Green Ammonia by Haldor Topsoe

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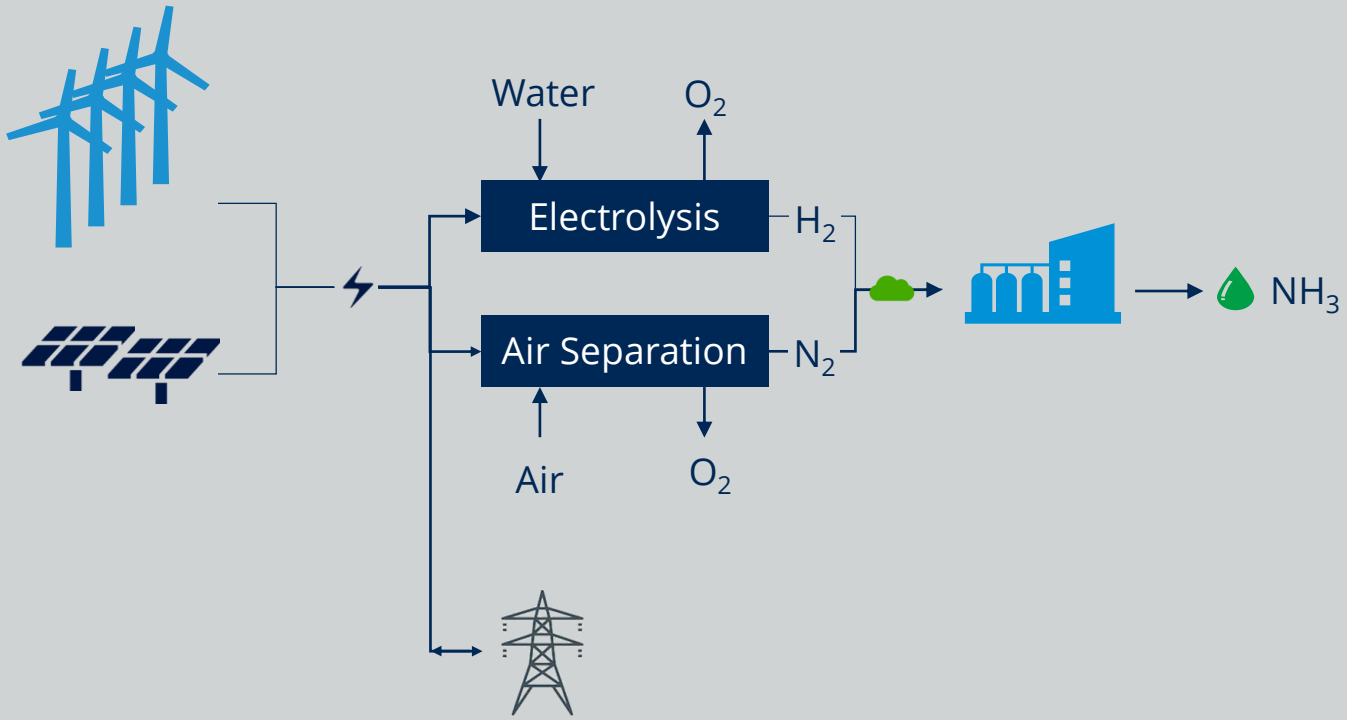
Power-to-ammonia
Dynamic operation by Topsoe

Decreasing capital investment cost
From renewable energy to electrolysis to synthesis

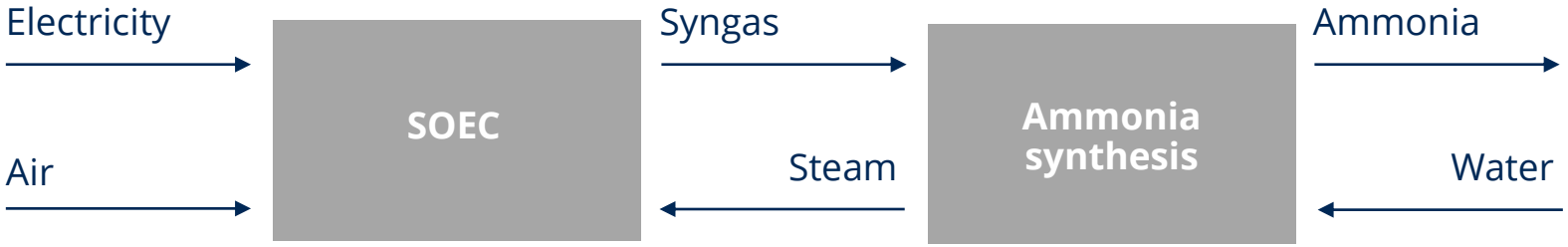


Advantages
Power-to-ammonia

- Fully flexible operation 10-100% plant load
- No hydrogen storage
- Store energy as NH3
- Grid balancing

Green Ammonia by SOEC (Solid Oxide Electrolysis Cell)

Synergy between SOEC and synthesis

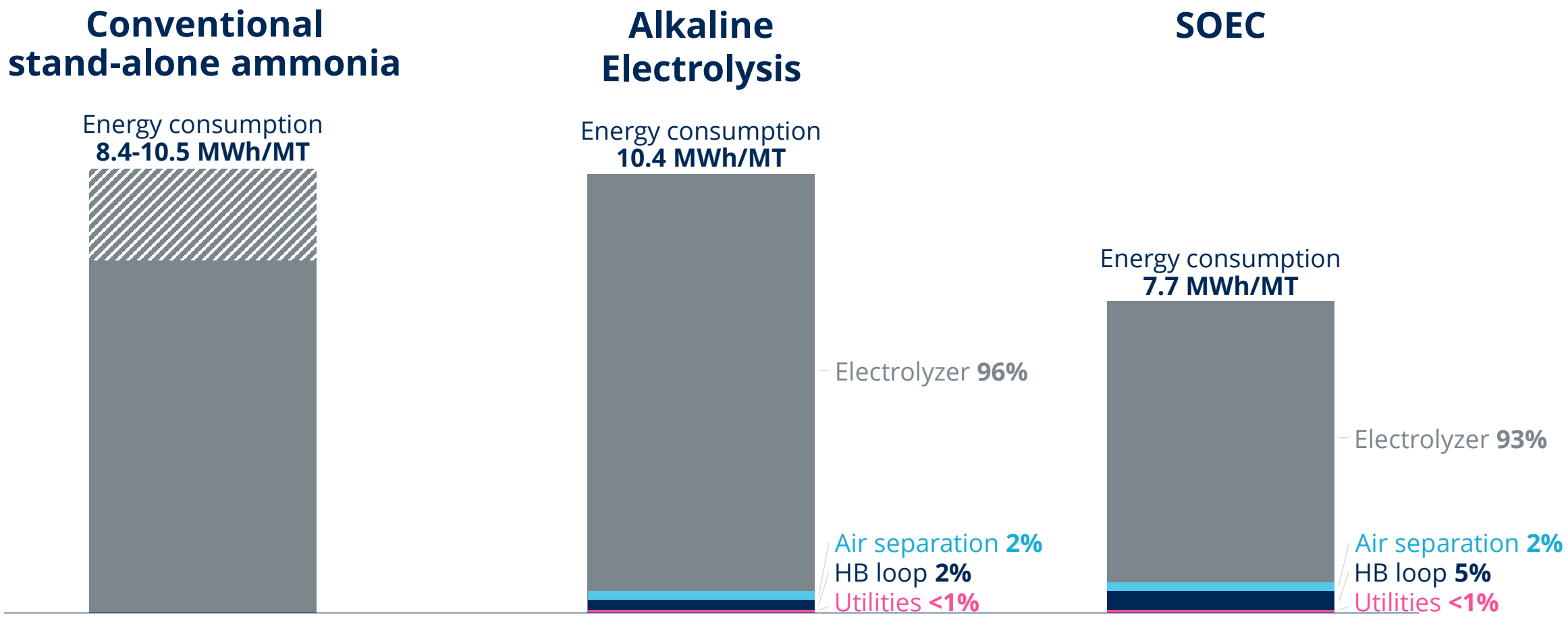


- SOEC more efficient than classical electrolysis
  - Internal waste heat used to split water
  - Also works as air separation unit
- Ammonia synthesis waste heat
  - Steam production
- SOEC is steam electrolysis
  - This is new and more efficient!

Presented by John B. Hansen in AIChE 2017

Classical alkaline electrolysis compared to SOEC

New Benchmark for specific energy consumption: SOEC4NH3



HALDOR TOPSOE

Green ammonia
Main challenges

- Renewable electricity cost
- Capacity factor of renewable electricity
- CAPEX of electrolysis

- Will there be a premium or incentive for a green product?
- CO_2 tax?
- How to get started with green ammonia?