PERSPEKTIVER I GRØN AMMONIAK—TIL TRANSPORT FUEL OG GØDNING?

AARHUS UNIVERSITY
DEPARTMENT OF ENGINEERING

DANSK BIOØKONOMI KONFERENCE, SAKSKØBING
25 SEPTEMBER 2019

EMIL DRAZEVIC
ASSISTANT PROFESSOR

OM MIG

2014- Phd, Zagreb Universitet, Kroatien

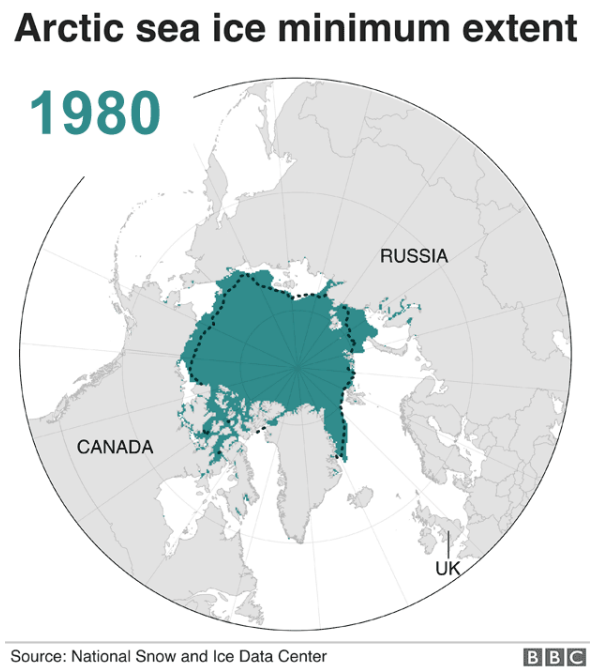
Transport of non-ionized organics through reverse osmosis and nanofiltration membranes

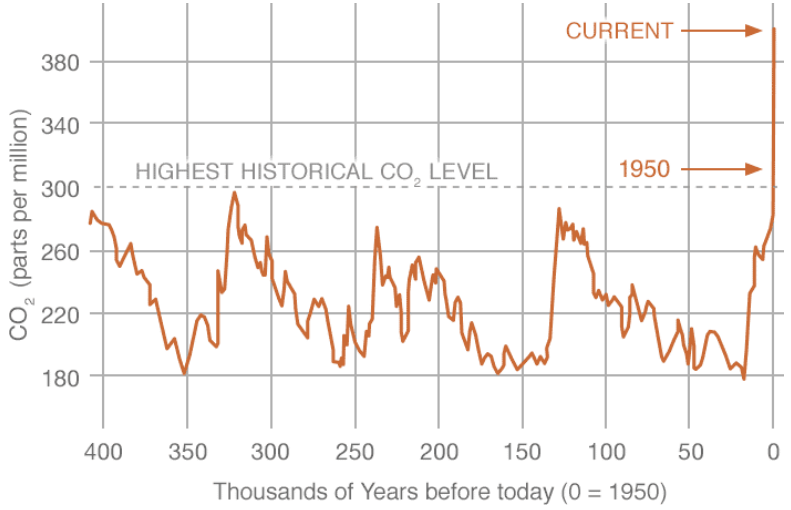
2015-2017- Marie Sklodowska Curie IF fellowship (1.4 mil DKK) til projekt"*All organic redox flow batteries*"

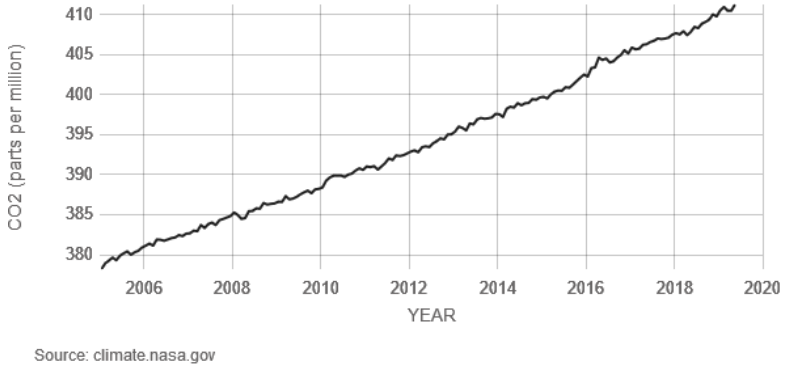
2018- Tenure Track Assistant Professor- Power to Chemicals Group

BCE-Electrochemical Engineering

KILMAFORANDRING







Antropocene-menneskes tidsalder, vores påvirkning af jorden har ændret klima!

HVORDAN KAN VI REDUCERE KONCENTRATION AF CO2?

$$CO_2\ payback\ time[years] = \frac{CO_2\ emitted\ manufacturing[tonnes]}{CO_2 saving[\frac{tonnes}{year}]}$$

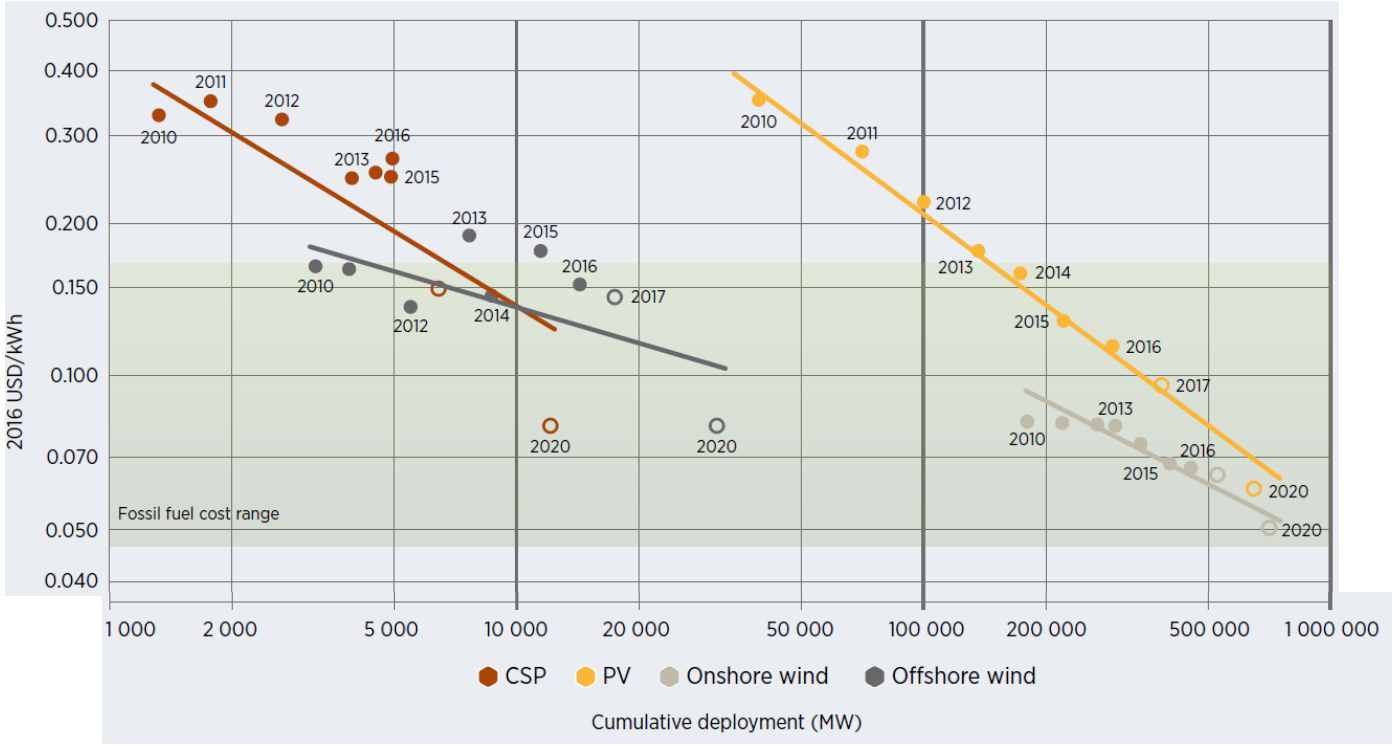
Where $CO_2 saving\left[\frac{tonnes}{year}\right] = Energy\ produced[\frac{MWh}{year}] \times 0.43[\frac{tonnes}{MWh}]$

CO_2 payback time < 3 år

CO_2 payback time < 10 år

Vi kan mindske vores CO_2 udledning med brug af vedvarende energi kilder!

HVAD ER PRISEN AF VEDVARENDE ENEGI?

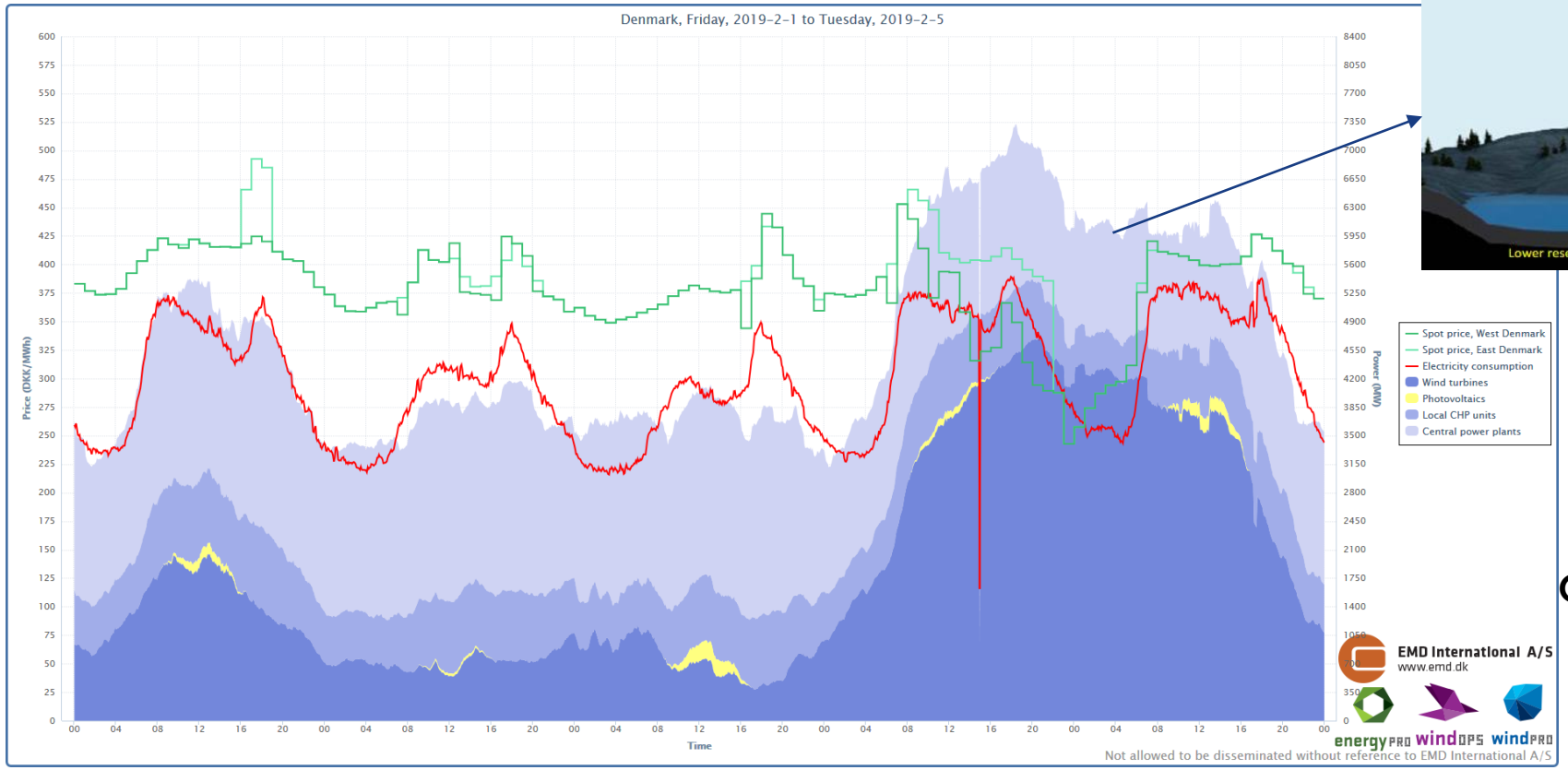


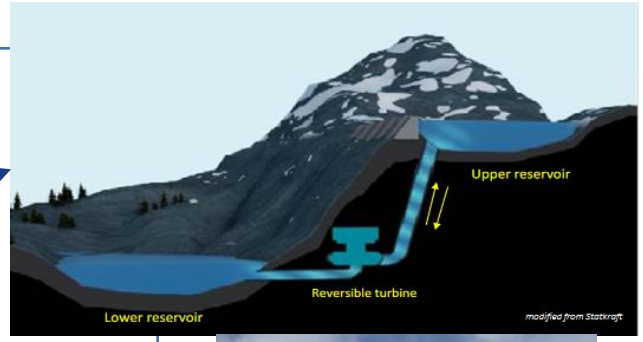
Kilde: Renewable Power Generation Costs in 2017 (International Renewable Energy Agency)

- Prisen af vedvarende energi er næsten det samme som den af fossil brændstoffer
- Priserne stadigvæk falder ned
- Folk vil have en forandring, en mere bæredygtig brug af vores ressourcer

KAN DET LADE SIG GØRE MED VEDVARENDE ENERGY?

Vinter 2019, Februar

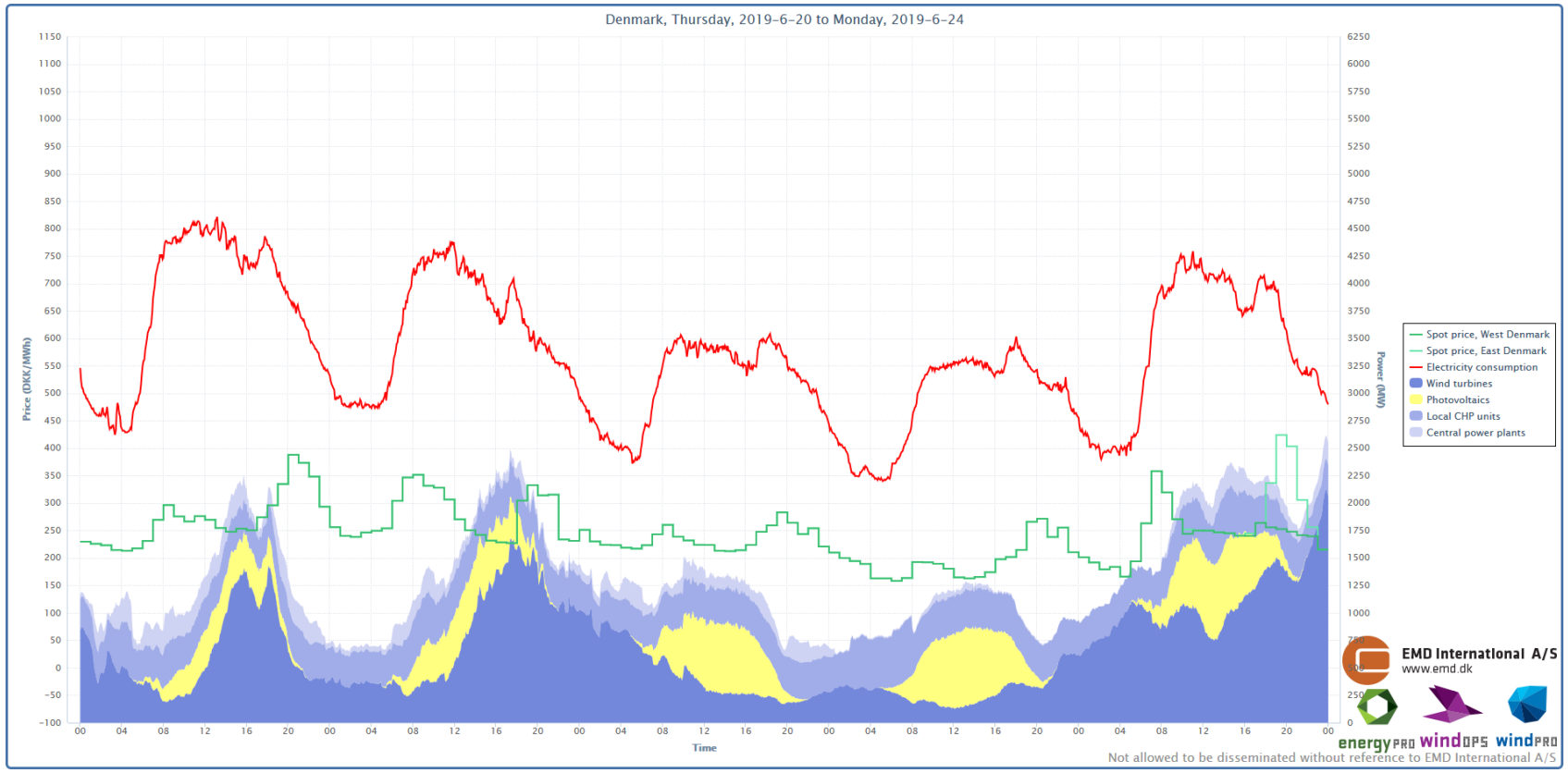




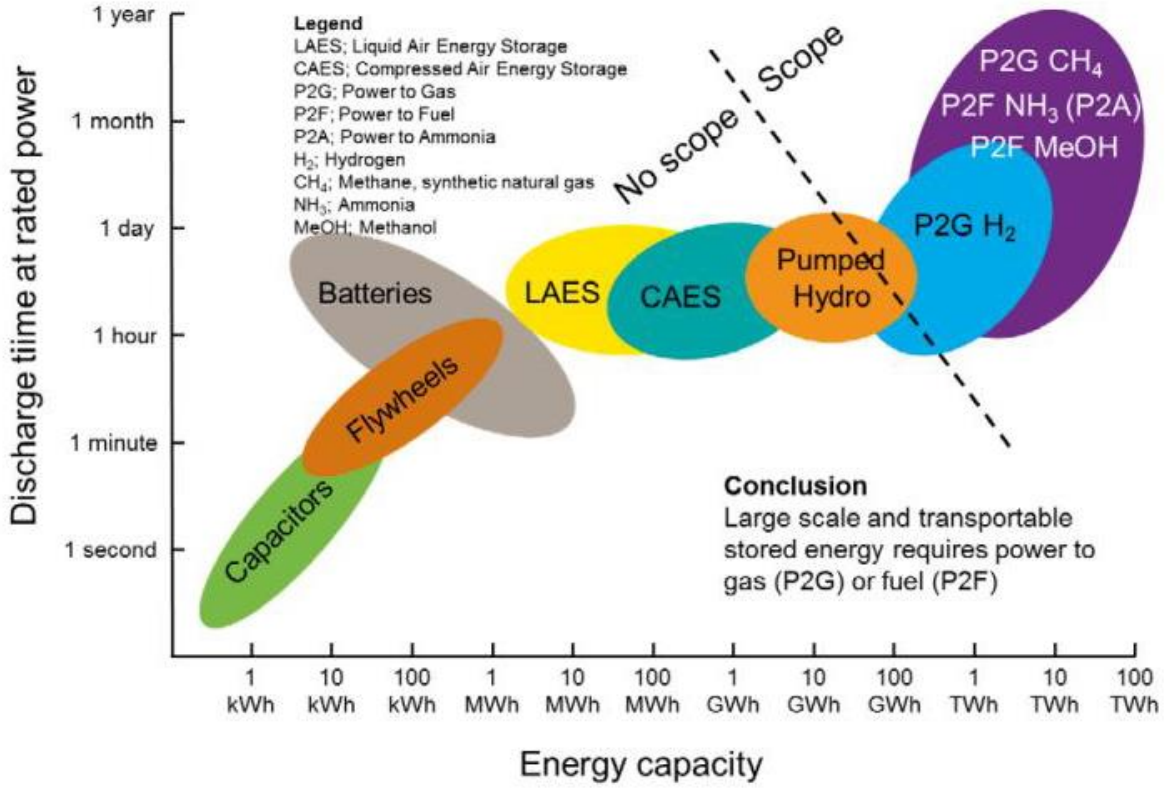
Omkring 56 TWh af PHES i EU

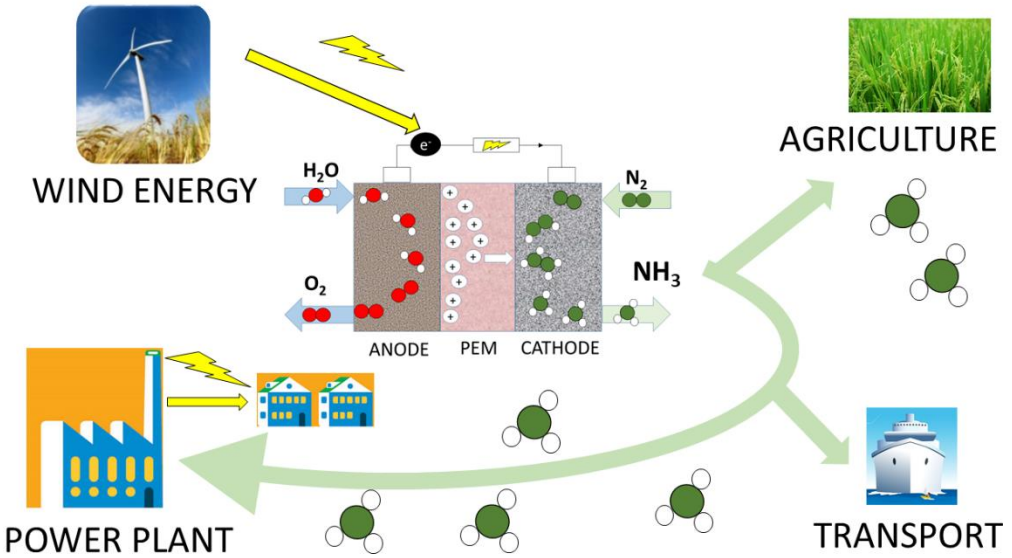
Assessment of the European potential for pumped hydropower energy storage, European Comission, 2013

Summer 2019, Maj



ENERGI LAGRING TEKNOLOGIER

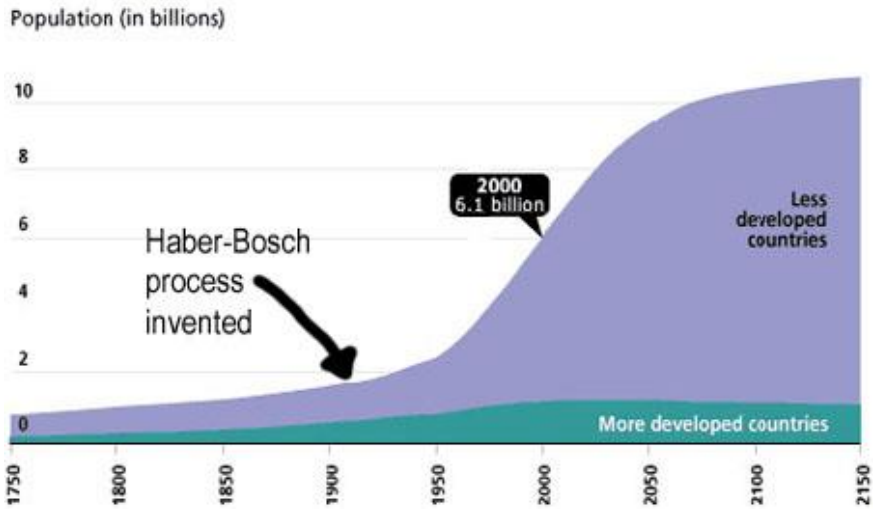




STATE-OF-THE-ART SORT AMMONIAK PROCES

- Haber-Bosch-1% CO_2 emission
- 1 MWh/tone ammoniak fremstillet

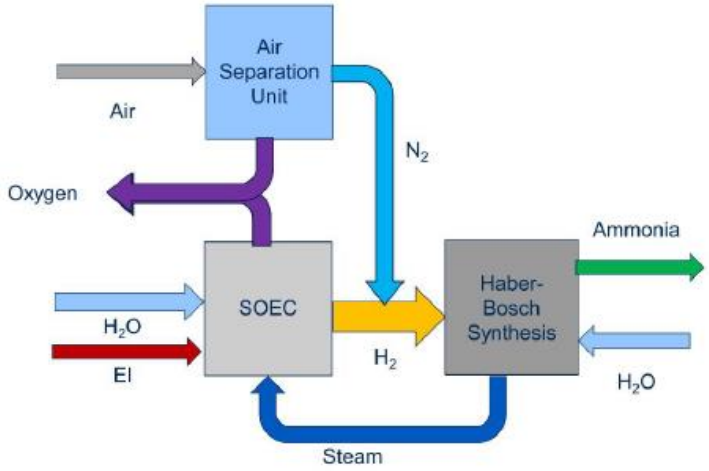
$$N_2 + H_2 \xrightleftharpoons{catalyst,\ 450°C,\ 200\ bar} NH_3 \qquad \Delta H = -92\ \text{kJ/mol}$$

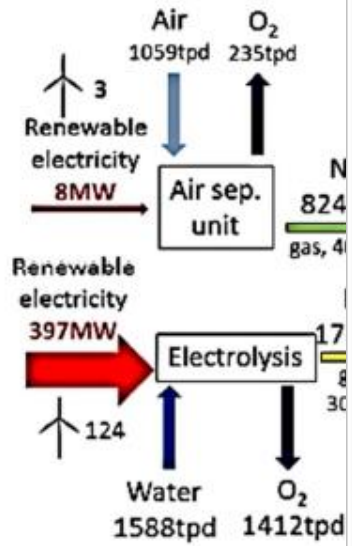


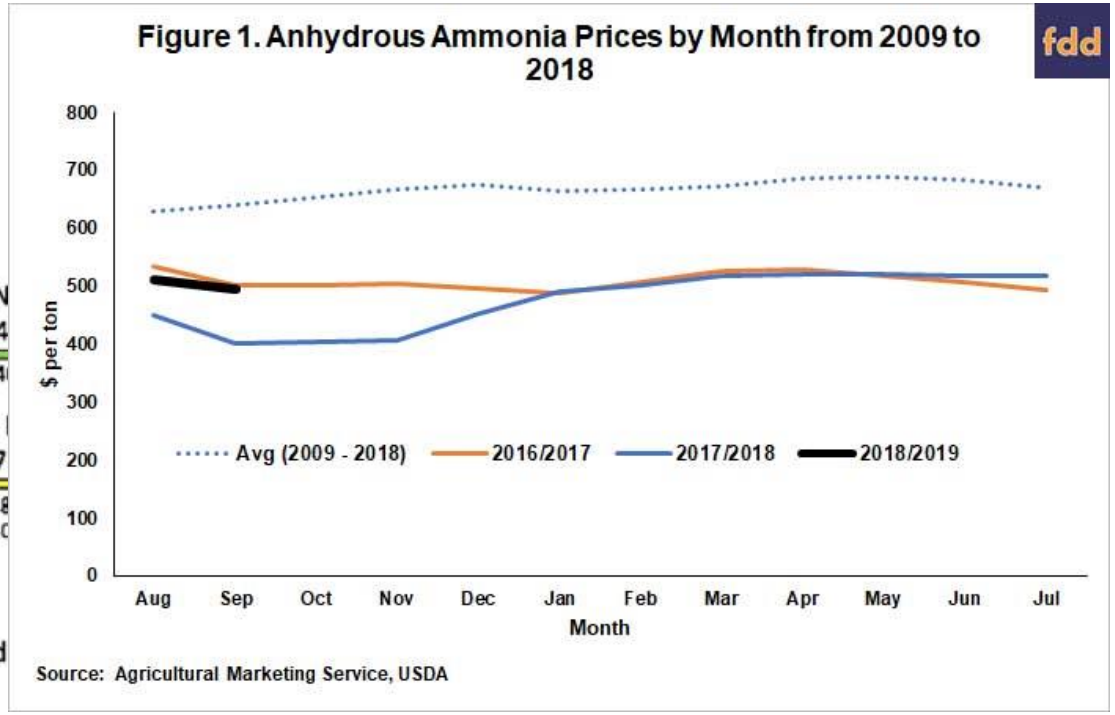
METAN som en meget BILLIG brint kilde!

STATE-OF-THE-ART GRØN AMMONIAK

- Ikke nogen 1% CO_2 emission
- 1 MWh/tone ammoniak fremstillet

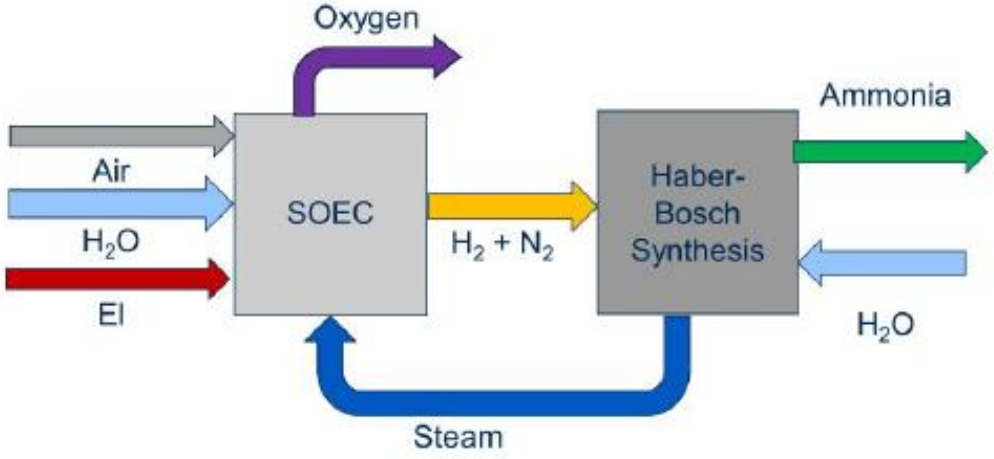






Vand og vedvarende energi som en brint kilde med energi forbrug op til 235$/ton!

EUDP PROJEKT SOC4NH3 (HTAS, AU, DTU, VESTAS, ØRSTED)

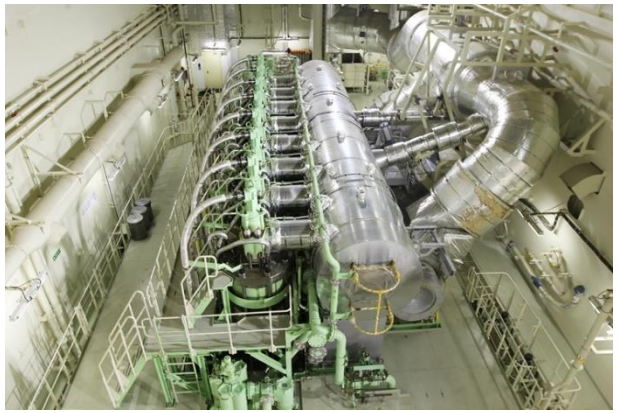


- Haldor Topsøe fast oxid elektrolyser celle.
- Energi forbrug omkring 0.73 MWh/ton NH_3 (171$/ton)
- Der er ikke brug for air-separation enhed
- Kommercialisering dog 5-10 år tid –afhænger meget af energi pris og CAPEX

AMMONIAK ANVENDELSER

Gødning

Brændstof



https://www.ammoniaenergy.org/university-of-minnesota-demonstrates-efficient-ammonia-dual-fuel-engine-system/

AMMONIAK SOM BRÆNDSTOF

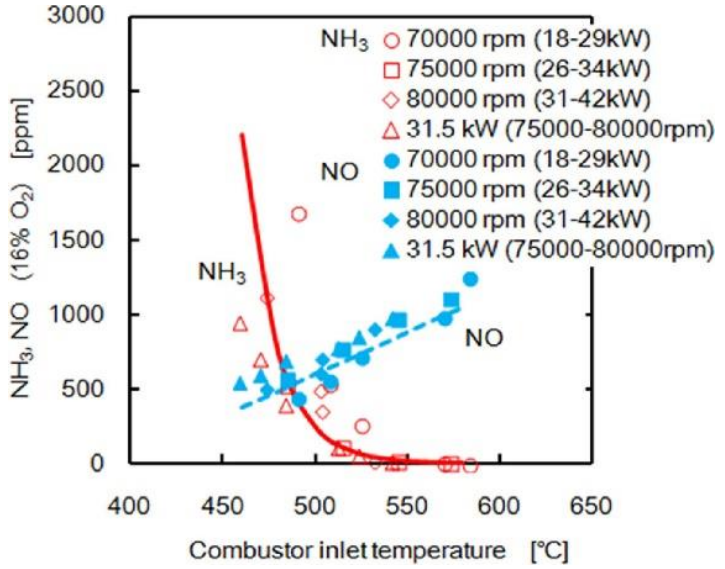
- En god energi inhold(4.7 kWh/L)) dog 3 gange lavere end diesel
- Motoren kan godt køre på ren ammoniak men der er behøv for diesel fordi motoren ikke kan starte selv på ren ammoniak
- NOX som sideprodukt-største ulempe
- Forventes at det bedst fungerer som blanding mellem diesel og ammoniak

$$2NH_3 + 3/2O_2 \rightarrow N_2 + 3H_2O$$

$$4NH_3 + 3O_2 \rightarrow 4NO + 6H_2O$$

$$2NH_3 \xrightarrow{varme} N_2 + 3H_2$$

$$2H_2 + O_2 \rightarrow 2H_2O$$



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