Siemens Energy

Our history

A young company ...

Siemens Energy was first listed on the Frankfurt Stock Exchange on September 28, 2020 – and is now an independent company.

SIEMENS energy

… with a strong heritage

In 1866, engineer and company founder Werner Siemens discovered the dynamo-electric principle. With this, he laid the foundation for modern electrical engineering, first enabling electricity to become part of our everyday lives.

Siemens Energy

As an integrated energy technology company

we support our customers along the energy value chain

Low- or zero-emission power generation

- Gas Services
- Siemens Gamesa Renewable Energy

Transport and storage of energy

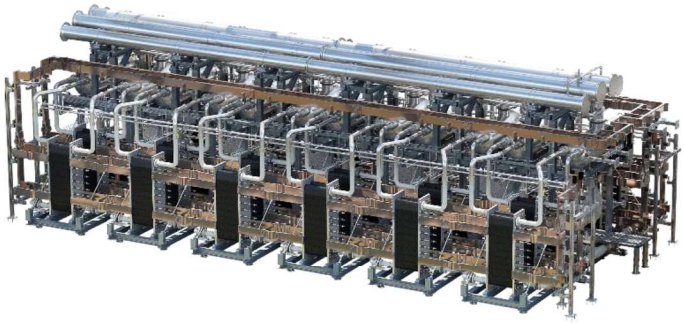
- Grid Technologies

Reducing GHG emissions & energy consumption in industrial processes

- Transformation of Industry

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

Silyzer 300
Full stack array
(24 stacks) …



… and close-up of electrolyzer plant in Oberhausen (Trailblazer)

17.5 MW
plant power demand

>75.5%
plant efficiency

24 stacks
to build a full stack array

335 kg
hydrogen per hour

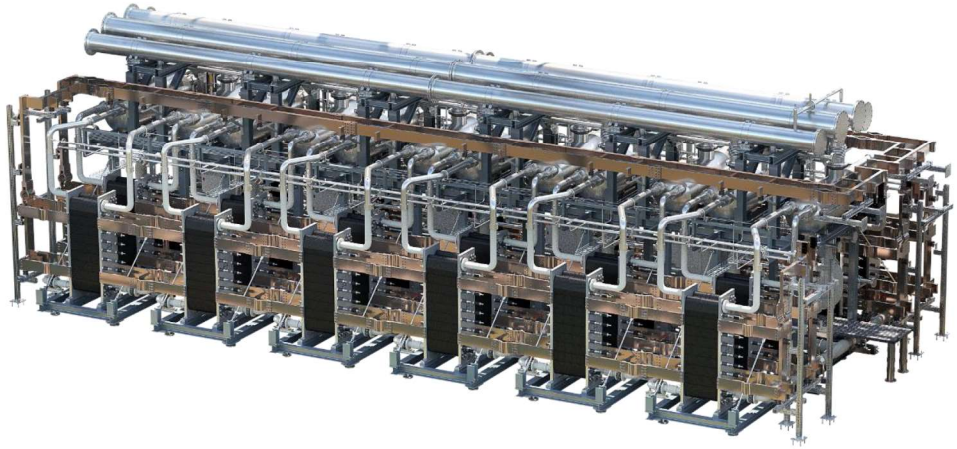
Silyzer 300
Fact sheet

Hydrogen production	335 kg/h
Plant efficiency (HHV[1])	>75.5%
Power demand	17.5 MW
Start-up time	<1 min, enabled for PFRS[2]
Dynamics in range	10%/s in 0 – 100%
Minimal load	40% single stack
Dimension full stack array	15.0 x 7.5 x 3.7 m
Electrolysis system building	35.5 x 15.5 x 9.0 m
Plant availability	~95%
Demin water consumption	10 l/kg H_2
Dry gas quality[3]	99.9999%
Delivery pressure	Customized

1 Plant efficiency includes rectifier, transformer, transformer cooling and gas cooling
2 Primary Frequency Response Service | **3** With DeOxo | **4** Operating Hours

May 2024

SIEMENS energy

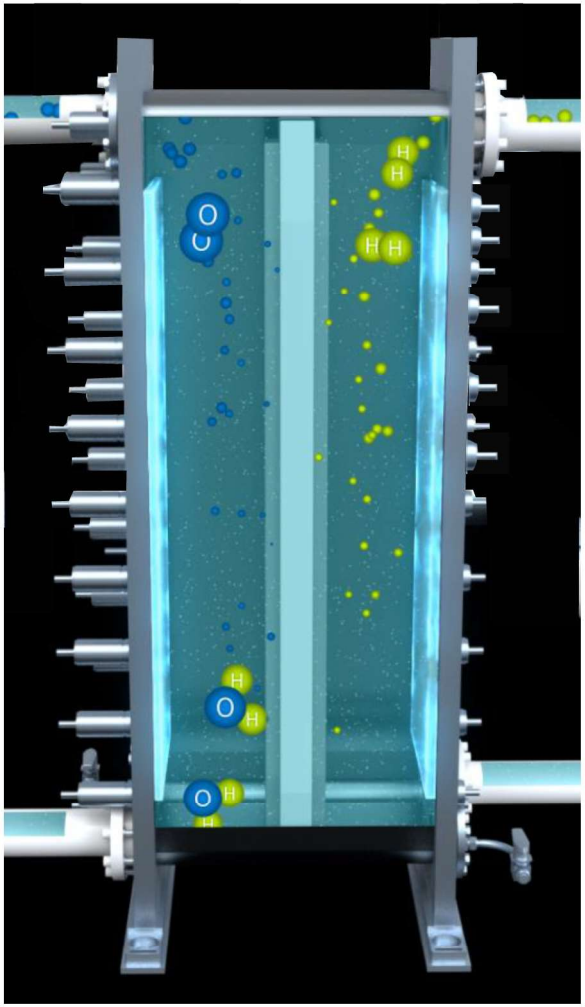


Module Heritage and Evolution

Silyzer 300 Module

Design philosophy

- ✓ Moderate current density
- ✓ Two-sided cooling
- ✓ Atmospheric pressure
- ✓ No differential pressure
- ✓ Low operation temperature
- ✓ Rectangular cell
- ✓ Vertical cell



Design features

- ✓ High efficiency w. thick membrane
- ✓ Low thermal load w/o hot spots
- ✓ Low H_2 to O_2 diffusion and no leaks
- ✓ No mechanical membrane load
- ✓ Long membrane stability
- ✓ Homogeneous load distribution
- ✓ No trapped gases

Future-proof flexible hydrogen production –
Silyzer 300 plant supports renewable sources and offers grid services

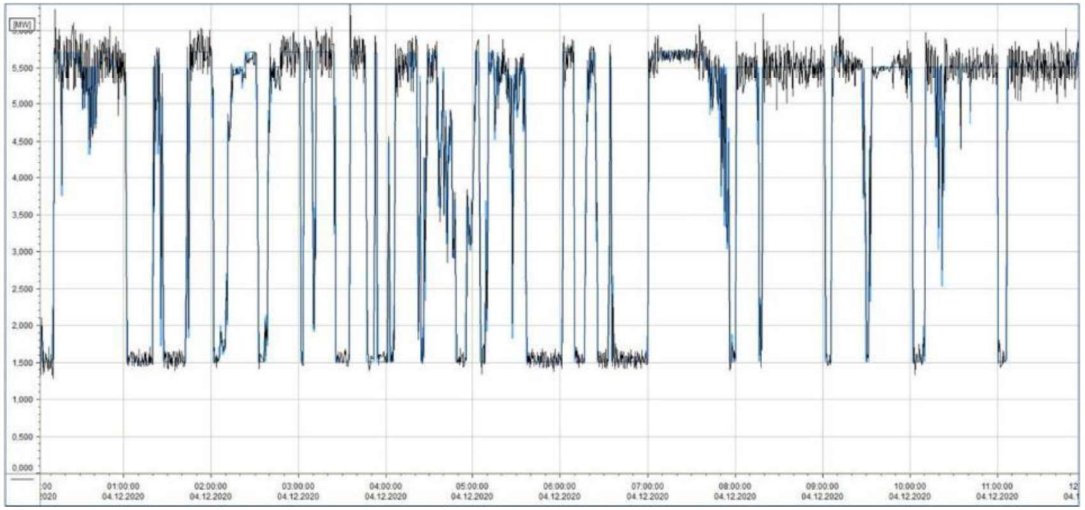
Infinitely variable plant operation

- Power controlled operation based on real power price with 15 min time frames (see example on right side)
- Dynamics: Maximal ramp rate in array 10% per second power change possible
- Always fast ramp-up

Real plant data from an exemplary electrolyzer

Target power selection

Power consumption electrolyzer

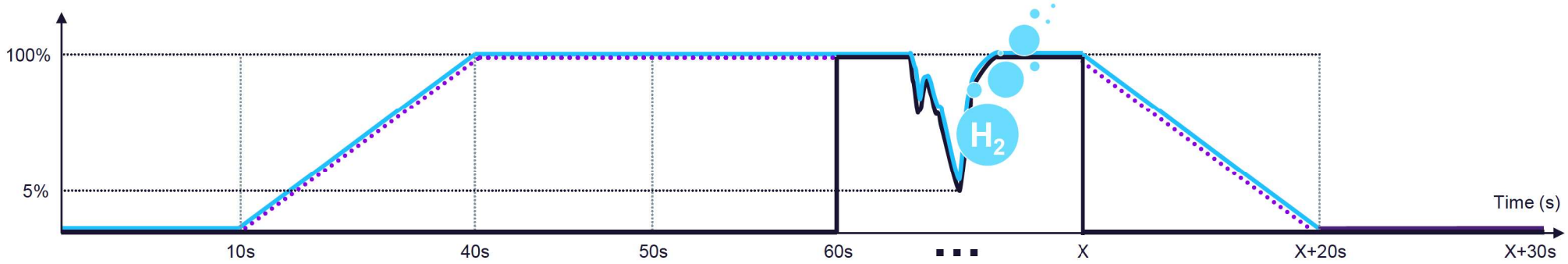


— Operating — Set point

The Silyzer 300 enables grid support services with efficient hydrogen yield and maximum dynamics

Start 0 – 100% H_2 | <1 min, enabled grid support

Dynamics in range | 10%/s in range 0 – 100%



TP = Terminal Point — Rectifier load — H_2 Delivery to TP ····· H_2 Ventilation

Delivering large-scale electrolysis systems
+ capacity increase in Germany is locked and loaded

SIEMENS energy

2021	2023	2024	2025
Erlangen	Erlangen + Berlin	Berlin	Berlin
250 MW - 750 MW	1 GW	2 GW	3 GW + 1GW/year

- Implementation of **modern robots**
- **Highly automated** production line
- **Industry 4.0 Digitalization** implemented

- **Standardized modular design** allows for internal and external local packaging
- **Packaging** will be established depending on the development of the markets

- **Capacity growth plan locked-in** and layouts finalized
- **Additional 1 GW per year** depending on demand

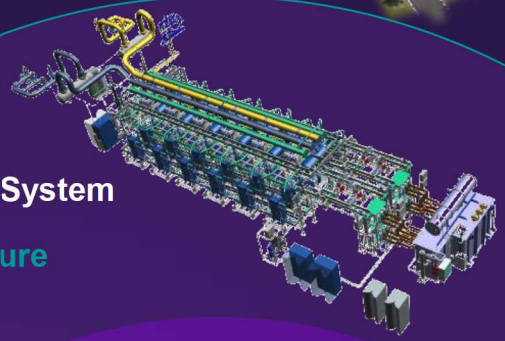
Silyzer 300 production concept

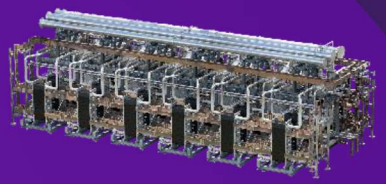
Electrolyzer reference plant
- Pre-engineered basic design
- Integrated solution with strong partner approach
- Turn-key possible with partners

Electrolysis System
- Minimize on-site installation
- Maximum of standardization by defined interfaces
- Build to print pre-engineered

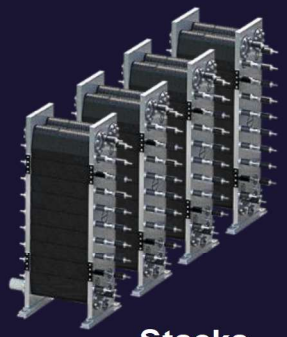
Localized decentral packaging
- High quality by pre-assembling
- Transportable units
- Strong local content

Cost efficient central stack factory
- High level of Automatization
- Large quantities and strong supply chain management
- Strong partner relation of key components





Industrial scale production of Electrolyzer with up to 1GW in 2023 and 3GW in 2025



Stacks

PEM Gigawatt factory

- Joint Venture Manufacturing in Berlin
- Industrial scaling up to 1GW in 2023 and 3GW in 2025 with a potential for more
- Highly automated PEM manufacturing according to latest production standards

Product development

- R&D for electrolysis technology
- Operations, engineering, sales and service

Array

Electrolyzer Packaging

- Siemens Energy internal and external partners for final assembly to prepare for optionality acc. to market trends
- Packager will be established locally in main markets to facilitate local value add

Projects completed or in implementation based on Silyzer 300
Scale-up is already happening

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6 MW	8.5 MW	up to 20 MW	50 MW	50 MW	70 MW	200 MW

H2Future Linz

- Green hydrogen for the steel making process
- Our partners: VERBUND, voestalpine, Austrian Power Grid (APG), TNO, K1-MET

Wunsiedel

- Green hydrogen for industry, grid services and mobility
- Our partners: Siemens AG, WUNH2, SWW Wunsiedel GmbH

Oberhausen

- Green hydrogen for Air Liquide pipeline infrastructure
- Our partner: Air Liquide

e-Methanol Kassø

- Green hydrogen for CO_2-neutral shipping at large-scale
- Our partner: European Energy

Hy4Chem-EI Ludwigshafen

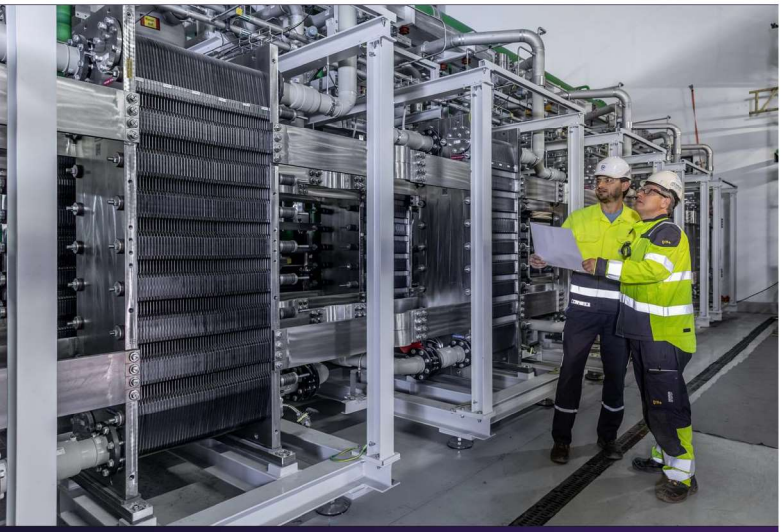
- Hydrogen as raw material for chemical plant
- Our partner: BASF

FlagshipONE

- Green hydrogen for CO_2-neutral shipping at large-scale
- Our partner: Ørsted

NormandHy

- Renewable electricity
- Engineering and Long Lead Started
- Our Partner: Air Liquide



up to **20 MW**
based on Silyzer 300[1]

335 kg
of green hydrogen per hour

2,680 kg
of green oxygen per hour

May 2024

TRAILBLAZER PROJECT OBERHAUSEN

Green hydrogen for Air Liquide pipeline infrastructure

SIEMENS energy

Project

Partners:	Air Liquide
Country:	Germany
Installation:	2023
Commissioning:	2023
Product:	Silyzer 300

Use cases

- Hydrogen for the Industry
- Hydrogen for mobility

Potential

- Connect hydrogen production to both existing hydrogen and oxygen pipelines
- First step: up to 20 MW capacity
- Potential to expand to 30 MW total planned capacity

Solutions

- Operation of a full 24-stack array Silyzer 300
- Electrolyzer will be integrated into existing local hydrogen and oxygen pipeline infrastructure of Air Liquide
- First electrolyzer to be built in the framework of the partnership between Air Liquide and Siemens Energy
- One of the largest renewable hydrogen and oxygen production plants of Germany

1 plant incl. additional auxiliaries such as compression for hydrogen and oxygen

Funded by the German Federal Ministry of Economic Affairs and Energy

KASSØ POWER-TO-X

First large-scale e-Methanol project in Europe

Project

- Partner: Solar Park Kassø ApS (100% owned by European Energy)
- Country: Denmark
- Site: Kassø Solar Park
- Installation: 2024 (done)
- Commercial operation: Q4 2024
- Product: Silyzer 300

Use cases

Hydrogen for e-Methanol (MAERSK)

Hydrogen for fuel blending (Circle K)

Challenge

- Fast track project (bid and execution)
- First 3 Array plant
- First large-scale e-Methanol plant build by customer

Solutions

- 3 full Arrays Silyzer 300
- Transformers, rectifiers, Arrays and demin water plant. T3000 automation for Silyzers
- Supervision for installation, commissioning by SE Denmark
- Powered by largest solar park in Scandinavia

50 MW
power demand based on Silyzer 300

1000 kg
of green hydrogen per hour

May 2024

BASF Hy4Chem-El

Industrial-scale electrolyzer to supply hydrogen as raw material to chemical plant

54 MW

Power demand based on Silyzer 300

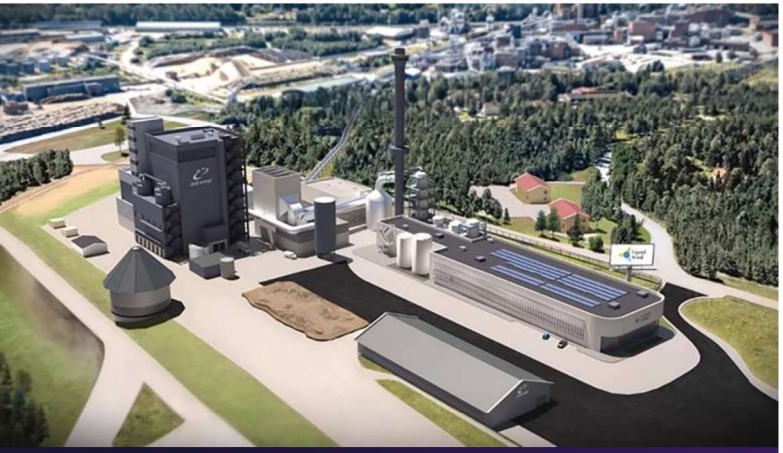
Capacity to produce

8,000 tons

of green hydrogen per year from 2025

up to **72 000 tons**

of carbon dioxide emissions will be avoided per year at BASF site Ludwigshafen



FlagshipONE

Largest commercial product plant for CO_2 neutral e-Methanol for marine use

Project

- Customer: FlagshipONE
- Investor: Ørsted
- Country: Sweden
- Installation: expected 2025
- Product: Silyzer 300

Use cases

Hydrogen for e-Methanol
Decarbonize the world's shipping industry

Challenge

- Europe's largest commercial e-Methanol product facility
- Blueprint: Liquid Wind plans 10 facilities by 2030
- FlagshipTWO electrolyzers capacity of 140 MW planned

Solutions

- 4x PEM Silyzer 300
- Plant wide electrification and automation system, digitalization solutions (digital twins), power distribution and compressor systems
- E-Methanol from hydrogen and biogenic carbon dioxide

70 MW
power demand based on Silyzer 300

50.000 tones
of e-Methanol per year from 2025

10 more plants
by 2030

May 2024

Air Liquide Normand'Hy

Industrial-scale hydrogen electrolyzer plant to decarbonize industry and mobility

200 MW

Power demand based on Silyzer 300

4 tons

of green hydrogen per hour

250 000 tons

of carbon dioxide emissions will be avoided

HARU ONI PILOT PROJECT

First integrated plant for climate-neutral e-fuel production from wind and water

SIEMENS energy

750,000 liters
of e-methanol per year from 2023
(130,000 liters of e-gasoline)

>55 m liters
e-fuel per year planned from 2025

>550 m liters
e-fuel per year
planned from 2027

Supported by:
Federal Ministry for Economic Affairs and Energy
on the basis of a decision by the German Bundestag

May 2024

Project

Customer:	HIF (Highly Innovative Fuels)
Off-taker:	Porsche AG
Country:	Chile, Patagonia
Installation:	2022
Product:	Power-to-methanol solution based on SE Electrolyzer

Use cases

- E-Fuel for Porsche cars
- Potential for adding Kerosene or Diesel production in future phases
- Methanol for ship motors

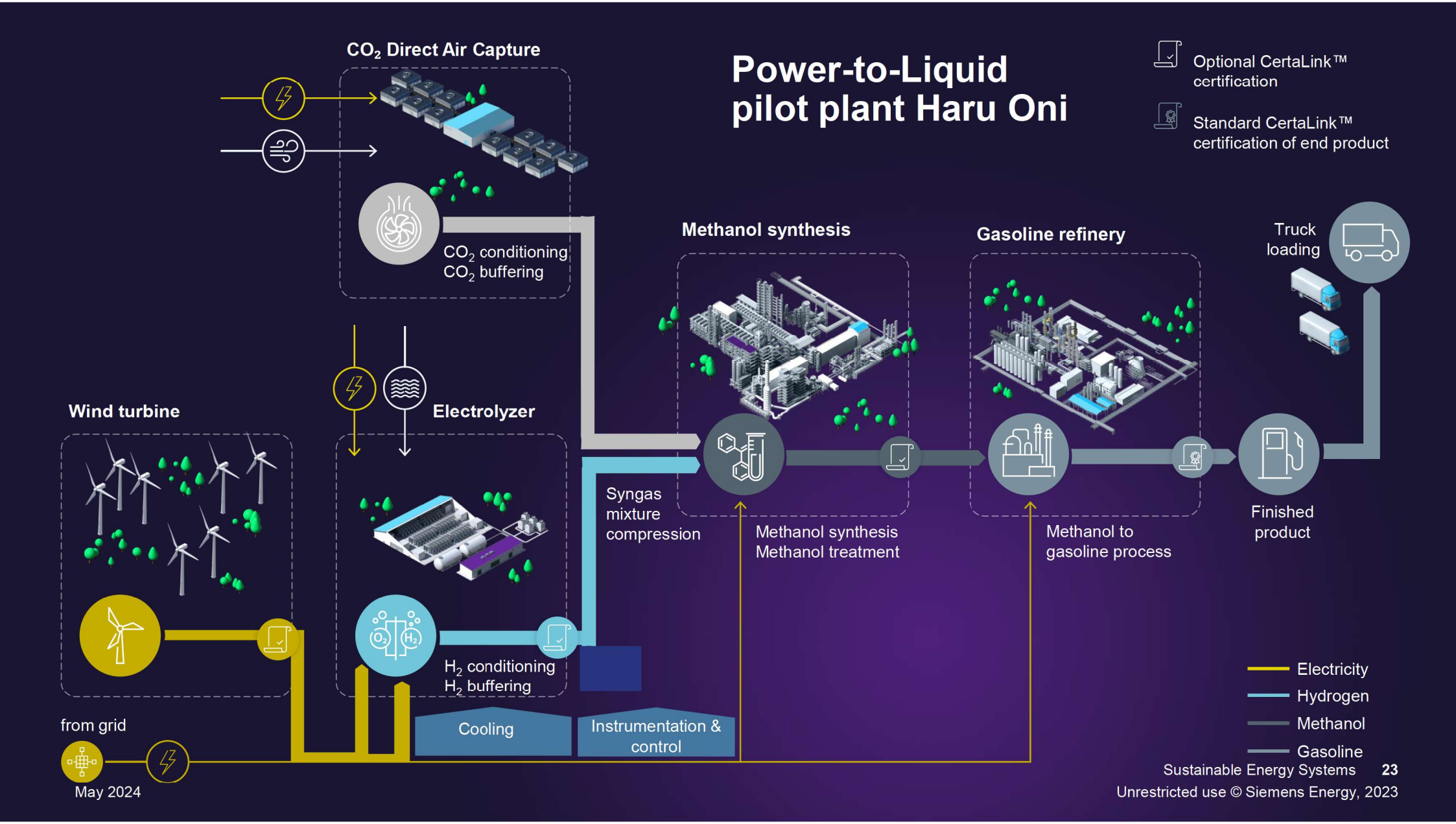
Challenge

- Huge wind energy potential in Magallanes
- Existing industry and port infrastructure

→ Perfect conditions to export green energy from Chile to the world

Solutions

- Production of e-gasoline and e-methanol at one of the best spots worldwide for wind energy
- Co-developer Siemens Energy realizing the system integration from wind energy to e-fuel production
- International Partners like Porsche and AME



Backup

Siemens Hydrogen Gas Turbines for our sustainable future

Heading towards 100% with full fuel flexibility H_2 ↔ Natural Gas

Gas turbine model		Power Output[1]	H_2 capabilities in vol. %	CO_2 reduction$_{2)}$ [%]
50Hz	SGT5-9000HL	595 MW	50	23%
	SGT5-8000H	450 MW	30	11%
	SGT5-4000F	329/385 MW	30	11%
	SGT5-2000E	187 MW	30	11%
60Hz	SGT6-9000HL	440 MW	50	23%
	SGT6-8000H	310 MW	30	11%
	SGT6-5000F	215 to 260 MW	30	11%
	SGT6-2000E	117 MW	30	11%
50Hz or 60Hz	SGT-800	50 to 62 MW	75	47%
	SGT-750	40/34 to 41 MW	40	17%
	SGT-700	33 to 35/34 to 36 MW	75	47%
	SGT-A35	27 to 37/28 to 38 MW	15 / 100	5 / 100%
	SGT-600	24/25 MW	75	47%
	SGT-400	10 to 14/11 to 15 MW	10 / 65	3 / 36%
	SGT-300	8/8 to 9 MW	30	11%
	SGT-100	5/6 MW	30 / 65	11 / 36%
	SGT-A05	4 to 6 MW	30	11%

DLE burner WLE burner Diffusion burner with unabated NOx emissions

Heavy-duty gas turbines Industrial gas turbines Aeroderivative gas turbines

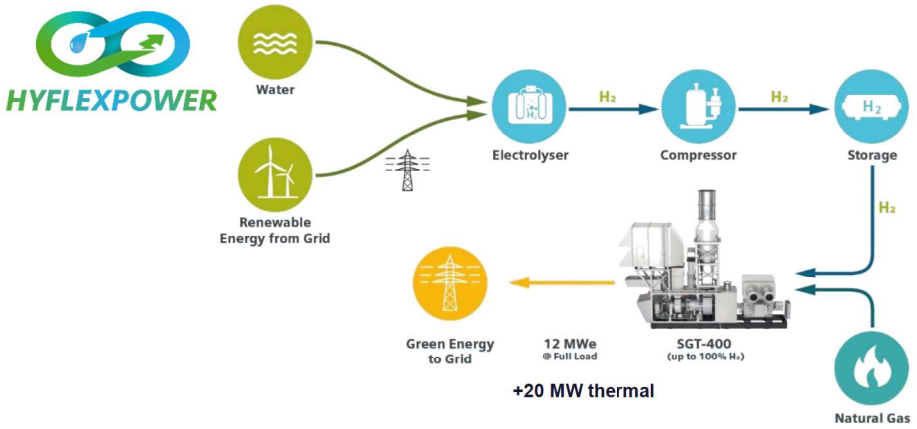
Values shown are indicative for new unit applications and depend on local conditions and requirements. Capability to operate on 100% natural gas is maintained (full fuel flexibility). Some operating restrictions/special hardware and package modifications may apply.

Higher H_2 contents to be discussed on a project specific basis

1 Power output in MW at ISO ambient conditions and natural gas; Version 5.4, July 2022

2) Compared with 100% natural gas operation

EU-funded HYFLEXPOWER Project (France)
A CO_2 free power-to-power path using 100% H_2 in DLE combustion



May 2020

Contract finalization and start of engineering development

2021

Installation of the hydrogen production, storage and supply facility at pilot demonstration site

2022

Installation of the gas turbine for natural gas/hydrogen mixtures and initial demonstration of advanced pilot plant concept

2023

Pilot demonstration with up to 100 percent hydrogen for carbon-free energy production from stored excess renewable energy

Source: http://www.hyflexpower.eu/

Comprehensive product portfolio for Hydrogen Compression
Indicative areas for best economical trade-off for H_2 – compression

Our most referenced product for H_2-compression, best flexibility and efficiency

Application areas:

- Conventional markets, e.g., refineries
- Small to medium sized H_2 applications and medium to high pressure ratios

and / or

Application areas:

- Large flow electrolysis system with potential flow fluctuation (renewables) and higher pressure ratios

Products can be combined for an optimum solution to project-specific requirements

Application areas:

- H_2-pipelines; H_2-transport in general
- SynGas applications
- Large flow electrolysis with lower pressure ratios

Optimized footprint and spare parts / maintenance concept

Pressure Ratio [-]

10,000 – 30,000 | 100,000 | 200,000 | Actual Inlet Flow [m^3/h]

Siemens Energy – Industrial Heat Pumps
Concept | Waste Heat Utilization from Electrolysers for Steam Production

OVERVIEW

Principle:

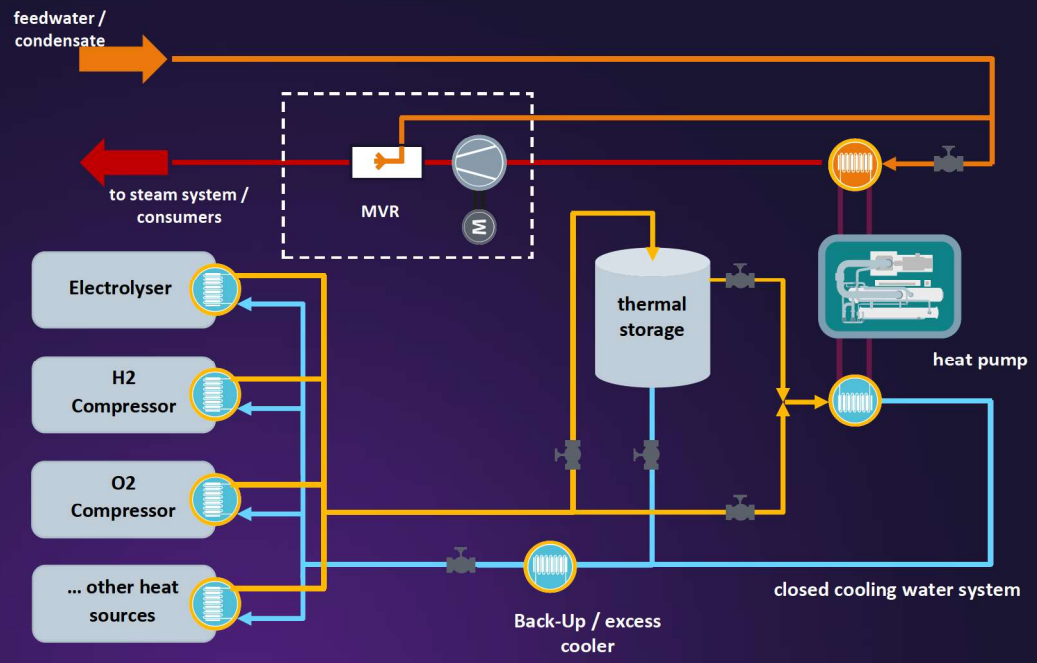
- Heat Pump absorbs the heat from the H2 production and lifts it to higher temperature level e.g. for process heating (steam)
- Heat Pump produces low pressure steam (up to 3.7 bara)
- Steam compressor with attemporation is used to produce demanded steam parameters

Challenges:

- Heat demand and waste heat from H_2 production may timewise not be congruent
- Fluctuating heat from H_2 production (esp. when driven be renewable electricity)

Concept:

- Optimized design and sizing of heat pump system by integrative measures e.g.:
  - integrating a thermal waste heat storage for electrolyzer
  - integrating a back-up / excess cooler to account for ageing of electrolyzer etc.



EXEMPLARY PROCESS DATA

Heat Source:

- approx. 8.5 MWth from H2 production (1 x electrolyzer only)
- required cooling from 48 °C → 35 °C

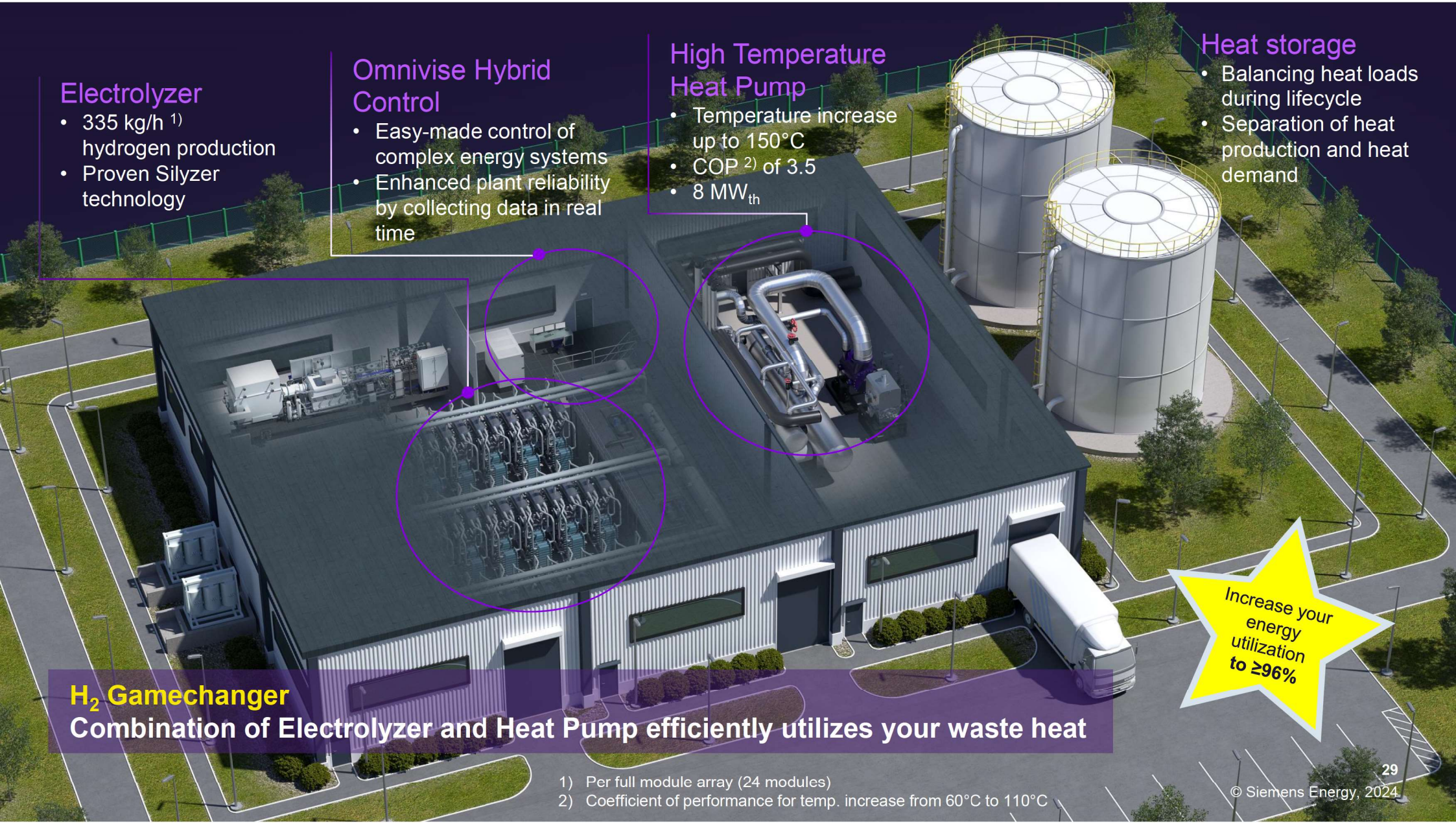
Heat Sink:

- approx. 15.1 MW_{th} process steam @ 8 bara, 190 °C

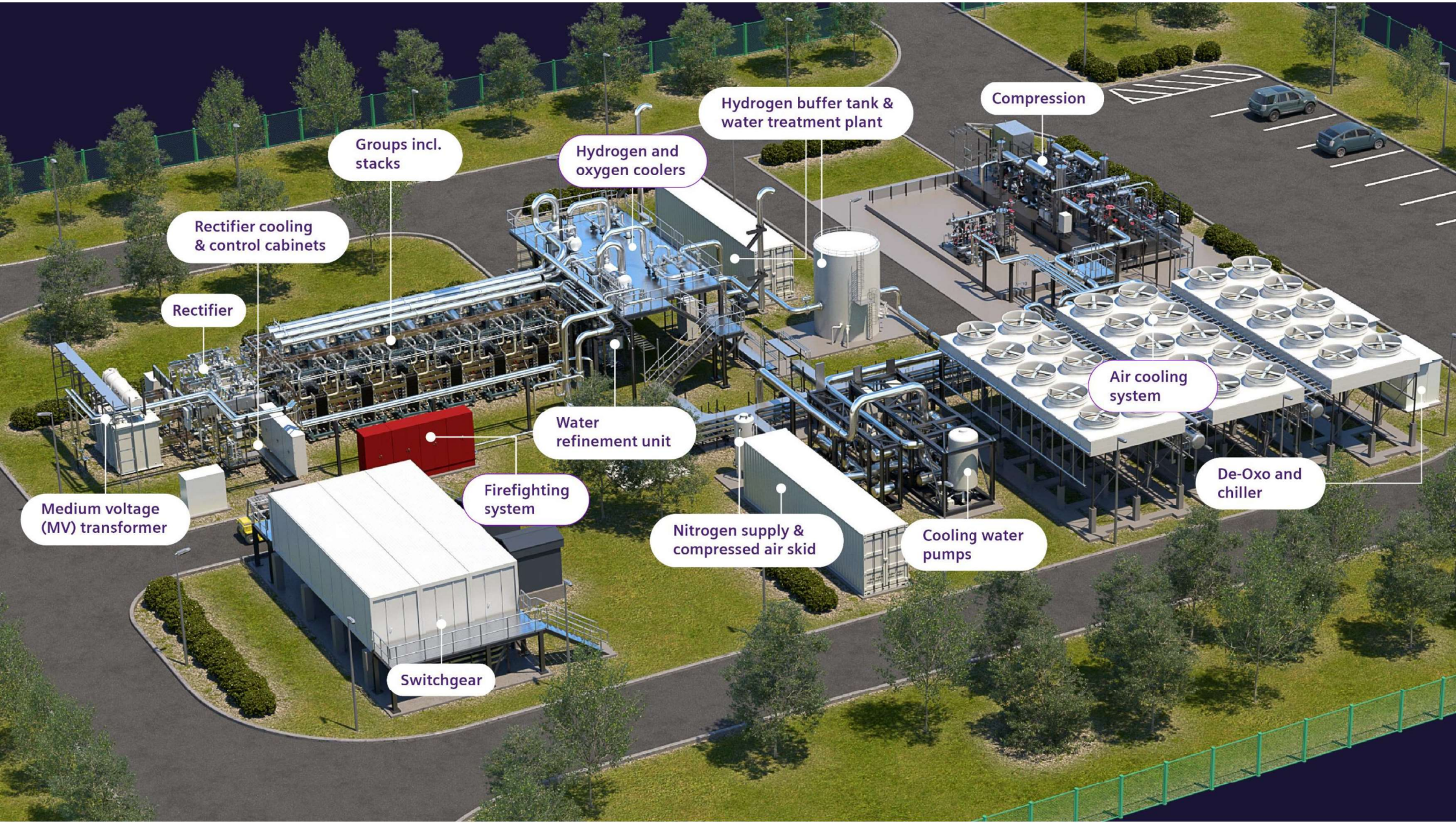
Heat Pump:

- COP ~ 2.1 (overall) → ~ 6.9 MW electrical power demand
- Footprint ~ 20m x 15m (heat pump) + 15m x 10m (steam compressor)

- combination of several H2 production lines onto one heat pump possible



1) Per full module array (24 modules)
2) Coefficient of performance for temp. increase from 60°C to 110°C


Groups incl. stacks
Hydrogen and oxygen coolers
Hydrogen buffer tank & water treatment plant
Compression
Rectifier cooling & control cabinets
Rectifier
Air cooling system
Water refinement unit
Firefighting system
De-Oxo and chiller
Medium voltage (MV) transformer
Nitrogen supply & compressed air skid
Cooling water pumps
Switchgear