Role of Hydrogen in the energy transition

OAPEC Symposium Session 2: Establishing a hydrogen economy

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Our purpose and mission

SIEMENS energy

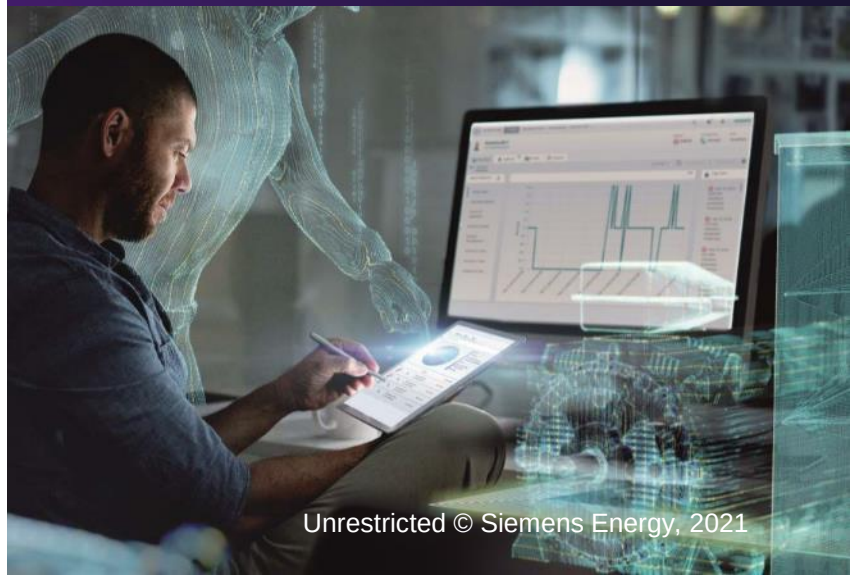
We energize society

by supporting our customers in **transitioning to a more sustainable world,** based on our innovative technologies and our ability to turn ideas into reality.

Low- or
zero-emission power
generation

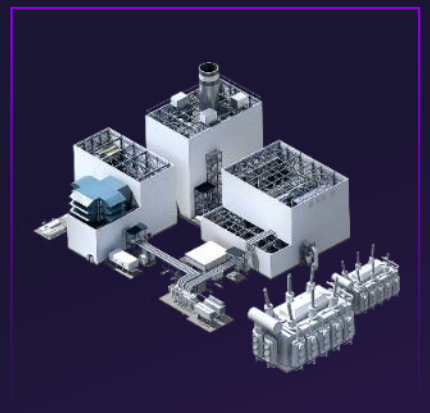
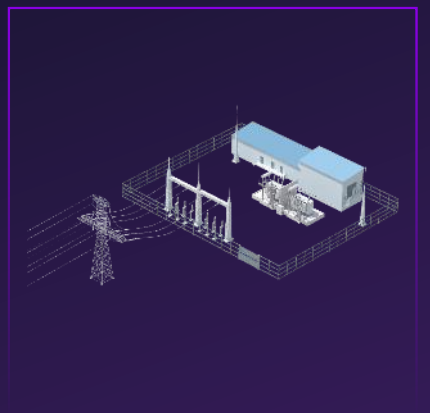
Transport
of electricity
and storage

Reducing CO_2 footprint and
energy consumption in
industrial processes



Our setup

Innovative products support customers in transitioning to a more sustainable world

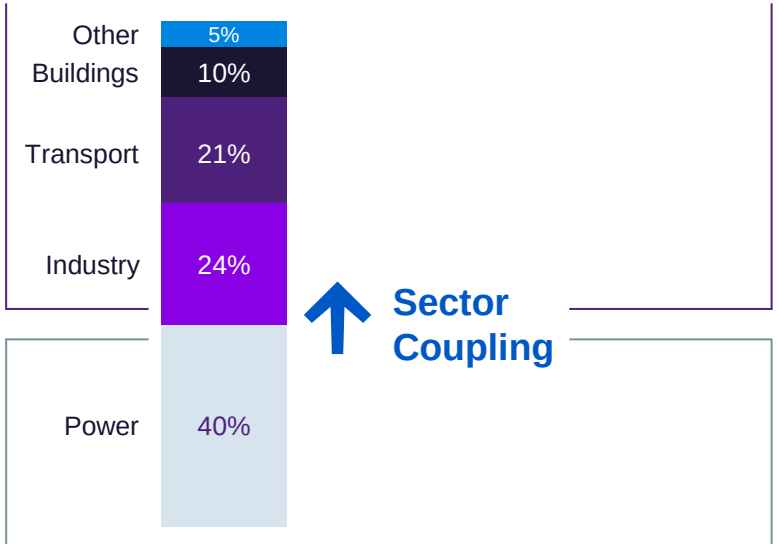
Generation	Industrial Applications	Transmission	SGRE	New Energy Business
				
NET ZERO through hybrid power plants	**up to 60%** H_2 capable gas turbine portfolio[1]	**SF_6-FREE** portfolio that is market-leading	**>260 Mt** GHG savings p.a. to customers	**100% H_2** Enabling hydrogen economy

1 Up to 60 vol.% dry low emission H_2 capability for SGT-600

“Sector Coupling” is the key lever for decarbonization of all end-user sectors – Power-to-Hydrogen as a vital tool

Shares in global CO_2 emissions by sectors

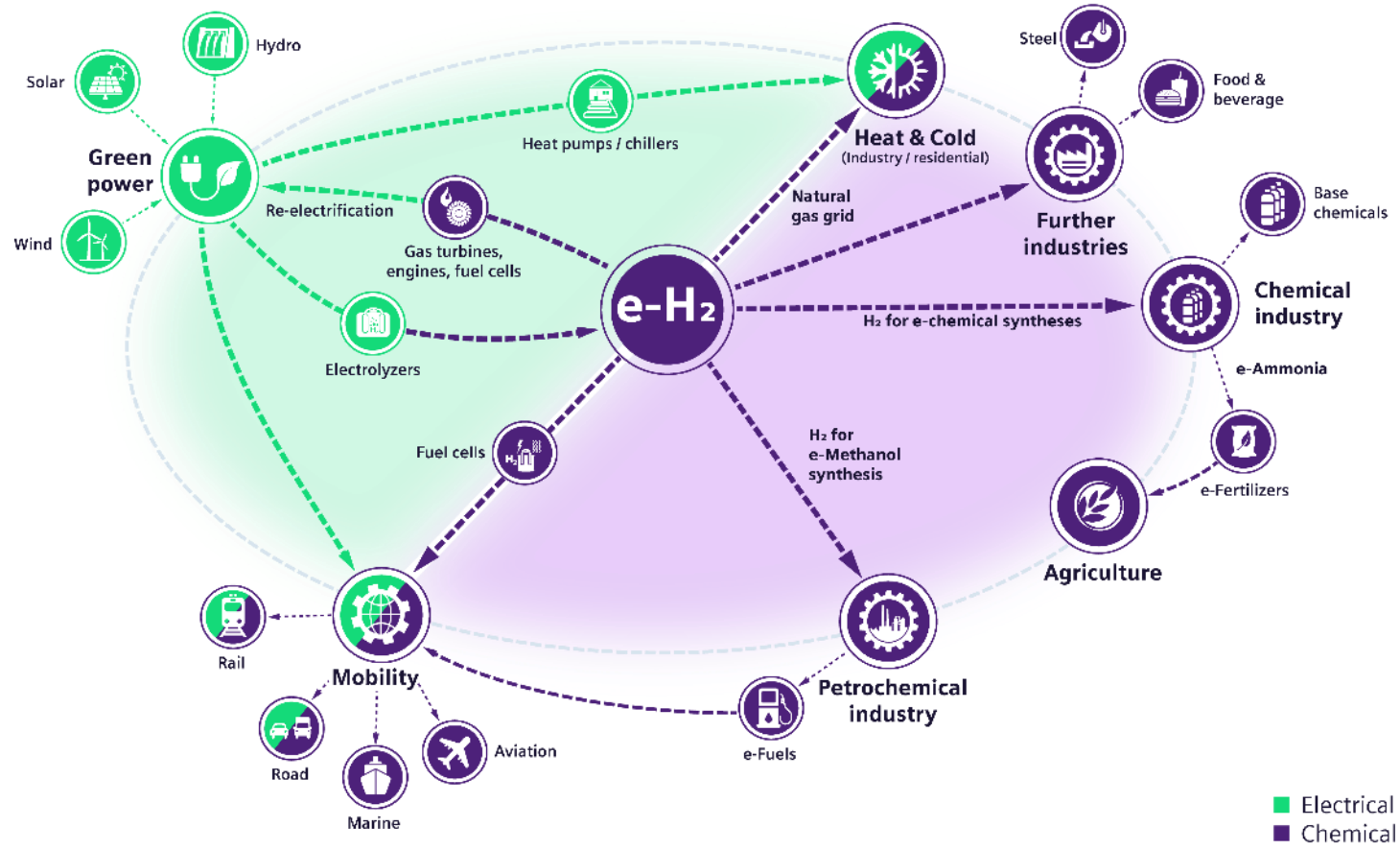
Increased future focus for emission reduction
Share on CO_2 emissions: 60%
Share of Renewables: 8%



Continuous emission reduction required
Share on CO_2 emissions: 40%
Share of Renewables: 22%

Source: World Energy Balances 2018

Sector Coupling – Links and Interactions



Major successes in our electrolyzer development

Since 1995	2011	2015	2018	2019	2020
Testing in Lab-Scale and Short-Stacks	**Lab-scale** demo	**World's largest Power-to-Gas plants** with **PEM electrolyzers** in 2015 and 2017 built by Siemens Energy	**Biggest PEM cell** in the world built by Siemens Energy	World's **largest Power-to-Gas plant** with PEM electrolysis **in operation**	**World's first integrated** & commercial large-scale plant for **e-fuel** production **announced**
					

Continuous laboratory and test operation

Silyzer 100 & Silyzer 200 in test rig and commercial operation

Silyzer 300 in test rig | Test plant operation

Silyzer 300 – Full Module Array
The next paradigm in PEM electrolysis

Silyzer 300 – full module array (24 modules)

17.5 MW
plant power demand

> 75.5 %
plant efficiency

24 modules
to build a full module array

335 kg
hydrogen per hour

The first industrial scale solar-powered green hydrogen plant in the Middle East

Project

- Partners: DEWA and Expo2020
- Country: UAE
- Location: Dubai (MBR Solar Park)
- Installation: 2020
- Product: Silyzer 200

Use cases

Re-electrification with a 280 kW hydrogen gas engine

Challenge

- Installation of world's first PEM electrolysis plant UAE ambient conditions
- Integrated H_2 plant for multiple purposes, incl. re-electrification with the largest pure hydrogen gas motor today (280 kW)
- First-of-its-kind character of the project in combination with a very tight implementation schedule and high exposure towards EXPO 2020 Dubai

Solutions

- One Silyzer 200 and state-of-the-art process control technology based on SIMATIC PCS 7
- Production of green hydrogen via photo voltaic during daytime, storage of hydrogen (93m³@35 bar) and re-electrification during nighttime
- Integrated remote monitoring, operation and maintenance concept, leveraging strong setup of Siemens Energy in Dubai

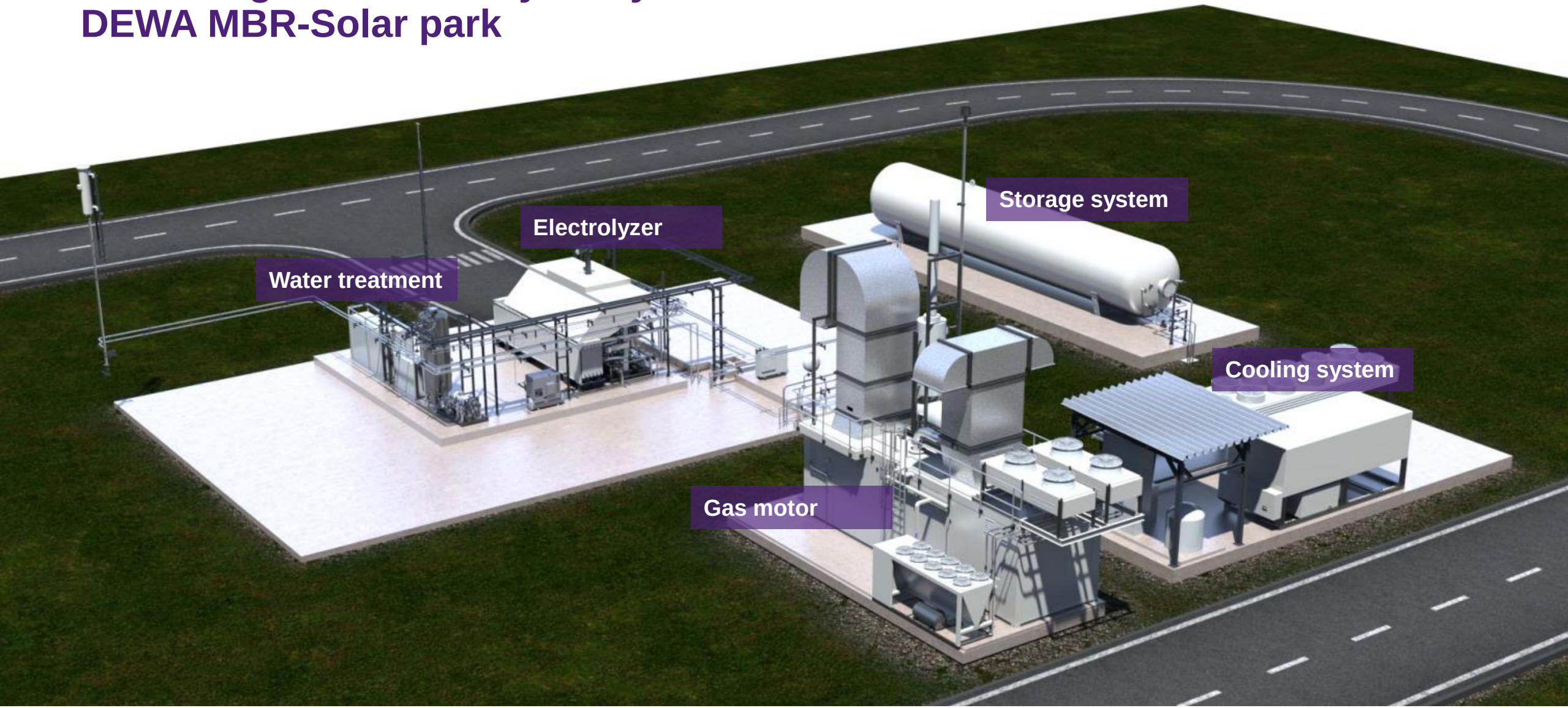
1.25 MW

Power demand based on Silyzer 200

228 Nm^3

of green hydrogen per hour

2021 integrated electrolyzer system at DEWA MBR-Solar park



Partnership in Abu Dhabi to develop value chain for Sustainable Aviation Fuel

Signatories of initial MoU, addition of further partner in discussion

Green Energy partnership

MUBADALA SIEMENS energy

Project

- Country: UAE
- Location: Masdar City
- Installation: 2023-24 (planned)
- Technology: PV, Silyzer 300, CO2, Kerosene synthesis

Use cases

- Synthetic Kerosene for sustainable aviation
- Green H2 infrastructure for decarbonized transportation around Masdar City and Abu Dhabi Airport
- Fuel for decarbonized shipping (use of by-products, tbd)

Key objectives of the project

- Integrate SE's electrolysis technology into Abu Dhabi's **existing industry landscape**
- Tap into **advanced renewable energy market with** extreme low PV prices
- Build foundation to position **UAE as Hub for synthetic fuel** by selecting and integrating robust and scalable technology
- **Localize critical know-how** for power-to-liquid applications with high potential for future scale up
- Ensure compliance with upcoming regulation in future export markets by early **involvement of local and international end-customer**
- Establish end-to-end **optimized and certified** e-fuel **value chain**
- Ensure alignment with **UAE-German Energy partnership** agenda

Green Hydrogen - why it is happening now (and not before) ?

- **Renewable energy cost development in the last 10 years (2010 -2019)**
  - Solar Photovoltaic (PV) -82%
  - Concentrated Solar Power (CSP) -47%
  - Onshore Wind -39%
  - Offshore Wind -29%
- **Economic stimulus and COVID recovery programs are set to support enegry transition technologies, thus create an „initial demand“ to scale up production**
- **Expected electrolyser cost development in next 30 years**
  - CAPEX per kW installed capacity 840 USD -> 200 USD (-2.5 % p.a.)

Green Hydrogen - why it is not happening faster ?

- Economic aspects of H2 production
- Need to set up complex value chains and new partnerships
- Need to gain operational experience with electrolyzer systems vs. ...
- Willingness to take risks
- Regulatroy environment not yet established

Scaling up power-to-liquid production

A few considerations …

Power supply	Electrolysis	Compression and storage	Synthesis	Logistics and offtake
❑ (Green) electricity tariff	❑ (Green) water requirements and availability	❑ Continuous supply requirements	❑ Synthesis technology development	❑ Local distribution vs. export
❑ Intermittency of electricity supply	❑ Operating hours / load factor	❑ Buffer storage requirements	❑ CO2 supply from an acceptable source (avoidable vs. non-avoidable)	❑ Transportation
❑ Co-location vs. grid connection vs. blending	❑ Utilities integration esp. cooling	❑ Compression cost, redundancy and scale effects		❑ Certification of green products
❑ Certification				❑ Price policy and long-term offtake

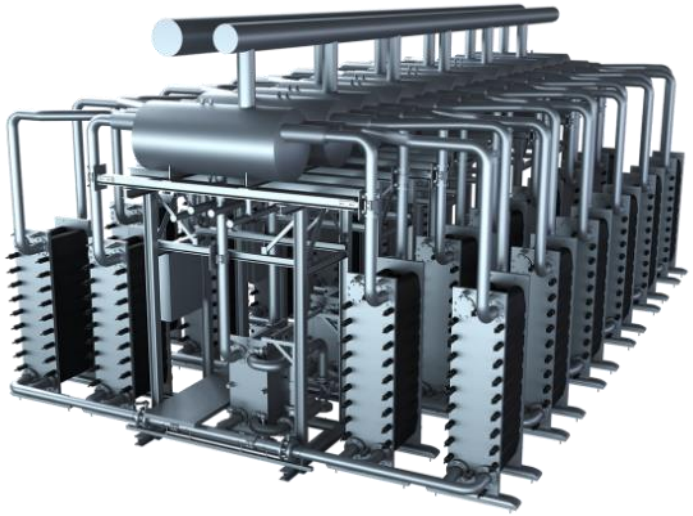
EPC

Operations, maintenance, replacement, recycling, digitalization, optimization

Guarantees and bankability

Tank you

Silyzer 300
Fact Sheet



Main technical data

Electrolysis type/principle	PEM	Rated H_2 production	335 kg/h
Rated Silyzer 300 power	17.5 MW	System efficiency	>76%
Dimension full array	15.0 x 7.5 x 3.7 m	Plant efficiency Silyzer 300	>75.5%
Start-up time until full load	<1min, enabled for grid support	Module design lifetime	Optimized for 80 kOH[5]
Output pressure	100 mbar	Module weight	2.1 t (water included)
Purity H_2	Up to 99.9999%	CE conformity	Yes
H_2 quality 5.0[3]	DeOxo/Dryer option	Rated tap[4] water requirement	4,700 l/h

All values calculated for ISO conditions: T_{amb} = 15°C, 60% rel. humidity, 1,013 bar, air cooled, new and clean, HHV[1] of hydrogen= 39.45 kWh/kg
1 Higher Heating Value | **2** Operating Hours | **3** 99.999% purity | **4** about 600 – 1,000 µS/cm | **5** after >80kOH operation still possible