Topsoe's Road Map to All Electric Ammonia Plants

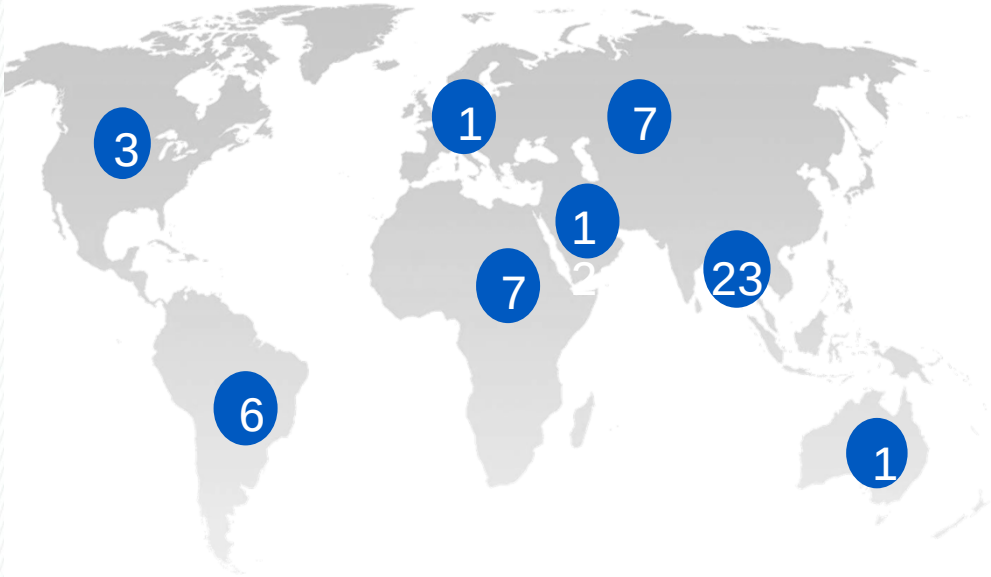
AIChE Fall Meeting 2018

31 October 2018, John Bøgild Hansen (Haldor Topsoe)

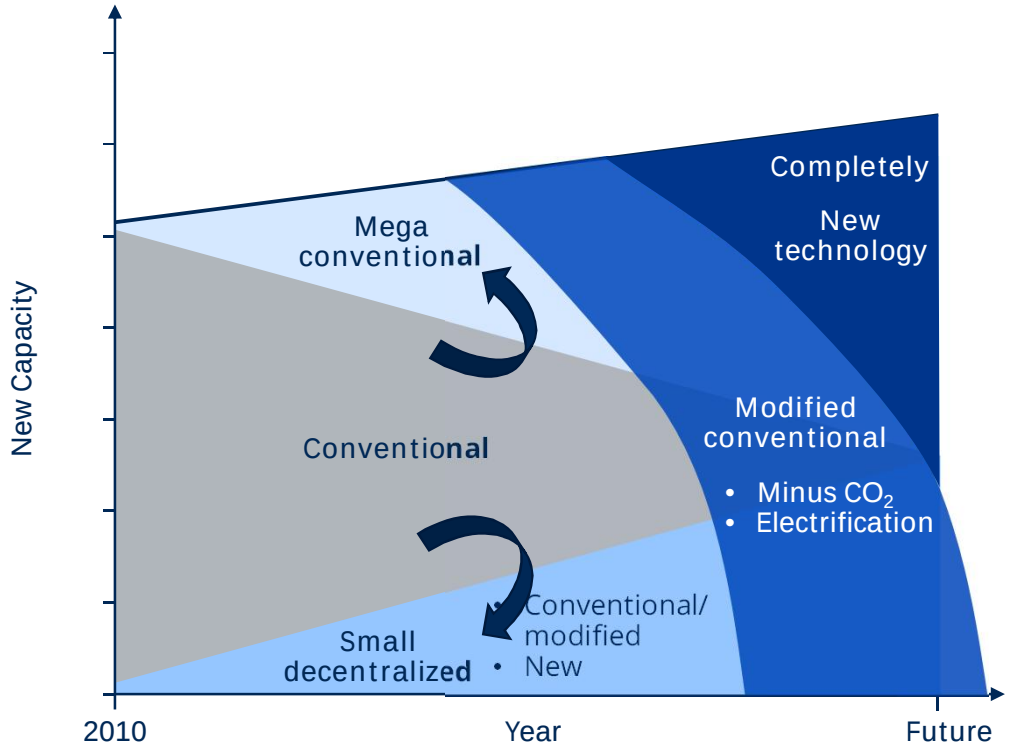
Topsøe Ammonia Catalyst Charges and Ammonia Plants

248 current catalyst references worldwide

Number of plants:	60
Accumulated capacity, MTPD:	99,505

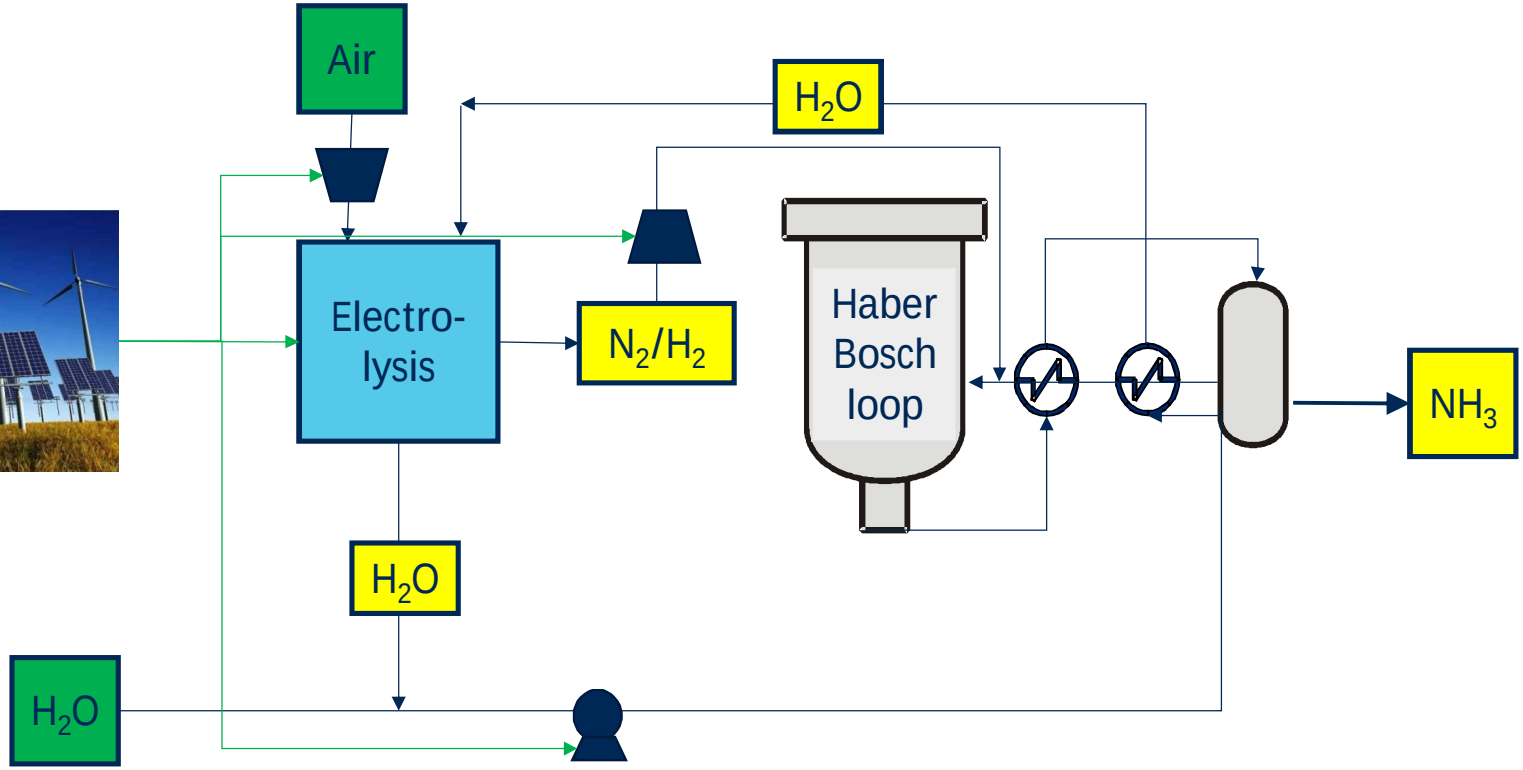


Future NH_3 production
The big picture

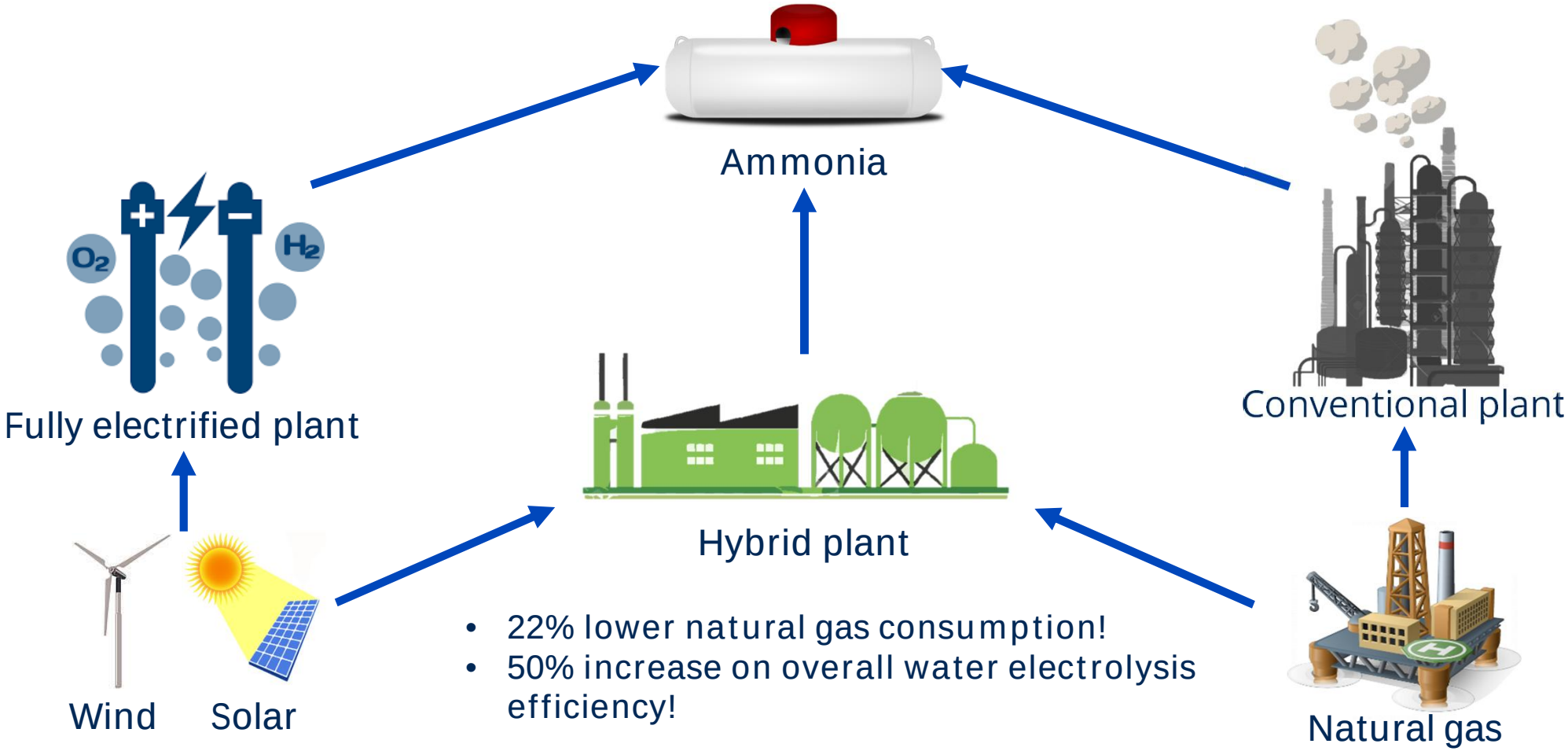


Long-term ambition

World scale ammonia production from air, water and renewable electricity

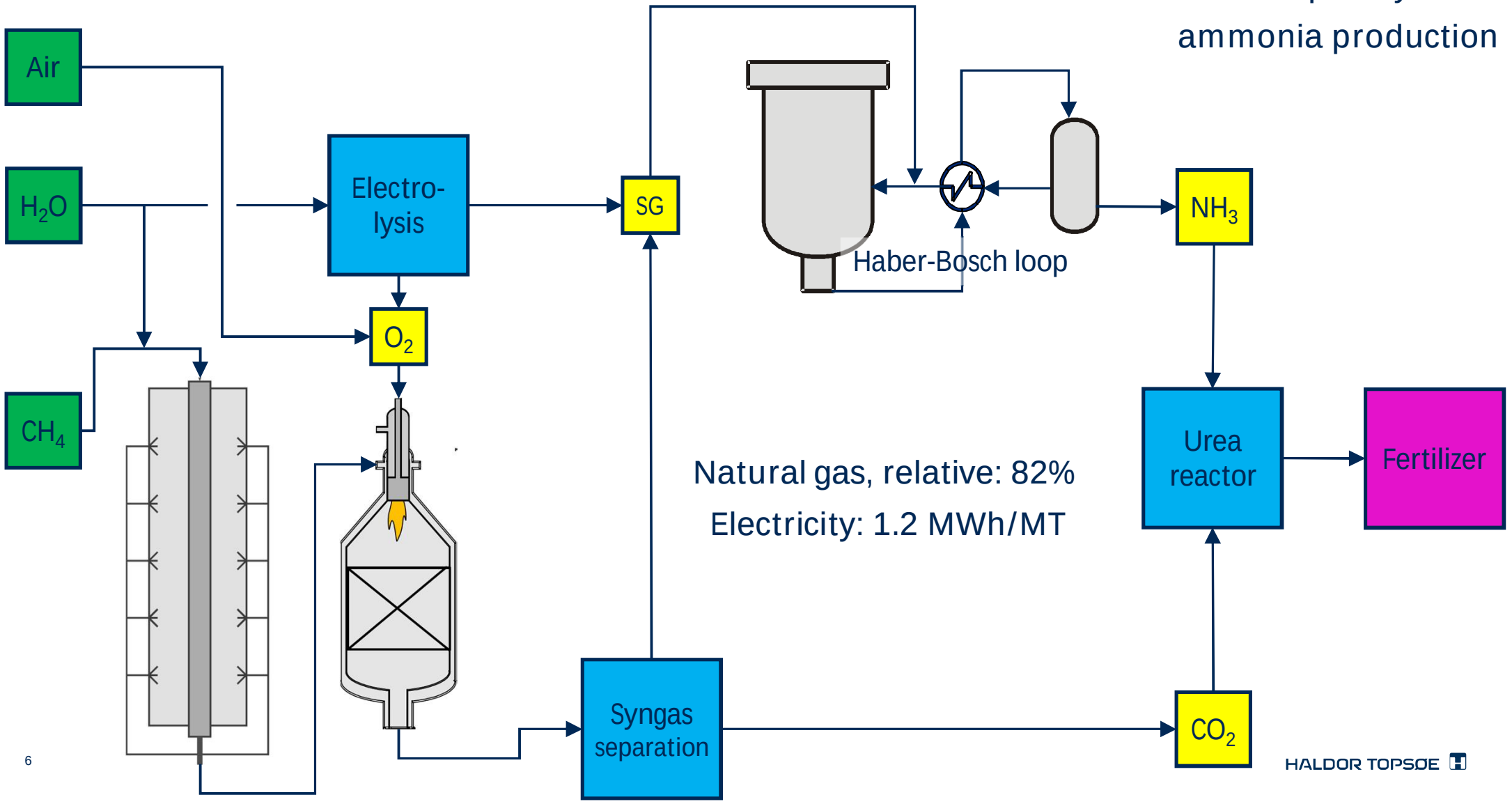


The hybrid plant solution



- 22% lower natural gas consumption!
- 50% increase on overall water electrolysis efficiency!

Revamped hybrid ammonia production



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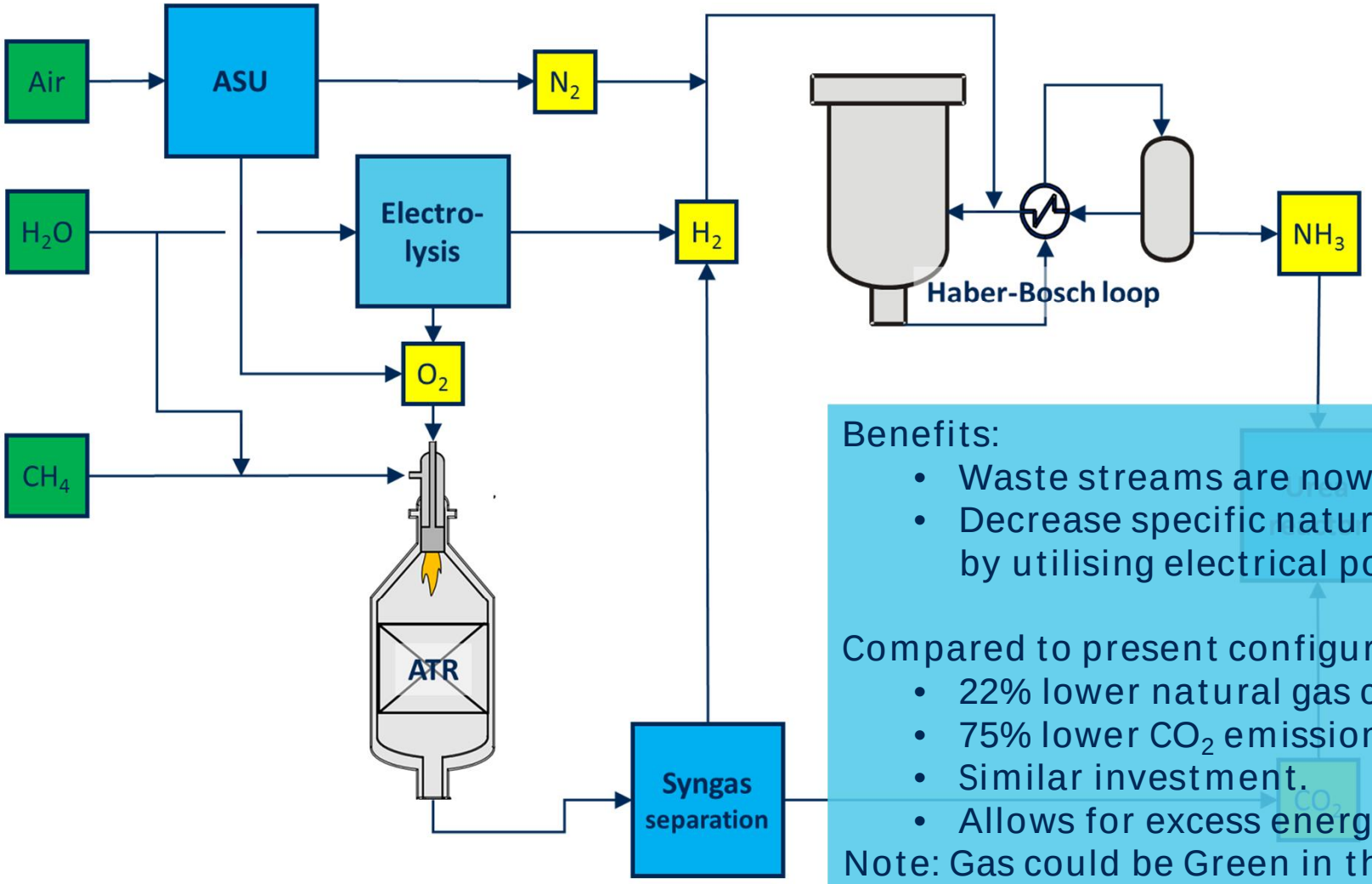
Tomorrow: Hybrid plants for greener ammonia



Benefits:

- Waste streams are now valuable streams.
- Decrease specific natural gas consumption by utilising electrical power.

Compared to present configuration:

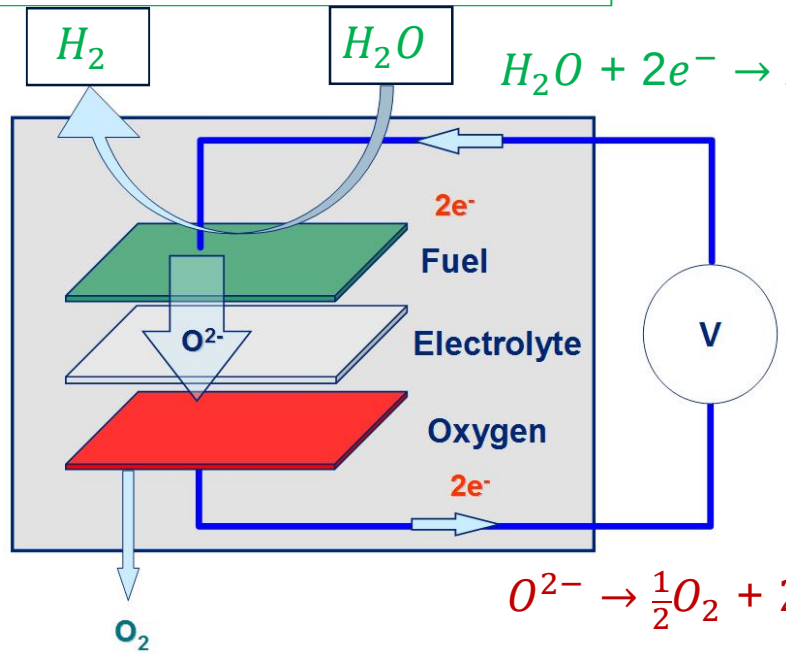
- 22% lower natural gas consumption!
- 75% lower CO_2 emissions in flue gas!
- Similar investment.
- Allows for excess energy storage.

Note: Gas could be Green in the future

H_2O to H_2 via electrolysis process

Electrochemical conversion using **solid oxide electrolysis cell** (SOEC) technology

Electrochemical conversion of H_2O to H_2 at the fuel electrode



$$H_2O + 2e^- \rightarrow H_2 + O^{2-}$$

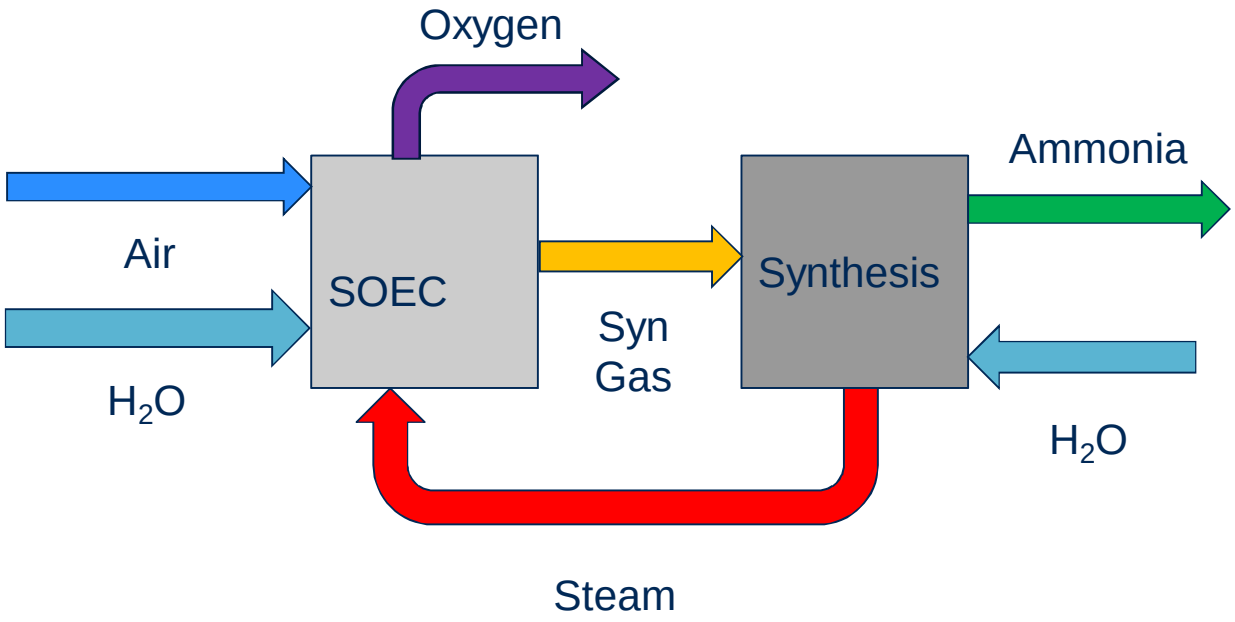
$$O^{2-} \rightarrow \frac{1}{2}O_2 + 2e^-$$

Production of O_2-enriched gas on oxy-side

Overall: $Heat(T\Delta S) + electricity(\Delta G) + H_2O \rightarrow H_2 + \frac{1}{2}O_2$

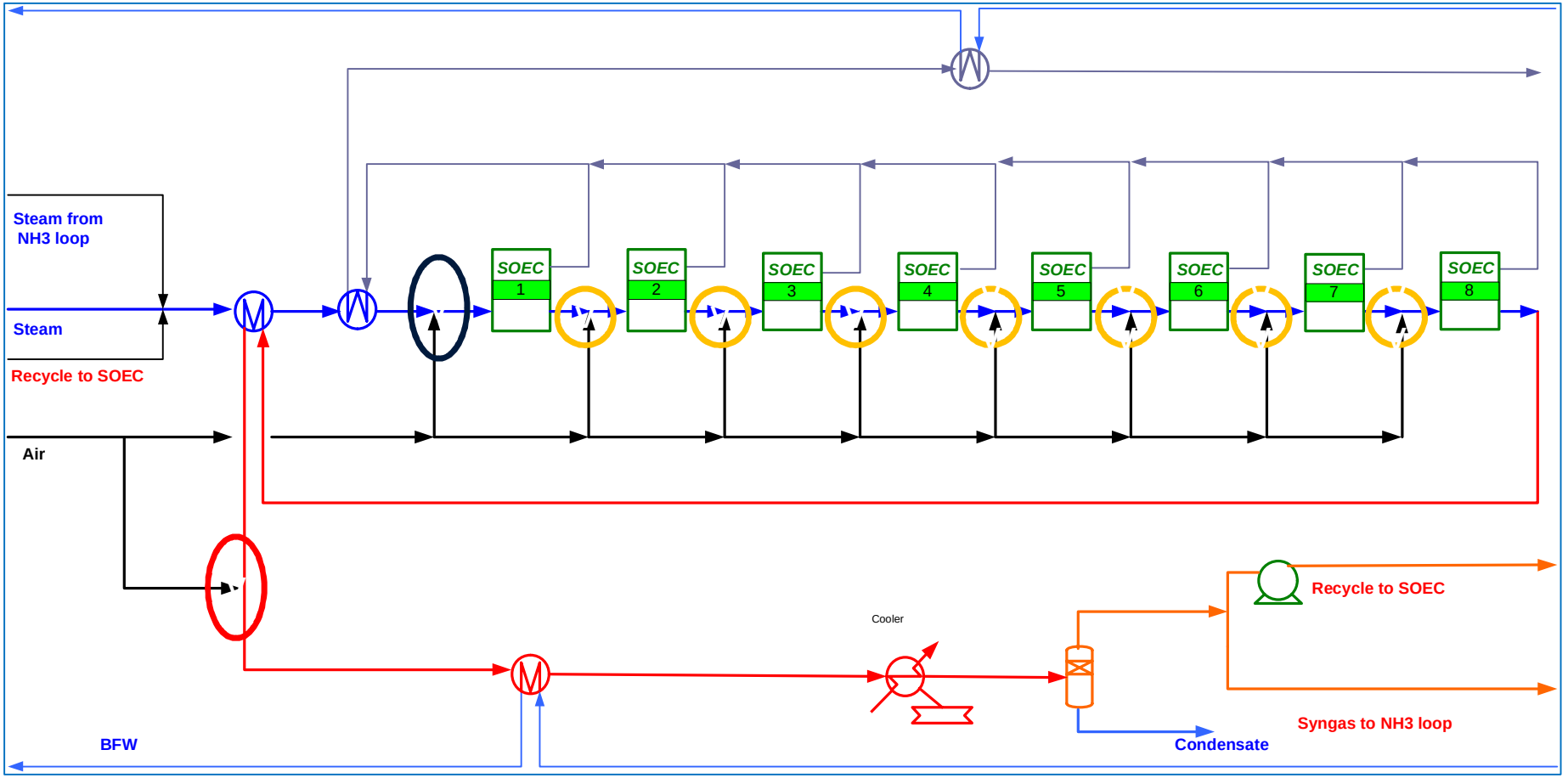
Power-to-X – electrification of ammonia production
Haldor Topsoe's future vision and ambitions

- Electrolysis offers potential to de-couple chemical synthesis from CO_2 emissions
- SOEC is attractive due to its ability to separate oxygen from air and incorporate waste heat to save power resulting in lower investment and higher efficiencies.



Ammonia Synthesis Gas Generation by SOEC without an ASU

Efficiency = 77 % on exergy basis – 71 % on LHV basis



Ammonia electrification road map

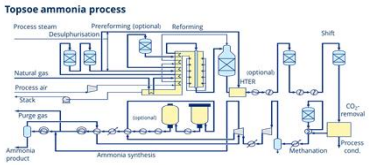
Conventional & SynCor Processes

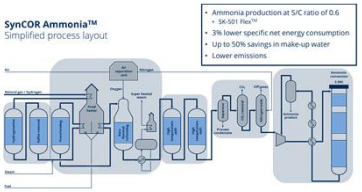
Hybrid revamp solution

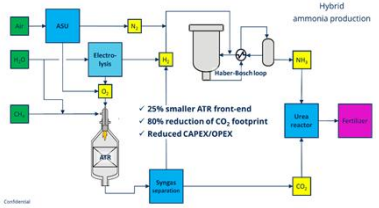
Hybrid grassroots solution

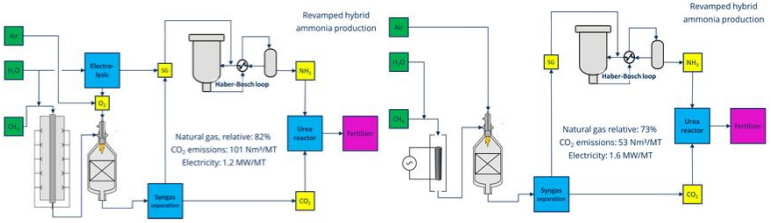
500 – 1000 kg/d SOEC+HB Demo

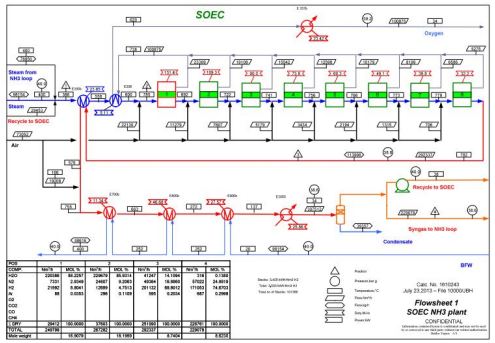
Commercialize Electrolyzer+HB

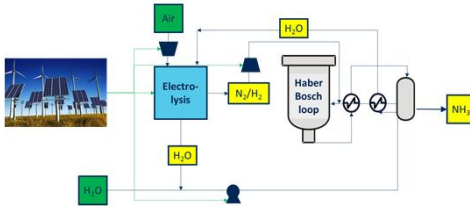












Ammonia Track

2018 2020 2022 2025 2030

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Imagine!
Topsoe's vision: Support sustainability…

1. Ammonia being produced from renewable energy, water and air

2. Ammonia being the preferred energy storage media in the power sector and fuel for heavy duty transportation service

3. Sustainable ammonia being produced cost competitive in world-scale capacities

4. Sustainable ammonia being used to feed the world and to power the world