GrInHy2.0

Green Industrial Hydrogen

Green Industrial Hydrogen via steam electrolysis

FCHJU meets GrInHy2.0

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Salzgitter, 2021-07-14

This project has received funding under grant agreement No 826350.

First GrInHy Project – Proof of energy-efficient hydrogen production

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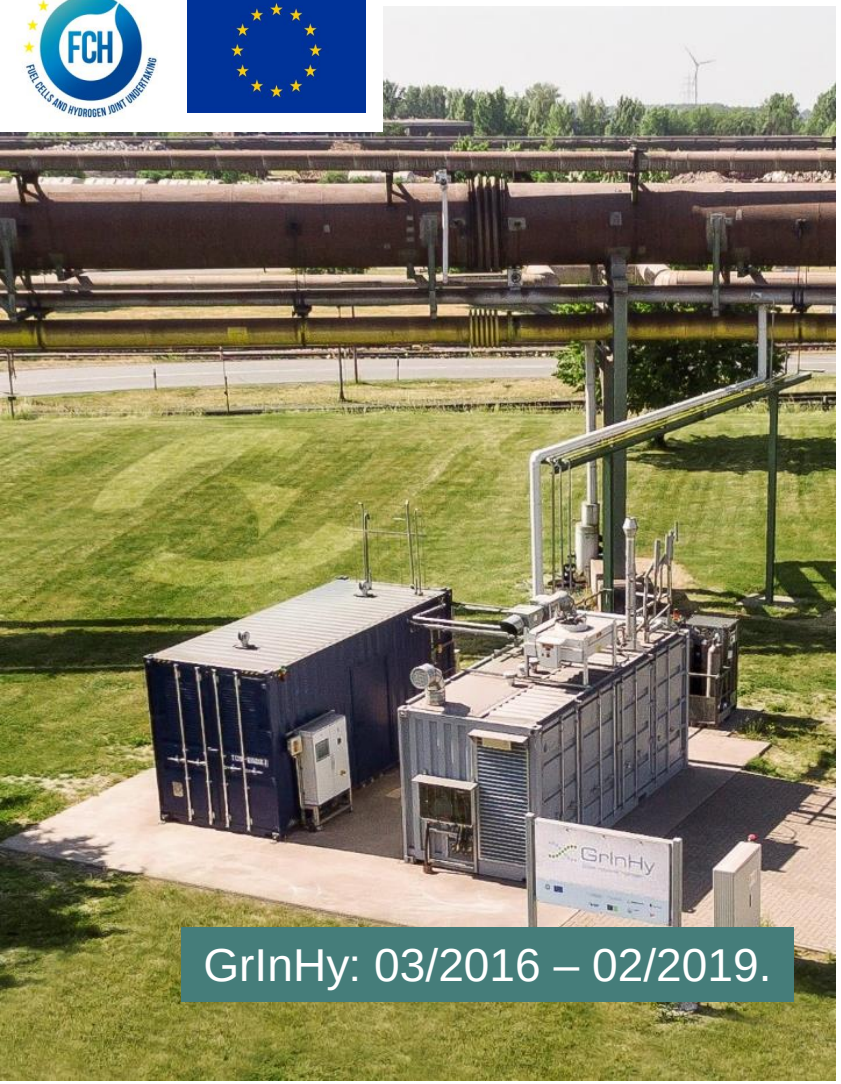
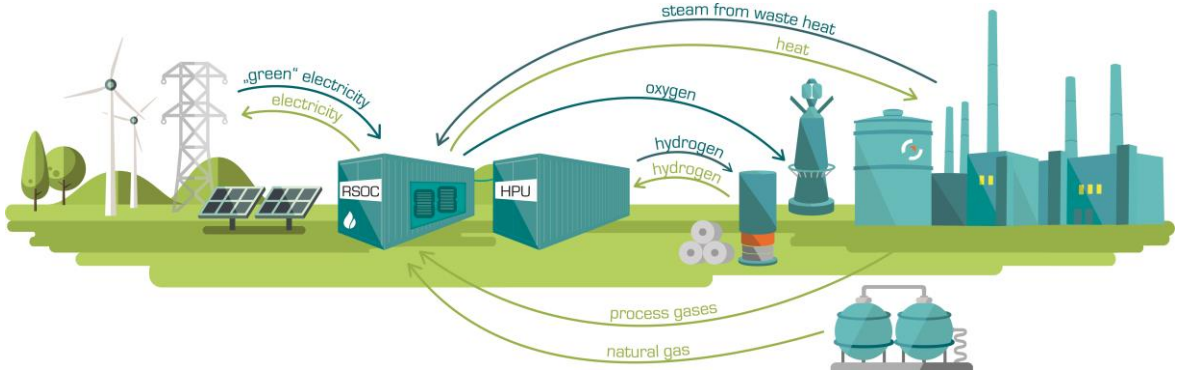


GrInHy: 03/2016 – 02/2019.



- World's biggest steam electrolyser producing 40 Nm^3_{H2}/h (150 kW_{AC})
- Integration into infrastructure of Salzgitter's iron-and-steel works
- Hydrogen based on steam from waste heat
- Electrolyser electrical efficiency of 78 $\%_{LHV}$ sets new standards
- Operational experience from 12/2017 – 08/2019
- 90,000 Nm^3_{H2} for today's steel annealing processes
- In total, the system was operated for approx. 10,000 hours during project duration

SALZGITTER MANNESMANN FORSCHUNG · SALZGITTER FLACHSTAHL · BOEING · sunfire · EIFER · ipm · POLITECNICO DI TORINO

Role of Partners

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SALZGITTER MANNESMANN FORSCHUNG
A Member of the Salzgitter Group

Overall project coordination and environmental studies

SALZGITTER FLACHSTAHL
A Member of the Salzgitter Group

Integration of electrolyser system and operation with steam from waste heat

sunfire®

Technical coordinator and manufacturer of steam electrolyser

PAUL WURTH
SMS group

Engineering and assembling of hydrogen processing unit for compression and drying

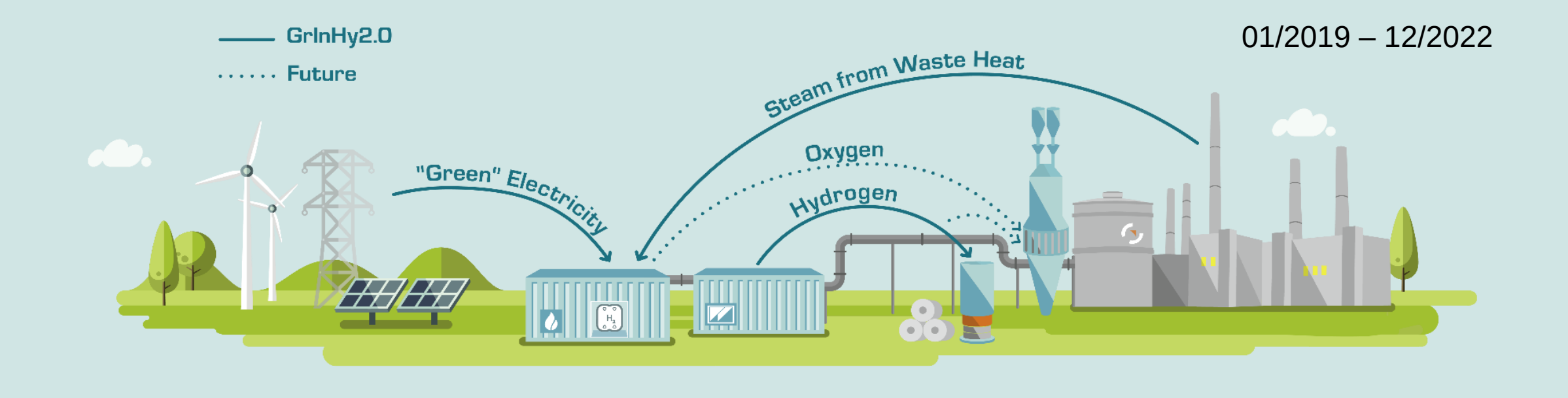
tenova

Implemention study of a hydrogen-based, low CO_2 steelmaking route in Europe

cea

Intensive long-term stack testing of SOECs

The GrInHy2.0 prototype in a Nutshell



- First High Temperature Electrolyser in megawatt scale:

  720 $kW_{el,AC}$ producing 200 Nm^3/h (18 kg/h)

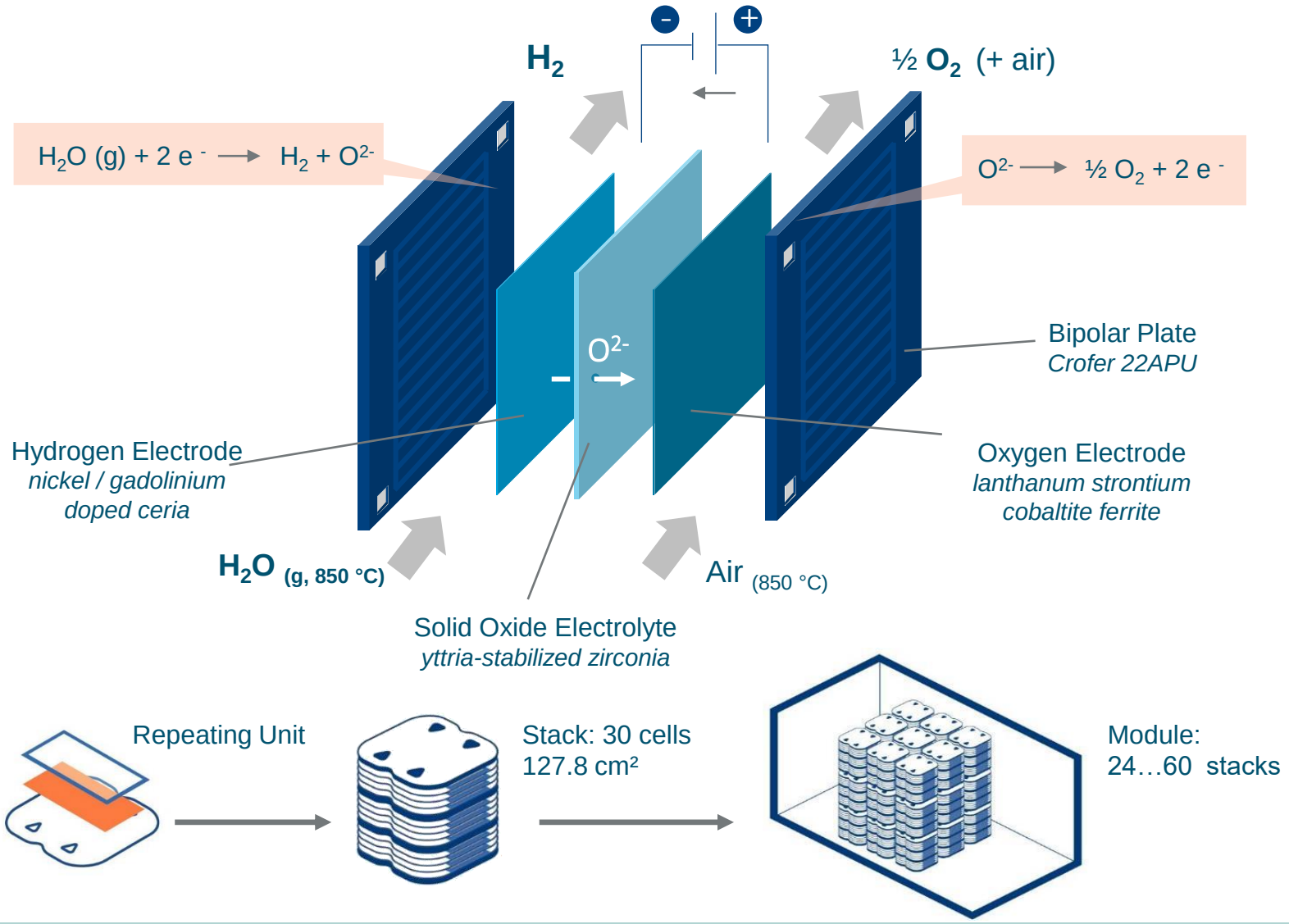
- Full integration into the existing infrastructure and management energy control system:

  >13,000 operating hours while producing at least 100 t hydrogen

- Hydrogen based on green electricity and industrial steam from waste heat:

  Electrical electrolyser efficiency up to 84 $\%_{el,LHV}$ (< 40 $kWh_{el,AC/kg}$)

Solid Oxide Electrolysis Cell (SOEC)



SOEC Advantages:

- One-third of the total energy comes from heat → SOECs require less renewable electricity
- Direct syngas production by Co-Electrolysis

$$2\,H_2O + CO_2 \rightarrow 2\,H_2 + CO + 1.5\,O_2$$

- Stack can be operated reversibly to generate electrical power

Technical Development since GrInHy

Lessons Learned

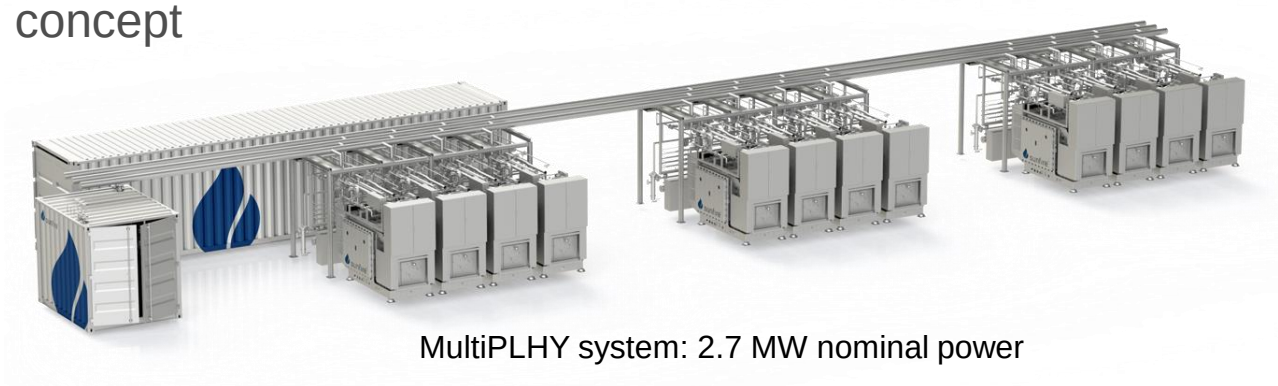
GrInHy → GrInHy2.0

- Increase the number of stacks per module
- Simplified manufacturing processes
- Highly integrated system layout
- HPU layout with optimized drying and compression concept → higher efficiency and ≈ 100 % H2 recovery

Lessons Learned

GrInHy2.0 → MultiPLHY

- Off-the-shelf power electronics → higher efficiency at lower costs
- Stack exchange concept → reduced maintenance costs and higher availability
- New installation and safety concept



MultiPLHY system: 2.7 MW nominal power

Next Steps

MultiPLHY → Generation 3

- Dedicated SOEC stack with higher power density, lower costs and increased robustness

Technical Development since GrInHy

GrInHy2.0
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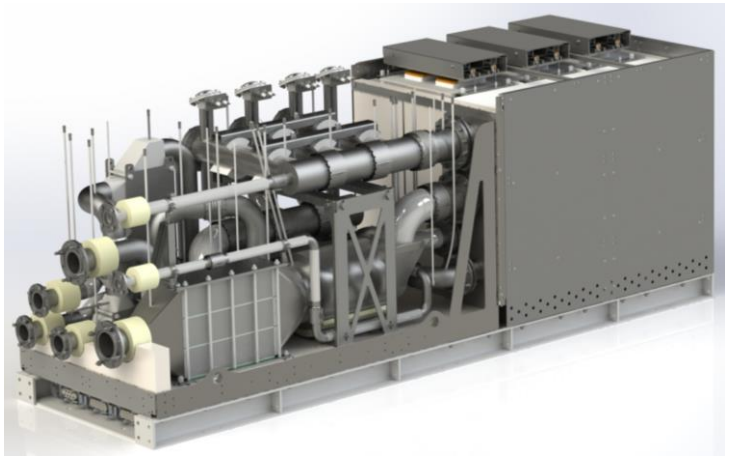
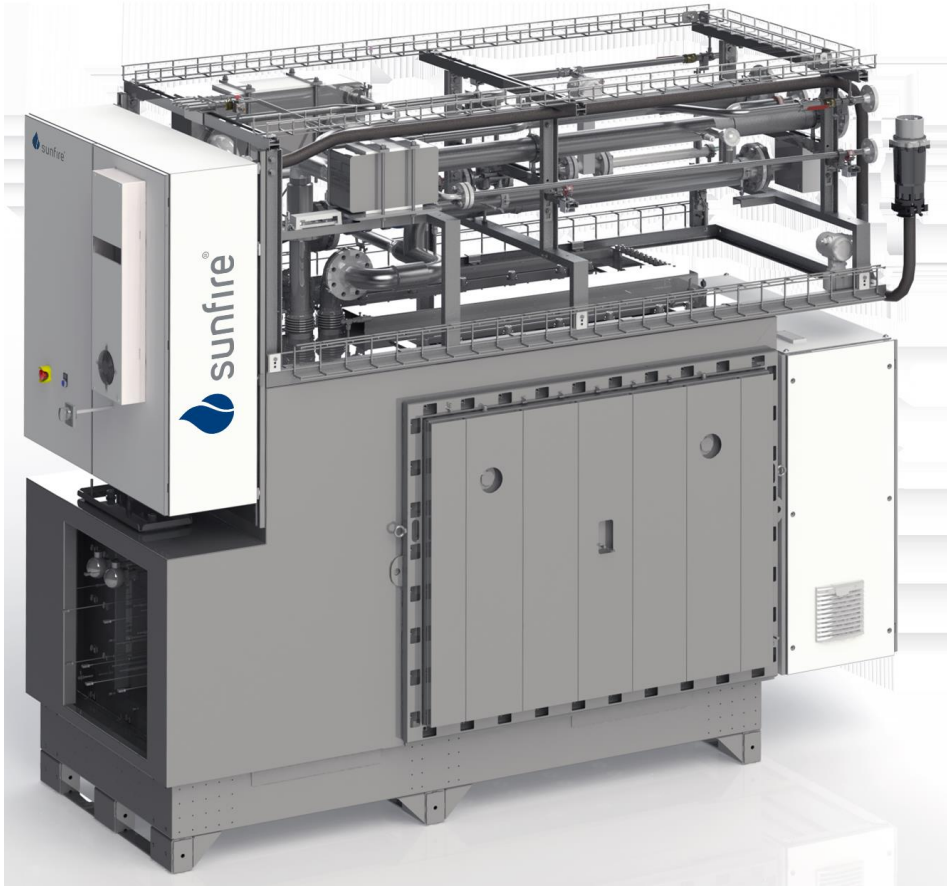
Module Development:

→ Major costs and footprint reduction



Gen0: 24 Stacks per Module ≈ 75 kW_{AC}

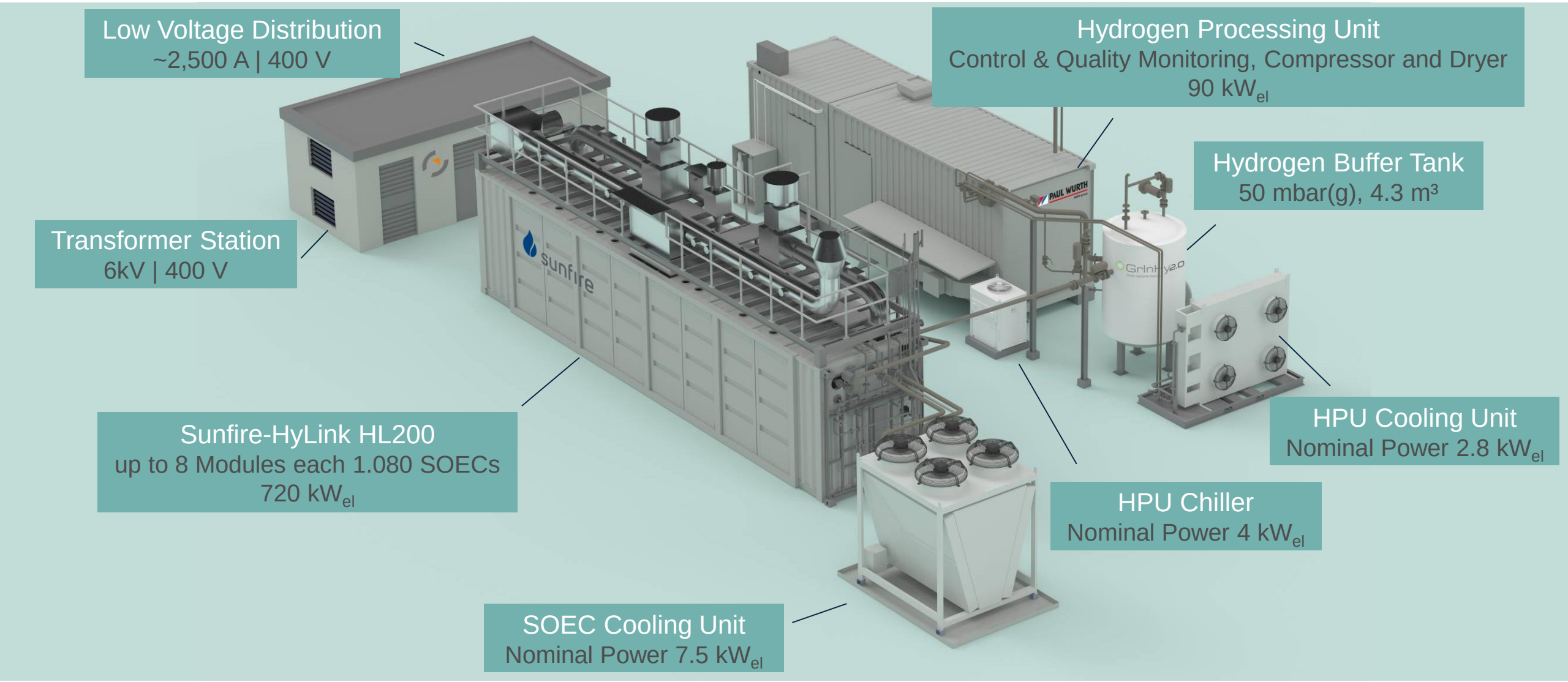
Gen1: 36 Stacks per Module ≈ 115 kW_{AC}



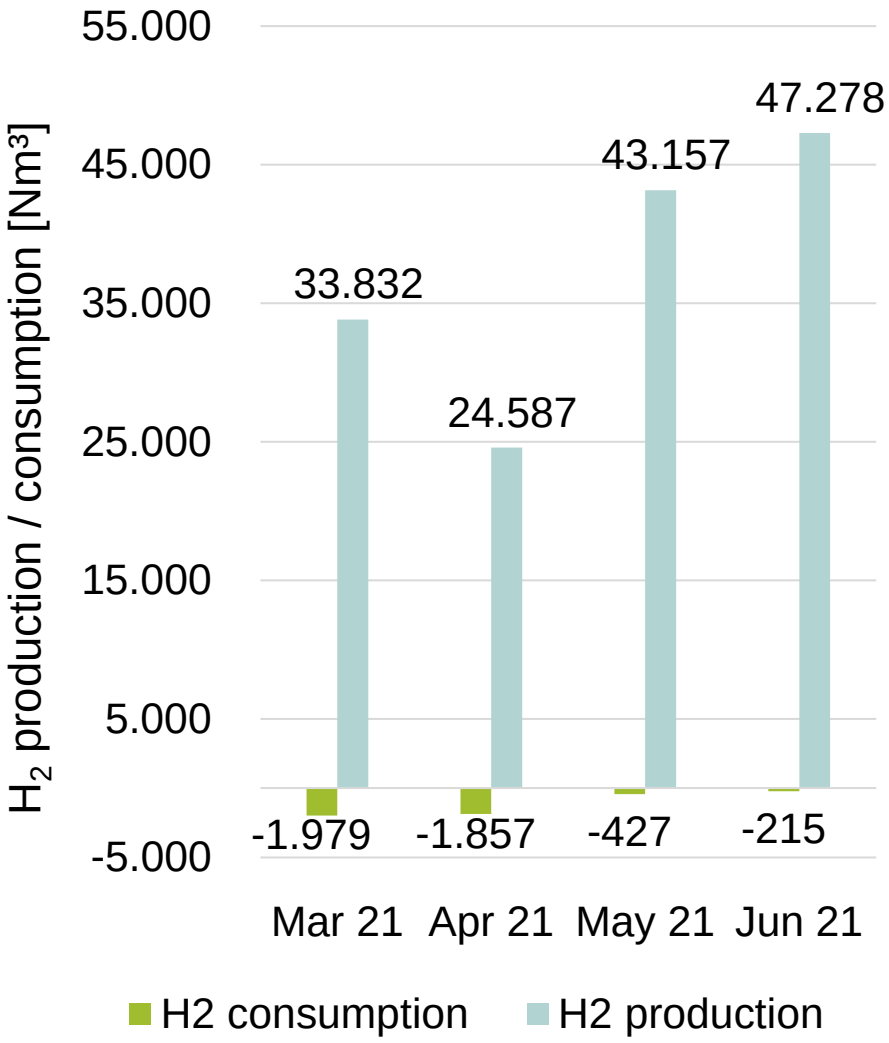
Gen2: 60 Stacks per Module ≈ 250 kW_{AC}

- WiP: Generation 3 with a new dedicated SOEC stack > 1 MW per Module

GrInHy2.0 Design

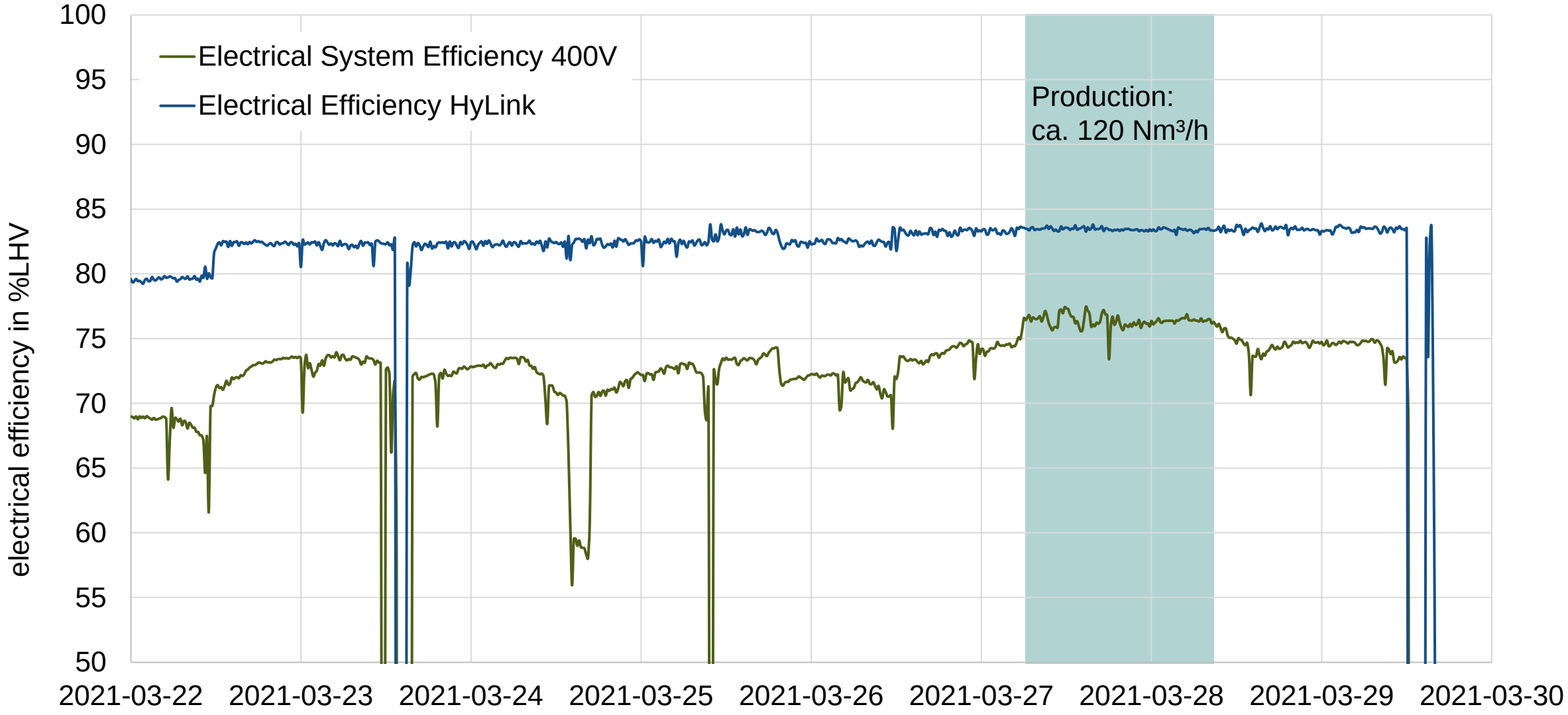


GrInHy2.0 – Status



- Since March: ~160,000 Nm³ H_2 injected (14.5 t_{H2})
- Actual Capacity: 105 Nm³/h (200 Nm³/h by end of 2021)
- Since May: ~87 % availability (time)

System validation: Electrical effciencies



Hydrogen Supply Salzgitter Flachstahl

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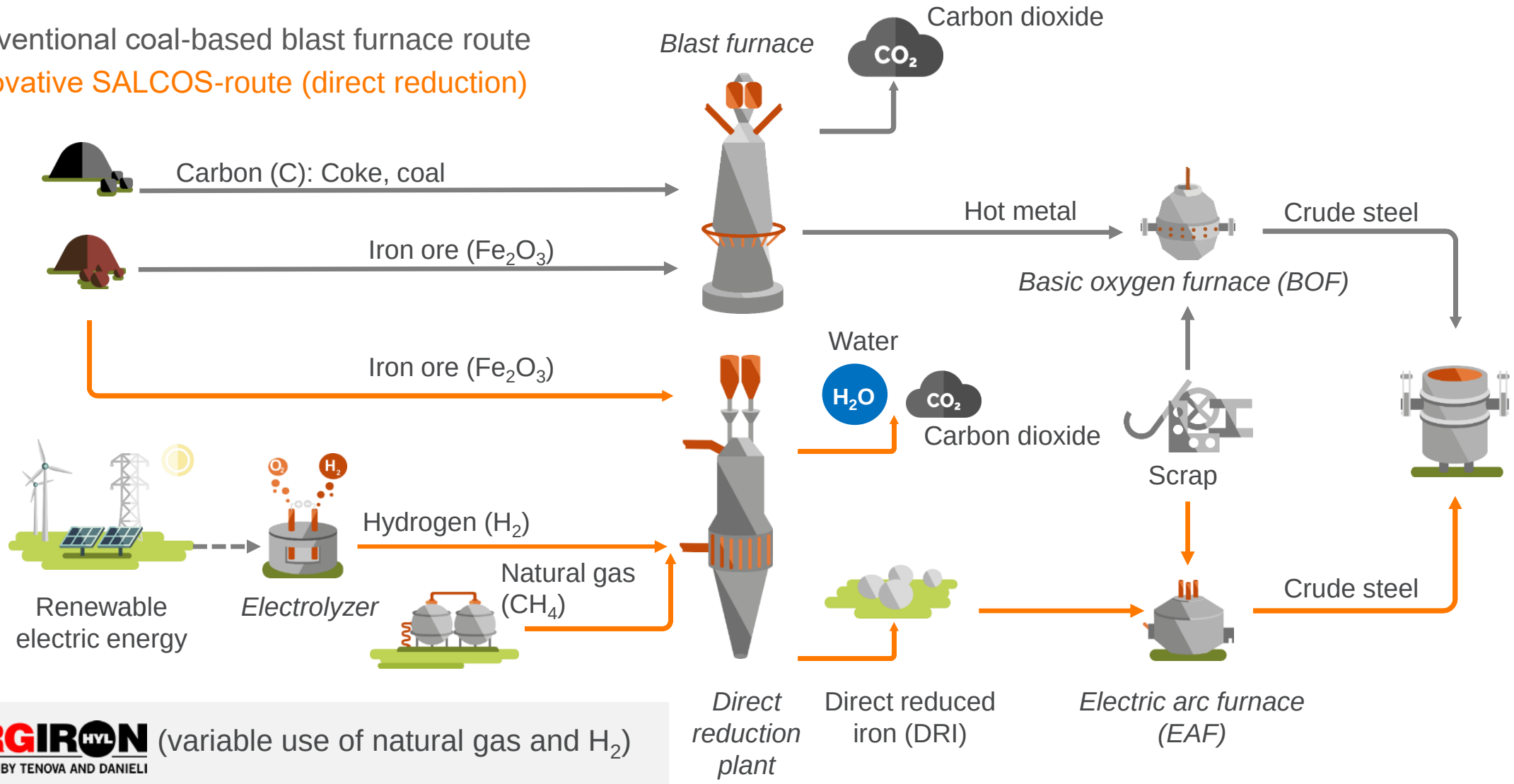
SALCOS® – Flexible hydrogen-based direct reduction

→ conventional coal-based blast furnace route
→ innovative SALCOS-route (direct reduction)



ENERGIRON HYL DRI TECHNOLOGY BY TENOVA AND DANIELI (variable use of natural gas and H_2)

Transformation of integrated steelmaking in Salzgitter to H_2 enhanced DRP/EAF-based steelmaking in three stages

SALZGITTERAG
Stahl und Technologie

Today | **Indicative: 2026+** | **Indicative: 2030+** | **Indicative: until 2050**

Status Quo | **Pilot phase** | **Completion**

SZFG 2019
Total CO_2-emissions 7.6 Mio. t/a

Blast Furnaces

Basic Oxygen Furnace

4.3 Mio. t_{CS}/a

Status Quo

2.3 Mio. t_{CO2}/a

(Stage I)
100 MW

1.9 Mio. t_{CS}/a

2.4 Mio. t_{CS}/a

Stage I

(Stage II)
500 MW

2.8 Mio. t_{CS}/a

1.5 Mio. Mio. t_{CS}/a

Stage II

more than - 95 % CO_2

DRP

EAF

4.3 Mio. t_{CS}/a

(Stage III)

Electrolyzer

Stage III

DRP: Direct Reduction Plant

EAF: Electric Arc Furnace

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This project has received funding from the Fuel Cells and Hydrogen 2 Joint Undertaking (JU) under Grant Agreement No 826350. This Joint Undertaking receives support from the European Union's Horizon 2020 Research and Innovation programme, Hydrogen Europe and Hydrogen Europe Research.