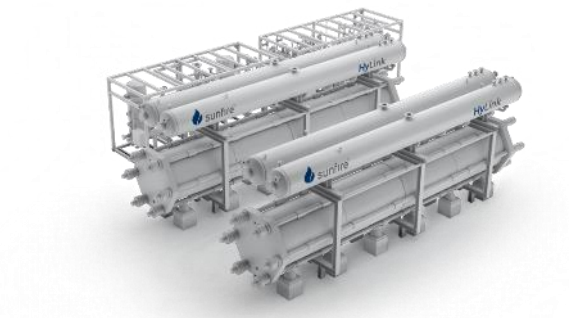
INNOVATIVE UND LANGLEBIGE LÖSUNGEN FÜR DIE INDUSTRIELLE ERZEUGUNG VON GRÜNEM WASSERSTOFF

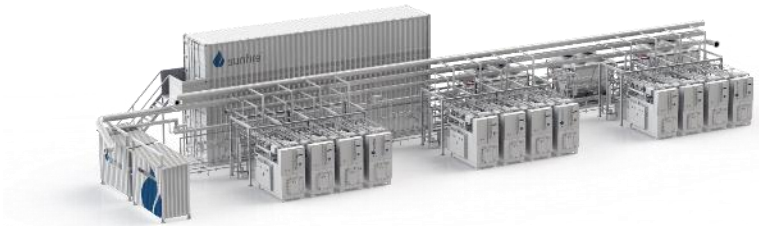
Christian von Olshausen
CTO und Gründer der Sunfire GmbH

Sunfire is a leading industrial electrolysis company

Solutions & Markets



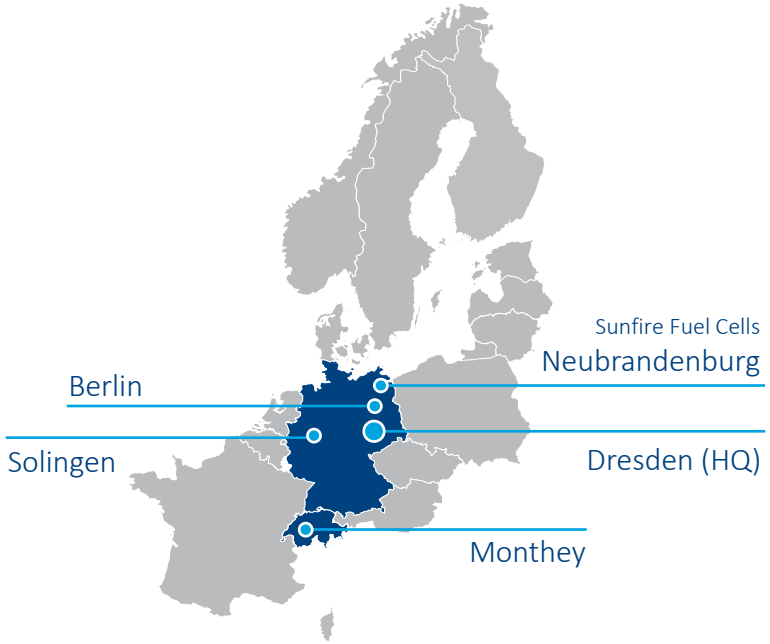
Pressurized Alkaline Electrolyzers



Solid Oxide (SOEC) Electrolyzers

Steel | Refineries | Utilities | Chemicals | Mobility

Company Sites



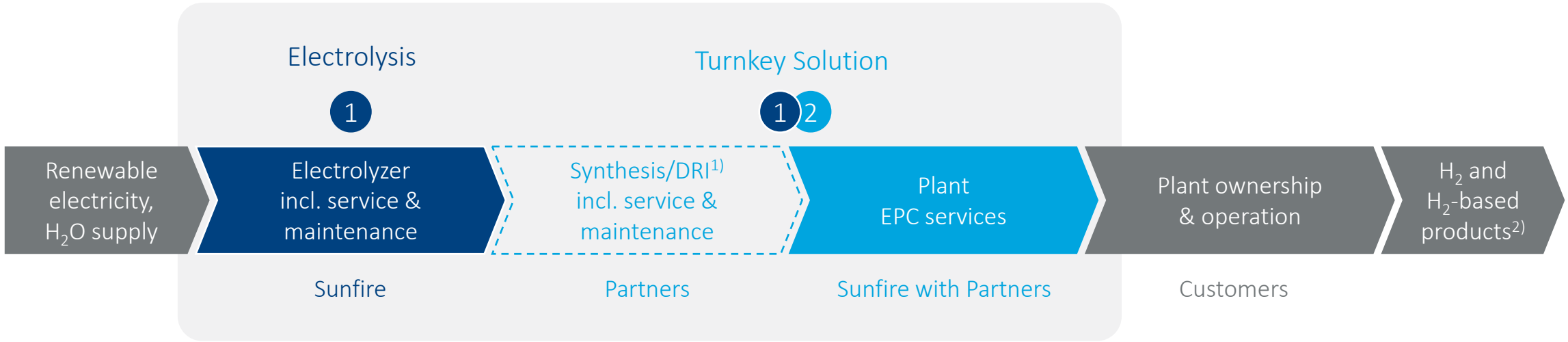
> 70	> 250 MW	100 MW	500 MW/year	> 500	> EUR 500 m
Electrolysis projects[1)]	Installed capacity[1)]	Largest electrolyzer installation	Production capacity as of 2023	Talented employees	Private and public funding

1) Including projects from predecessor alkaline company “IHT SA” prior to the acquisition by Sunfire


OUR VISION
A WORLD
WITHOUT FOSSIL FUELS

We offer two solutions: From pure electrolysis equipment to plant EPC services

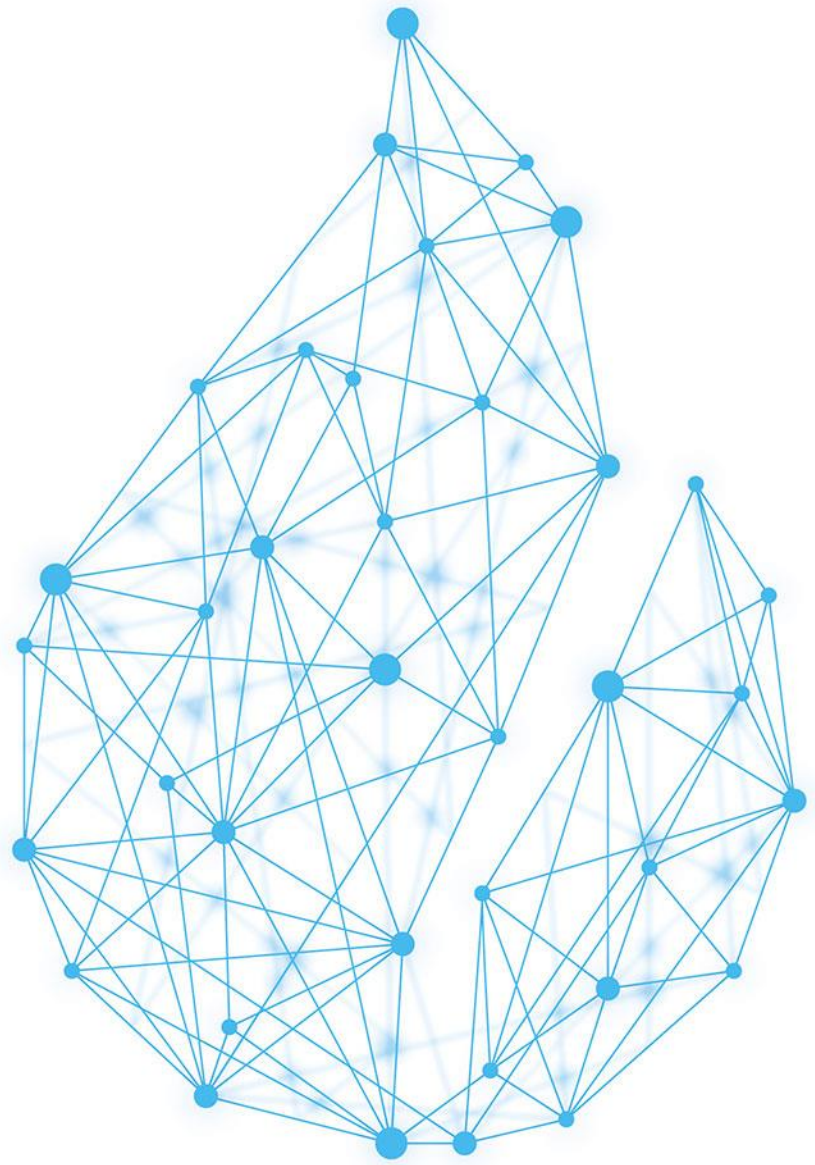
Sunfire in the Hydrogen Value Chain



1) Direct Reduced Iron Process 2) Renewable hydrogen-based products include steel pellets, ammonia, methanol, jet fuel, gasoline, etc.

OVERVIEW

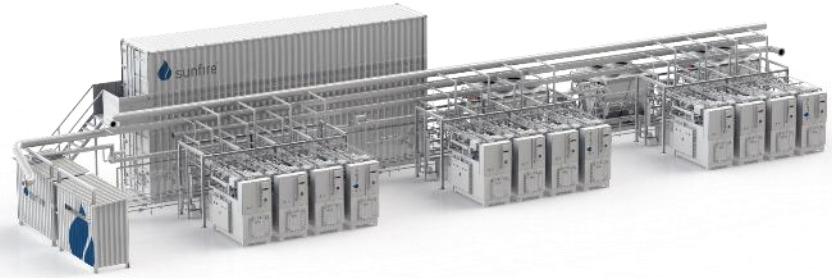
Electrolysis



Sunfire’s electrolyzer portfolio covers SOEC and pressurized Alkaline technology

- Electrolysis
  - Low temperature electrolysis
    - Alkaline
      - Atmospheric
      - Pressurized
    - PEM
  - High temperature electrolysis
    - SOEC
      - Steam Electrolysis
      - Co-Electrolysis

Sunfire-HyLink Alkaline

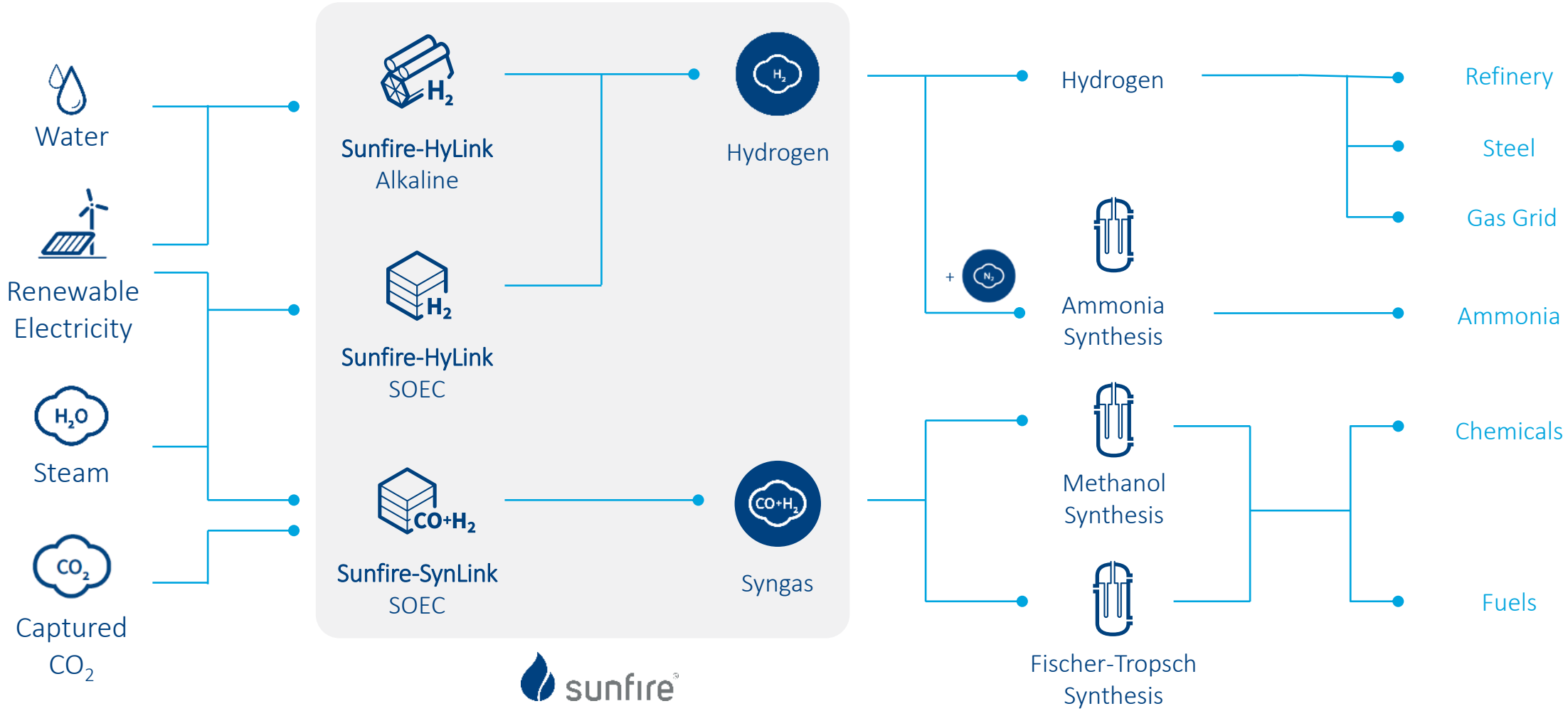


Sunfire-HyLink SOEC

Sunfire-SynLink SOEC

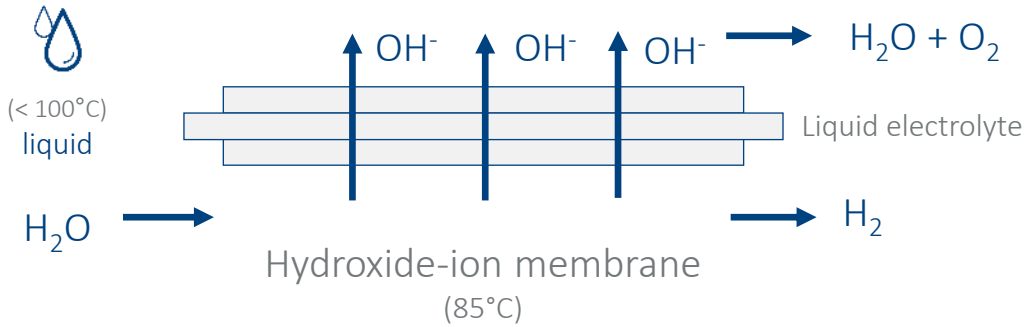
PRODUCTION PATHWAYS

Sunfire has an electrolysis solution for every carbon-intensive process



SOEC and pressurized Alkaline combine individual strengths

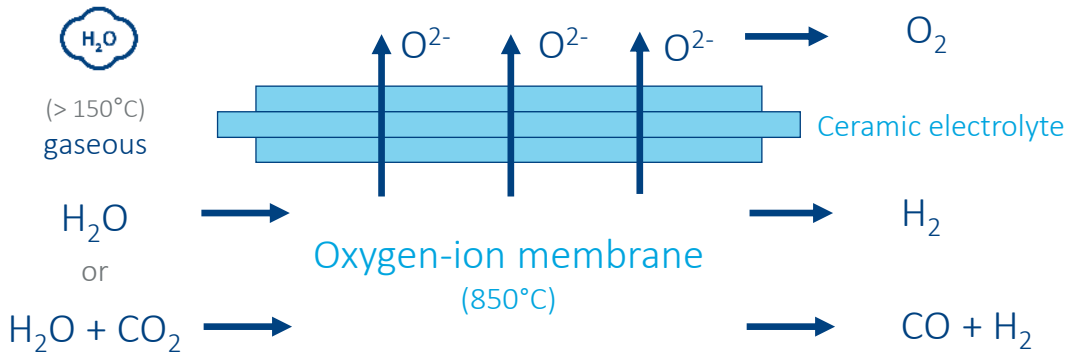
Pressurized Alkaline



Key characteristics

- Highest maturity level (lowest CAPEX)
- Most durable technology (proven runtime > 30 years)
- Pressurized hydrogen production (up to 30 bar(g))

SOEC

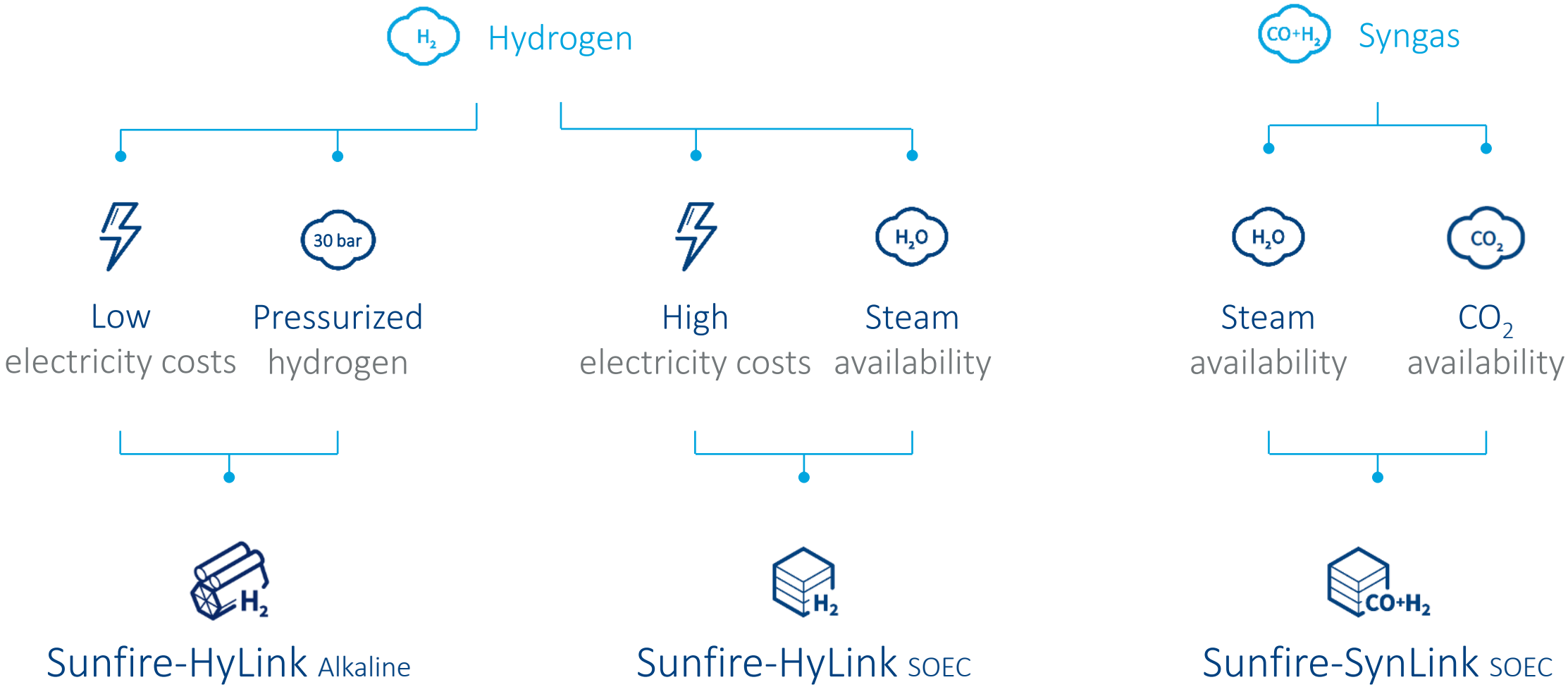


Key characteristics

- Use of industrial waste heat for steam provision
- Highest electrical conversion efficiency (3.6 kWh/Nm^3_{AC})
- CO_2 conversion to syngas

SOLUTIONS

Based on your individual needs, we offer the optimal electrolysis solution



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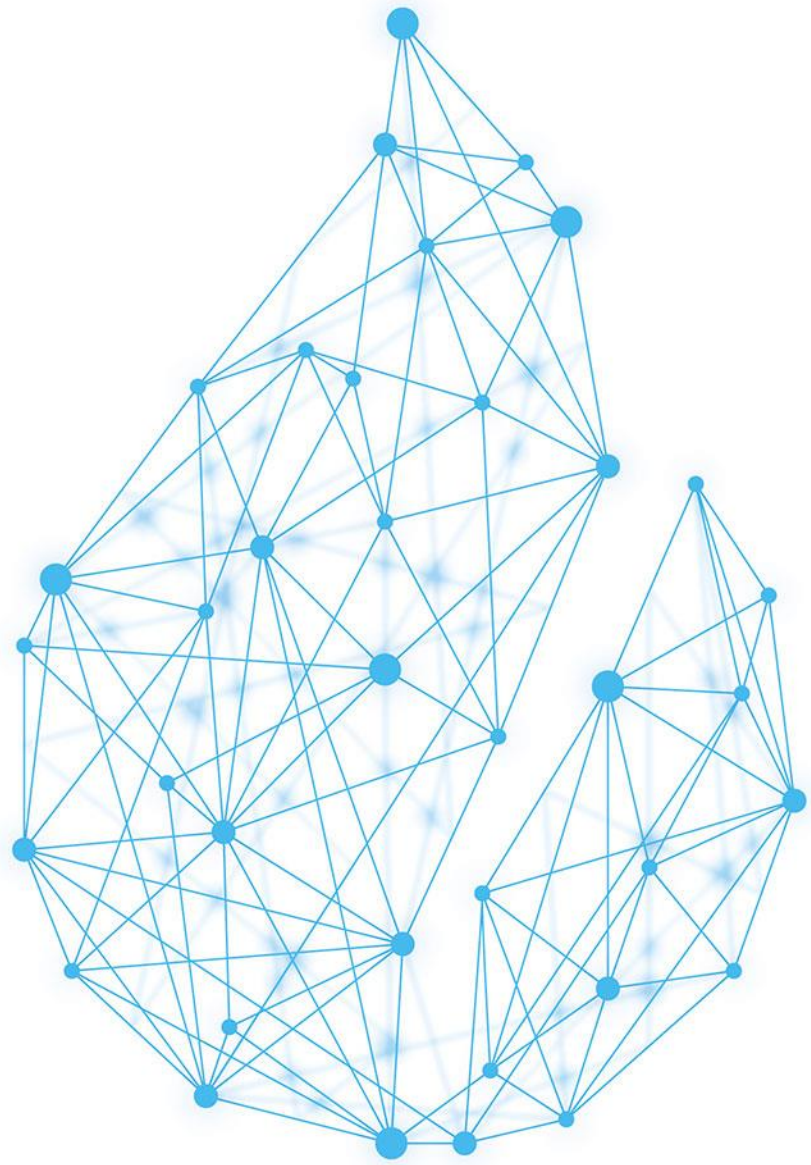
ALKALINE ELECTROLYSIS

Sunfire-HyLink Alkaline



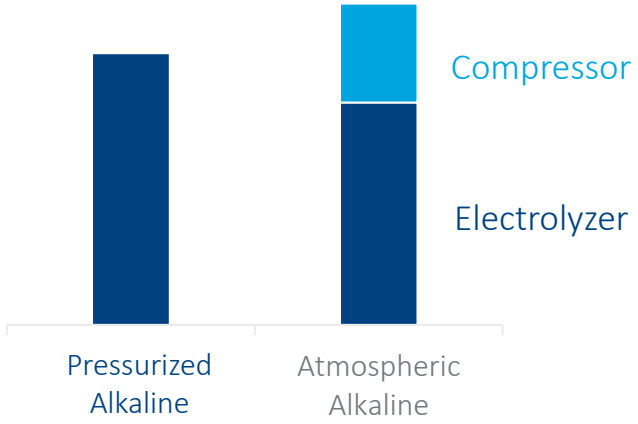
CORE ADVANTAGES

Sunfire-HyLink Alkaline is our ultra-reliable, pressurized electrolysis solution

Pressurized Hydrogen

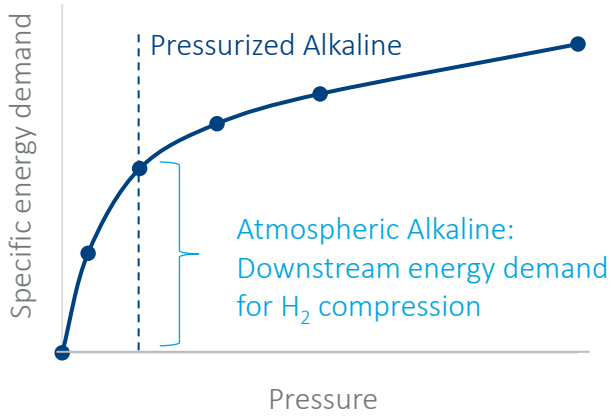
30 bar(g)

CAPEX perspective



- Hydrogen is usually used at high pressure
- Pressurized Alkaline electrolysis avoids additional investments into compressors which would be required with atmospheric electrolyzers

OPEX perspective



- Compressors consume significant energy for compression – especially at lower hydrogen pressure
- Pressurized electrolysis reduces OPEX requiring less energy-intensive compression

Reliability

> 30 years proven system runtime

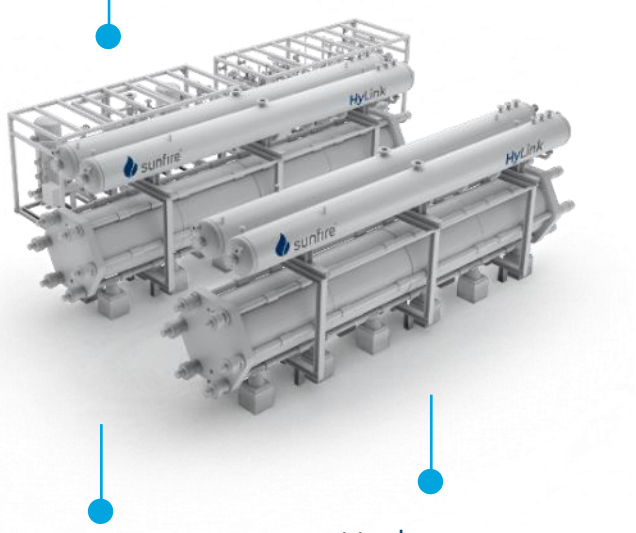
Example reference projects

ZW	100 MW	45 years
PE	25 MW	55 years
CH	8 MW	38 years
∑	> 245 MW	

- Demonstrated system lifetime of > 30 years in the scope of several projects
- Demonstrated stack lifetime of more than 90,000 hours

TECHNICAL SPECS

Performance under pressure



Hydrogen production

Production capacity dynamic range	25 % … 100 %
Delivery pressure	30 bar(g) without additional compression
Hydrogen purity [1)]	99.8 % before gas cleaning
Operating temperature	up to 78 °C

Electrical efficiency

Specific power consumption at stack level (DC)	4.23 … 4.48 kWh/Nm³
Specific power consumption at module level (AC)	4.46 … 4.64 kWh/Nm³

Feedstock

Electrolyte	25 % KOH aqueous solution

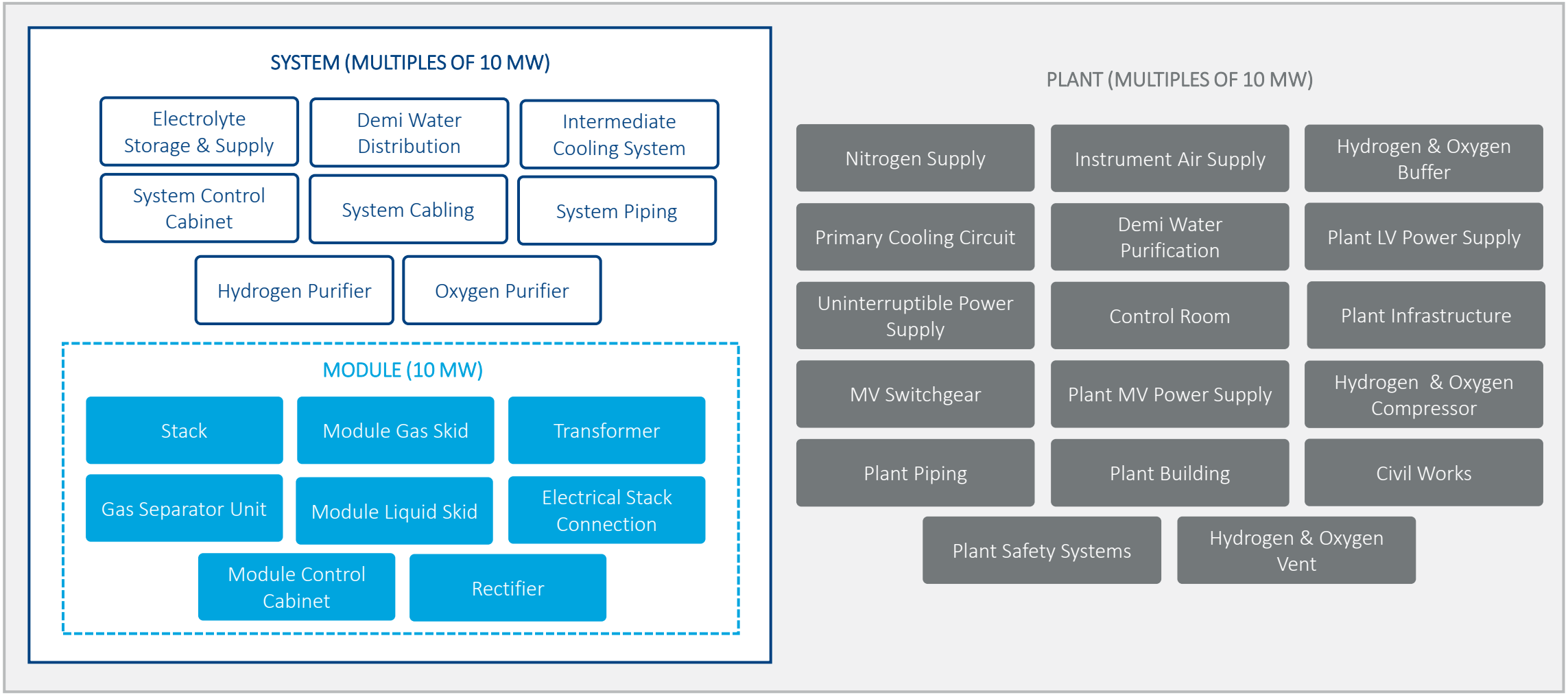
Other specs

Proven system runtime	> 30 years
Stack lifetime [2)]	90,000 equivalent operating hours
Footprint [3)]	~ 375 m²
Ambient temperature	5 °C … 40 °C

1) Depending on load point, up to 99.998% after gas cleaning 2) Equivalent operating hours are calculated based on the operation profile of the electrolyzer (including e.g. start-stops)
3) Average space requirement for a 10 MW module comprising stacks, balance of stack, module control cabinet, and power supply unit

SCOPE OF SUPPLY

Standardized product offering and strategic cooperation with specialized EPC partners



Sunfire | Sunfire (optional) | EPC Partner

REFERENCES (1/2)

Since 1957: A decade-long, proven track record of commercial projects

> 245 MW
Installed pressurized Alkaline electrolysis capacity

> 60 projects
with industrial companies

> 30 years
proven system runtime

ZW

Sable Chemicals

100 MW

Chemicals

1971 - 2016

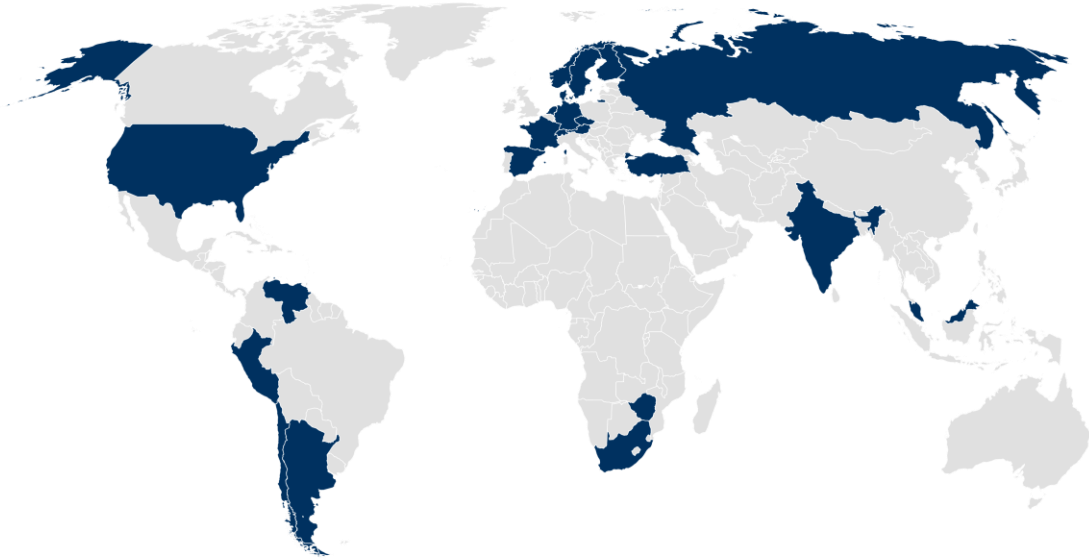
PE

Industrias Cachimayo

25 MW

Chemicals

since 1965



Note: Projects shown were realized by predecessor alkaline company “IHT SA” prior to the acquisition by Sunfire

REFERENCES (2/2)

Sunfire is realizing large-scale projects based on Alkaline electrolysis technology

AT [1)]

Demo4Grid
3 MW

Industrial Energy

In operation since 2022

DE

RWE
10 MW

Power-to-Gas

Commissioning 2023

FI

P2X Solutions
20 MW

Hydrogen & e-Fuels

Commissioning 2024

DE

Uniper
30 MW

Power-to-Gas

Commissioning 2025

SWE

Uniper
30 MW

Power-to-Gas

Commissioning 2026

EU

640 MW Offtake Agreement for Power-to-X Projects

1) Disclaimer: Please find the funding acknowledgement information at the end of the presentation

REFERENCES

DE

RWE

10 MW

Power-to-Gas

Commissioning 2023

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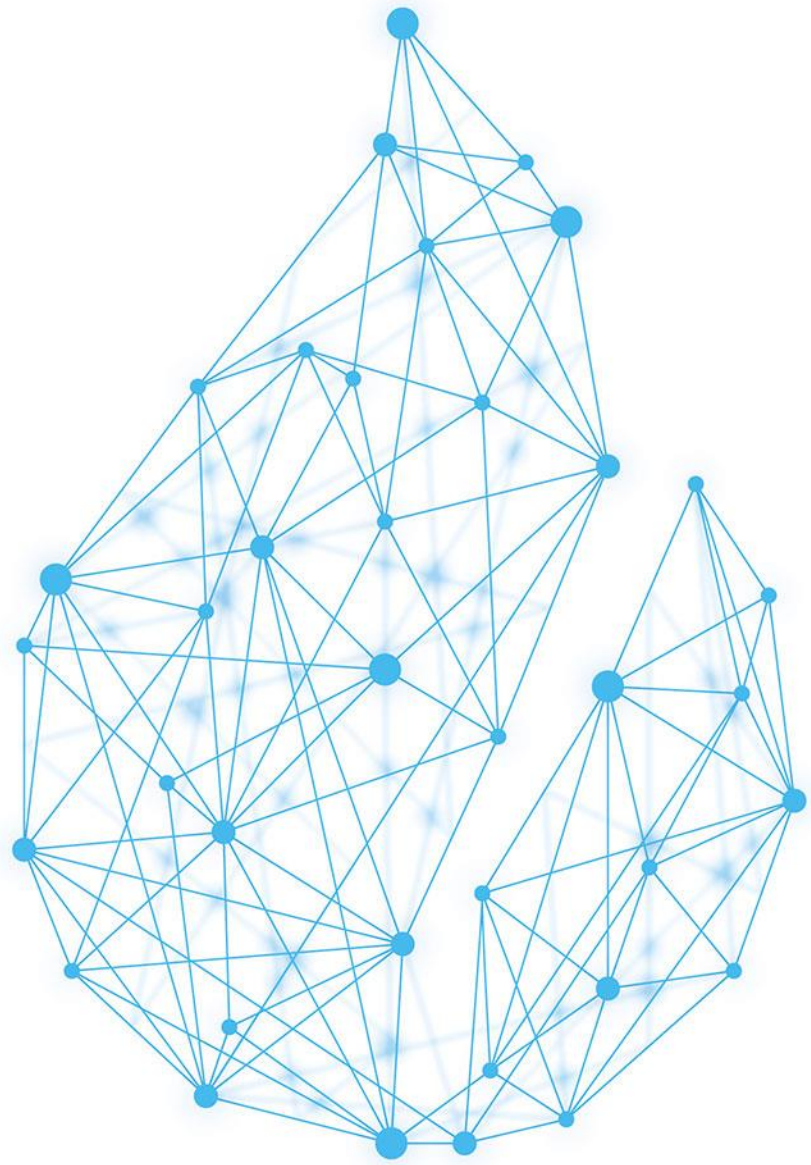
SOEC ELECTROLYSIS

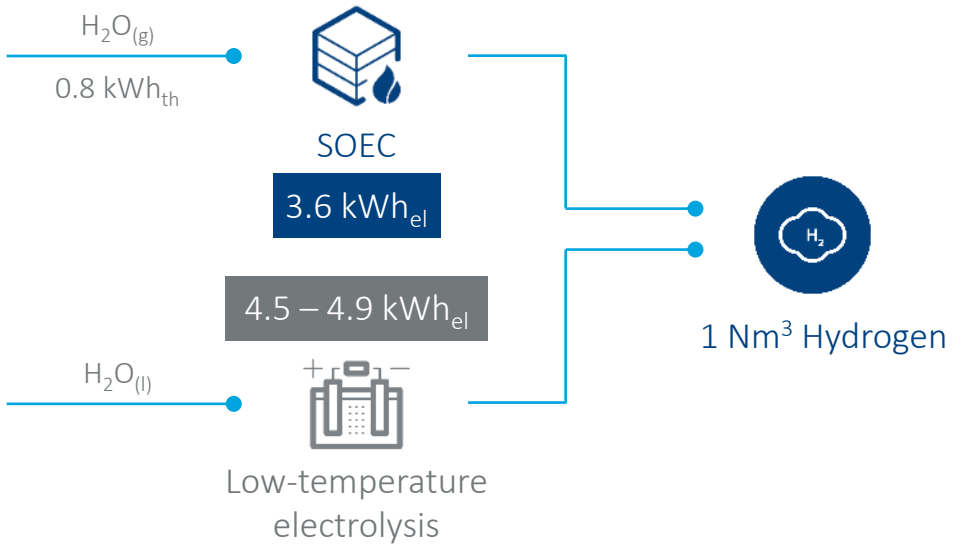
Sunfire-HyLink SOEC
Sunfire-SynLink SOEC



SOEC achieves superior electrical efficiency and produces syngas in one step

Electrical Efficiency[1)]

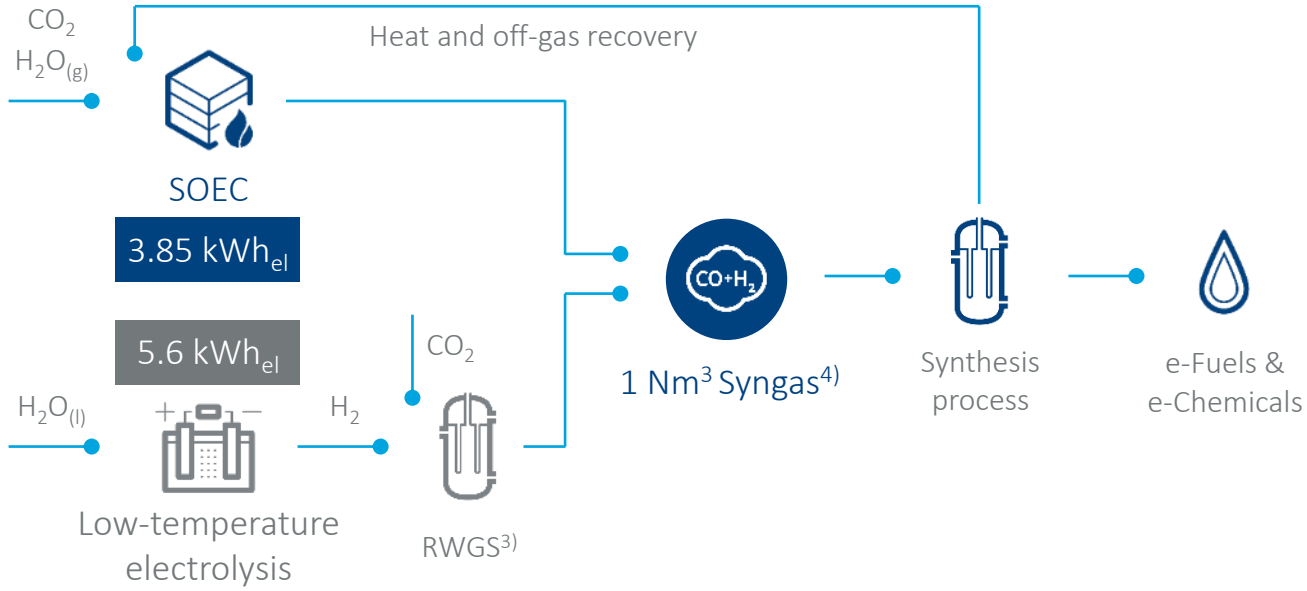
3.6 kWh_{el}/Nm^3



- SOEC uses heat (provided as steam) as additional energy feed to electricity, thus lowering electricity demand
- The efficiency advantage translates into electricity savings of up to 25 %

CO_2 utilization capability

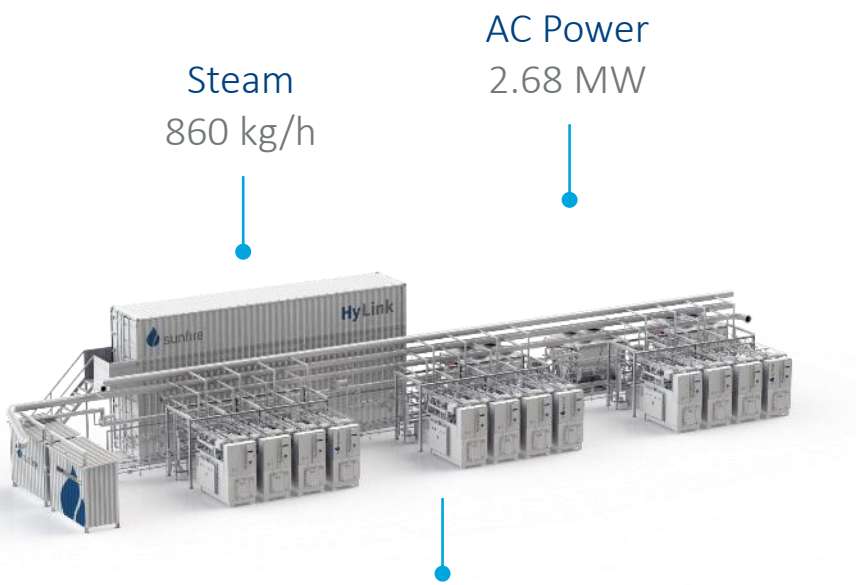
One-step syngas production



- With a one-step SOEC co-electrolysis of CO_2 and H_2O to syngas, significant CAPEX and OPEX savings can be realized
- Production of syngas for Fuels and Chemicals requires a more CAPEX and energy intensive 2-step process using low-temperature electrolysis

1) Lower heating value of hydrogen referred to AC power input 2) Provided as steam
3) Reverse-Water-Gas-Shift reaction is required in order to generate Carbon monoxide (CO) 4) 3.169 kWh/Nm³ lower heating value of syngas (H_2:CO = 2)

Highest electrical efficiency



Hydrogen production

Production capacity dynamic range	5 … 100 %
Delivery pressure	0 bar(g)
Hydrogen purity	max. 99.99 %
Hot idle ramp time	< 10 min
Operating temperature	up to 850 °C

Power input and electrical efficiency

Specific power consumption at system level (AC)[1)]	3.6 kWh/Nm³
System electrical efficiency[2)]	84 %

Steam input

Temperature	150 … 200 °C
Pressure	3.5 … 5.5 bar(g)

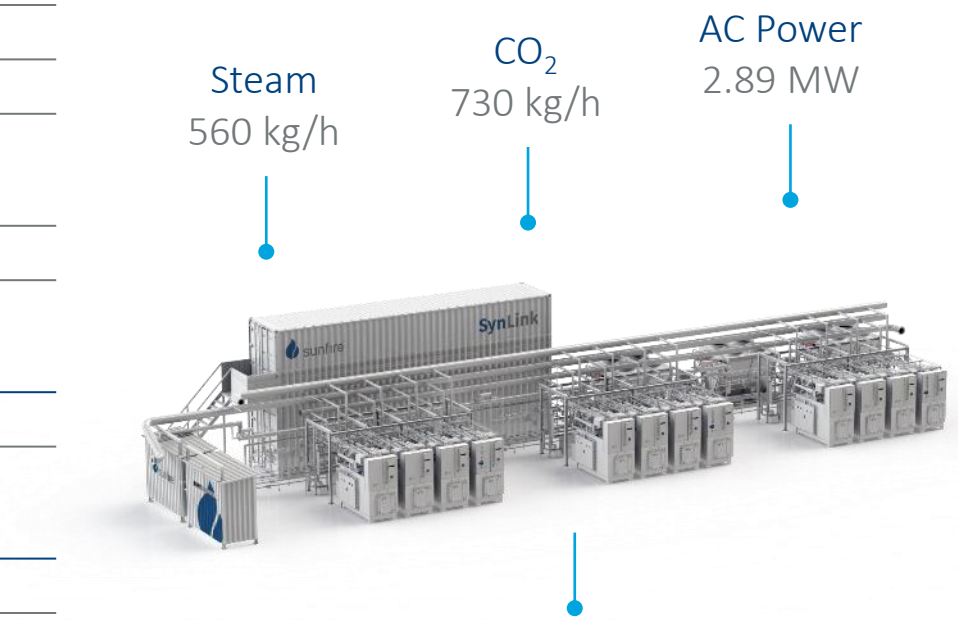
Other specs

Footprint[3)]	~ 300 m²
Ambient temperature	- 20 … 40 °C

1) Power consumption at ambient pressure 2) Lower heating value of hydrogen referred to AC power input
3) Average space requirement for a 2.68 MW system comprising all auxiliary systems

Direct conversion of CO_2 and H_2O into syngas

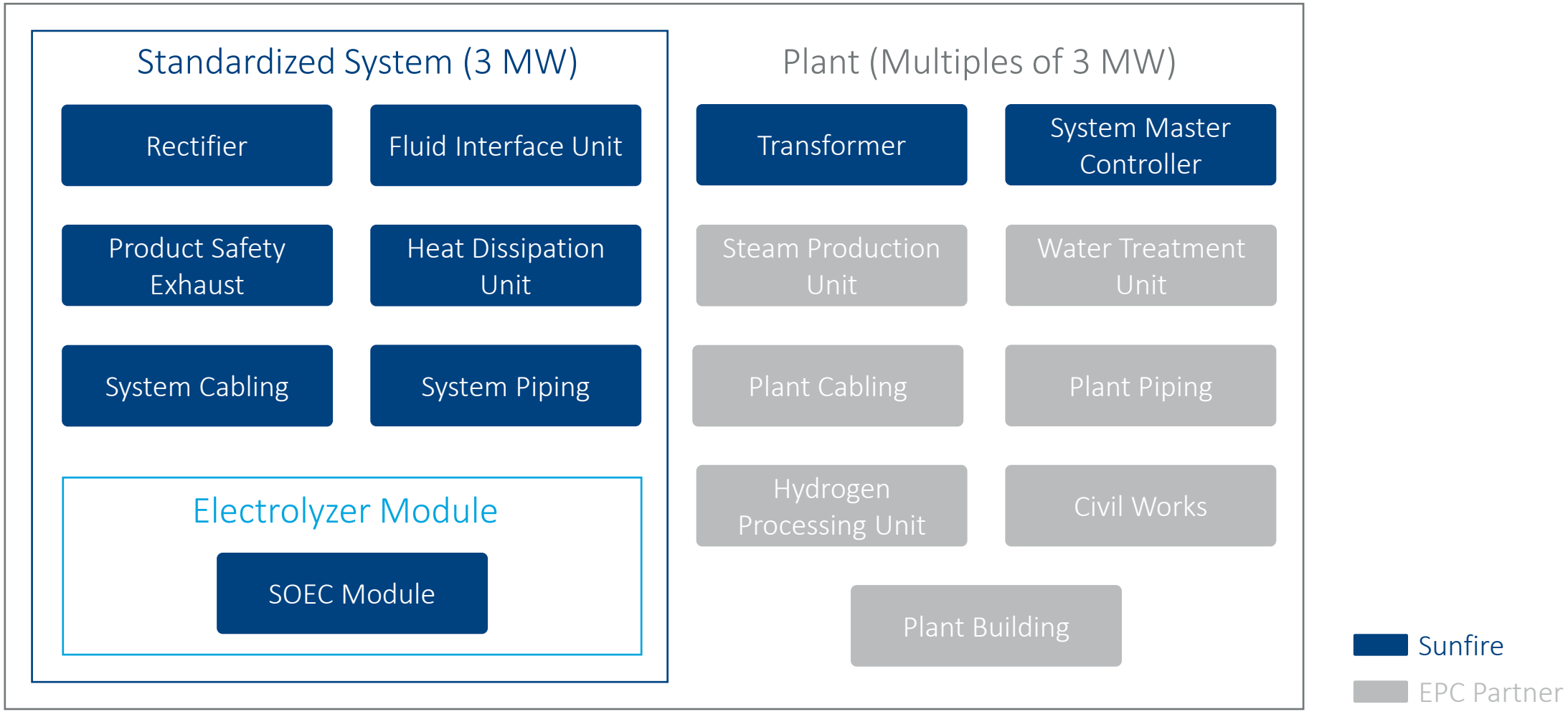
Syngas production	
Production capacity dynamic range	5 … 100 %
Delivery pressure	0 bar(g)
Hot idle ramp time	< 10 min
Available H_2:CO ratios	1.5 … 3.5
Power input and electrical efficiency	
Specific power consumption at system level (AC)[1)]	3.85 kWh/Nm³
System electrical efficiency[2)]	82 %
Steam input	
Temperature	150 … 200 °C
Pressure	3.5 … 5.5 bar(g)
CO_2 input	
Temperature	0 … 40 °C
Pressure	6 … 8 bar(g)
Other specs	
Footprint[3)]	~ 300 m²
Ambient temperature	- 20 … 40 °C



1) Power consumption at ambient pressure 2) Lower heating value of syngas (H_2:CO = 2) referred to AC power input
3) Average space requirement for a 2.89 MW system comprising all auxiliary systems

SCOPE OF SUPPLY

Standardized product offering and strategic cooperation with specialized EPC partners



REFERENCES

SOEC has reached multi-megawatt scale

> 5 MW
Installed SOEC electrolysis capacity

> 10 industrial projects
with global companies

World's longest
SOEC operating experience

NL 1)

MultiPLHY
3 MW
HyLink SOEC
Refineries
Commissioning 2023

DE

e-CO_2Met
1 MW
HyLink SOEC
Chemicals
Commissioned 2022

DE 1)

GrInHy2.0
1 MW
HyLink SOEC
Steel industry
Commissioned 2020

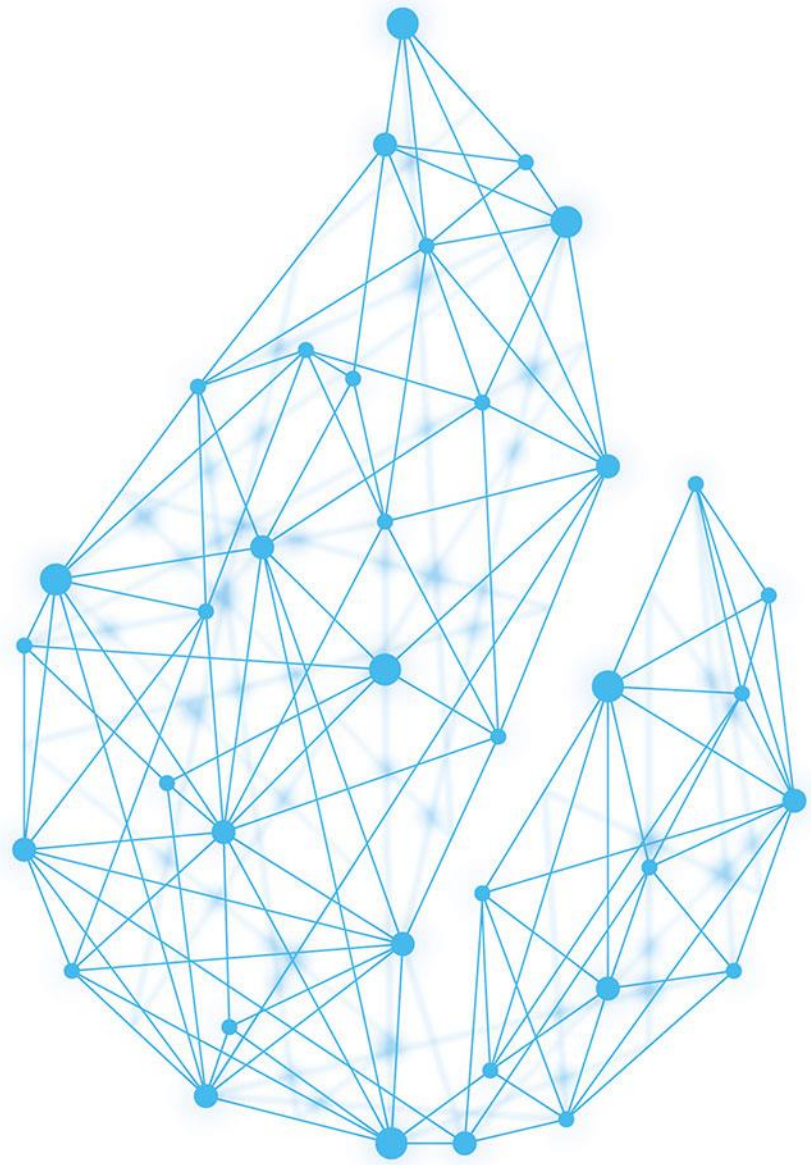
DE

Kopernikus P2X
0.2 MW
SynLink SOEC
Power-to-X
Commissioned 2022

1) Disclaimer: Please find the funding acknowledgement information at the end of the presentation

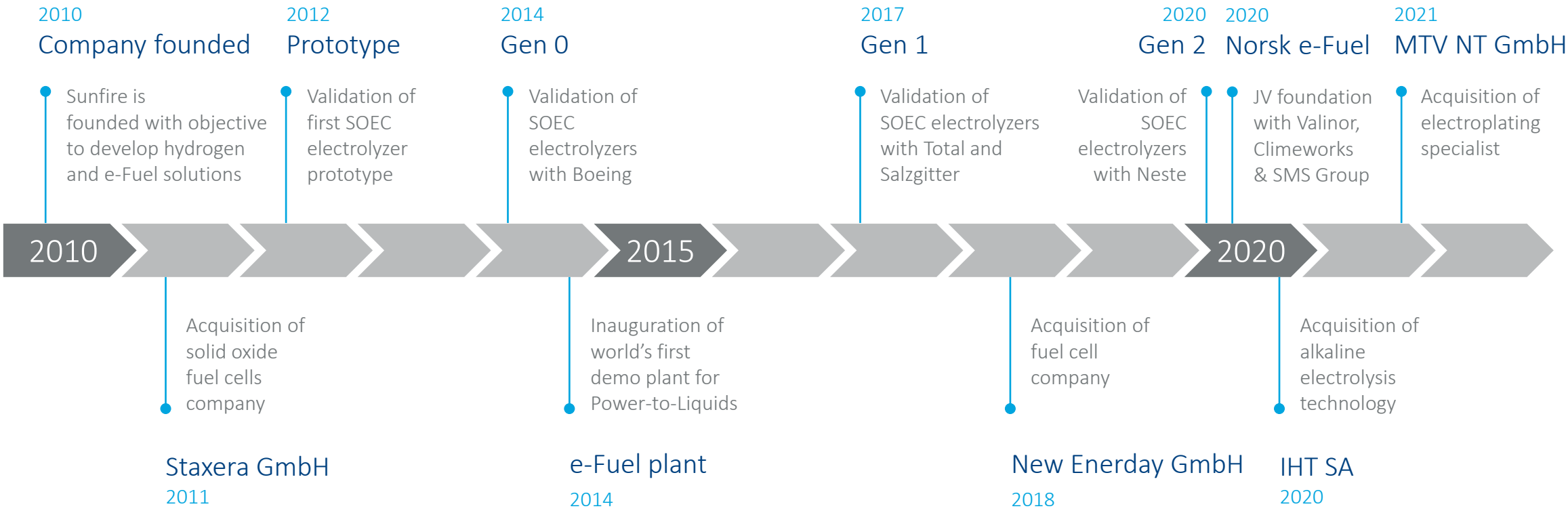
COMPANY

Dedicated to Excellence



HISTORY

From a start-up to a leading industrial electrolysis company in ten years



SERIES D ROUND

Sunfire has raised EUR 195 million (USD 215 million)[1)]

CIP Copenhagen Infrastructure Partners

lightrock

PlanetFirst PARTNERS

CARBONDIRECT

BlueEarth CAPITAL

HydrogenOne CAPITAL | FUTURE FUEL.NOW

amazon [2)]

Management (left to right): Bernhard Zwinz, Nils Aldag & Christian von Olshausen

1) Series D1 (October 2021): EUR 109 million; Series D2 (March 2022): EUR 86 million

2) Investment sum will not be disclosed

PEOPLE

We are dedicated to deliver on our promise

Bernhard Zwinz

COO

Christian von Olshausen

CTO & Founder

Nils Aldag

CEO & Founder

Frank Posnanski

CFO

Dr. Frank Mastiaux

Exec. Chairman

> 500	50 %	Excellence	# 1
Employees	Graduated engineers	Best talents in their field	Electrolysis team

SITES

We currently produce in Dresden, Solingen, Monthey & Neubrandenburg

SOEC Electrolyzers

Dresden, Germany (HQ)

- Cell, stack and system manufacturing
- R&D center

Alkaline Electrolyzers

Solingen (DE) & Monthey (CH)

- Stack manufacturing
- R&D center
- Electroplating

SOFC Fuel Cells

Neubrandenburg, Germany

- System manufacturing
- R&D center

Production upscaling in preparation

SCALING

We increase manufacturing capacity for Alkaline electrolyzers to 500 MW/year by 2023

Sunfire‘s Galvancis facility for alkaline electrolyzer production in Solingen, Germany

500 MW/year
production capacity operational by 2023

Industrial manufacturing
with lean, fully automated processes

Further scaling step to 1 GW/year
already in preparation

Made in Germany
High-quality manufacturing in Germany

Note: The final investment decision should be made upon completion of site selection for all production steps and is subject to obtaining the necessary financing, including those requested within the IPCEI framework

RENEWABLES EVERYWHERE

Sunfire GmbH · Gasanstaltstrasse 2
01237 Dresden · Germany
www.sunfire.de

ACKNOWLEDGEMENT

Selected Sunfire projects shown in this presentation have received funding from the EU

1) Demo4Grid: This project has received funding from the Fuel Cells & Hydrogen 2 Joint Undertaking (now Clean Hydrogen Partnership) of the European Commission under grand agreement No 736351 and the Swiss State Secretariat for Education, Research and Innovation (SERI) under contract number 17.00002. This Joint Undertaking receives support from the European Union's Horizon 2020 research and innovation programme, Hydrogen Europe and N.ERGHY.

2) MultiPLHY: This project has received funding from the Fuel Cells and Hydrogen 2 Joint Undertaking (now Clean Hydrogen Partnership) under grant agreement No 875123. This Joint Undertaking receives support from the European Union's Horizon 2020 research and innovation programme, Hydrogen Europe and Hydrogen Europe Research.

3) GrInHy2.0: This project has received funding from the Fuel Cells and Hydrogen 2 Joint Undertaking (now Clean Hydrogen Partnership) 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.

Clean Hydrogen Partnership

Co-funded by the European Union

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