Siemens Energy

13. Niedersächsische Energietage
Fachreferat: Wie kann der Hochlauf einer H₂-Wirtschaft aus technischer Sicht gelingen?

02nd November 2021
Stefan Engelshove
Boundary conditions are changing
Major green initiatives drive hydrogen related initiatives and investments

GLOBAL
- Paris Agreement
- Clean Hydrogen Ministerial (CN, US, EU, NL, NO, IN, JP, SK, NZ, KSA)

CHINA
- 14th 5-year plan
- China Hydrogen Alliance

EUROPE
- EU Green Deal
- European Clean Hydrogen Alliance (ECH2A)

UNITED STATES
- Biden Green Energy Plan
- various initiatives

UNIVERSAL ENERGY

SAUDI ARABIA
- The 2030 Solar Plan
- NEOM

SAUDI ARABIA

QATAR
- Qatar Vision 2030

UNITED STATES
- Biden Green Energy Plan
- various initiatives

JAPAN
- Japan Climate Initiative
- Basic Hydrogen Strategy

QATAR
- Qatar Vision 2030

SOUTH KOREA
- Green New Deal

UNITED STATES

SAUDI ARABIA

UAE
- UAE Energy Strategy 2050

GLOBAL

EUROPE

SAUDI ARABIA

UAE

SOUTH KOREA


*€300bn* investment expected through 2030

*€80bn* thereof investment volume “mature”

228 announced projects

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Today’s challenge: Green energy needs to travel from lowest cost regions to decarbonize demand centers

33 Giga tons
Total energy-related emissions in 2019

- China: 10.8 Giga tons
- United States: 5.3 Giga tons
- India: 2.6 Giga tons
- Russia: 1.7 Giga tons
- Japan: 1.1 Giga tons
- Germany: 0.7 Giga tons

Least
Most
PV/wind resources for renewable hydrogen production

X.X – CO₂-Emissions
Demand centers with high CO₂ emissions
Strong growth in green hydrogen production drives cost competitiveness

Announced clean hydrogen capacity through 2030

Production capacity
Mt p.a.

Hydrogen production pathways, including carbon costs

Production cost of hydrogen
USD/kg

We are serving the entire hydrogen value chain
The three levers for decarbonization and related technologies

Fuel Shift/Hybridization

Efficiency Increase

Deep Decarbonization

- Waste Heat Recovery
- Next Generation Grid Access
- Integrated Low Carbon Hybrid Solutions
- Power-to-Heat
- Power-to-X
- H₂ Gas Turbines (co-firing)
- Coal-to-Gas Shift
- Off-shore & Marine Energy & Efficiency Solutions
- Combined Heat and Power
- Plant Flexibility Solutions
- Brownfield Engine Exchange
- Highly Efficient HVDCs
- Gas Engines
- Off-shore & Marine
- High Heat Recovery
- SeaFloat
- Highly Efficient Turbines, Compressors and Plants
- Eco Design Transformer
- Turbine / Compressor / Generator Upgrades
- Plant Performance Optimization
- Low Carbon Gas Turbine Fuels
- Next Generation Grid Access
- Thermal Storage Integration
- Battery Integration
- Grid Stability Packages
- Power from Shore and Subsea Grid
- Hydro Power
- Biomass / Geothermal
- Green Energy Storage
- Fuel Cells
- Solar Power
- Carbon Capture
- Blue Products (SF₆ free, GHG free transmission)
- Electrolyzers
- H₂ Gas Turbines (100%)
- New Energy Carriers
- Off-shore & Marine
- Net Zero Operations
- Wind Power
- Zero Carbon Hybrid Solutions
- Green Energy Storage
The Design of Future proof Energy Systems is Core Element for Decarbonized Energy Systems

Technologies:
- Heat pump
- H₂ capable gas turbine
- ...

Energy System Design:
Customer Challenge

Optimized Energy System

Decarbonization Project Types:
- Hybrid
- Heat
- ...

AV Site specifics

€ Cost

CO₂ Carbon
Supply and demand
The hydrogen network in Germany and Europe – Program “H2-network”

A H2-network requires storages for high availability!

Vision for a German H2-network

Vision for a European H2-network

Quelle: Whitepaper H2 Siemens Energy

Quelle: European Hydrogen Backbone
Project at a glance
Western Green Energy Hub (WGEH)

General Information

- **Project Level:** Market Intelligence
- **Project Phase:** Feasibility Study
- **Lead Division:** SE
- **Lead Customer:** WGEH
- **Country of Installation:** Australia
- **Start of Operation:** FID 2028
- **Initiative / Program:** InterContinental Energy / CWP Global / Mirning Green Energy
- **Type of Hydrogen:** green
- **Brownfield / Greenfield:** Greenfield
- **Power of demand:** 28 GW (50 GW upstream / 20 MTPA ammonia)
- **Salesforce ID:** …

Western Green Energy Hub

Basin/District scale green hydrogen and ammonia project on Mirning land located across Dundas Shire and the City of Kalgoorlie-Boulder, Western Australia.

Source Pictures: InterContinental Energy
Project at a glance
GET H2 - Germany

General Information

- Project Level: Target Project
- Lead Division: SE
- Lead Customer: RWE; BP; nowega; OGE; Evonik; Gascade; BASF; Uniper; Thyssengas
- Country of Installation: Germany
- Start of Operation: 2030
- Initiative / Program: GET H2
- Type of Hydrogen: Green
- Brownfield / Greenfield: Brownfield / Greenfield
- Power of demand: (Elektrolyzer) ...
- Salesforce ID: ...

Invest 660 Mio.€
Kilometer 1294 km

DolWin4 and BorWin4
Hanekenfähr: Project start in autumn 2020

Source Pictures: GET H2
Source Picture: Amprion

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Project at a glance
Fairfuel atmosfair – PtL in Werlte - Germany

General Information

- Project Level\(^1\):
- Project Phase\(^2\):
- Lead Division: SE NEB
- Lead Customers: atmosfair
- Country of Installation: Germany
- Start of Operation: 2021
- Initiative / Program: ...
- Type of Hydrogen\(^3\): green
- Brownfield / Greenfield: Greenfield
- Power of demand: 1,25 MW (Elektrolyzer)
- Salesforce ID: ...

Air capture module

With this module we sequester CO\(_2\) directly from the atmosphere. This process is very energy-intensive.

Electrolyser

Active electrolyser: hydrogen is produced from water using electricity.

Source Picture: Siemens

Source Picture: atmosfair

Fischer-Tropsch synthesis

Here, carbon and hydrogen are synthesized into hydrocarbons which is the feedstock for the refinery.

Refinery

Using the synthetic hydrocarbons,ases are processed into jet fuels or road fuels for transportation.

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Project at a glance
Haru Oni - Chile

General Information

- Project Level: Target Project
- Lead Division: SE NEB
- Lead Customer: Porsche
- Country of Installation: Chile, Magellanes
- Start of Operation: Pilot phase 2022
- Initiative / Program: Highly Innovative Fuels (HIF)
- Type of Hydrogen: Green / eMethanol & eFules
- Brownfield / Greenfield: Greenfield
- Power of demand: (Elektrolyzer) ...
- Salesforce ID: ...

Source Picture: Siemens Energy
Siemens Energy Electrolyzer portfolio scales up by factor 10 every 4 – 5 years

Silyzer portfolio roadmap

<table>
<thead>
<tr>
<th>Year</th>
<th>Power (MW)</th>
<th>Description</th>
</tr>
</thead>
</table>
| 2011 | 0.1 | Silyzer 100 Lab scale demo  
~20 kOH\(^1\),  
~30 t of H\(_2\) |
| 2015 | 1 | Silyzer 200  
~130 kOH\(^1\),  
~1700 t of H\(_2\) |
|       |       | World’s largest Power-to-Gas plants with PEM electrolyzers in 2015 and 2017 built by Siemens |
| 2018 | 10 | Silyzer 300 |
|       |       | Biggest PEM cell in the world built by Siemens |
| 2023+ | 100 | Silyzer 300 plant |
|       |       | Pre-engineered and pre-fabricated electrolyzer systems enhanced with optimized operational concepts (digital twin) |
| 2028+ | 1,000 | Large scale, modular design electrolyzer plants |

\(^1\) Operating Hours; Data OH & tons as of Oct 2020
Prepared for delivery at Gigawatt scale
Standardization, Modularization and Manufacturing

• **Standardized plant** design based on **modular** building-blocks
• **Pre-fabricated groups** with pre-defined interfaces
• **Integrated digital engineering** tools

• **Ramp-up of manufacturing** towards a lean **Gigafactory**
• **Flexible expansion** to **Multi-GW**
• **Automated**, highest-quality Silyzer production
Prepared for delivery at Gigawatt scale
Standardization, Modularization and Manufacturing

• Standardized plant design based on modular building-blocks
• Pre-fabricated groups with pre-defined interfaces
• Integrated digital engineering tools

• Increase the scaling in a system up to GW scale
• Flexible expansion to GW production
• Footprint reduction due to compact design
• Cost-optimized and pre-engineered solutions
MPFO as an idea for modular systems „Plug and produce“ – „Modular Production Facilities Oil“

MPFO – Development

Further targets
- Cost reduction due to barrel price collapse
- Unmanned operation
- Production optimization
- Reduction of installation and commissioning time

Development MkII – Digitalization
- Modular Automation (ZVEI White Paper – 2015 / ISA 106)
  - State based control concept
  - Automated modules integration
- Expert Advice System
  - Automated operating sequences
  - Operating advices
  - Support functions
  - Plant status visualization
  - KPI Dashboard
  - Production optimization

Unmanned operation
20% lower CAPEX/OPEX
Reduction of inst. comm. time by 70%
Production optimization

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MPFO as an idea for modular systems
„Plug and produce“ – „Modular Production Facilities Oil“
MPFO as an idea for modular systems
Integrated Operation

- Reservoir information
- Injection rate
- Well potentials

MindSphere

Module 1
Module 2
Module n

MPFO 1
MPFO 2
MPFO n

Expert Advice System

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Digitalization

Digitalization Core Technologies

Traditional Systems

- Production Management and Planning
- Energy Management
- Maintenance Management
- Data Storage
- SCADA
- Training Systems
- ERP
- Advanced Process Control (APC)

Digitalization

- Digital Twin
- Cloud
- AR/VR
- Analytics & Apps
- Systems Integration
- IIoT
- Cyber Security
- Additive Manufacturing

Consulting and Roadmap
Conclusions

WHY
• A quick technical setup is required to achieve the climate goals.
• Hydrogen is the second stage of the energy transition
• Indispensable for decarbonization

WHAT
• Large Power-to-X solutions enabled by the full Industry competence
• Digital twin and service concepts

HOW
• Secure technology and modularization
• High standardization systems
• Integrated digitalization system
• Strong international partner ecosystem
• Training concepts for employees – qualification systems

We know how to industrialize technologies!