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

- **Mega conventional**
- **Conventional**
- **Small decentralized**
- **Conventional/modified New**
- **Modified conventional**
- **Completely New technology**
- **Minus CO$_2$**
- **Electrification**
Long-term ambition
World scale ammonia production from air, water and renewable electricity
The hybrid plant solution

- **Fully electrified plant**
- **Wind**
- **Solar**
- **Ammonia**
- **Hybrid plant**
- **Conventional plant**
- **Natural gas**

- 22% lower natural gas consumption!
- 50% increase on overall water electrolysis efficiency!
Revamped hybrid ammonia production

Natural gas, relative: 82%
Electricity: 1.2 MWh/MT
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 CO₂ emissions in flue gas!
- Similar investment.
- Allows for excess energy storage.

Note: Gas could be Green in the future
H₂O to H₂ via electrolysis process
Electrochemical conversion using solid oxide electrolysis cell (SOEC) technology

Electrochemical conversion of H₂O to H₂ at the fuel electrode

H₂O + 2e⁻ → H₂ + O²⁻

O²⁻ → ½O₂ + 2e⁻

Production of O₂-enriched gas on oxy-side

Overall: Heat (TΔS) + electricity (ΔG) + H₂O → H₂ + ½O₂
Power-to-X - electrification of ammonia production
Haldor Topsoe’s future vision and ambitions

- Electrolysis offers potential to **de-couple chemical synthesis from CO₂ 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

Commercialize Electrolyzer+HB

500 – 1000 kg/d SOEC+HB Demo

Ammonia Track

- 2018
- 2020
- 2022
- 2025
- 2030
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