From CO_2 til Fuel using fuel cells

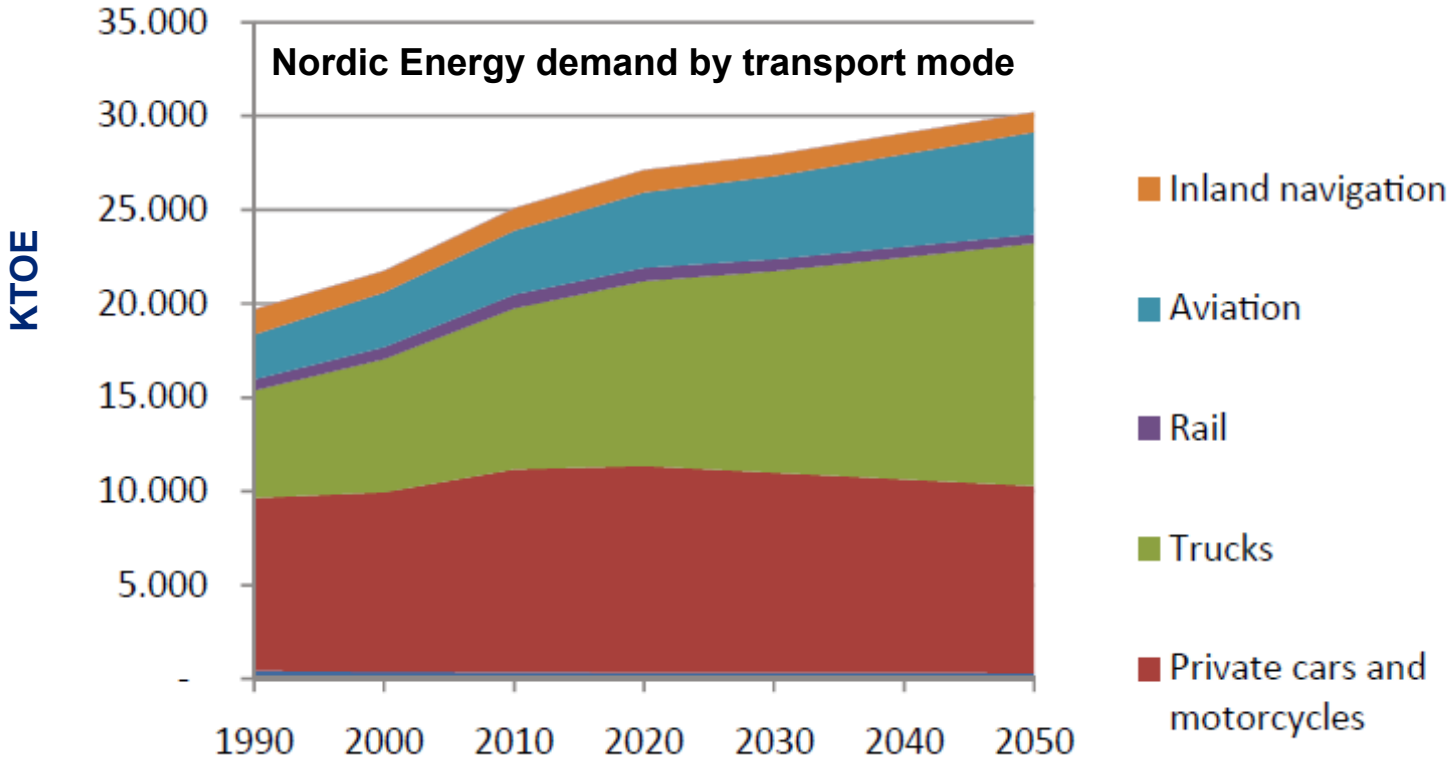
RESEARCH | TECHNOLOGY | CATALYSTS

Claus Friis Pedersen

Outline

- Why Fuel from CO_2 (CO_2 Electrofuels)
- The Nordic Energy Research project and partners
- Infrastructure and Feedstock
- Solid Oxide Electrolysis
- Summary

Future transportation energy demand



Heavy transportation will account for the majority of the transportation energy demand

The road to sustainable fuels?

Source

Storage

Application

Battery Performance?
Biofuel Availability?

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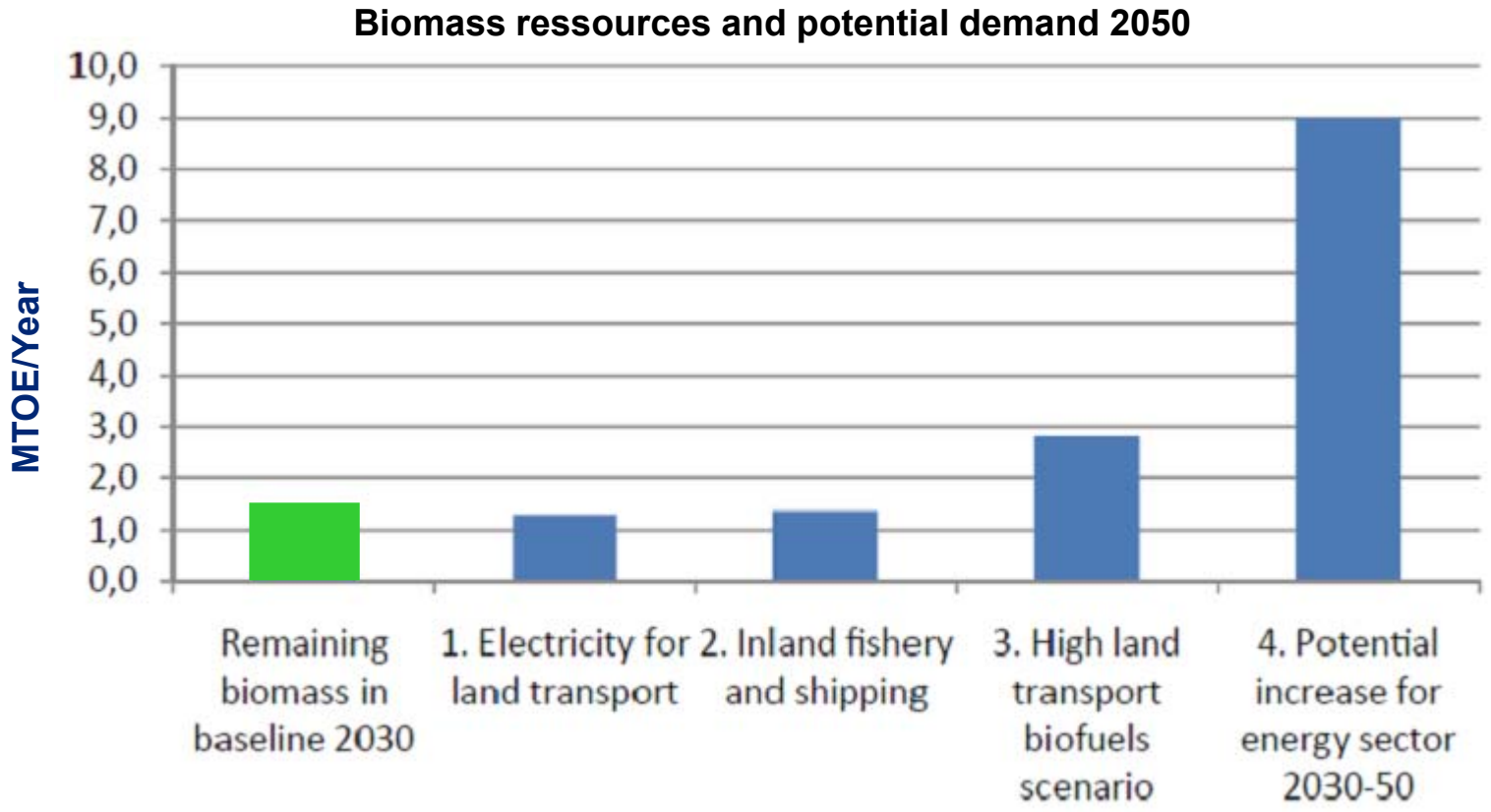
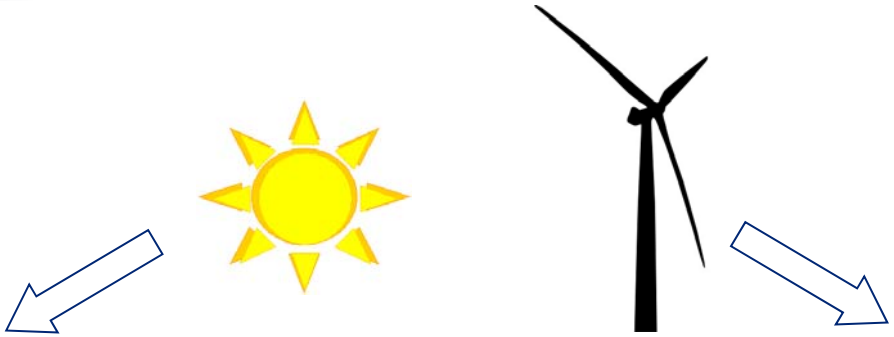
Biomass availability and demand



The Challenge…

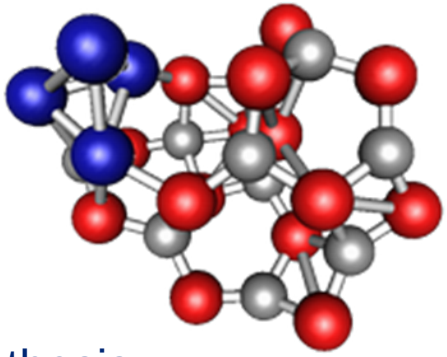
Ragnarock Int. Conference on Climate Changes, 23 June, 2009, Milan, Italy
Claus Krog Ekman

Introducing CO2 Electrofuels



Electrolysis

Gasification



Fuel Synthesis

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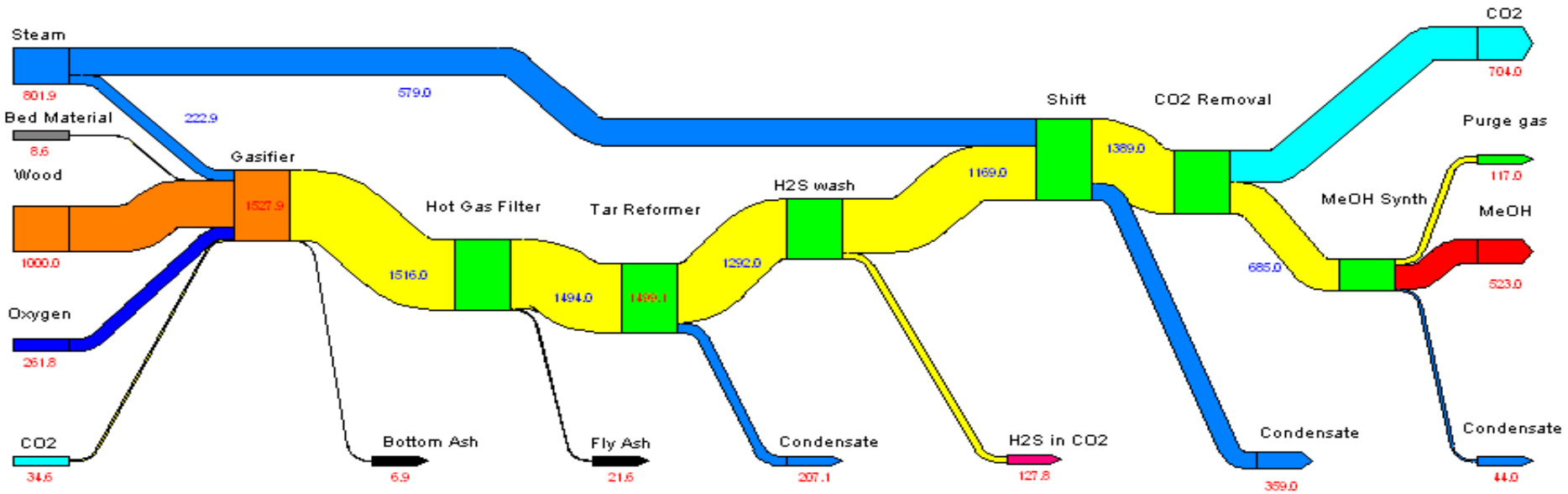
Traditional Wood to MeOH

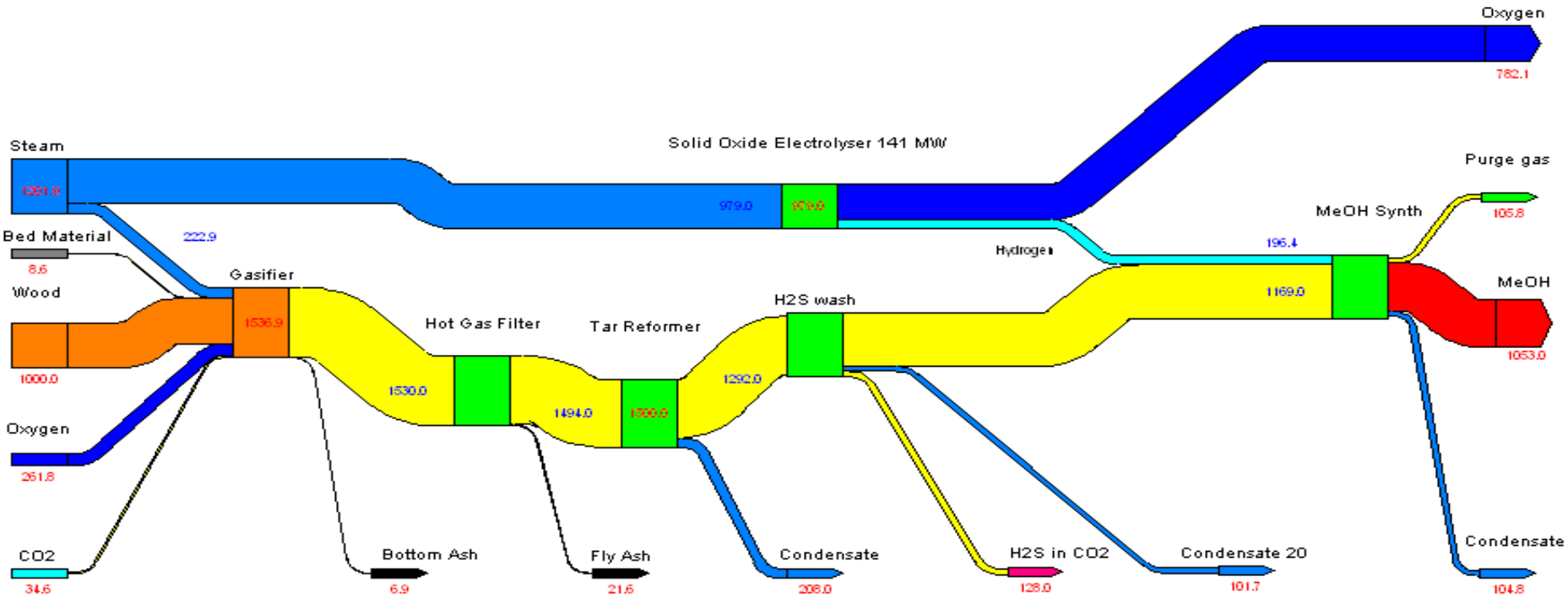


Mass balances for Wood Gasification to MeOH

Flows in Metric Tons per day

Carbon surplus in biomass…..

CO_2 Electrofuels Wood to MeOH



Mass balances for combined Wood Gasification and SOEC to MeOH

Flows in Metric Tons per day

Output is doubled. Oxygen is for free

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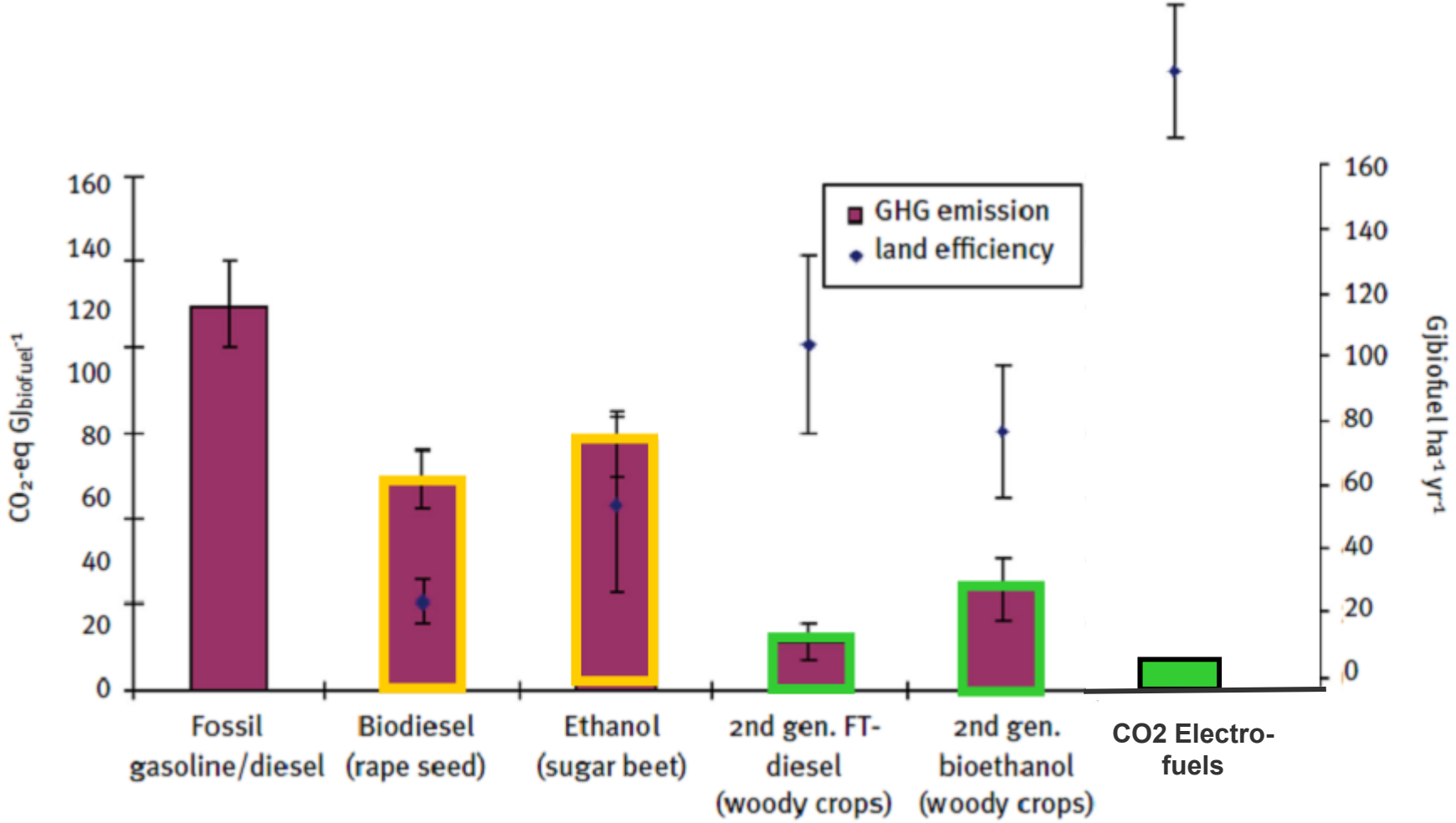
A third generation biofuel?



The CO_2 Electrofuel Project

VOLVO e.on CHEMREC

Energy to Succeed

Nýsköpunarmiðstöð Íslands

Olíudreifing

SORPA Flokkum og skilum

WÄRTSILÄ

Ea Energy Analyses

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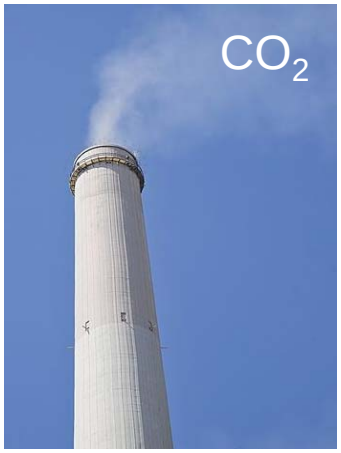
DTU

Is CO_2 electrofuels a viable and competitive technology for the Nordic countries?

Nordic Project Background



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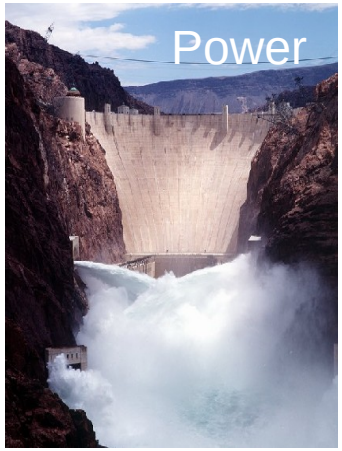
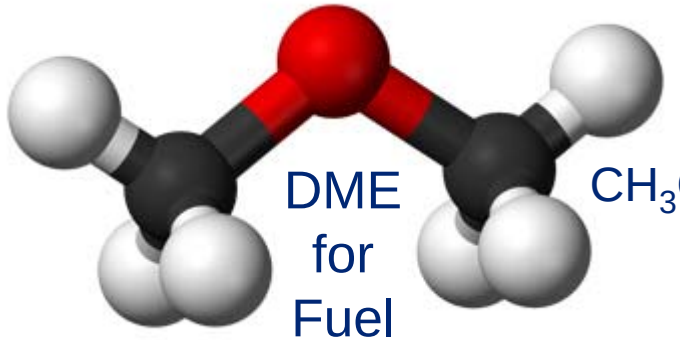


Further studies required on:

- DME infrastructure
- Feedstock, electricity, CO_2, water & steam etc.
- Reduction of electrolysis CAPEX & OPEX

⇓

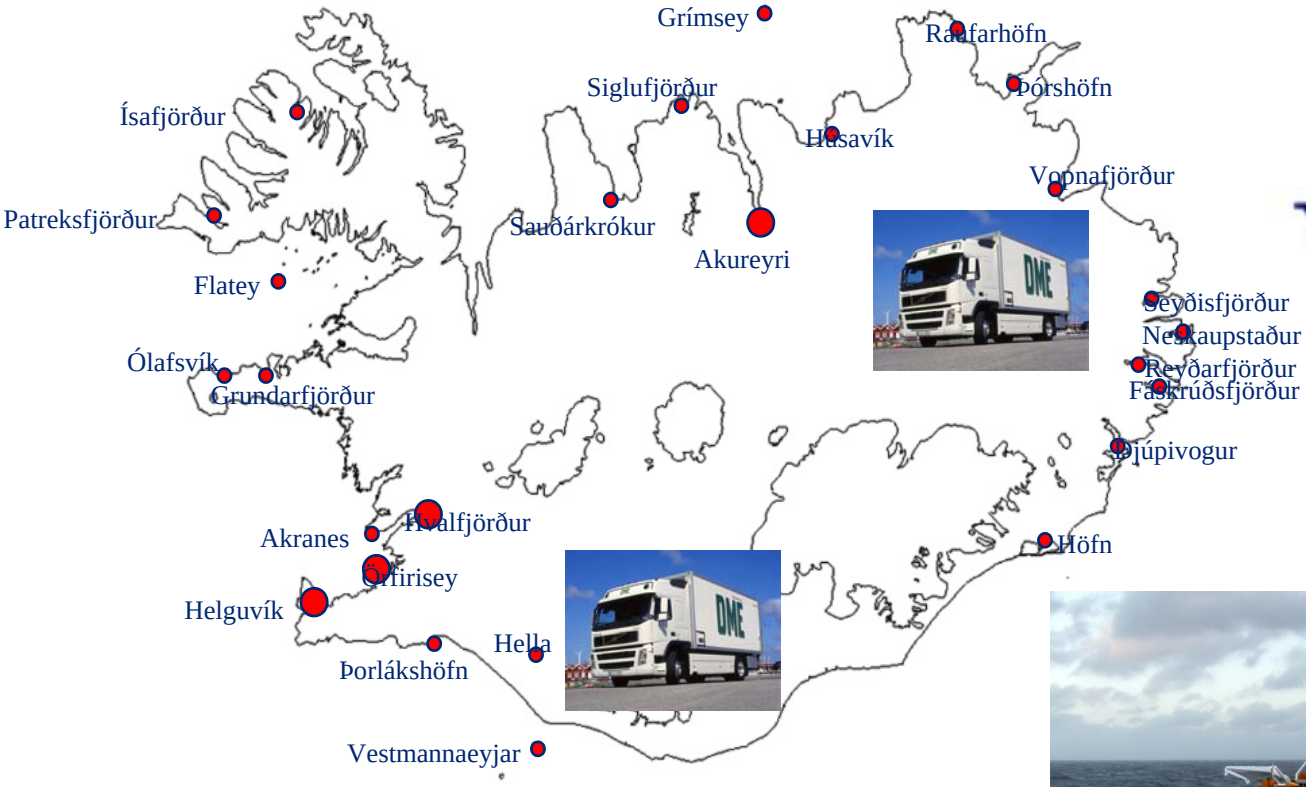


Infrastructure

Olíudreifing

WÄRTSILÄ

VOLVO



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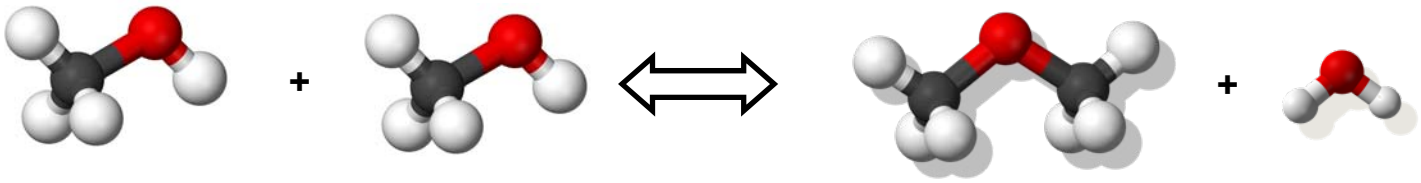
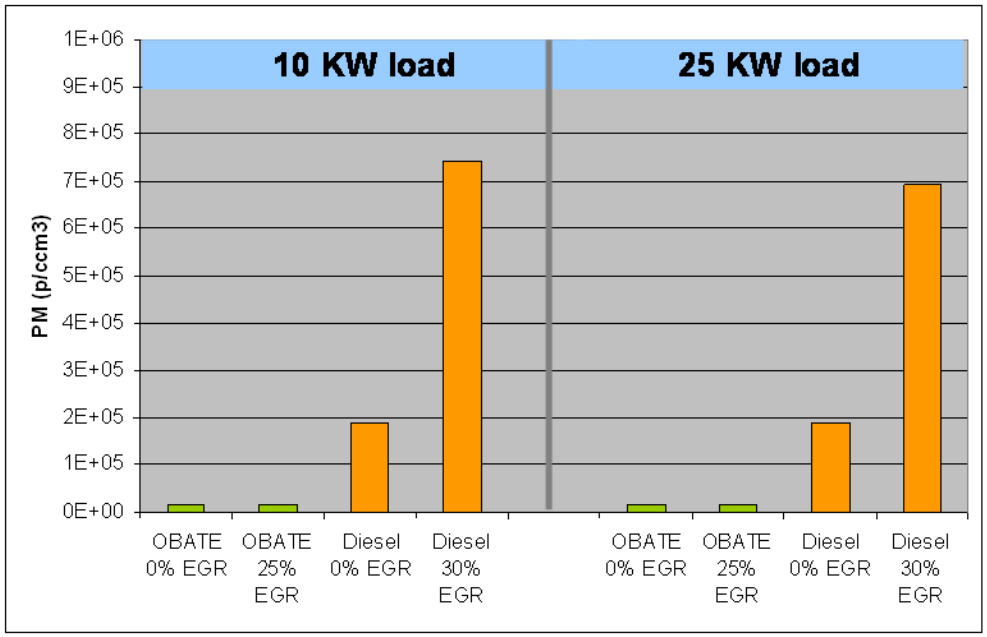
On board Methanol to DME conversion



Methanol DME H_2O



Methanol is easy to store and transport

DME is an excellent 'Diesel' fuel

Feedstock analysis

CO_2

CHEMREC
Energy to Succeed

SORPA
Flokkum og skilum

Power

e·on

Ea Energy Analyses

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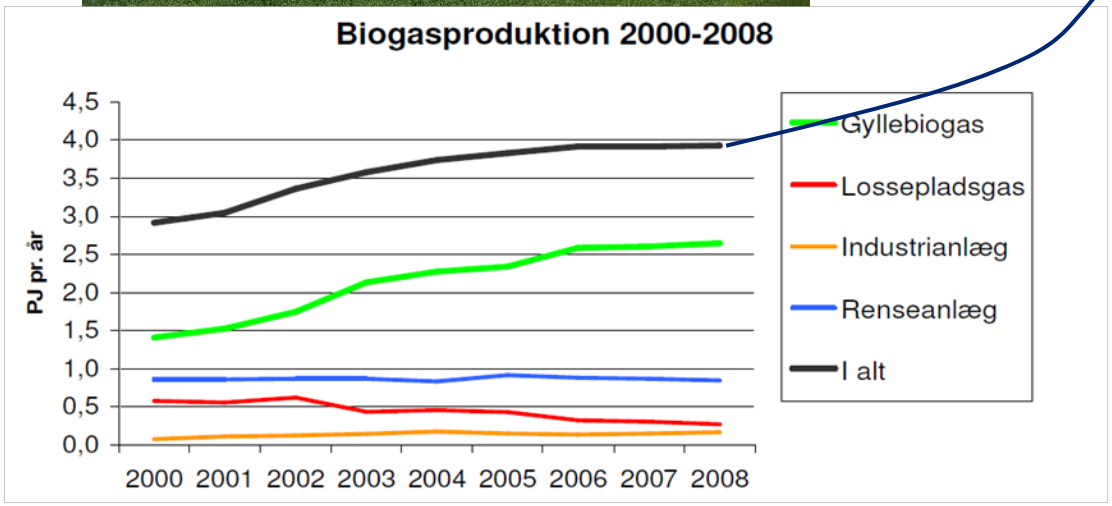
Biogas in Denmark



19 PJ target in 2020

Total potential estimated to 40 PJ

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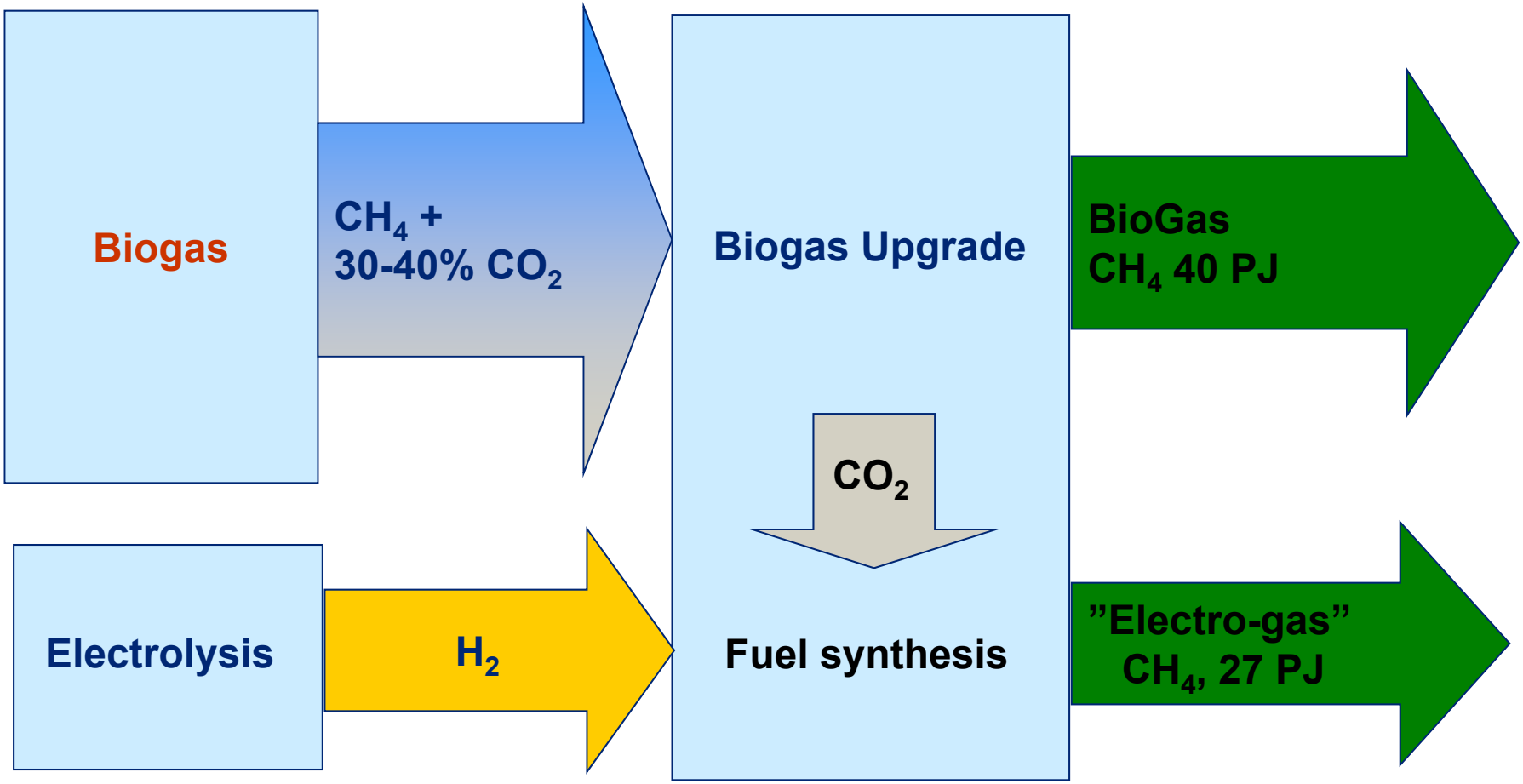
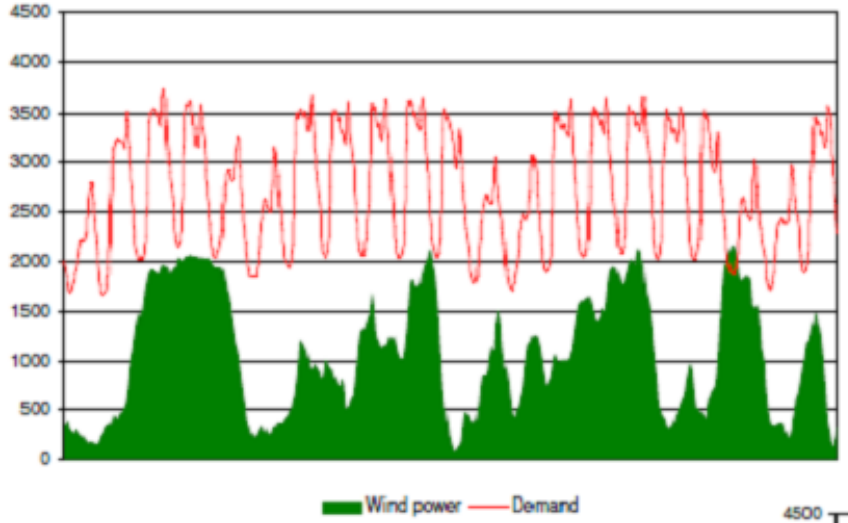
Upgrading to from CHP to pipeline quality



65% more with CO_2 electro-gas……..

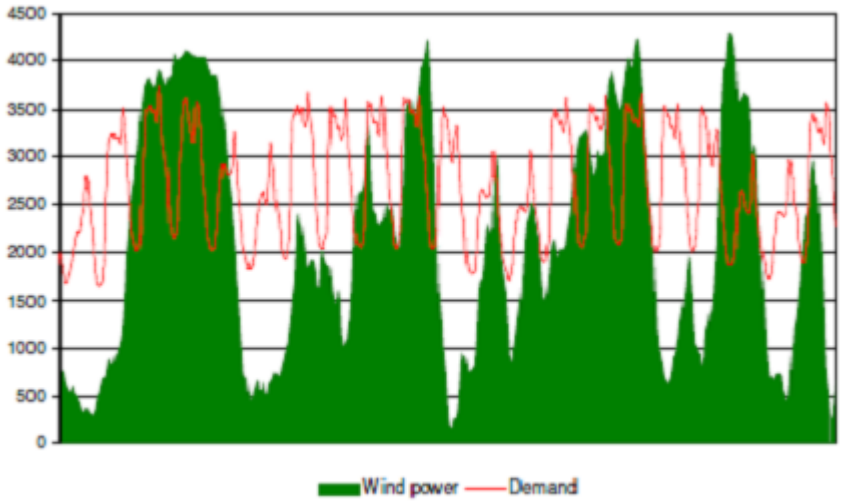
Load balancing issues



DK West January 2008

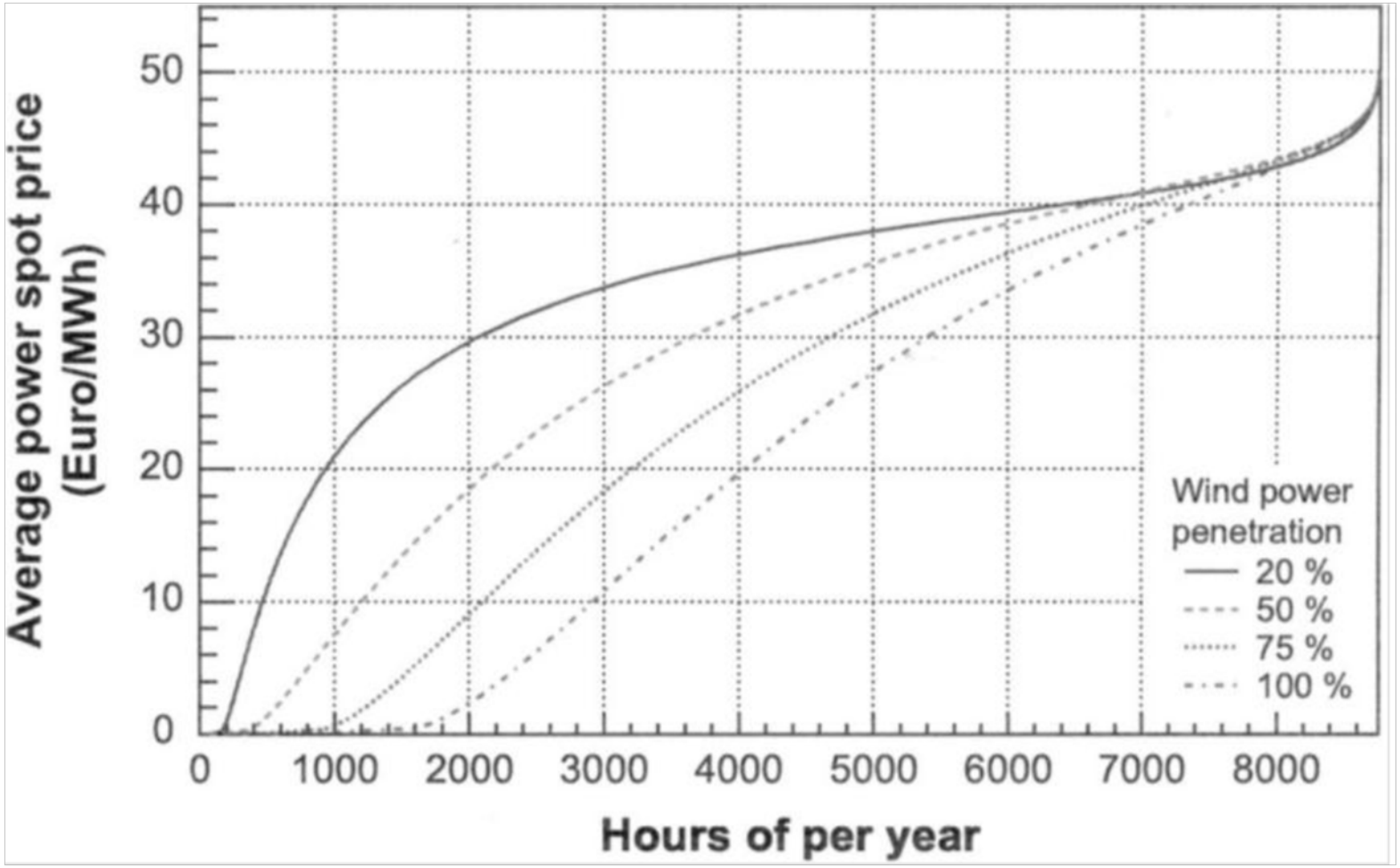
Demand

Windpower



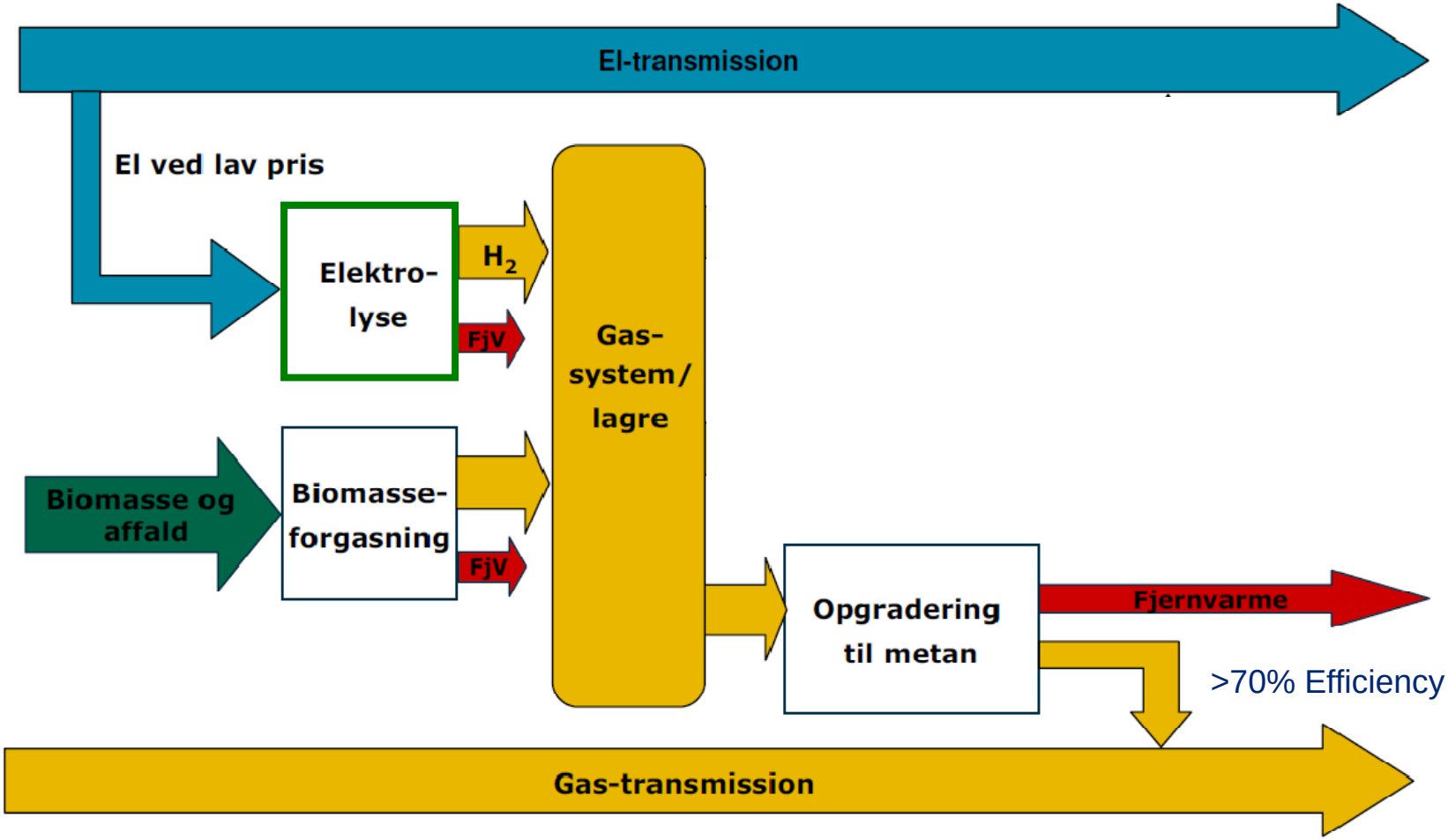
January 2008 + 3,000 MW

Future trends in electricity cost distribution



Claus Jørgensen, S. R. (2008). Production price of hydrogen from grid connected electrolysis in a power market with high wind penetration. *International Journal of Hydrogen Energy*(33), pp. 5335-5344.

A possible energy infrastructure



ENERGINET.DK

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Solid Oxide Fuel Cells & Electrolysis

650 – 800 °C

CO
H_2

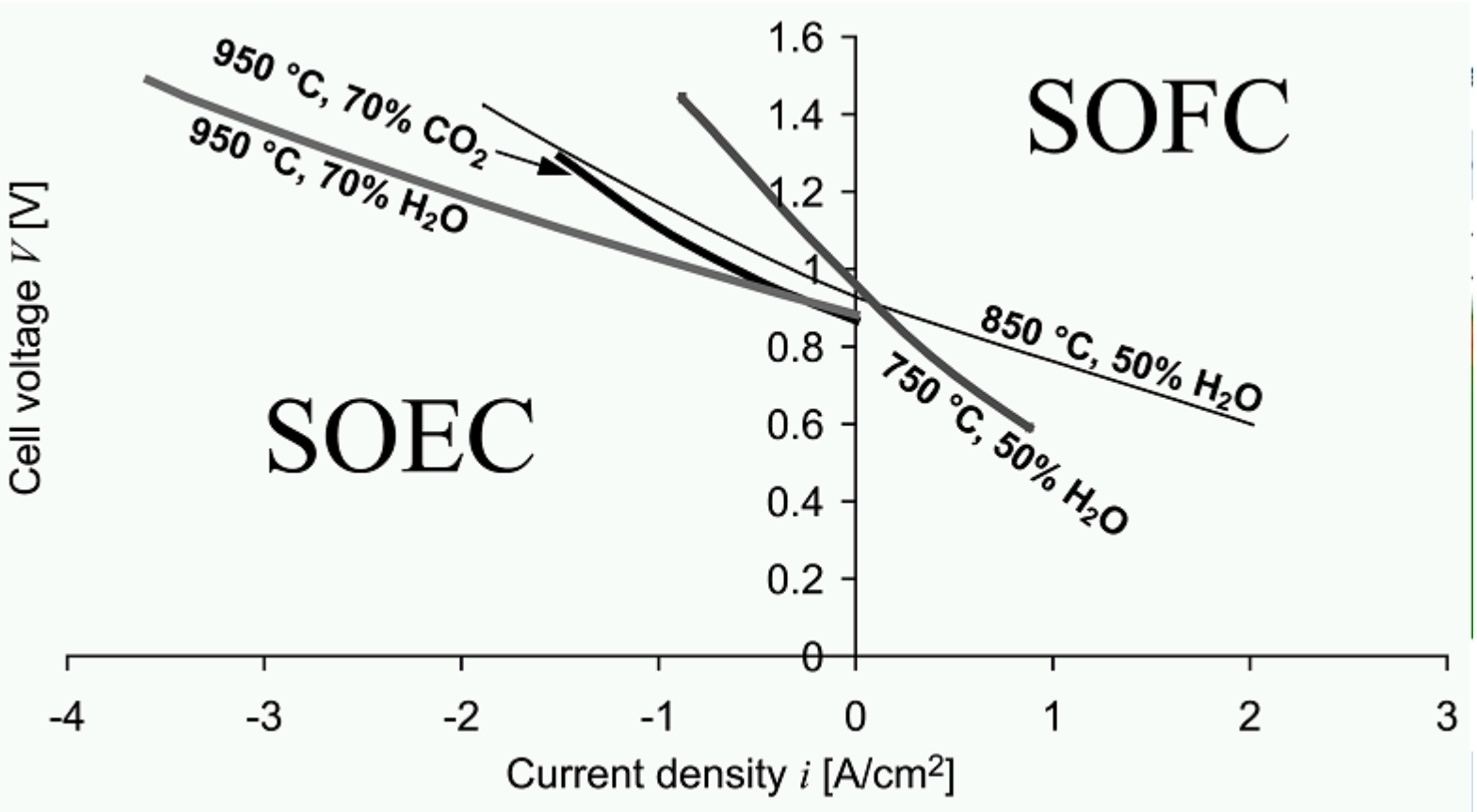
CO_2
H_2O

CH_4

CO
H_2

CO_2
H_2O

Solid Oxide I-V curves



No Kinks and same slope
Higher current in SOEC mode

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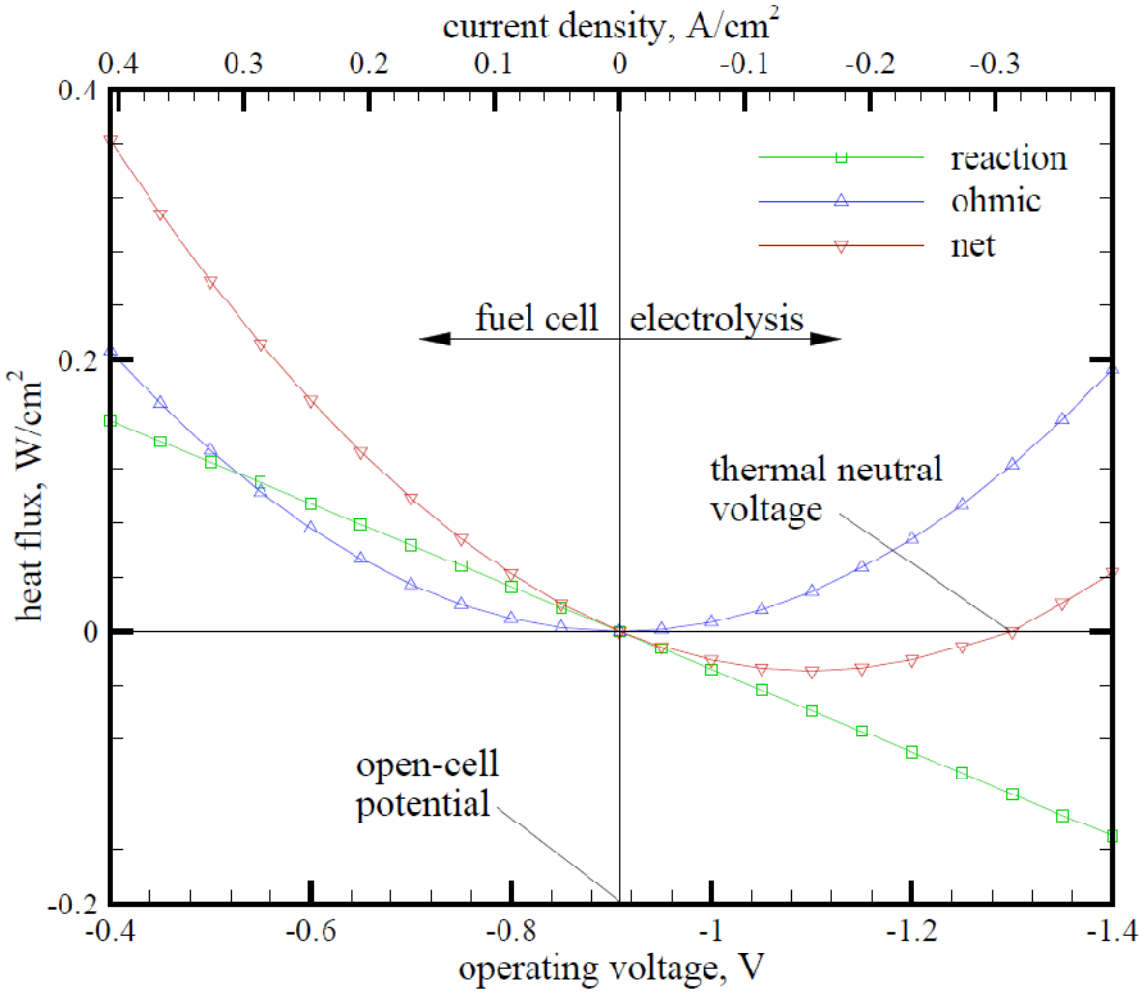
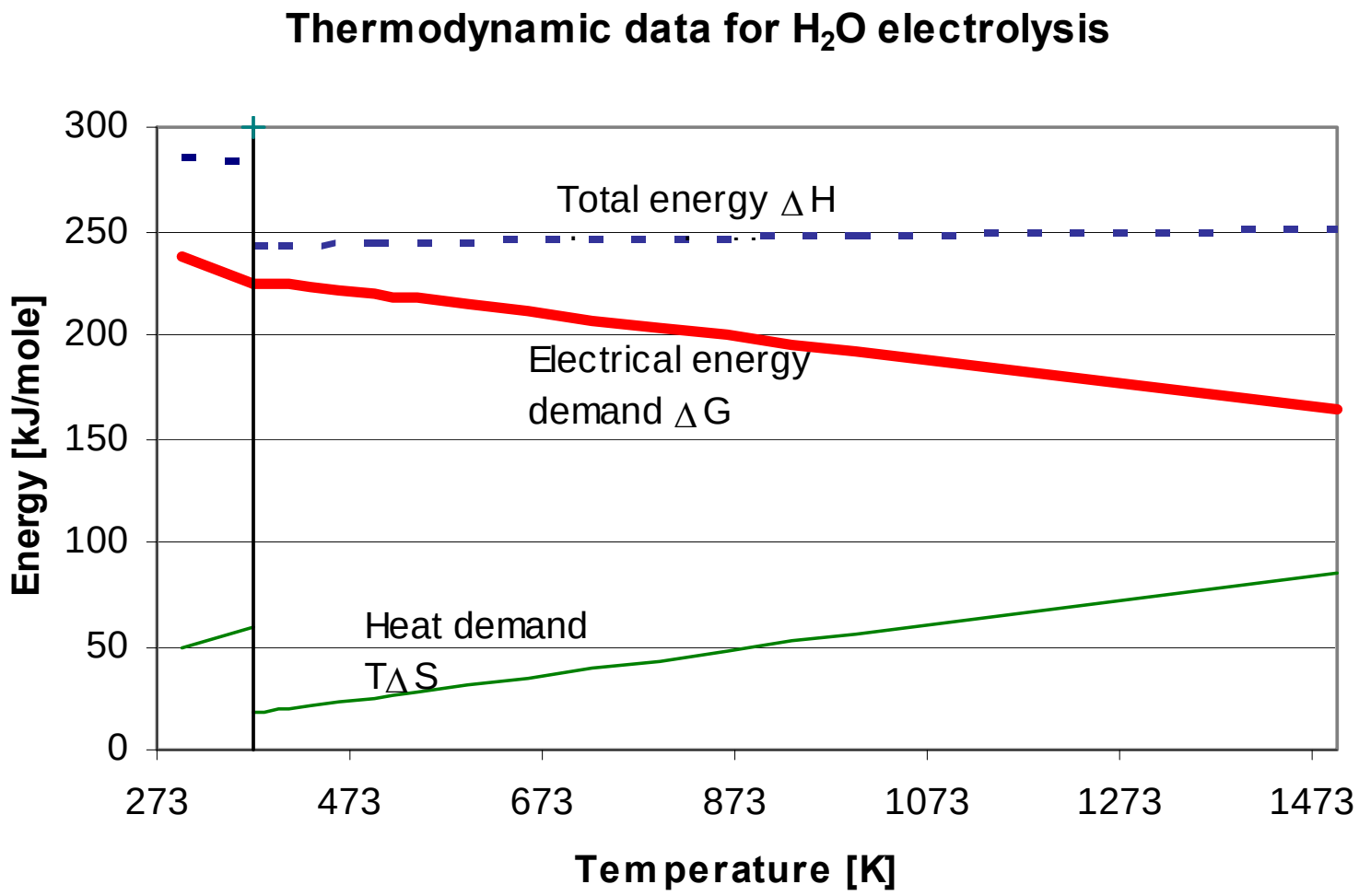
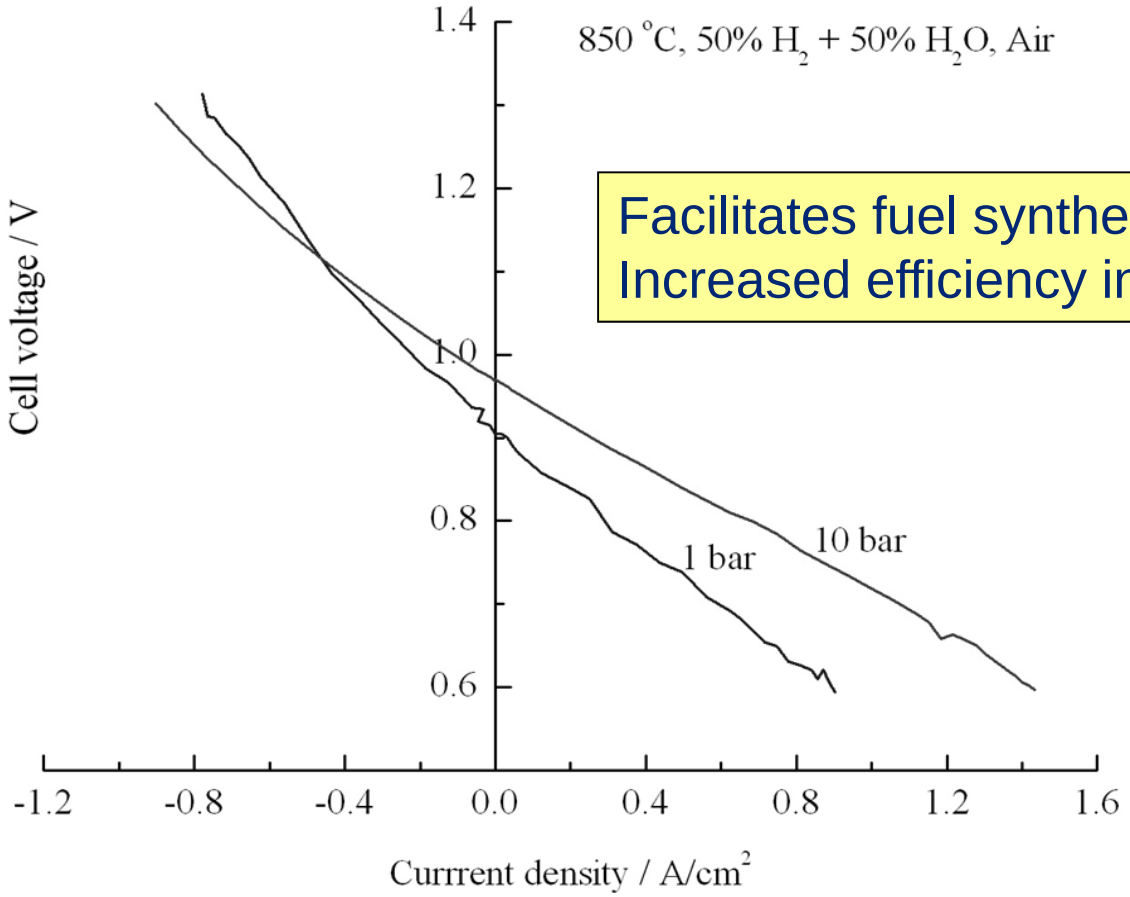
Heat in SOFC and SOEC mode



High electrolysis efficiency at high temperature

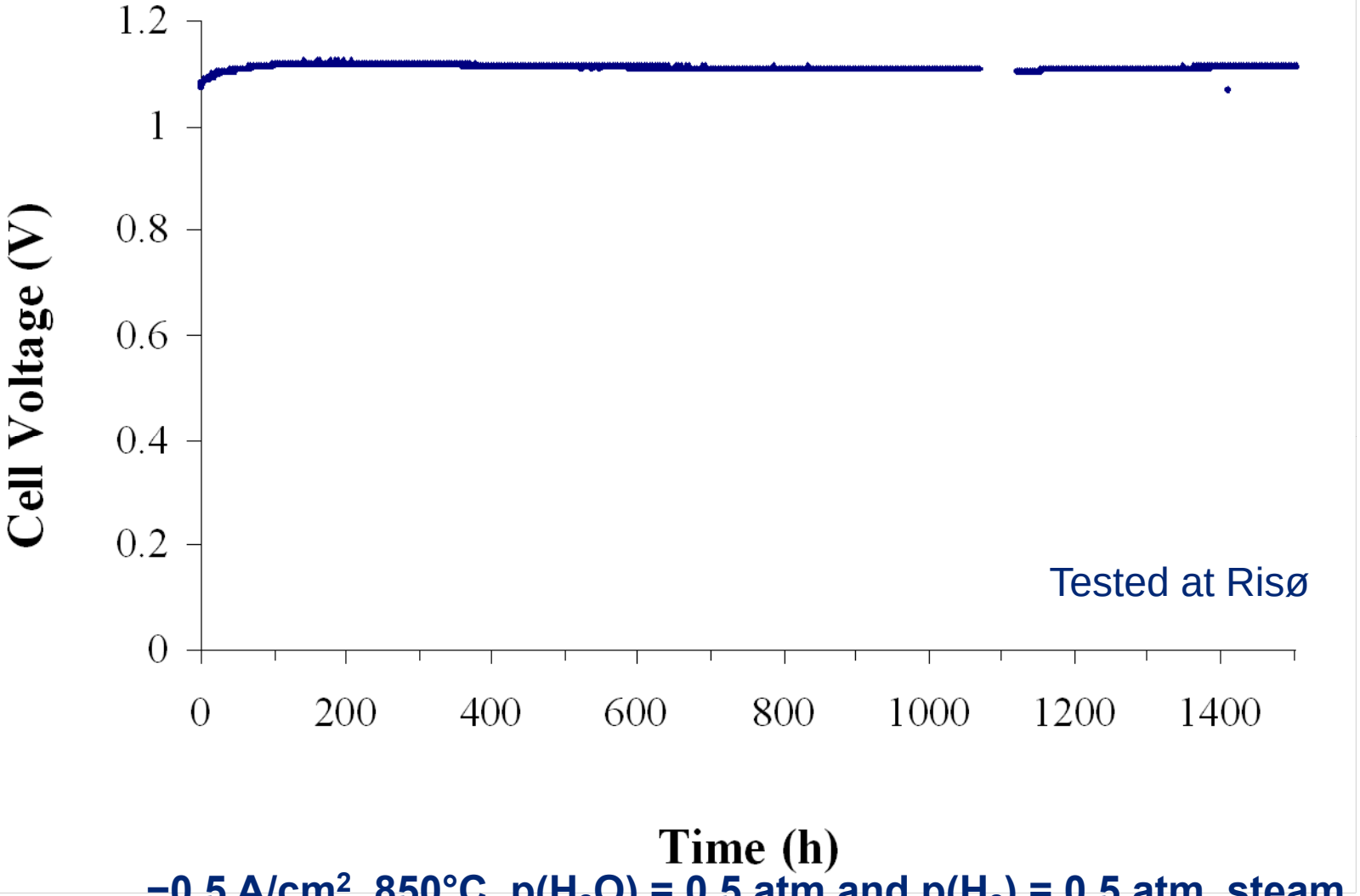


High pressure operation



Facilitates fuel synthesis in SOEC mode
Increased efficiency in SOFC mode

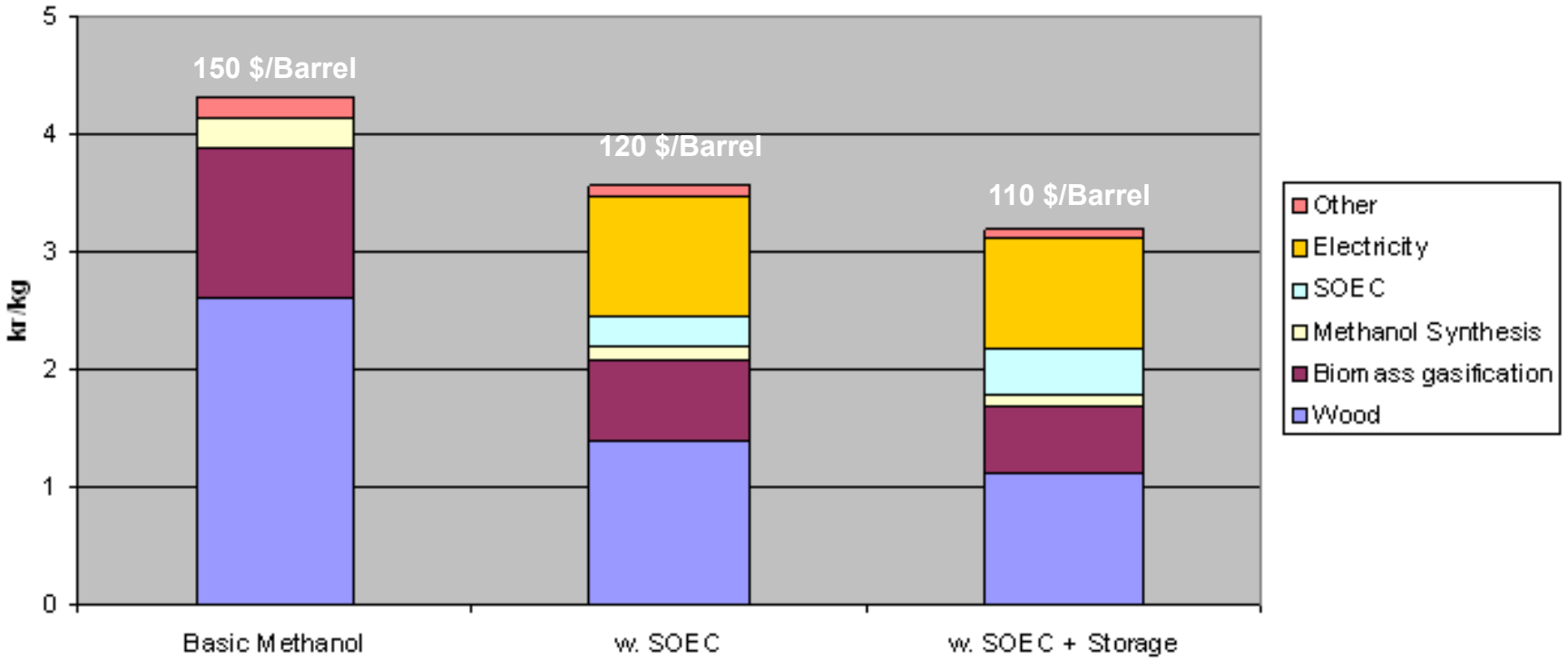
SOEC Durability - Cells



−0.5 A/cm^2, 850°C, p(H_2O) = 0.5 atm and p(H_2) = 0.5 atm, steam utilization 28%.

Is this (economically) viable?

Wood to Methanol price estimates



Summary

- Biomass ressources are limited and additional fuels are relevant for heavy transportation
- CO_2 Electrofuels can provide BOTH additional heavy transportation fuels AND power grid load balancing.
- SOEC may be an enabling technology for CO_2 electrofuels due to:
  - High efficiency
  - Optimum syngas composition through H_2O and CO_2 electrolysis
  - SOFC and SOEC synergies