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Hydrogen Solutions

Green hydrogen in industry and energy applications

www.siemens.com/silyzer

Hydrogen from renewables enables sector coupling between energy, industry and mobility

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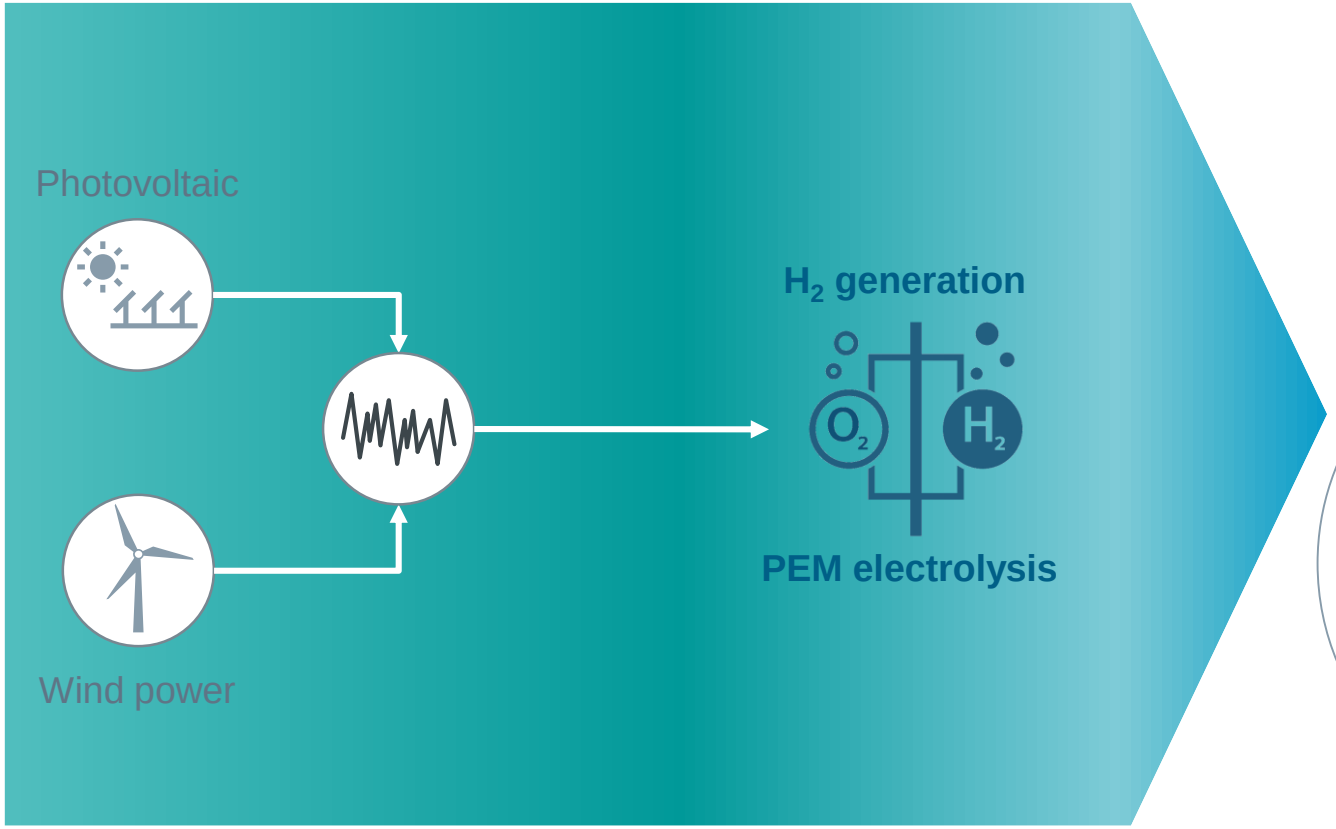

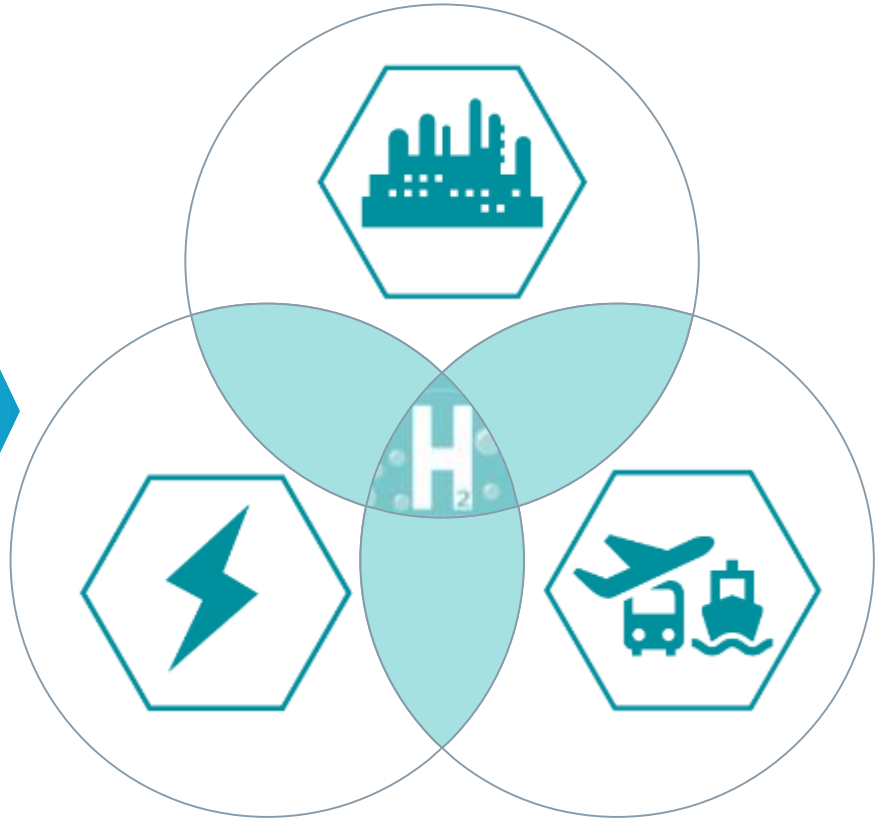

Today, approx. 95% of hydrogen production has high CO_2 emissions

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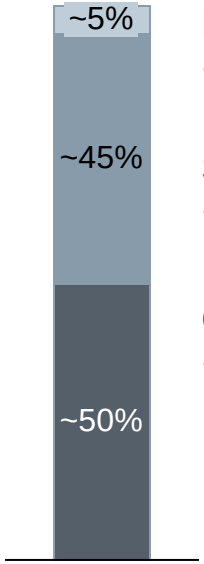
Global H_2 supply …

- **Main share** of production is **captive** (68%) [1], i.e., hydrogen **produced and consumed in-house** for producing other products
- Three **main technologies** to produce H_2



Electrolysis & others [1]

- Utilize electricity to split water into hydrogen and oxygen

Steam Methane Reforming (SMR) [2]

- Synthesis from steam and natural gas, today most economic method

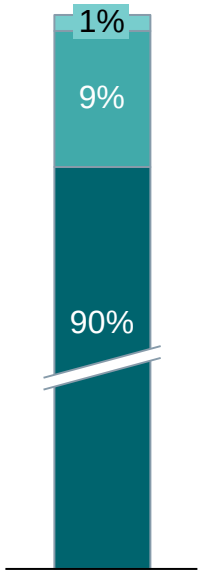
Coal gasification / partial oxidation

- Produced as part of, e.g., chemical processes in refineries

Global Hydrogen 44 Mio t in 2016 [4]

… meets global H_2 demand

Hydrogen market is divided in three sectors while **industry being by far largest one**



Mobility [3] [4]

- Expected growth by **green H_2**
- Penetration of **FCV** and **synfuels** are key drivers

Energy [3] [4]

- Expected growth due to need for **storage of curtailed renewables**

Industry [4]

- Includes chemical, refineries, metal processing and others
- Expected growth due to CO_2 emissions regulations

! Electrolysis is a CO_2 neutral production method for hydrogen

Source: 1) Freedonia; 2) Hydrogen Generators GIA; 3) Navigant; 4) CertifHY

Hydrogen is multi-functional
It connects Energy, Mobility and Industry

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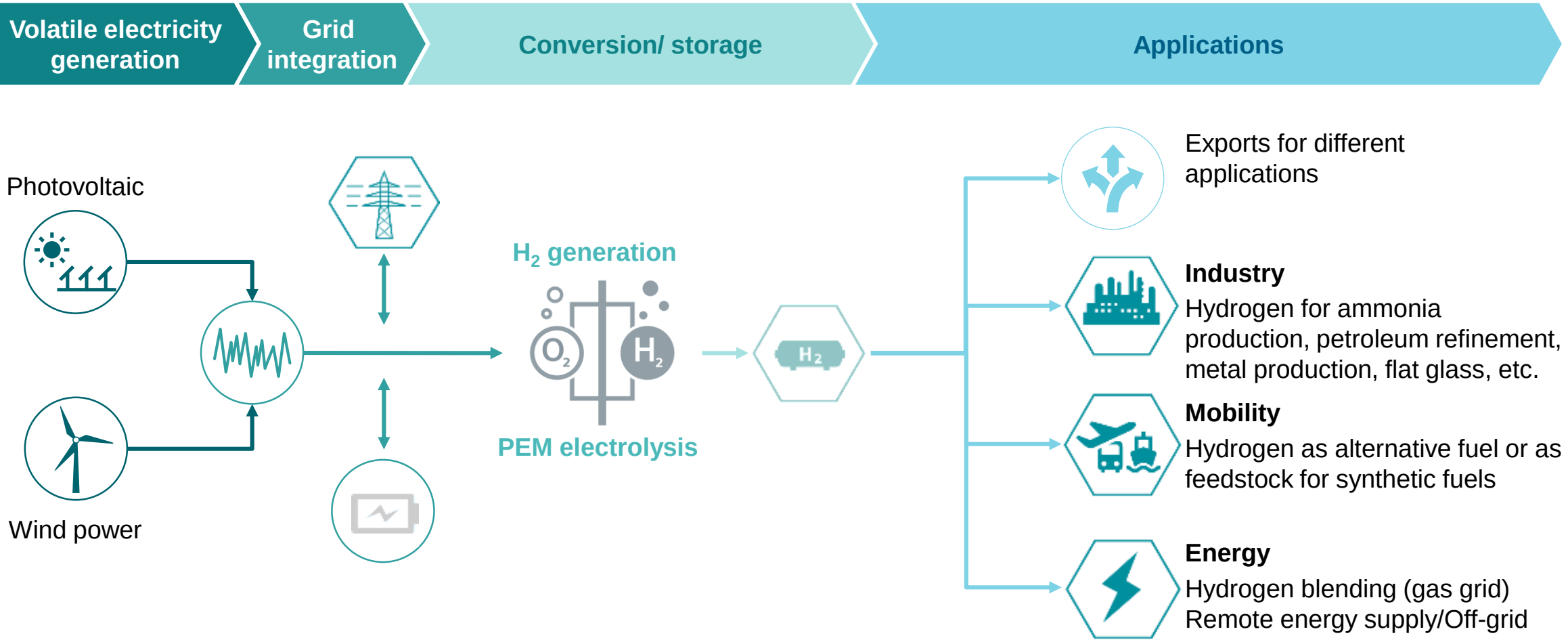

Why a Proton Exchange Membrane (PEM) electrolyzer system?

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PEM is the natural choice for our future renewable energy system

- Incredibly fast start-up and shut-down
- Highest operational flexibility
- Black start capability

PEM is clean by nature

- No CO_2 emissions, unlike SMR, which emits 8-10 kg CO_2 for each kg of hydrogen
- There is nothing except water, hydrogen and oxygen in the system
- Highest hydrogen purity >99.9%
- Oxygen as the only “contaminant”
- No aggressive chemical electrolyte (e.g. KOH  in Alkaline systems)

PEM is competitive

- Competitive hydrogen price per kg at green electricity prices <3 ct/ kWh
- Small footprint compared to Alkaline systems
- Significantly lower OPEX compared to Alkaline systems due to maintenance-free stack

PEM = Proton Exchange Membrane; SMR = Steam Methane Reforming; OPEX = Operational Expenses

We have references for our Silyzer portfolio in all applications

Year	Country	Project	Customer	PEM electrolysis capacity	Product offering
2015	Switzerland	Energy System Integration Platform	Paul Scherrer Institut	100 kW/ 200 kW (peak)	Container solution
2015	Germany	Argon purification/ Use of H_2 for HRS	Air Liquide, Duisburg	300 kW	Container solution
2016	Germany	Energy Lab 2.0	Karlsruhe Institute of Technology	300 kW	Container solution
2015	Germany	Energiepark Mainz	Municipality of Mainz	3.8 MW/ 6 MW (peak)	Pilot Silyzer 200
2016	Germany	Wind Gas Haßfurt	Municipality of Haßfurt Greenpeace Energy	1.25 MW	Silyzer 200
2017	Germany	H&R	H&R Ölwerke Schindler GmbH	5 MW	Silyzer 200
2018	Austria	H2Future*	voestalpine, Verbund, Austrian Power Grid (APG)	6 MW	Pilot Silyzer 300

*) 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.

H2Future
The next step towards large scale hydrogen electrolysis

Facts & figures

- EU funded project for demonstration of large-scale rapid response electrolysis
- Project consortium members: voestalpine, K1-MET, Verbund, ECN, APG, Siemens
- Installation site: voestalpine steel works
- Country: Austria
- Installed: planned end 2018
- Product: Silyzer 300

Use cases

6 MW

rated power based on Silyzer 300

Challenge

- Integrate a new generation of PEM electrolyzer into the processes and infrastructure of an existing steel work

Customer Benefits

- Gather experience with multi-megawatt PEM electrolysis as decision base for future large scale decarbonization projects
- Provide grid services for an electricity market with growing rates of renewable energy

Silyzer portfolio scales up by factor 10 every 4-5 years driven by market demand and co-development with our customers

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Silyzer portfolio roadmap

Reduction of H_2 production cost (€/kg H_2)

2011 – 2015

Silyzer 100
100 – 300 kW
Lab-scale

2015 – 2018

Silyzer 200
1 MW class
Commercial product

2018 – 2023+

Silyzer 300
>10 MW class
Commercial solution

Next generation
Silyzer >100 MW
First concepts

>2030

>1,000 MW
First investigations in cooperation with chemical industry

Flanking by politics requested to accelerate the implementation of energy transition with green hydrogen

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Promising examples of outstanding hydrogen business developments

United Arab Emirates	1st steps towards a hydrogen society are being defined; mobility and energy applications will be implemented
South Australia	Moonshot city concept. First “city concept” based on autonomous energy supply by green hydrogen are under intense discussion

Political support requested

Refinement of the eligibility criteria by EU or national bodies, to allow market participants to opt for large scale green hydrogen solutions, considering market driven parameters

Adjust focus from R&D funding of projects towards commercial use cases in industries with most efficient, green H2 generation costs

Set clear conditions for distinctive energy transition

Increase awareness of the value of hydrogen as a safe solution

Contact page

Eric Klein

Head of Global sales and project management

Hydrogen Solutions

Guenther-Scharowsky-Str. 1
91058 Erlangen

Mobile: +49 172 35 44 267

E-mail:
Eric.Klein@siemens.com

siemens.com/silyzer