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FCH JU – 7th stakeholder forum

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Siemens PEM electrolysis technology is based on more than 40 years of experience

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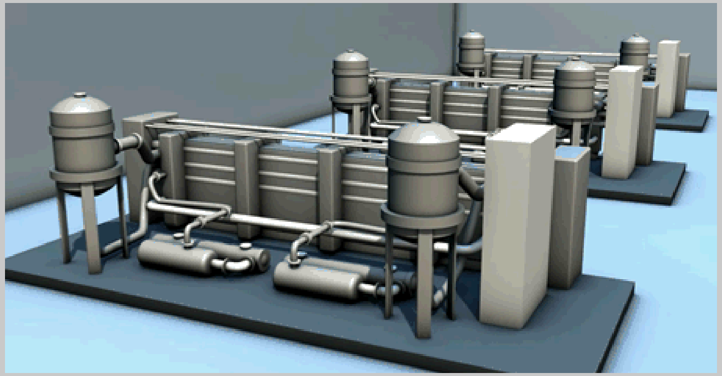
SILYZER 200:
1,25 MW per unit
PEM System



Expertise

- Start of PEM electrolyzer development in 1998
- Continuous lab ops > 60.000 h
- 12y field operation (prototype)
- 45y electrode know-how
- 50+y experience in hd rectifiers
- Complete solution in one hand : heavy duty rectifiers (up to 70.000 A), transformers, control units incl. remote operation and condition monitoring for state-of-the-art operation, grid connection and gas turbines
- Expertise in automated production equipment

Benefits

- Best-in-class PEM electrolysis, based on own developed system and proven Siemens components
- Double digit MW class for efficient hydrogen production up to 35 bar (3.5 Mpa) output pressure
- Extreme dynamic operation from 0 to max-power combined with a strong lifetime commitment
- Small system footprint
- Low TCO, high robustness, low investment risk
- Industrialized production
- Safety culture & discipline as guarantee

Observations on electrolysis technology – The Siemens perspective

- Several companies of various sizes offer different PEM and alkaline electrolysis systems to the market. Technology is available for advanced grid services e.g. frequency control. In Europe, first projects ≥ 1MW PEM Systems per unit are started (e.g. Energie Park Mainz with 6 MW)
- The long-term performance of the different systems is to be observed in the field (customer or subsidized projects) in combination with new applications requiring intermittent operations (e.g. degradation, overall efficiency, opex, capex etc.)
- Limited number of positive business cases and non-subsidized market in combination with RE at this stage
- Electrolysis technology will achieve competitive cost position once industrialized production in place
  => this requires high level of upfront invest despite a non-existing market
  => to increase market penetration at early stage, stable and supportive regulatory framework is key: the gap between investment and market volume increase has to be as short as possible
- The integrated value-chain and the role of the different players around the electrolysers is still to be developed – new players might emerge (e.g. system operators)

FCH JU objectives fully support this approach – Technical objectives are clear

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1a- Hydrogen production from renewable electricity for energy storage and grid balancing

Main priorities:

1. Market deployment of affordable and reliable large green **H_2 production systems** from renewable energy power which are designed for **integration in smart grids** (off-peak over-production, on-peak shaving, grid balancing)
2. Position **H_2 as a cost effective and safe storage medium** of renewable electricity, for grid services and long term energy storage (including blending into the natural gas grid).
3. Develop affordable, reliable and efficient systems to **convert H_2** (or H_2 blended into natural gas) **into electricity and heat**.
4. **Demonstrate the business model** via integrated projects of H_2 production for grid balancing, peak shaving, energy storage and other possible applications.

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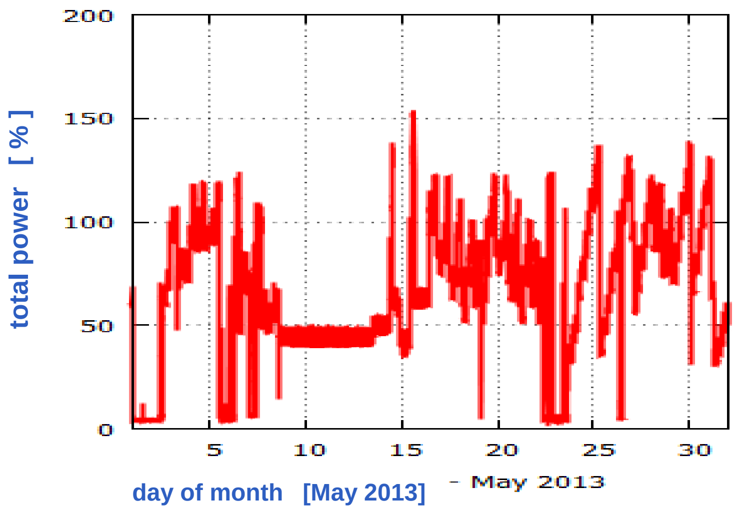
KPI for water electrolysis

		State-of-the-art	2017	2020	2023
KPI 1	H2 production electrolysis, energy consumption (kWh/kg) @ rated power	57-60 @100kg/d	55 @500kg/d	52 @1000+kg/d	50 @1000+kg/d
KPI 2	H2 production electrolysis, CAPEX @ rated power including ancillary equipements and comissioning	8.0 M€/(t/d)	3,7 M€/(t/d)	2.0 M€/(t/d)	1.5 M€/(t/d)
KPI 3	H2 production electrolysis, efficiency degradation @ rated power and considering 8000 H operations / year	2% - 4% / year	2% / year	1,5% / year	<1% / year
KPI 4	H2 production electrolysis, flexibility with a degradation < 2% year (refer to KPI 3)	5% - 100% of nominal power	5% - 150% of nominal power	0% - 200% of nominal power	0% - 300% of nominal power
KPI 5	H2 production electrolysis, hot start from min to max power (refer to KPI 4)	1 minute	10 sec	2 sec	< 1 sec
	H2 production electrolysis, cold start	5 minutes	2 minutes	30 sec	10 sec

Electrolyzers for grid services require specific properties

typical load profile of an electrolyzer in a grid service project



source: Siemens

Main technical requirements:

- quality of grid connection (harmonic distortions, power factor, flicker etc.)
- capable to be connected to grid control systems (hardware & software)
- low energy consumption in stand by mode; quick cold start
- low degradation in intermittent operation modes
- safety standards for customer friendly installations (not only restricted to chemical plants)
- high efficiency of the overall system in intermittent operation
- robustness and reliability prioritized over short-term performance (e.g. membrane thickness)
- service-friendly setup

Water electrolyzer technology

Key topics needing to be addressed soon

- Achieve the MAWP KPIs and increase number of innovative electrolysers in operation in the field
- Develop “coalition of the willing” operators + financial institutes – to bridge low volumes and help BC
- Create transparency on the market to support investors:
  - Clear definition of an electrolysis system (e.g. components included)
  - Clear definition of an electrolyser vs. storage solutions
  - Clear definition of standardized KPIs: overall system efficiency (kWh/Nm^3) as of AC-connection (in addition to stack efficiency), aging, dynamic behavior in relation with aging, ramp-up time etc.
- Increase market awareness on electrolysers’ industrial investment requirements (lifetime robustness, certification level, service etc.) to convince from technological maturity
- Clarification in the various legislation of the status of green hydrogen as alternative fuel