H2FUTURE – Hydrogen Electrolysis

HYDROGEN MEETING FUTURE NEEDS OF LOW CARBON MANUFACTURING VALUE CHAINS

08.10. 2019

Hermann Wolfmeir

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FUEL CELLS AND HYDROGEN JOINT UNDERTAKING

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voestalpine Stahl GmbH
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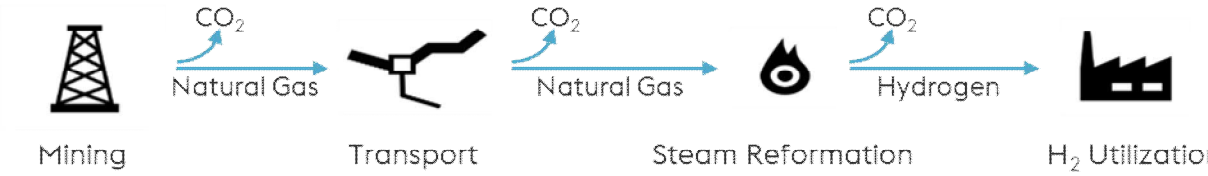
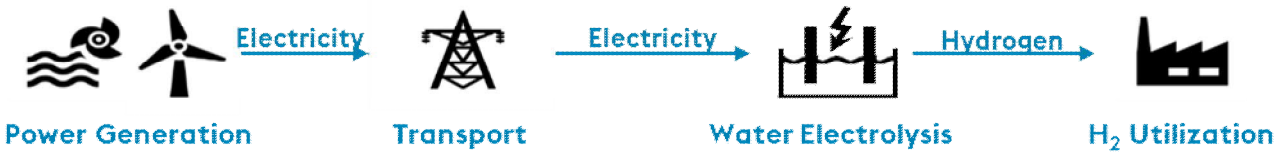
H2FUTURE
PROJECT IDEA

» TODAY: Hydrogen is produced via steam reformation from fossil fuels, mostly from natural gas. This leads to substantial CO_2 emissions.



CO_2 = 0,6 to 0,8 kg/m³ H_2

» IN THE FUTURE: Water electrolysis via electricity from renewable energy sources will be the main source of green hydrogen with a minimal CO_2 footprint.



CO_2 = 0,0 kg/m³ H_2

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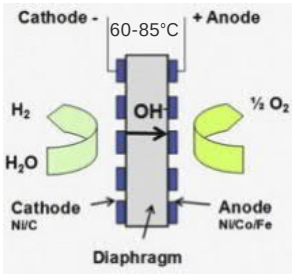
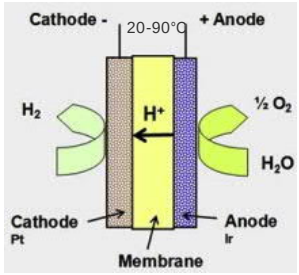
TECHNOLOGIES READY TO THE MARKET

Alkaline Electrolysis

Anode: $2OH^- \rightleftharpoons \frac{1}{2} O_2 + H_2O + 2e^-$
Cathode: $2H_2O + 2e^- \rightleftharpoons H_2 + 2OH^-$
Total: $H_2O \rightleftharpoons H_2 + \frac{1}{2} O_2$

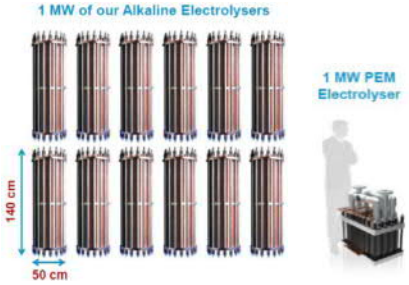


PEM – Electrolysis (proton exchange membrane)



Anode: $H_2O \rightleftharpoons 2H^+ + \frac{1}{2} O_2 + 2e^-$
Cathode: $2H^+ + 2e^- \rightleftharpoons H_2$
Total: $H_2O \rightleftharpoons H_2 + \frac{1}{2} O_2$

- More than 100 years of development history
- Life time up to 40 years at stable operation
- Up to 5 MW, high efficiency
- Liquid electrolyte 20-25% KOH
- Low dynamics
- No partial load<30%
- Current densities 0,25 A/cm²



- Solid electrolyte: perflourosulfonated polymer membrane (e.g. Nafion ®)
- High current densities up 2 A/cm²
- High dynamics, load range 10 to100%
- Number of suppliers for plants >1MW modest
- Life time ?

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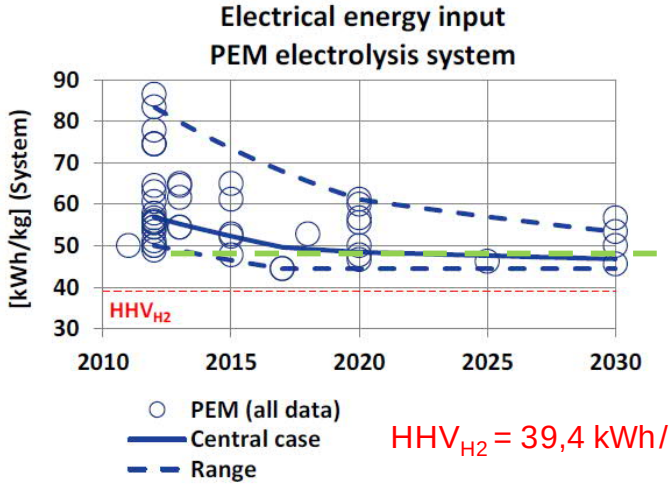
Pictures:
Carmo et al.: A comprehensive review on PEM water electrolysis, Int. J. Hydrogen Energy, 38 (2013)
Friedrich ; Zukunftspotenziale der Elektrolyse; Univ. Stuttgart

EU HORIZON 2020 CALL FOR TENDER: CALL FCH-02-7-2016 SCOPE AND OBJECTIVES (1)

FUEL CELLS AND HYDROGEN JOINT UNDERTAKING

- Design and installation of a 6 MW PEM (1200m^3_n/h) electrolyser system
  - The hydrogen purity should meet the application requirements…
  - Storage and compression are not in the scope of this topic



W_{el} = 48 kWh/kg

HHV_{H2} = 39,4 kWh/kg = 3,54 kWh/$m^3_{(STP)}$

- To demonstrate an energy consumption of 48 kWh/kg H_2 for PEM technology at nominal power
- Ambitious efficiency target
- η_{System} = 82%

Source: Development of Water Electrolysis in the European Union FCH JU (2014)

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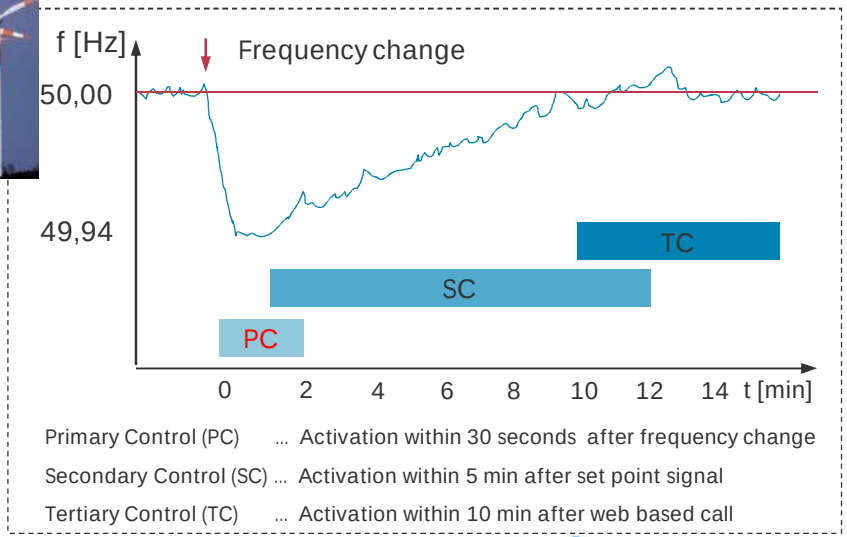
EU HORIZON 2020 CALL FOR TENDER: CALL FCH-02-7-2016 SCOPE AND OBJECTIVES (2)

FUEL CELLS AND HYDROGEN JOINT UNDERTAKING

- Two year demonstration
- To demonstrate a CAPEX for the of <1000 €/kW for PEM technology
- To develop a large scale electrolyser of sufficiently rapid response time (of the order of a few seconds), to participate in the existing primary and secondary grid balancing markets

Volatile generation and volatile demand

Impact and response



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PROJECT OVERVIEW
H2FUTURE

One of the biggest forthcoming PEM electrolyser units in the world with 6 MW power and 1200 m^3/h H_2 production at voestalpine Linz for full scale demonstration of H_2 production and grid balancing

© Siemens AG

Project Budget:	17,8 M€
Total EU Funding:	12,0 M€ (70% funding)
Project Duration:	4,5 years (2017-2021)

LOCATION SELECTION
“BG 89 WASSERSTOFFANLAGE NORD”

- voestalpine is in charge of providing the infrastructure
- Location next to power station ensures availability of
  - Electricity
  - Cooling water
  - Deionized water
  - Nitrogen
  - Pressurized air
  - Connection to COG-network

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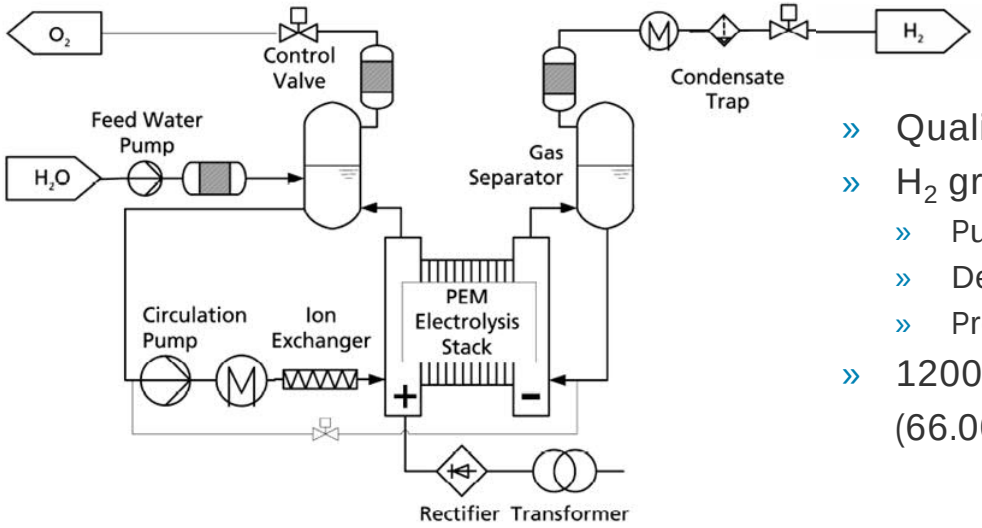
BASIC & DETAIL ENGINEERING

» Principal layout of PEM-electrolyser system



COG- network

- Quality of H_2 is not comparable to H_2 for fuel cells …
- H_2 grade level as energy carrier and reducing agent
  - Purity ≥ 98%
  - Dew point ≤ 10 °C
  - Pressure max. 150 mbar
- 1200 $m^3_{(STP)}/h$ of H_2 introduced into COG network (66.000 $m^3_{(STP)}/h$)

Flow Chart: Smolink, PEM Water Electrolysis, Present Status of R&D, 18th world Hydrogen Conference, Essen, 18.05.2010

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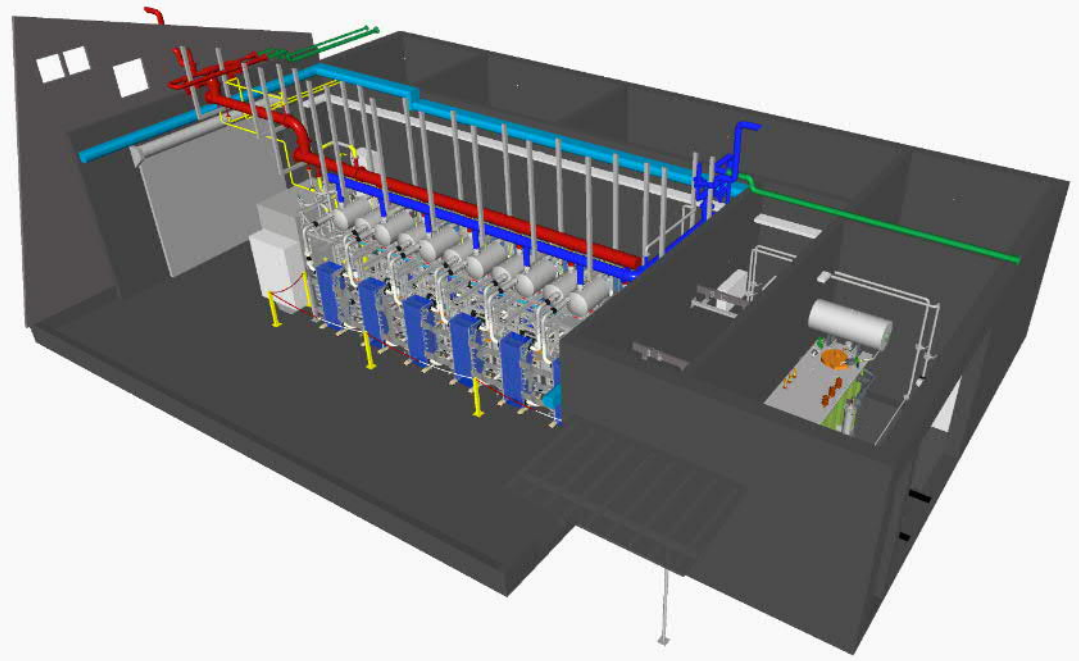
LAYOUT OF PEM ELECTROLYSER SYSTEM
TECHNICAL CHARACTERISTICS



- Rated power 6 MW
- Hydrogen 1200 $m^3_{(STP)}/h$
- Oxygen 600 $m^3_{(STP)}/h$
- Cells 600 (12 x 50)
- Membrane 0,5 m^2/cell
- Current density 1 A/cm^2
- Current 5000 A
- Voltage up to 2 V/cell
- Cooling Water 350 m^3/h
- Pressure max. 150 mbar
- Purity > 98 % H_2
- Dew point < 10 °C

At least 170 comparable units for supplying a DR-plant like Texas necessary

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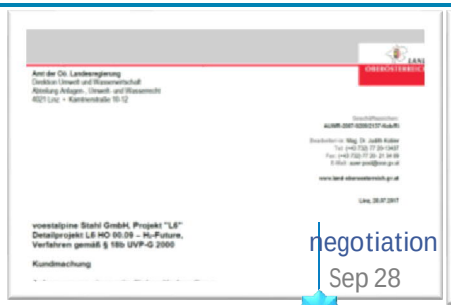
SOME MILESTONES



negotiation
Sep 28

Certificate of approval
Nov 8

2017 Jul | Aug | Sep | Oct | Nov | Dec | Jan | Feb | Mar | Apr 2018

Submission
Jul 17


PROJEKT L6 –DETAILPROJEKT **L6 HO 00.09**

Einreichunterlagen für
UVP-Änderungs-Genehmigungsverfahren §18(b)
zum Anlagenverbund Hochofen

Technisches Projekt
H_2-Future

Bereich: BT – Hochofen

groundbreaking
Jan 21/29

Press conference start of construction
Apr 16

HYDROGEN STEELMAKING
PROJECT STATUS H2FUTURE (2017-2021)


15.03.2018


02.07.2018


07.08.2018

» August 2018: Finalization electrolyzer building, delivery of transformer

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PROJECT STATUS H2FUTURE

September 2018:
installation of ventilation and cooling system

October 2018:
assembly works transformer and rectifier

29.10.2018

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H2FUTURE
PROJECT STATUS H2FUTURE

30.01.2019

November 2018 –

February 2019

Installation of heat exchangers

assembly works, final piping works

completion of infrastructure

18.02.2019

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PROJECT STATUS H2FUTURE

March / April 2019

Delivery of first 3 modules

September 2019

Completion of first row

October 2&3 2019

R&D OBJECTIVES OF VOESTALPINE
IS PEM ELECTROLYSIS A RELIABLE TECHNOLOGY?

- Systematic upscaling requires answers of following questions /topics
- Operation of PEM electrolyser
  a. operating range
  b. Efficiency: Influence of dynamic operation, continuous and overload operation
  c. Degradation of PEM due to ageing and poisoning
- Durability considering the mode of operation
  a. Maintenance intensity
  b. Tightness
  c. Corrosion
- Quality of product and input reactant streams
  a. Requirements deionized water
  b. Quality of H_2 and O_2 dependent on operation mode
- Influence of operation time

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Thank you! Questions?

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