eFuels aus der Sicht der Industrie

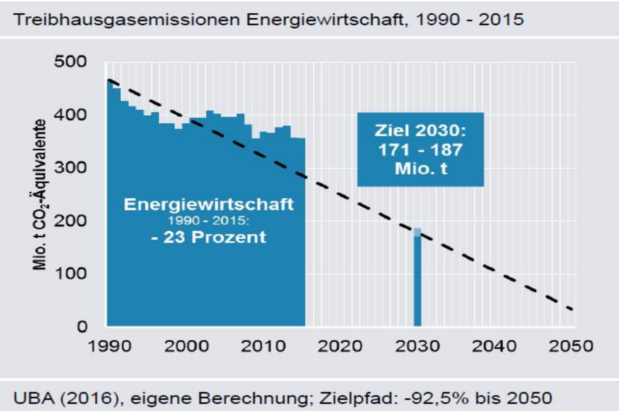
Manfred Waidhas, Siemens AG, Hydrogen Solutions

siemens.com/silyzer

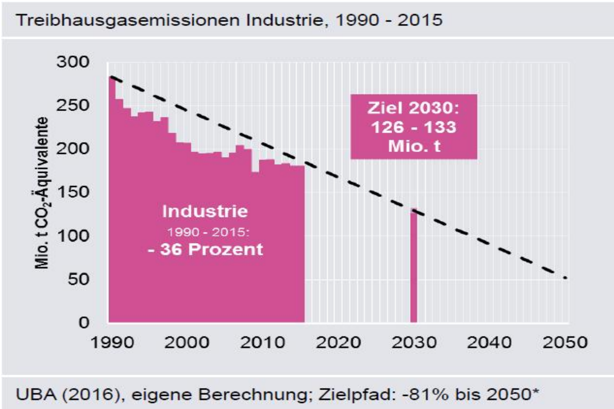
Becoming serious – CO_2-emission reduction targets DE

ludwig bölkow

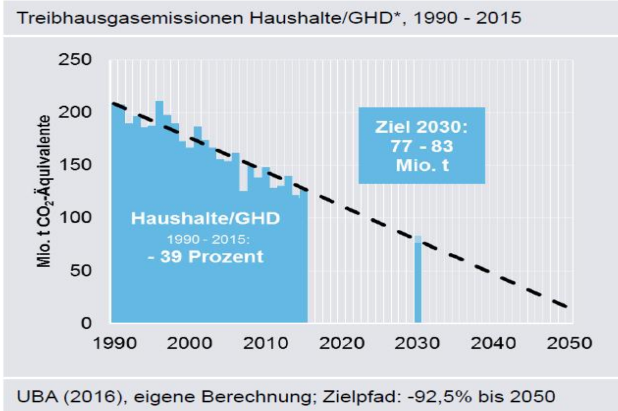
Electricity sector (target: -92.5%)



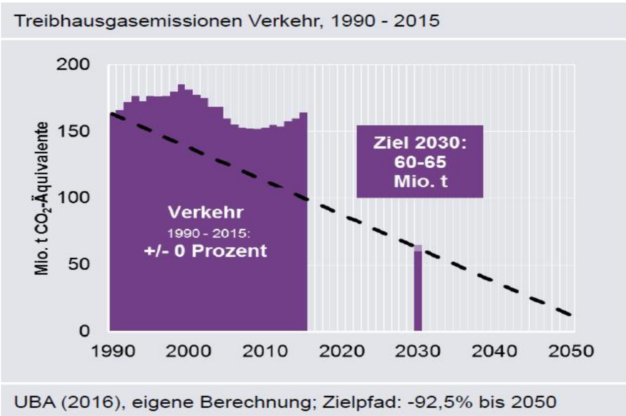
Industry (target: -81%)



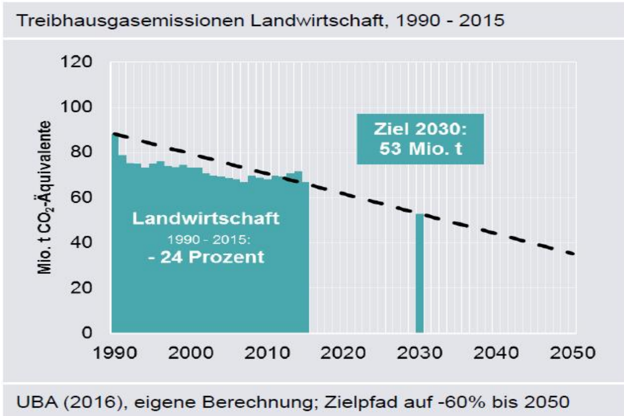
Households/SMEs (target: -92.5%)



Mobility (target: -92.5%)

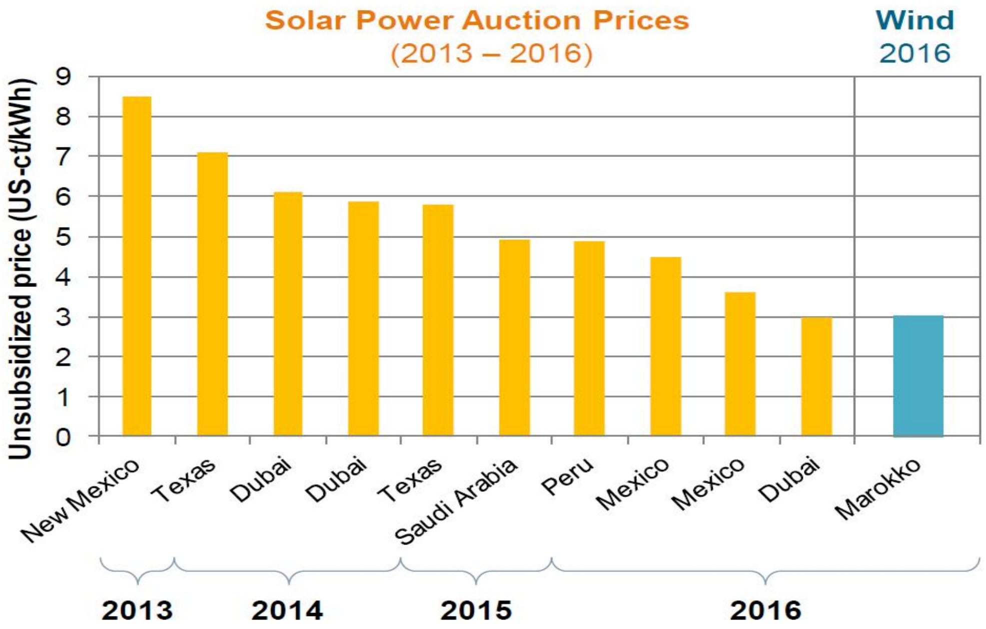


Agriculture (target: -60%)



Source: Agora Energiewende, 20.09.2016

Renewable power generation technologies
becomes cost competitive



source:http://cleantechnica.com,16.04.2016

- Most recent electricity contracts in Middle East are below 24 USD/MWh (e.g. Saudi-Arabia: 17.8 USD/MWh)
- Many countries with low electricity costs are highly interested to invest in green P2X technologies

Renewable power generation
Extension and smart storage concepts essential

1. CO_2-reduction is clearly linked with renewables.
2. Enforced extension of renewables is mandatory to reach defined CO_2 reduction targets

Energy storage capacities in the TWh-range will be needed

Different storage technologies for different applications – Hydrogen for large-scale and long-term energy storage

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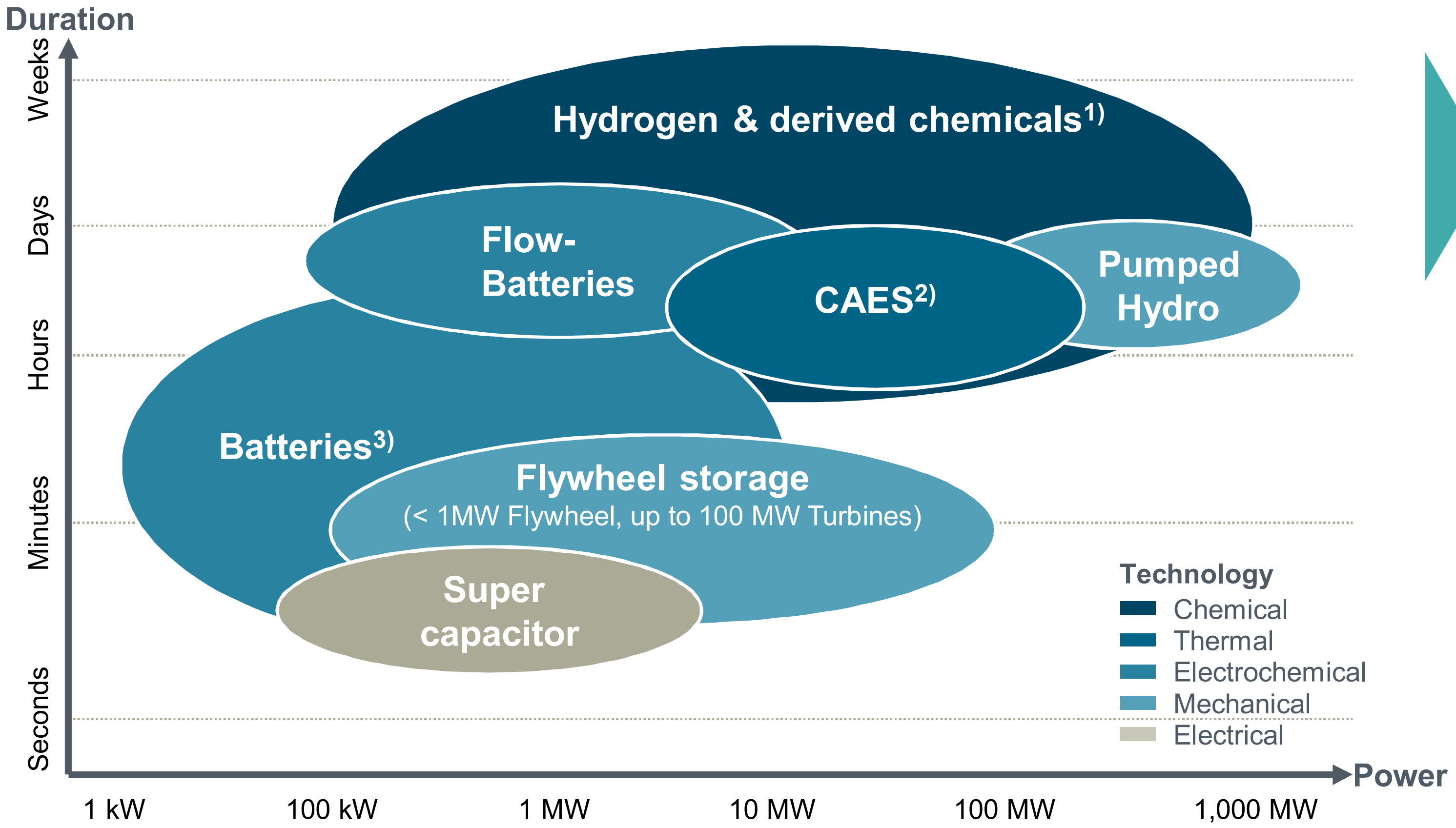

Hydrogen can be stored cost-effectively on a large scale.

1) such as Ammonia, Methanol or others; 2) Compressed Air Energy Storage; 3) Li-Ion, NaS, Lead Acid, etc.

Electrical Energy Storage

The common understanding has to be re-defined

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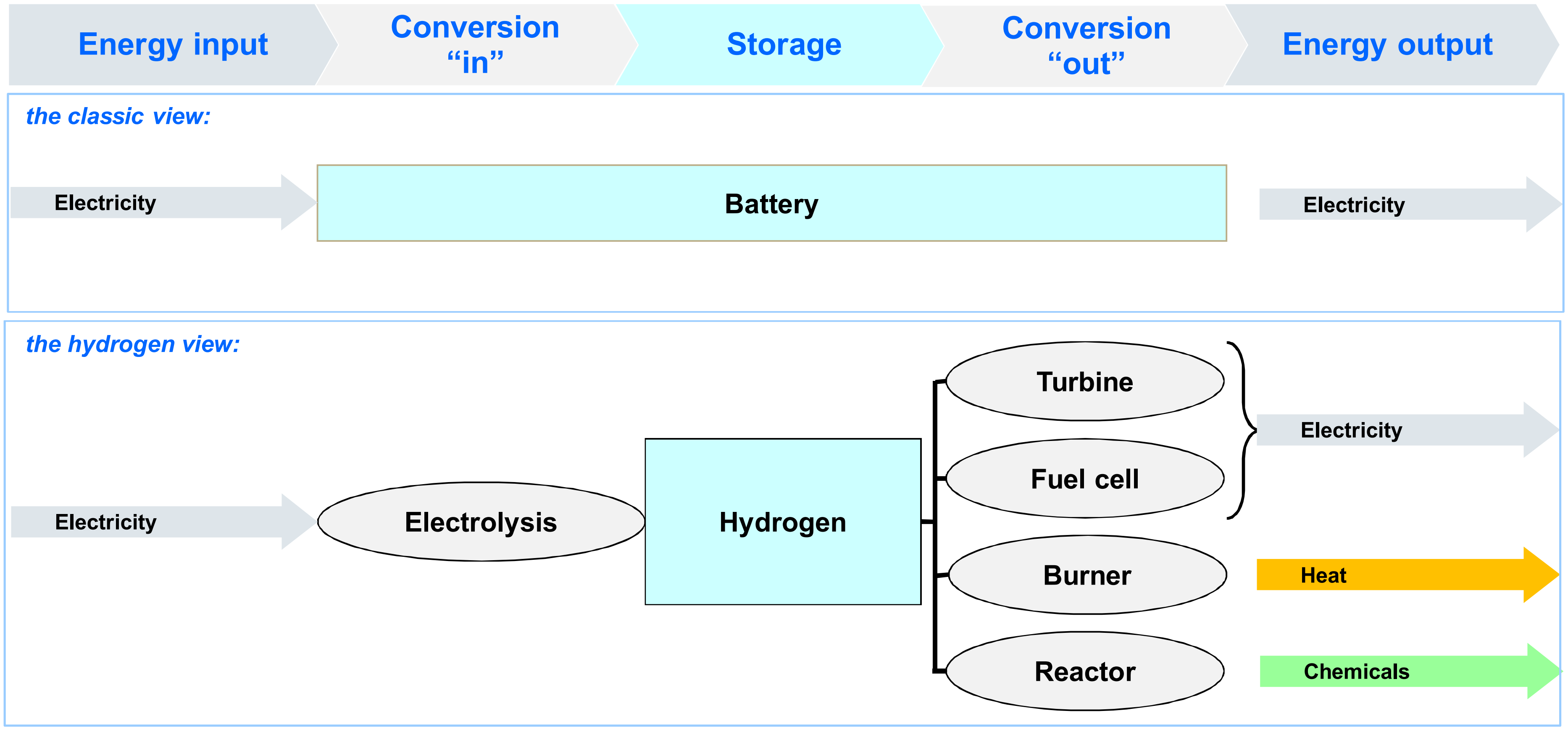

Hydrogen is multi-functional
It connects Energy, Mobility and Industry

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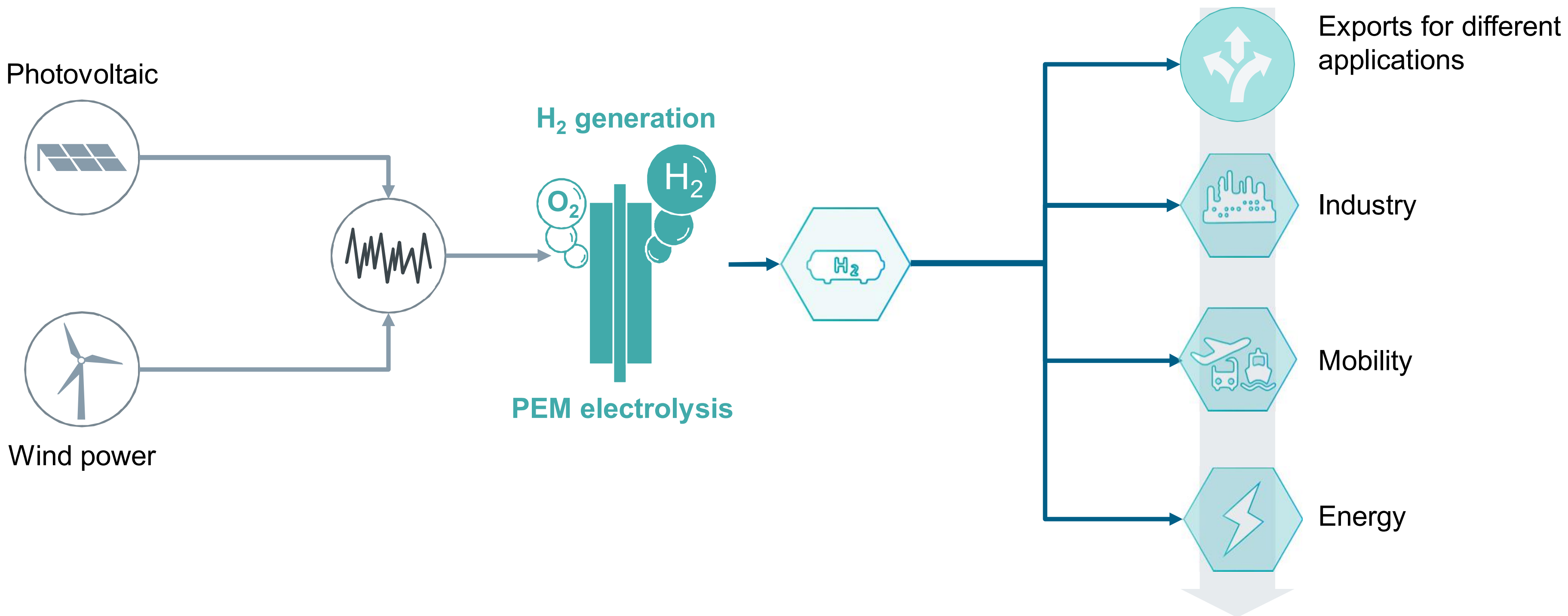
Volatile electricity generation	Grid integration	Conversion/ storage	Applications



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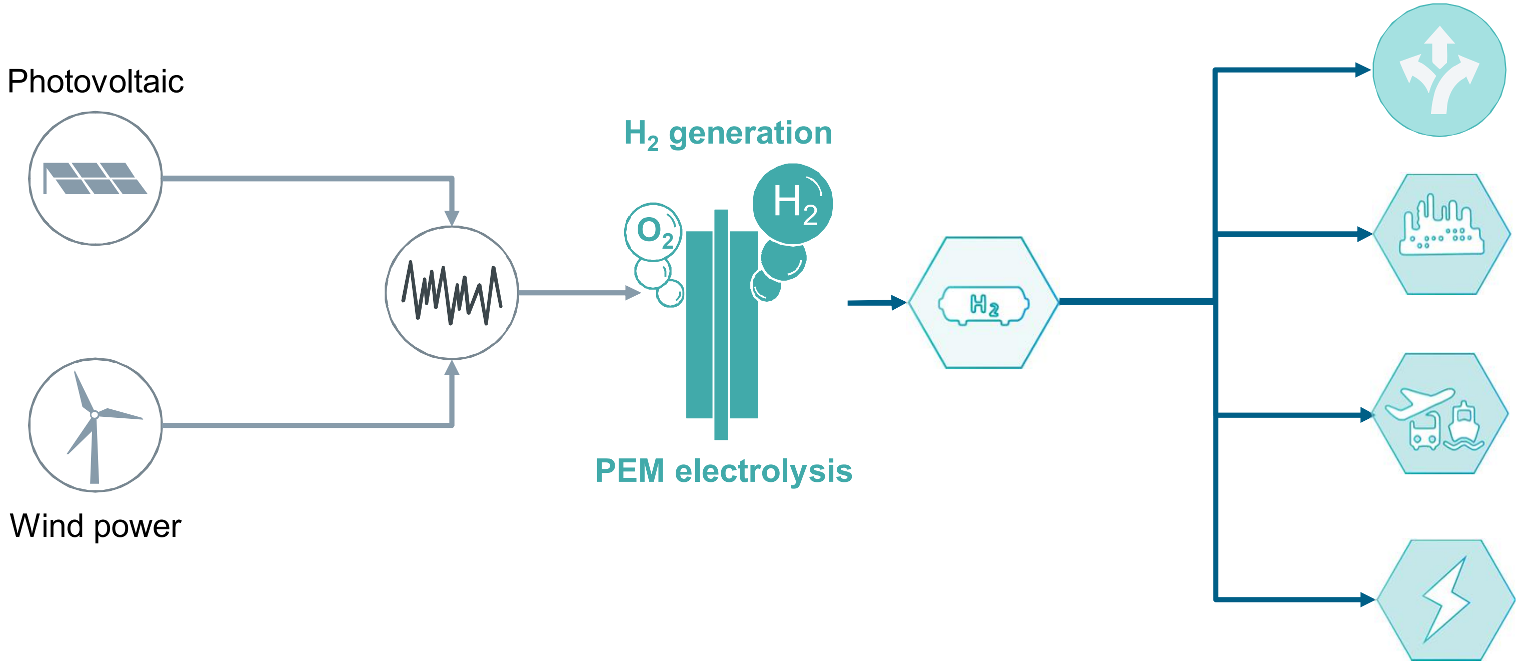

Exports for different applications

Industry
Hydrogen for ammonia production, petroleum refinement, metal production, flat glass, etc.

Mobility
Hydrogen as alternative fuel or as feedstock for synthetic fuels

Energy
Hydrogen blending (gas grid)
Remote energy supply/Off-grid

Green (CO_2-free) hydrogen:
a broad variety of potential applications

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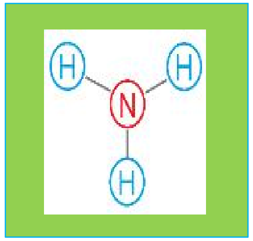
Industry *

- Refineries



- Ammonia plant

- Steel production

Mobility

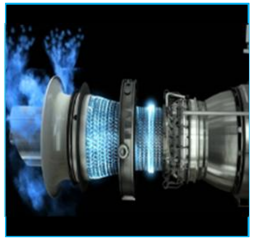
- H_2 as fuel for public transport

- Substitute of bio-ethanol admixing

E Fuels

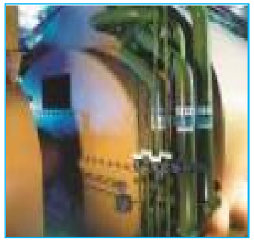
- Carbon-based synthetic fuels

Energy



- Re-electrifi-cation in H2-turbines

- Admixing to conventional gas turbines



- Generator cooling

* Besides these: glass, semiconductor, food&beverage

The different use cases for green hydrogen…
….follow a `merit order´principle

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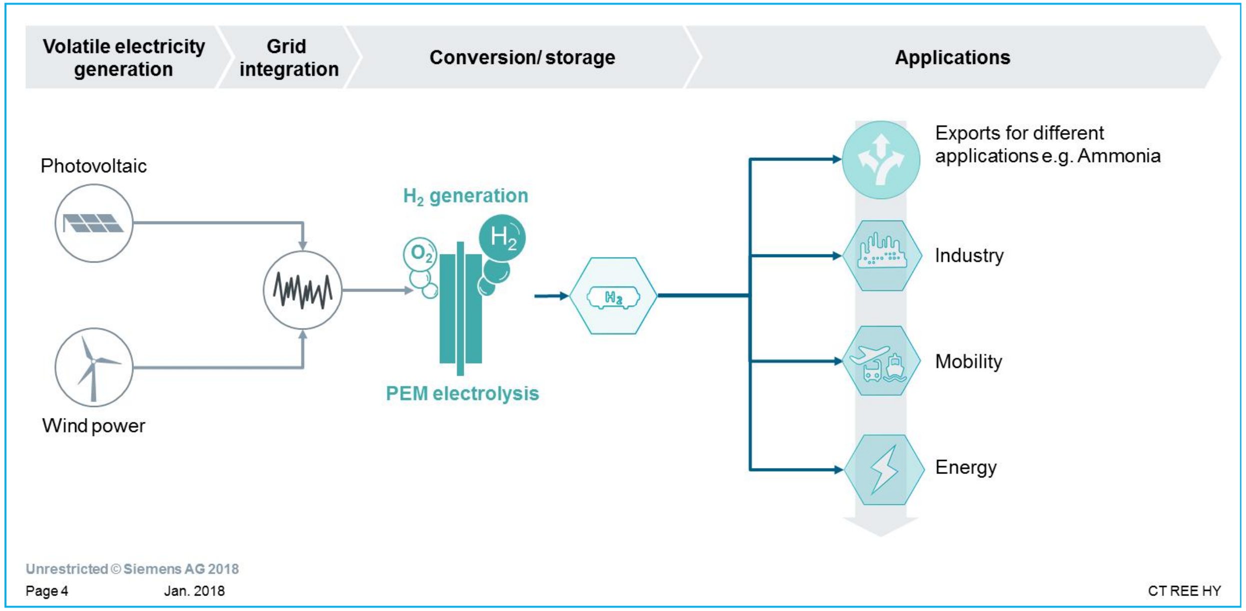

current H_2 market prices

mobility	**~ 4 – 10 USD/kg**
industry	**~ 1,4 – 5 USD/kg**
energy	**~ 0,7 – 1 USD/kg**

- Compared to re-electrification (“power to power”) the use of hydrogen in industry or mobility leads more easily to a positive business case.
- The three use cases have different maturity, market potential and market starting points.

H_2 production via electrolysis
Economy of operation

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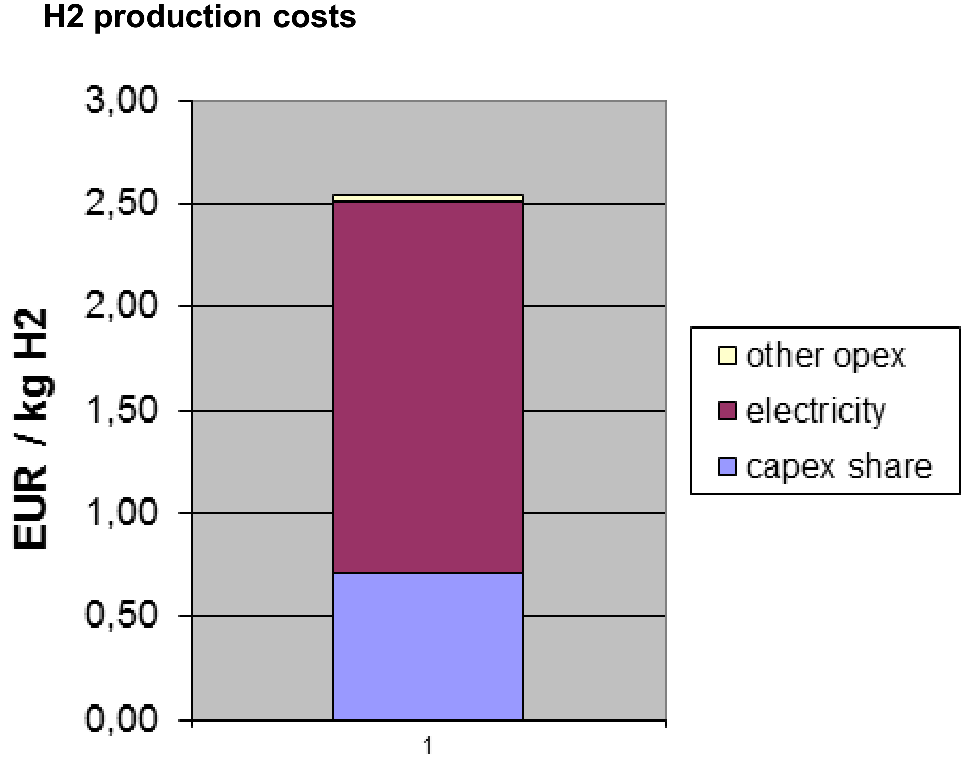
Nur als Idee:
sollte auf UEA-verhältnisse angepasst werden

input parameter:	
electricity costs [ct/kWh]:	**3,2**
capex electrolyzer [€/kW]:	**1.000**
utilization rate [hours per year]:	**4000**
product life [y]:	20
system efficiency [% HHV]:	70
additional capex [€/kW]:	0
additional opex [%] * :	5
interest rate [%]:	0
depreciation period [a]:	10

* service, maintenance, operation (without electricity)

Important: above choosen parameter are arbitrary values and do not reflect data of Siemens electrolyzers !



E fuels:
tightly connected with availability of CO2 sources

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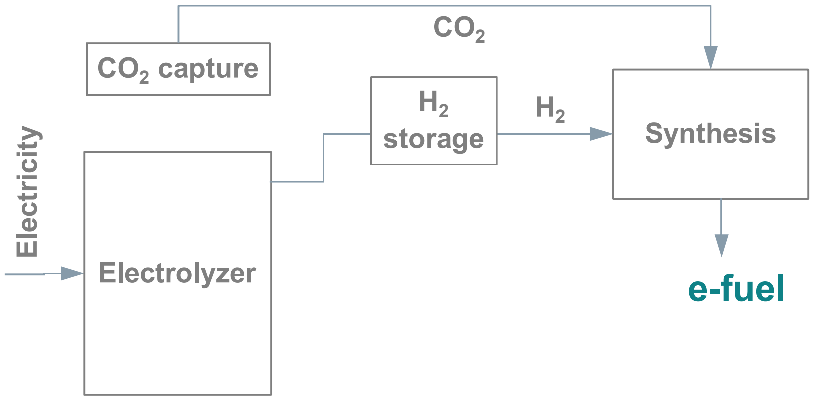

- Heavy duty, long distance transport, especially aviation and marine transport require fuels with high volumetric energy density.
- High volumetric energy density can only be achieved by carbon based fuel.
- The production of eFuels requires a CO2 source as feedstock in order to be CO2-neutral.
- Availability and costs of suited CO2 supply are essential for related business cases
- Electrolyzer technology in the GW range will be required. Up-sizing is mandatory but no critical technical hurdles are expected.
- Low RE electricity prices are the key enabler.

* Besides these: glass, semiconductor, food&beverage

Overall process efficiency decreases when hydrogen is further converted in downstream synthesis plants

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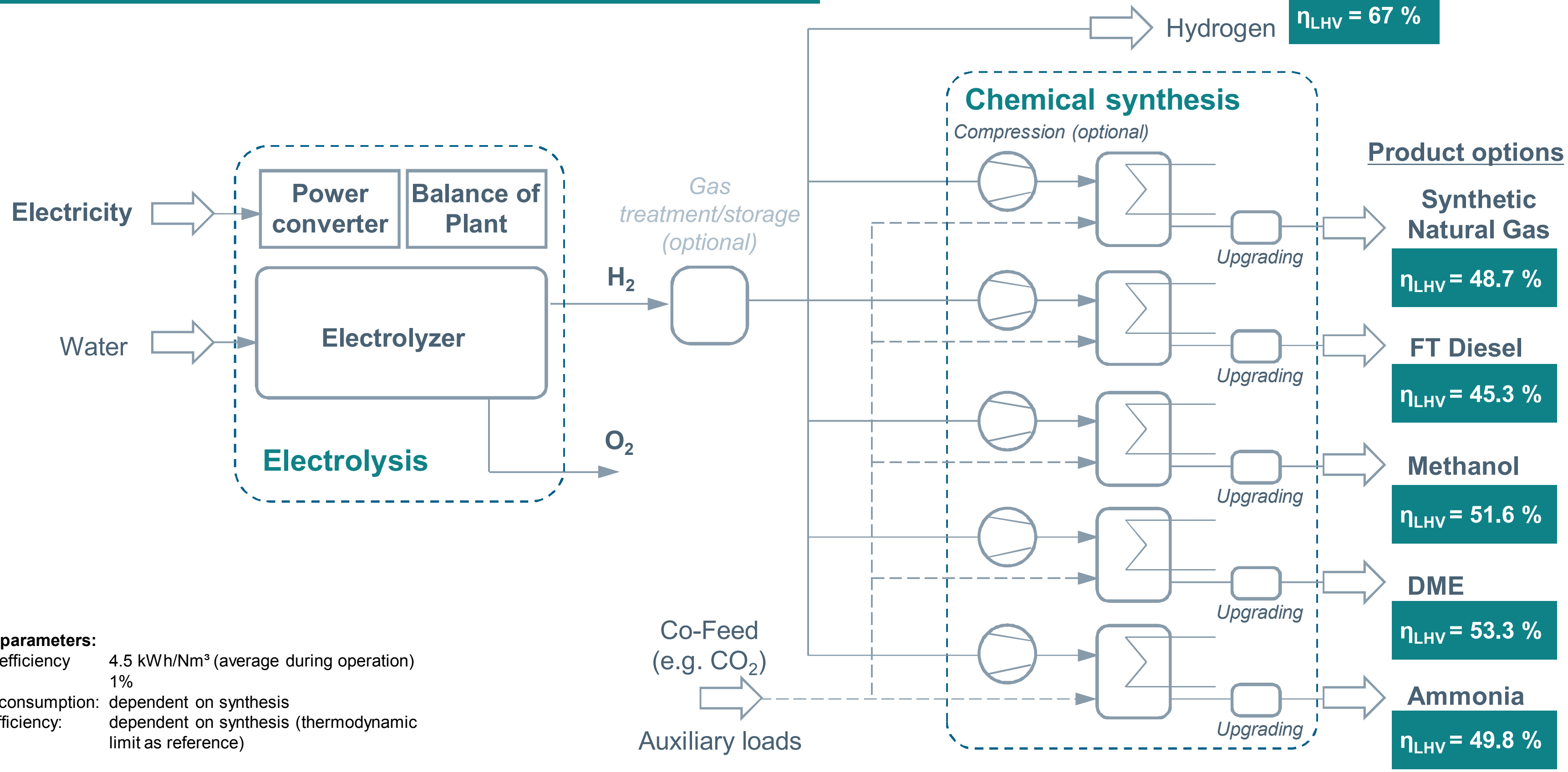
source: Alexander Tremel, Siemens AG

Realistic process efficiency considering economic perspective



Simulation parameters:

Electrolysis efficiency	4.5 kWh/Nm³ (average during operation)
H2 loss:	1%
Aux. power consumption:	dependent on synthesis
Synthesis efficiency:	dependent on synthesis (thermodynamic limit as reference)

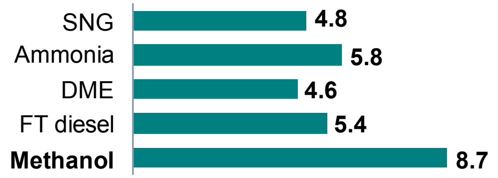
Methanol is liquid synthesis product with already good fit to existing infrastructure and relatively low cost

source: Alexander Tremel, Siemens AG

Multi-objective product evaluation based on quantitative and qualitative parameters (starting point: hydrogen)

Economics

Production cost of synthetic product, value (conventional / green), plant **CAPEX**

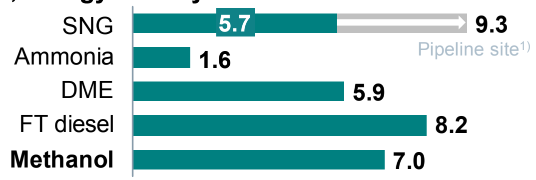


Technology

Technology fit to “Power-to-Fuel use case" (smaller scale, complexity, flexible, efficiency)

Acceptance

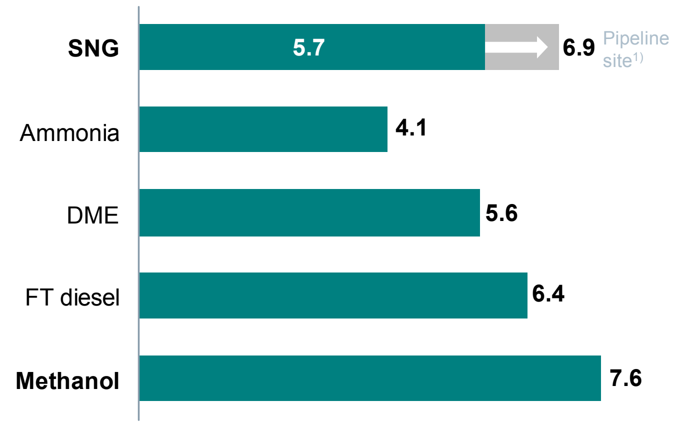
Evaluated by **infrastructure fit, health and environment issues, energy density**



Summary: Methanol with highest score

- Evaluation based on green field plant without existing infrastructure (exception see footnote)
- Detailed evaluation is site and costumer specific and may result in deviating outcome

Total score (0-10 points):



Methanol with highest total score; SNG score strongly depends on local infrastructure

1) Energy density for transport not an issue for SNG; Infrastructure 100% in place

Based on: Tremel et al. (2015), Int J Hydrogen Energy 40, 11457-11464, http://dx.doi.org/10.1016/j.ijhydene.2015.01.097

The story will not end with the Silyzer 200/300 – … we are targeting >100 MW

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Silyzer portfolio roadmap

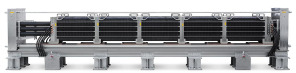
Reduction of specific price (€/kW)

2011 – 2015

Silyzer 100
100 – 300 kW
Lab-scale

2015 – 2018

Silyzer 200
1 MW class
Current commercial product

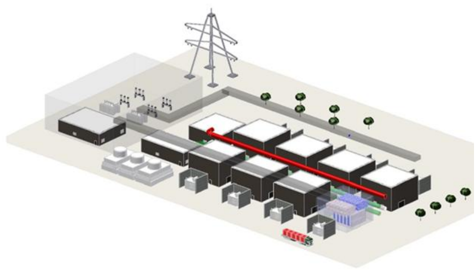


2018 – 2023+

Silyzer 300
>10 MW class
Sales release 2018

>2030

Next generation Silyzer >100 MW
Under development



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

ENERGIE PARK MAINZ

Project scope and key facts

Development of an decentralized hydrogen energy storage plant

- Location: Mainz (Germany)
- Partners Stadtwerke Mainz, Linde, Siemens, RheinMain University
- Connected to a wind-farm (8 MW)
- 6 MW peak electrolyzer (3 stacks, each 2 MW)
- 1000 kg H_2 storage (33 MWh)
- 200 tons H_2 target annual output
  - Injection in local gas grid
  - Multi-use trailer-filling
- Funding: ~50% (BMWi)
- Timeline: 10/2012 – 12/2016

Source: Wikipedia Source: Energiepark Mainz

Ein Forschungsprojekt von STADTWERKE MAINZ AG, Hochschule RheinMain University of Applied Sciences Wiesbaden Rüsselsheim, THE LINDE GROUP Linde, SIEMENS

Gefördert durch Bundesministerium für Wirtschaft und Energie aufgrund eines Beschlusses des Deutschen Bundestages

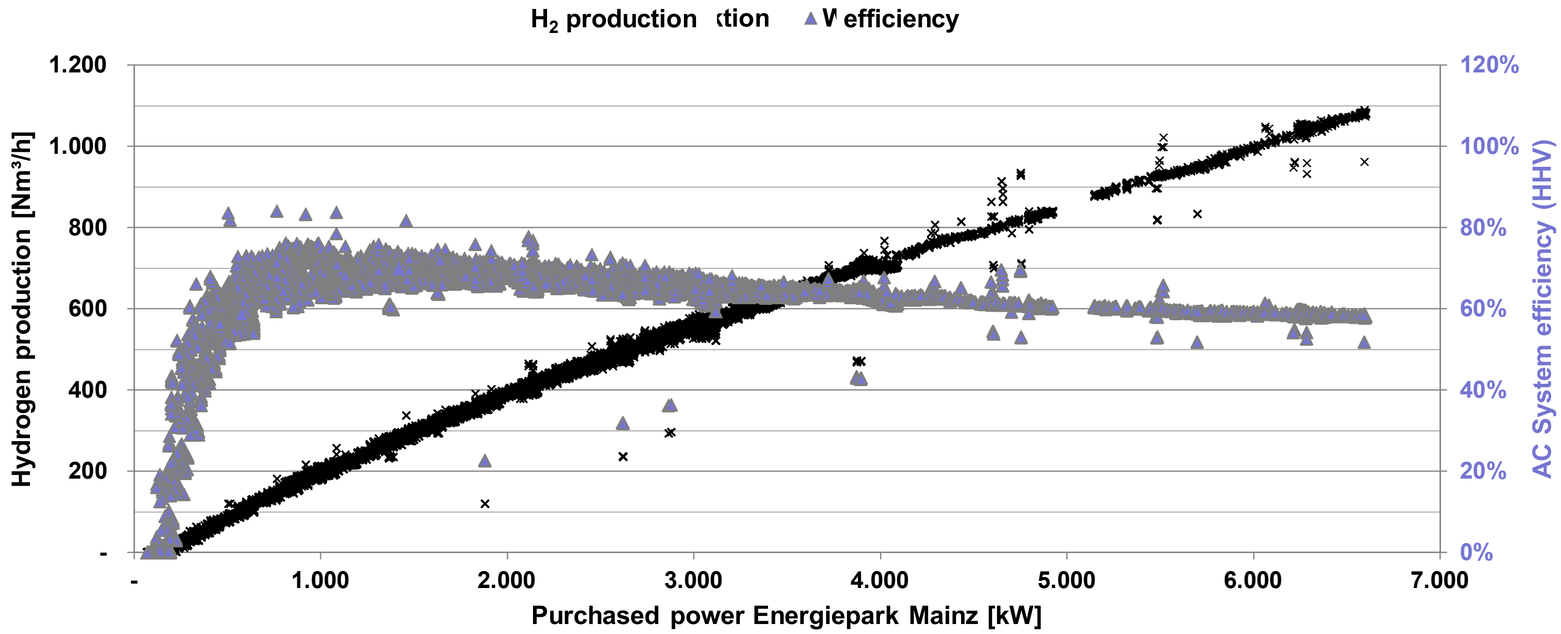
ENERGIESPEICHER Forschungsinitiative der Bundesregierung

ENERGIE PARK MAINZ

Energiepark Mainz – Status

Electrolyzer system

- Efficiency evaluations under consideration of **overall** purchased electricity and measured H2 production (outlet electrolyzers)
- Data obtained by measurements in Oct 2015



H2FUTURE

Hydrogen from electrolysis for low carbon steelmaking

Blast Furnace in Linz; Source: Voestalpine

Project Consortium:

- **Verbund** (*utility/grid operator in AT = Electricity provider*)
- **VoestAlpine** (*steel manufacturer = Hydrogen consumer)*
- ***ECN (****Energy Research Centre of the NLD*)
- **Siemens Hydrogen Solutions** (*Technology provider)*

Project description:

EU funded project to show viability of a PEM electrolyzer as flexible load for grid services. Hydrogen used within the steel making/processing to reduce CO_2 foot-print.

Time line:

Jan. 2017 – Jun. 2021

Electrolyzer:

- 6 MW rated power
- new cell and stack design
- designed for power range of ≈ 10 - 100 Megawatt

More details:

http://www.h2future-project.eu

Funded by

Summary

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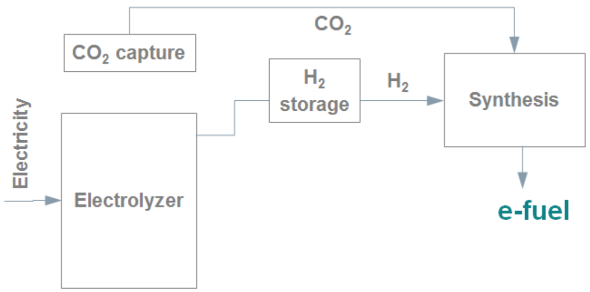

- CO_2-reduction targets are clearly linked with renewables. Decreasing generation costs foster new business opportunities
- Power to X concepts will be essential to reach CO_2 reduction targets. H2 via electrolysis is a key element for sector coupling.
- The de-fossilation of the mobility sector provides specific challenges. In particular heavy duty transport and aviation require 'power supplies' with high volumetric energy density.
- Electricity-based liquid fuels are a major option for above mentioned area. Technical solutions are / will be available.
- However, any market outlook is uncertain since political targets and market regulations are hardly to predict.

Contact page

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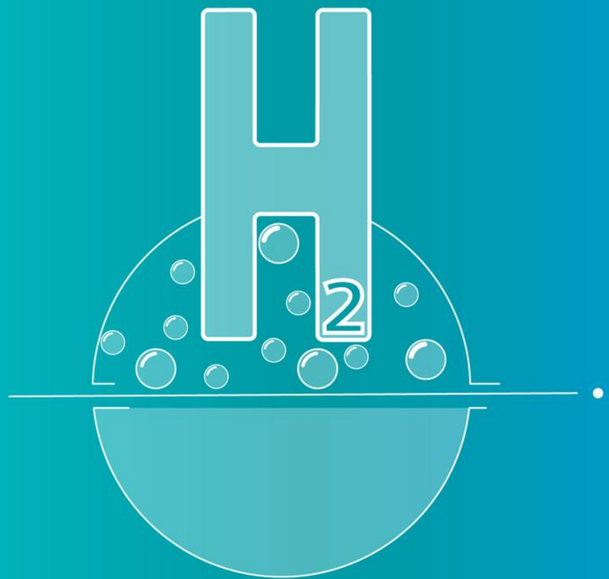

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