Hydrogen at scale

26 January 2022

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Perfecting
chemistry for a
better world
Our purpose
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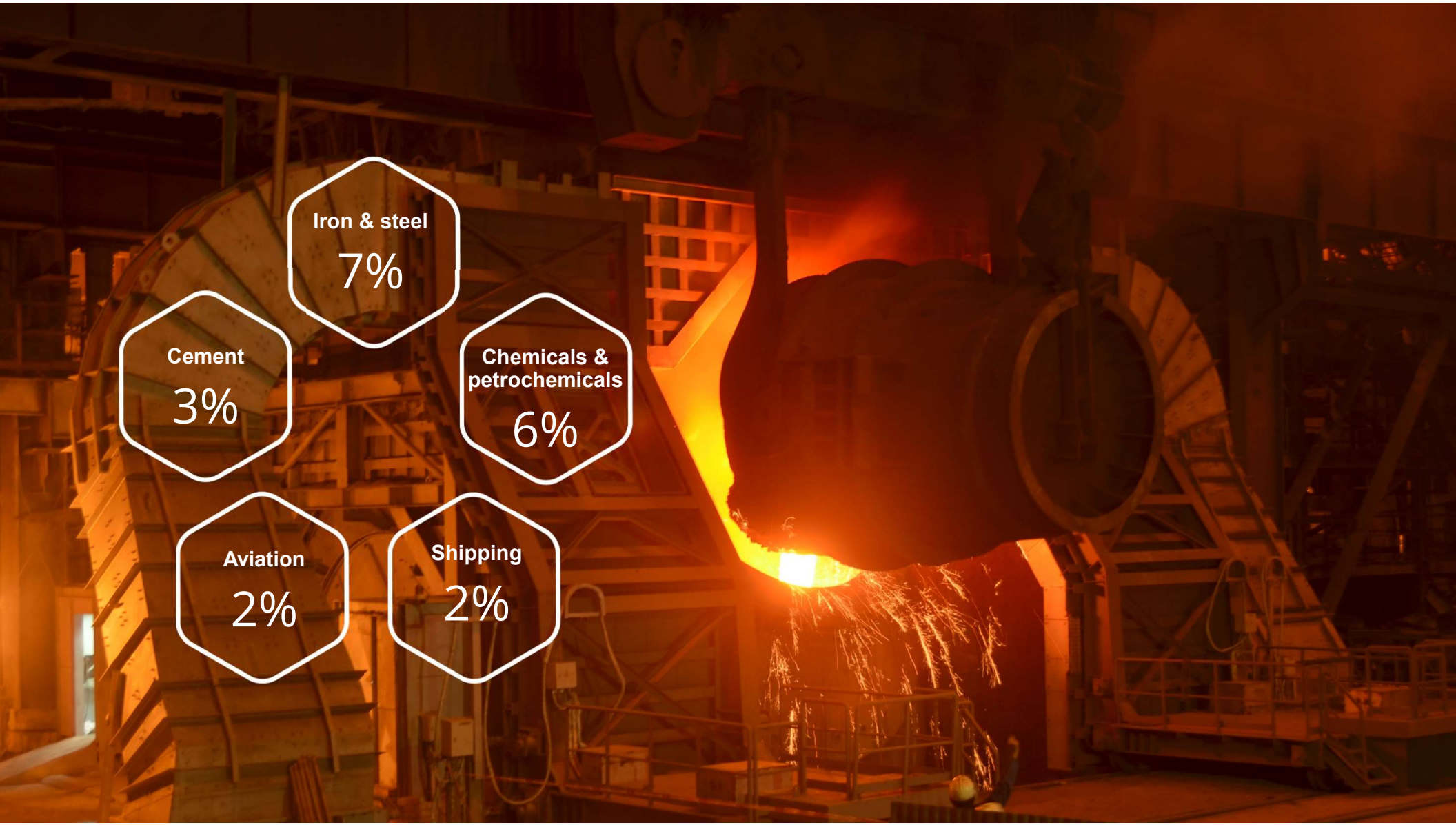
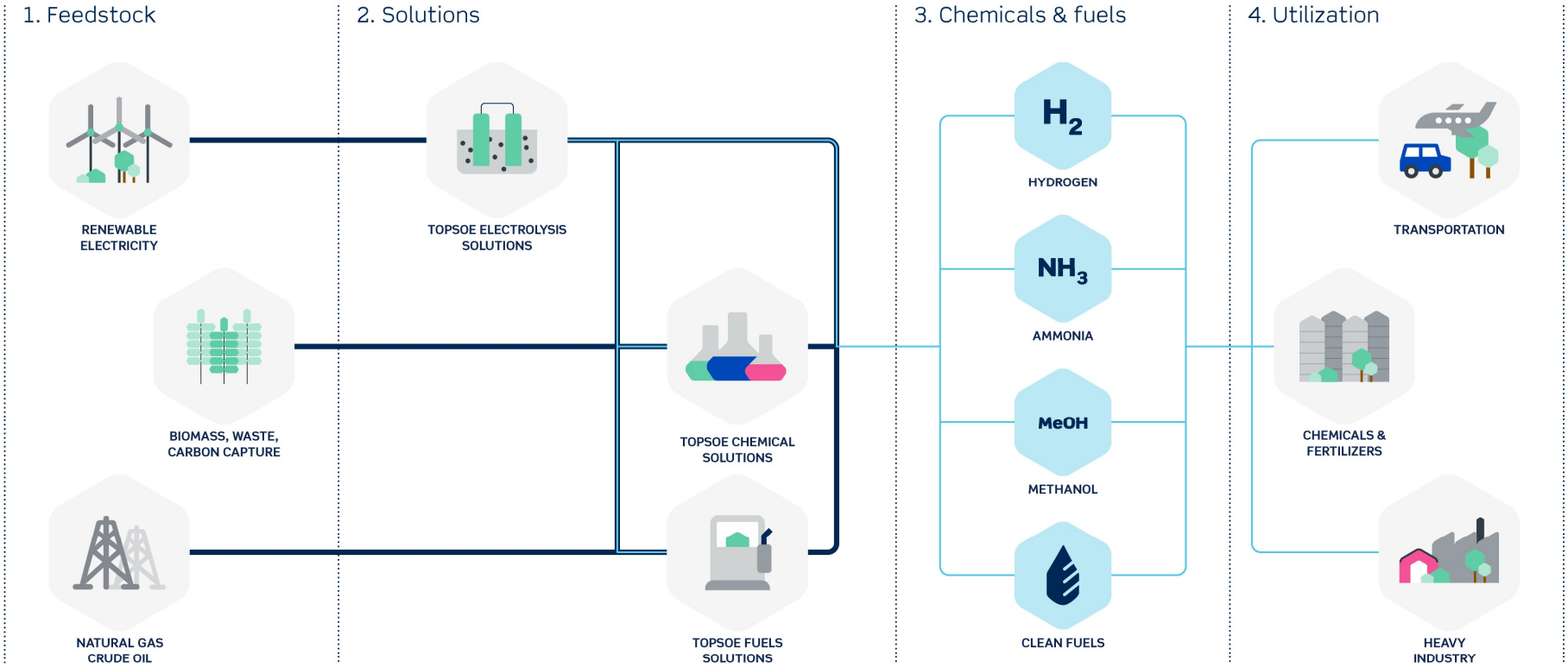
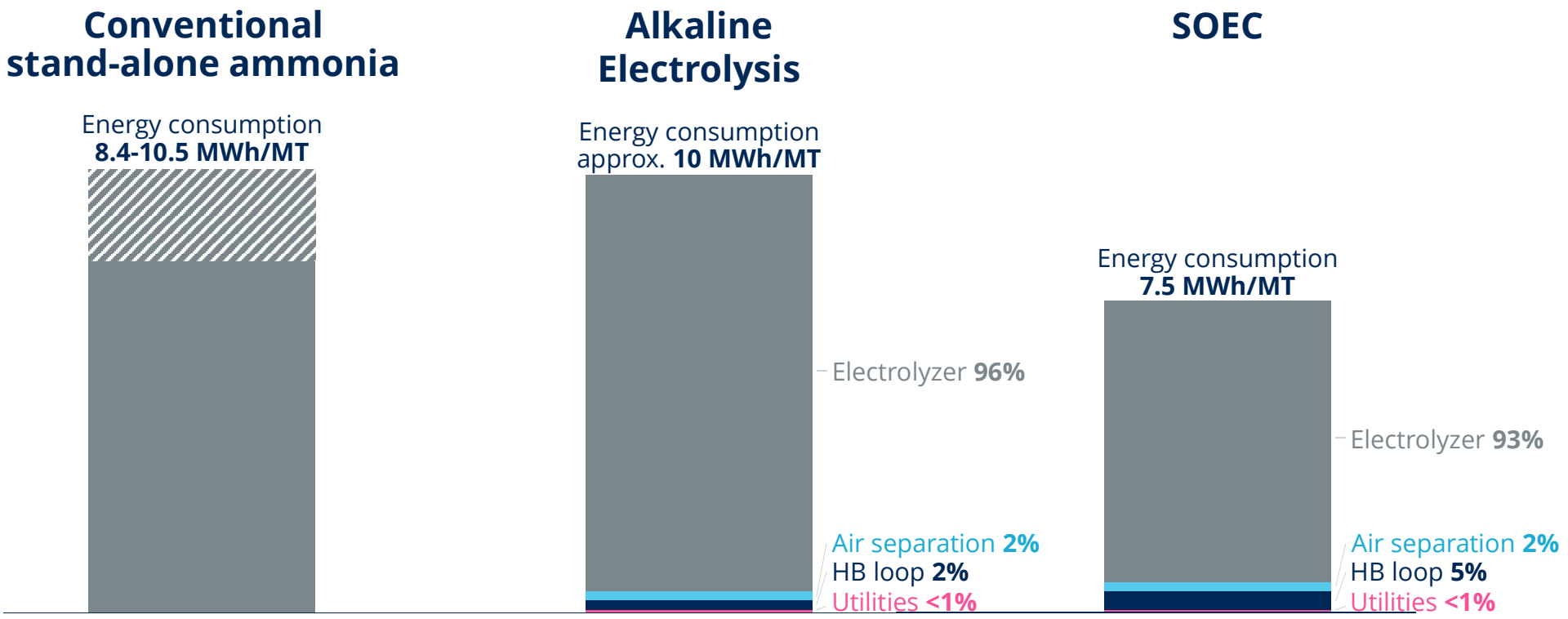
Electrify the World


Iron & steel
7%
Cement
3%
Chemicals & petrochemicals
6%
Aviation
2%
Shipping
2%

Topsoe solutions accelerate the energy transition

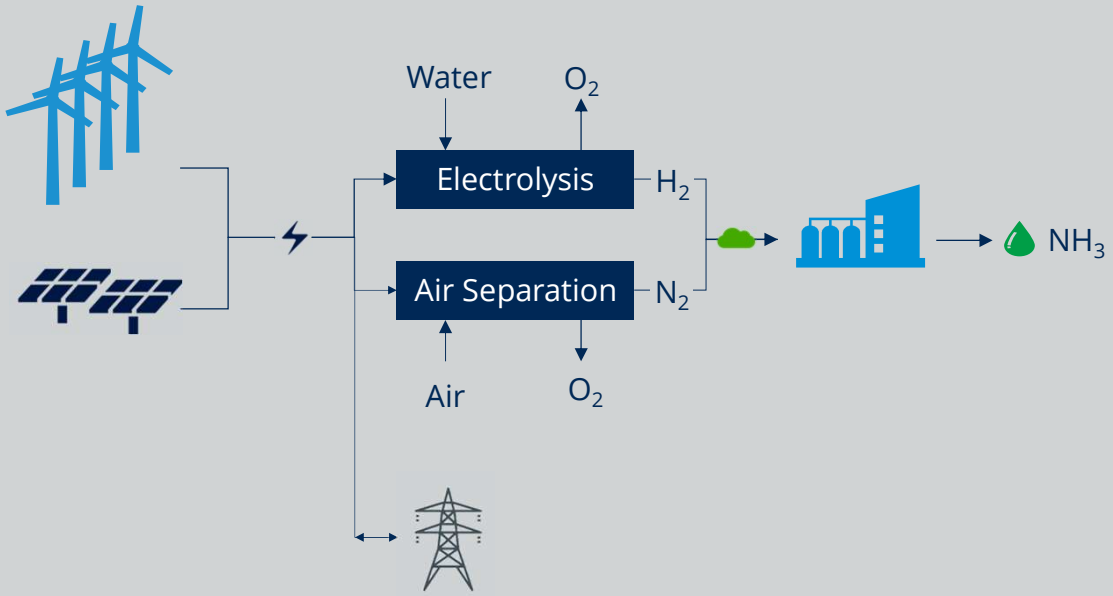


Electrolysis efficiency advantages becomes huge at plant level – Illustrated for ammonia production by 25% energy savings per ton ammonia produced



Dynamic ammonia production for fluctuating power supply

Decreasing capital investment cost
From renewable energy to electrolysis to synthesis



Advantages
Power-to-ammonia

- Fully flexible operation 10-100% plant load
- No hydrogen storage
- Store energy as ammonia
- Grid balancing

Enabling the transition

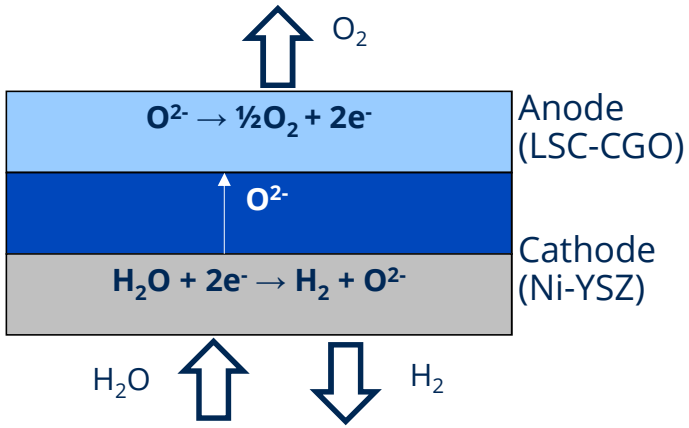
We know how to transform renewable electricity

We're among a very small group of companies with deep insight into the production of green hydrogen from renewable electricity – and we possess the knowledge needed to produce green fuels and chemicals from that hydrogen.

Our solutions produce green hydrogen, ammonia, methanol, and other e-fuels. Together, they represent the most promising fuels and chemicals of the future.

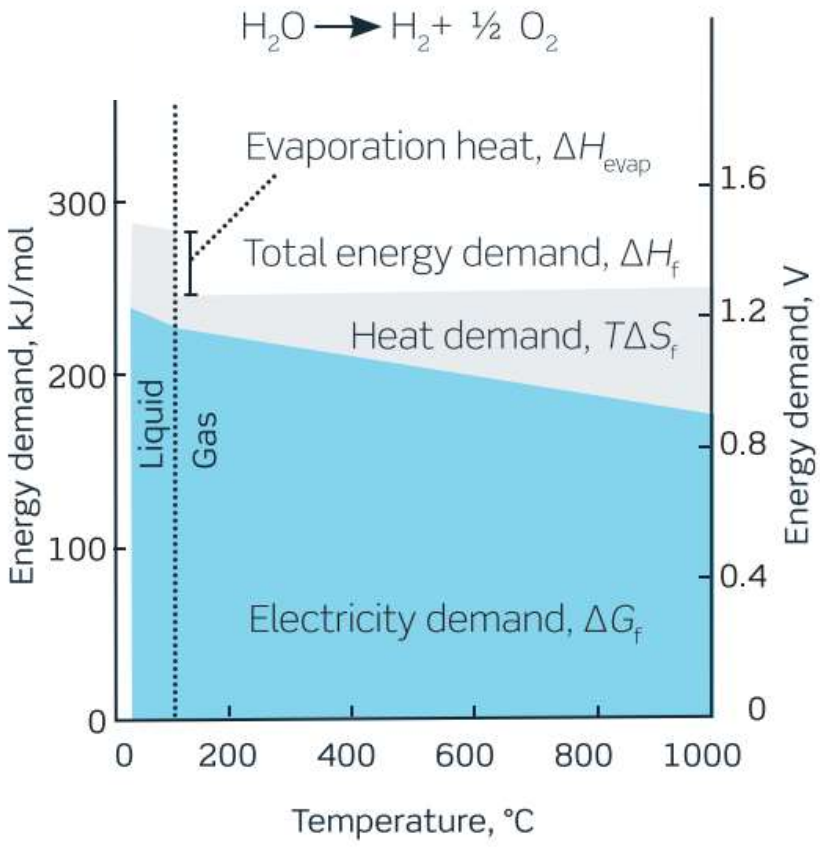
Solid Oxide Electrolysis Cell (SOEC) electrolysis

SOEC electrolysis



Stack power consumption

~3 kWh/Nm^3 H_2



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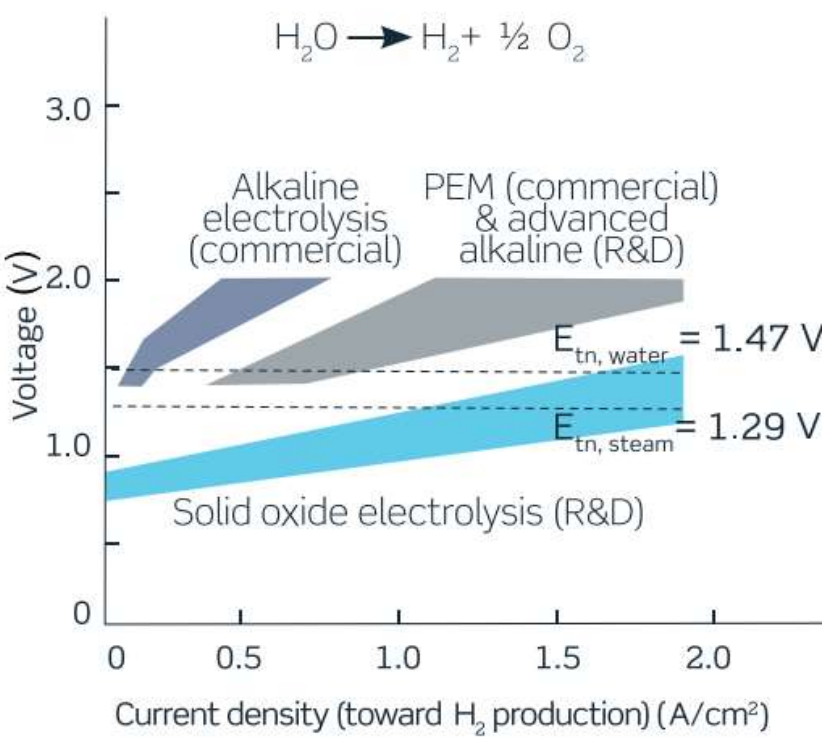
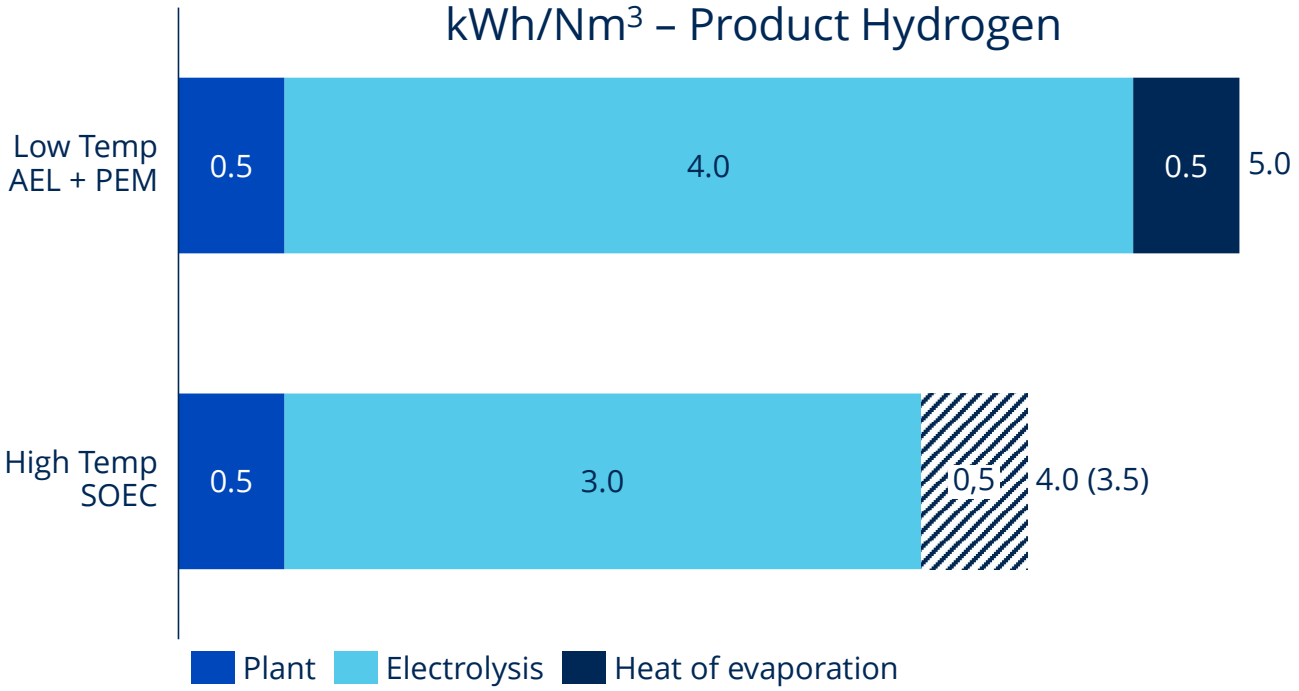
Fast kinetics drive SOEC efficiency and slow kinetics necessitates high voltage ranges for low temperature electrolysis

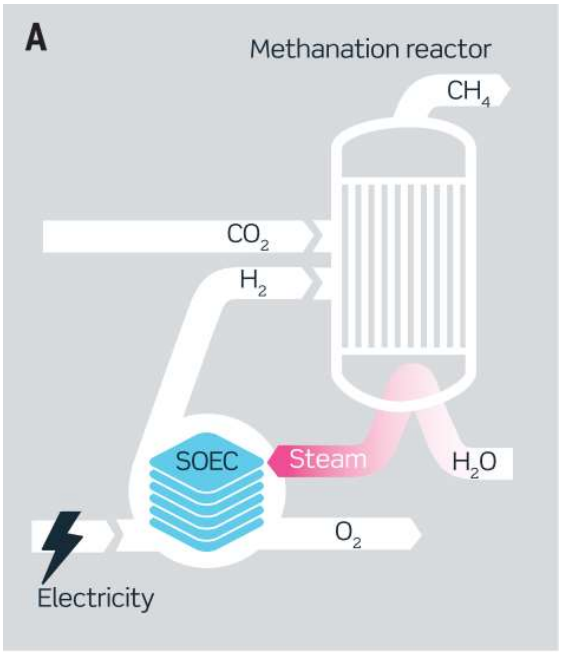


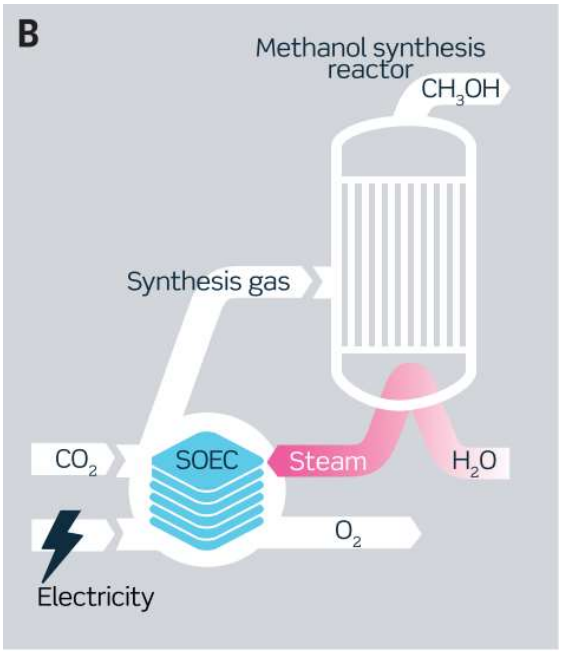
- High Temperature electrolysis offers a superior efficiency than alternatives
- Lower voltage translates into lower OPEX (lower electricity demand per quantity of produced gas)
- Higher current densities are associated with lower CAPEX (fewer electrolyzers needed to achieve the required capacity for gas production)

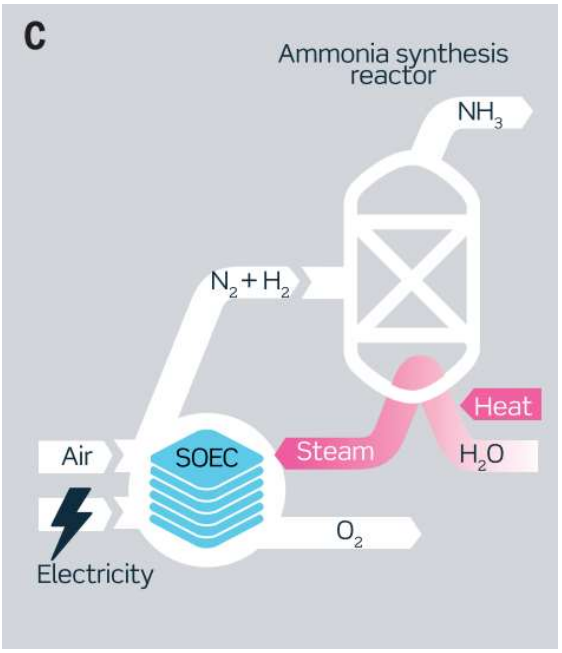
SOEC Electrolysis is significantly more efficient than low temperature electrolysis

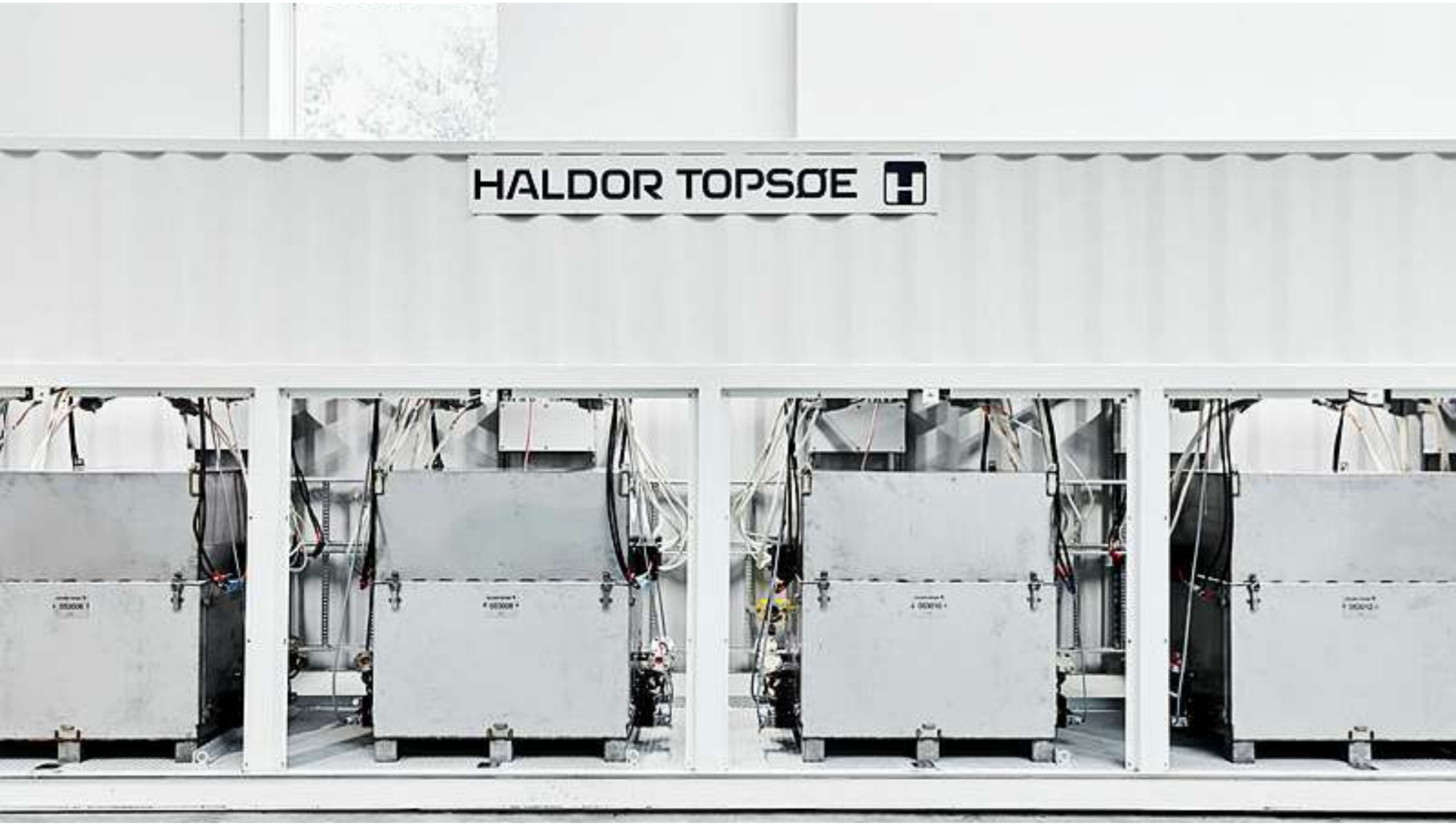


Integration of SOEC with methanation, methanol, FT or ammonia





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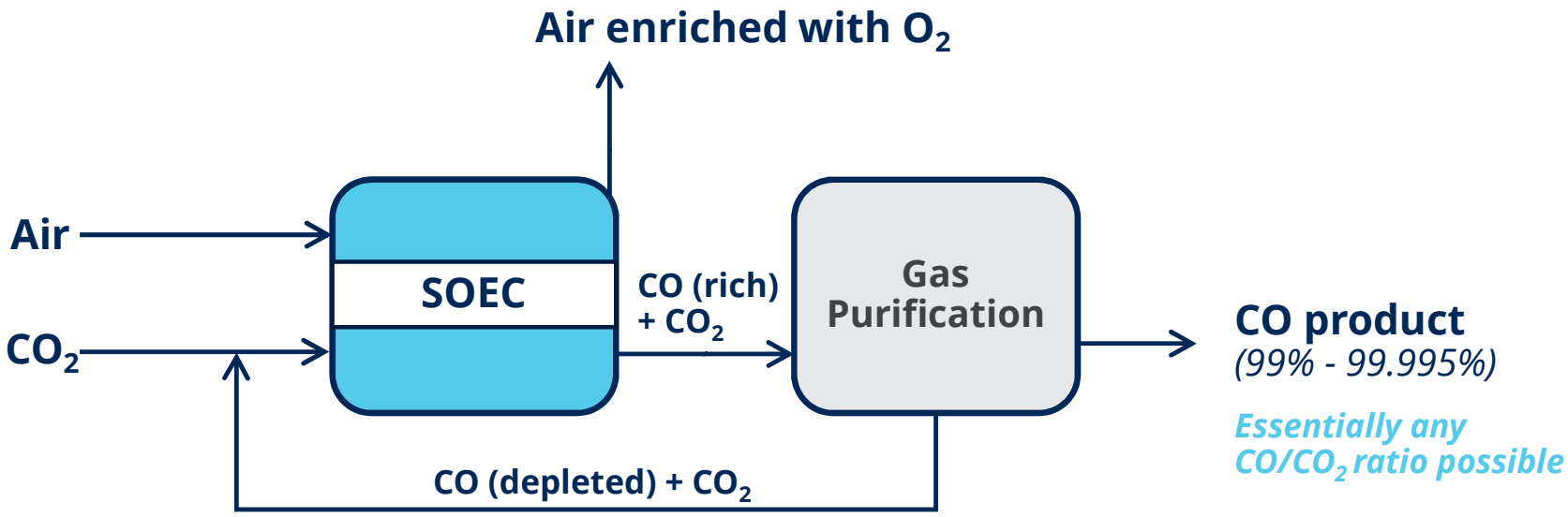
Carbon monoxide production from Carbon dioxide and renewable power



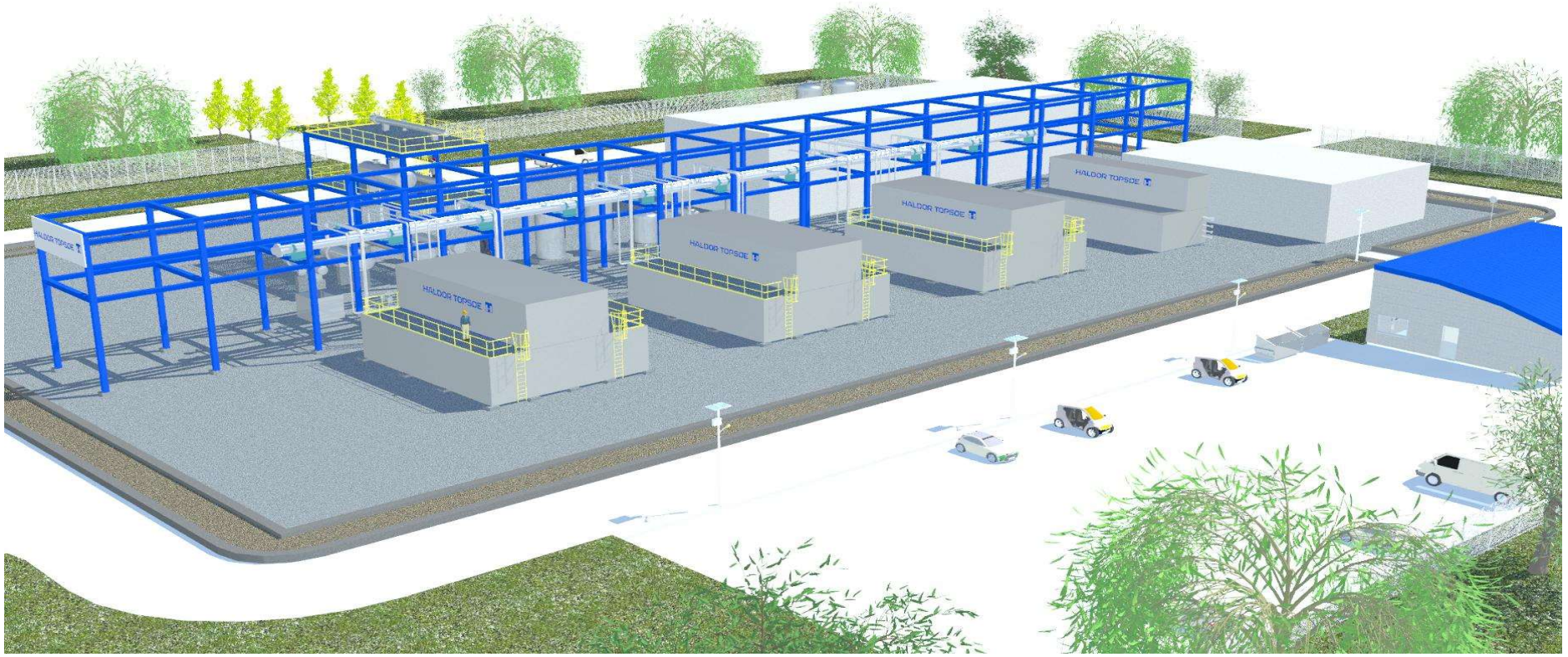
Demo site at National Lab, Denmark

- 50 kW Biogas upgrade
- 50 kW Ammonia Synthesis

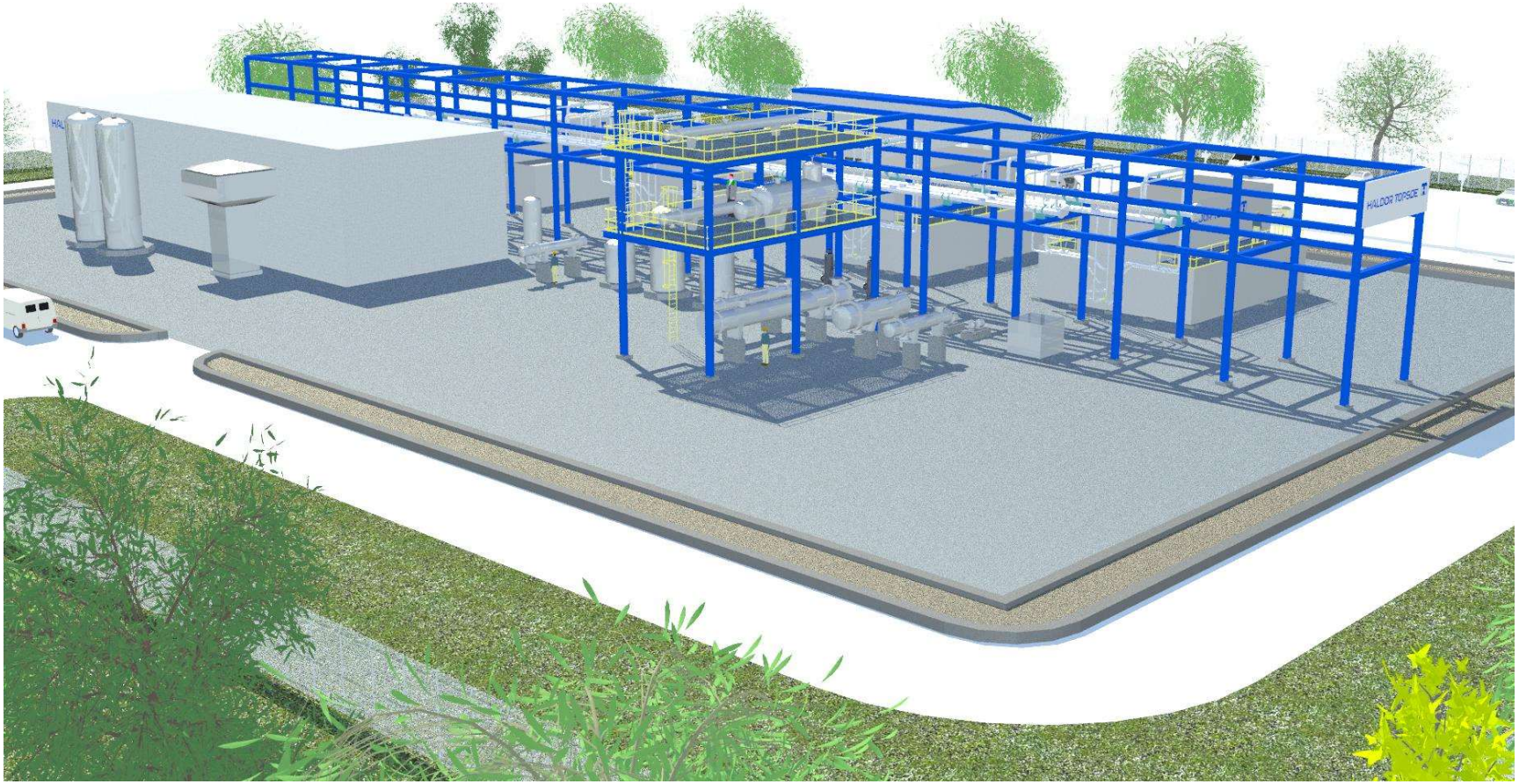
Operating plant at customer site, USA

- 2 x750 kW ultrapure CO production

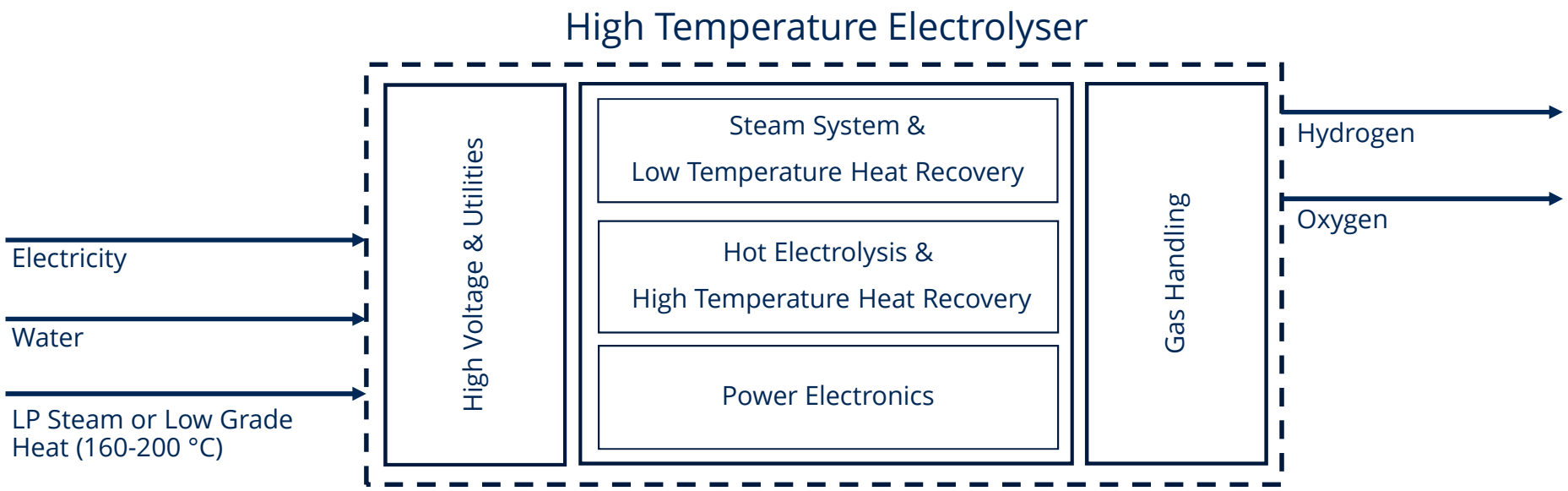
Industrial SOEC plant



Industrial SOEC plant



High Efficiency comes from Core Electrolysis Operation and High System Efficiency



SOEC Electrolysis offers a wide range of advantages

Lower power consumption

- SOEC has the highest efficiency of all electrolysers
- Without heat integration, SOEC is 20 % more efficient than alkaline and PEM
- With heat integration, SOEC is 30 % more efficient than alkaline and PEM

Non noble materials

- SOEC consists of materials that are abundant in nature and can therefore easily be scaled up without material availability constraints
- The use of non noble materials will benefit cost as the raw materials will not become more expensive due to scarcity

Syngas creation

- In addition to the electrolysis of steam, SOEC can electrolyse CO_2 and thereby generate CO
- CO_2 electrolysis enables carbon capture & utilization from a point source and provides advantages for making eFuels such as eJet, eDiesel and methanol

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