivers for $\text{H}_2$ production cost

**Technology specific drivers**
- Efficiency
- Electrolyzer plant CAPEX
- Maintenance cost

**H2 production cost**

**Site specific drivers**
- Electricity price
- Uptime
With the Silyzer 300 you get a highly efficient plant

View for 17.5MW 24 modules:
air cooled
ISO conditions¹

~77%
~76%
~74%

1) ISO conditions: 15°C, 1013mbar, 0m, 60% rel. hum.
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Page 7 June 2019

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Hydrogen Production Cost in 2020

Operation time / h

1) Grey $H_2$: Hydrogen produced by conventional methods as steam methan reforming
2) € 6 ct./kWh: e.g. onshore wind (4-6ct./kWh) or PV in Germany
3) € 3 ct./kWh: Reachable in renewable intense regions like Nordics (Hydro Power), Patagonia (Wind), UAE (PV)
H2FUTURE – a European Flagship project for generation and use of green hydrogen

Project
- Partner: VERBUND (coordination), voestalpine, Austrian Power Grid (APG), TNO, K1-MET
- Country: Austria
- Installed: 2019
- Product: Silyzer 300

Use cases
- Hydrogen for the steel making process
- Supply grid services

Challenge
- Potential for “breakthrough” steelmaking technologies which replace carbon by green hydrogen as basis for further upscaling to industrial dimensions
- Installation and integration into an existing coke oven gas pipeline at the steel plant
- High electrolysis system efficiency of 80%

Solutions
- Operation of a 12-module array Silyzer 300
- Highly dynamic power consumption – enabling grid services
- State-of-the-art process control technology based on SIMATIC PCS 7

6 MW
Power demand based on Silyzer 300

1,200 Nm³
of green hydrogen per hour

This project has received funding from the Fuel Cells and Hydrogen 2 Joint Undertaking under grant agreement No 735503. This Joint Undertaking receives support from the European Union’s Horizon 2020 research and innovative programme and Hydrogen Europe and NERGHY.
Thank you!

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