Biogas Upgrading and High Temperature Electrolysis

RESEARCH | TECHNOLOGY | CATALYSTS

John Bøgild Hansen

HALDOR TOPSØE

Haldor Topsøe group – Key figures 2008

Headquarter in Lyngby, DK

- Turnover: DKK 5.0 billion (USD 920 MM)
- Result: DKK 533 MM (USD 97 MM)
- 2052 employees

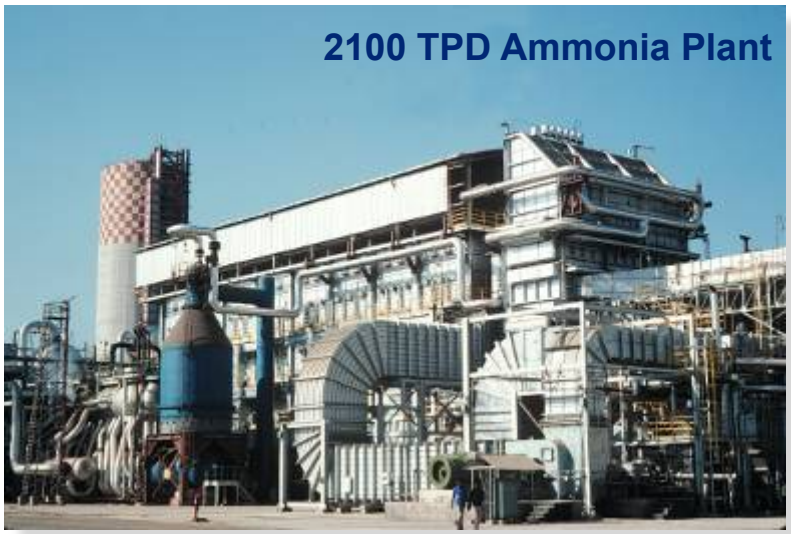
Catalyst plant in Frederikssund, DK

Catalyst plant in Houston, Texas

Business areas

- Fertilizer industry
- The refining industry
- The environmental and power sector
- The heavy chemical and petrochemical industries

Topsoe SynGas Technologies



- Synthesis Gas
- Ammonia
- Hydrogen
- Carbon Monoxide
- SNG
- Methanol
- DME
- Gasoline - TIGAS

HALDOR TOPSOE

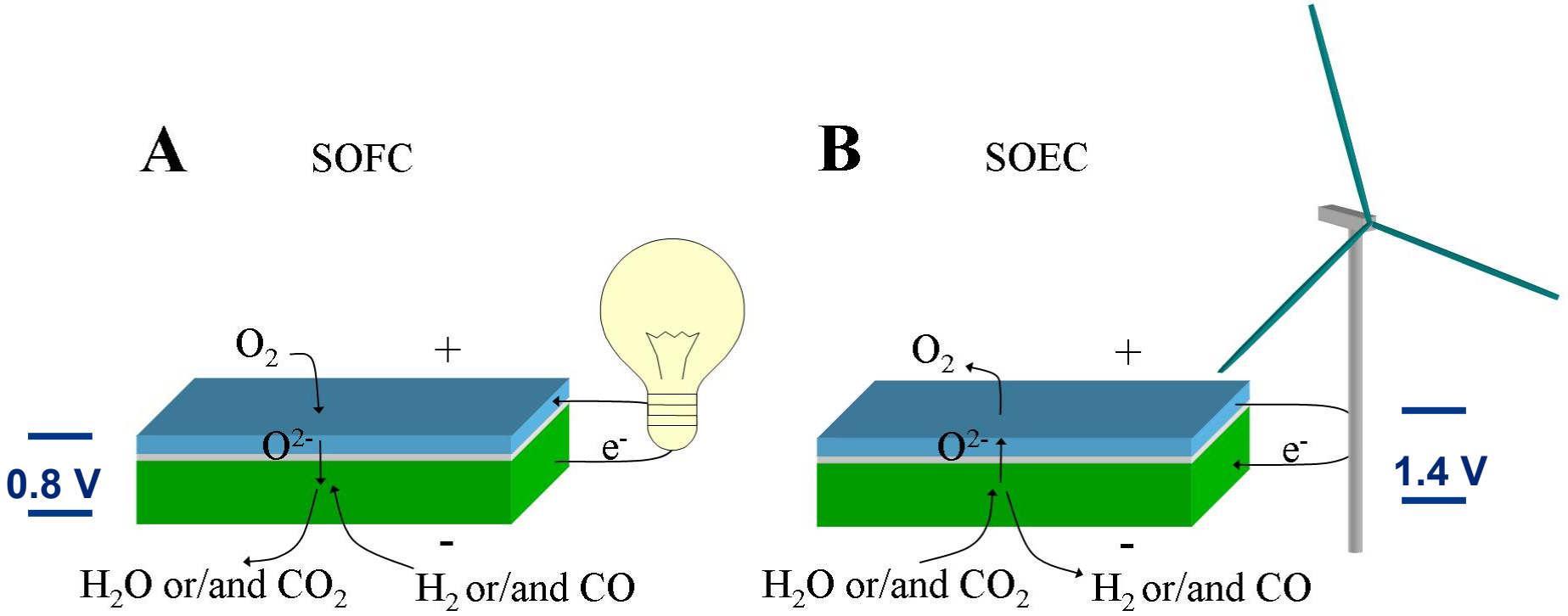
New production facility in Denmark

- Inauguration: April 2009
- Capacity ≈ 5 MW/yr
- Investment: >13 mio. EUR

High technology – industrial relevance – low production cost

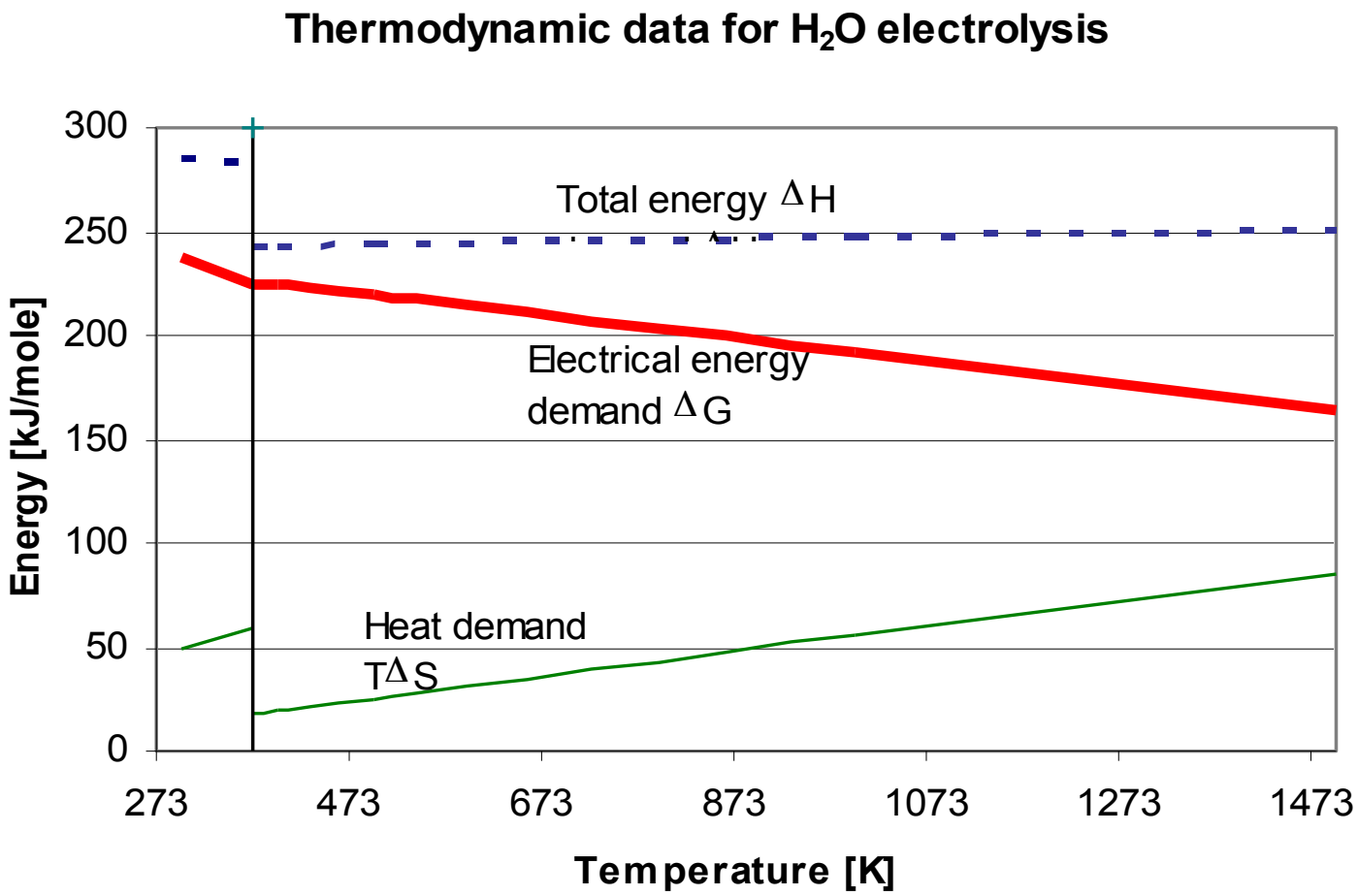
HALDOR TOPSOE

Principle of SOEC



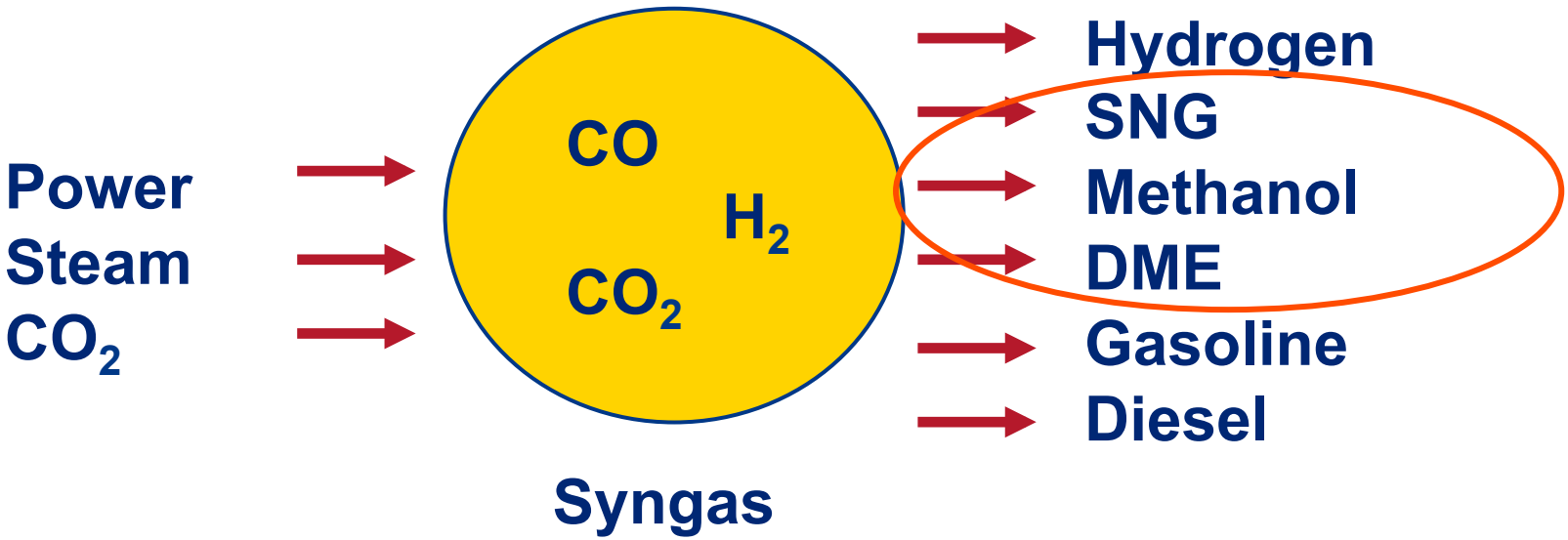
800 °C **EMF ca. 1.1 V**

SOEC more efficient than present Electrolysers



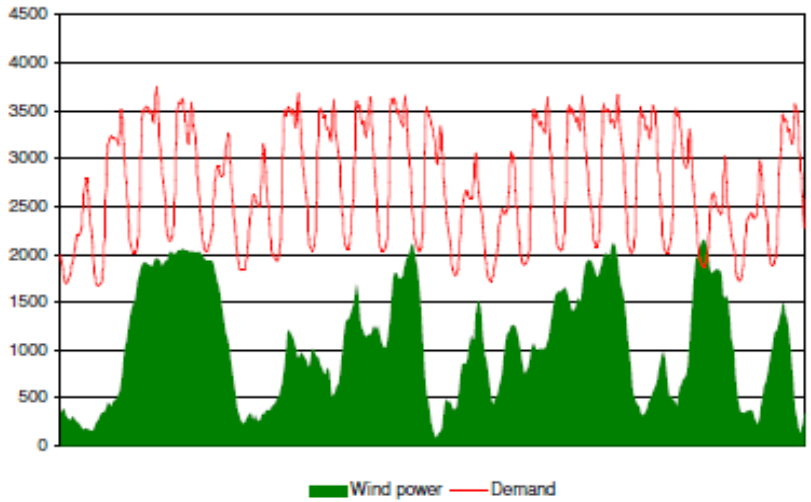
Thermodynamics for CO_2 electrolysis is similar to H_2O electrolysis

Electrolysis



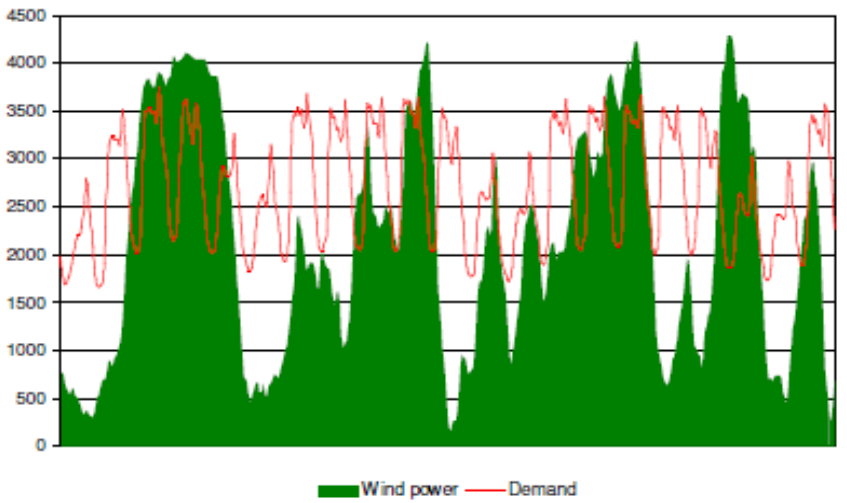
ENERGINET/DK

From 20 % to 50 % Wind power – massive overflow



DK West January 2008

Demand and Wind power



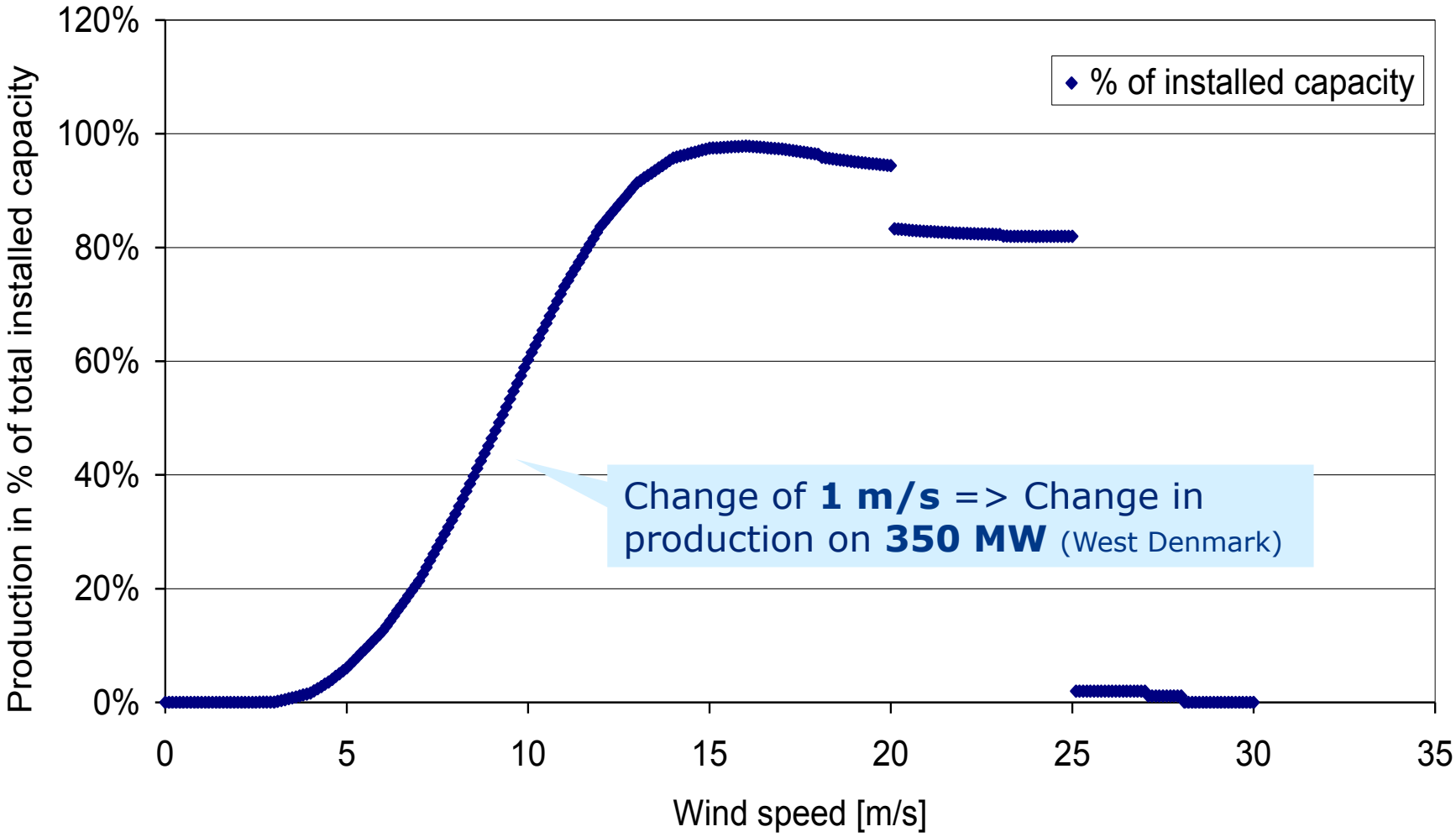
January 2008 + 3,000 MW

Effective Wind power integration using:

- Robust Transmission grid – with strong interconnectors
- Coherent energy system with high flexibility
- Intelligent control using Smart Grids applications

HALDOR TOPSØE

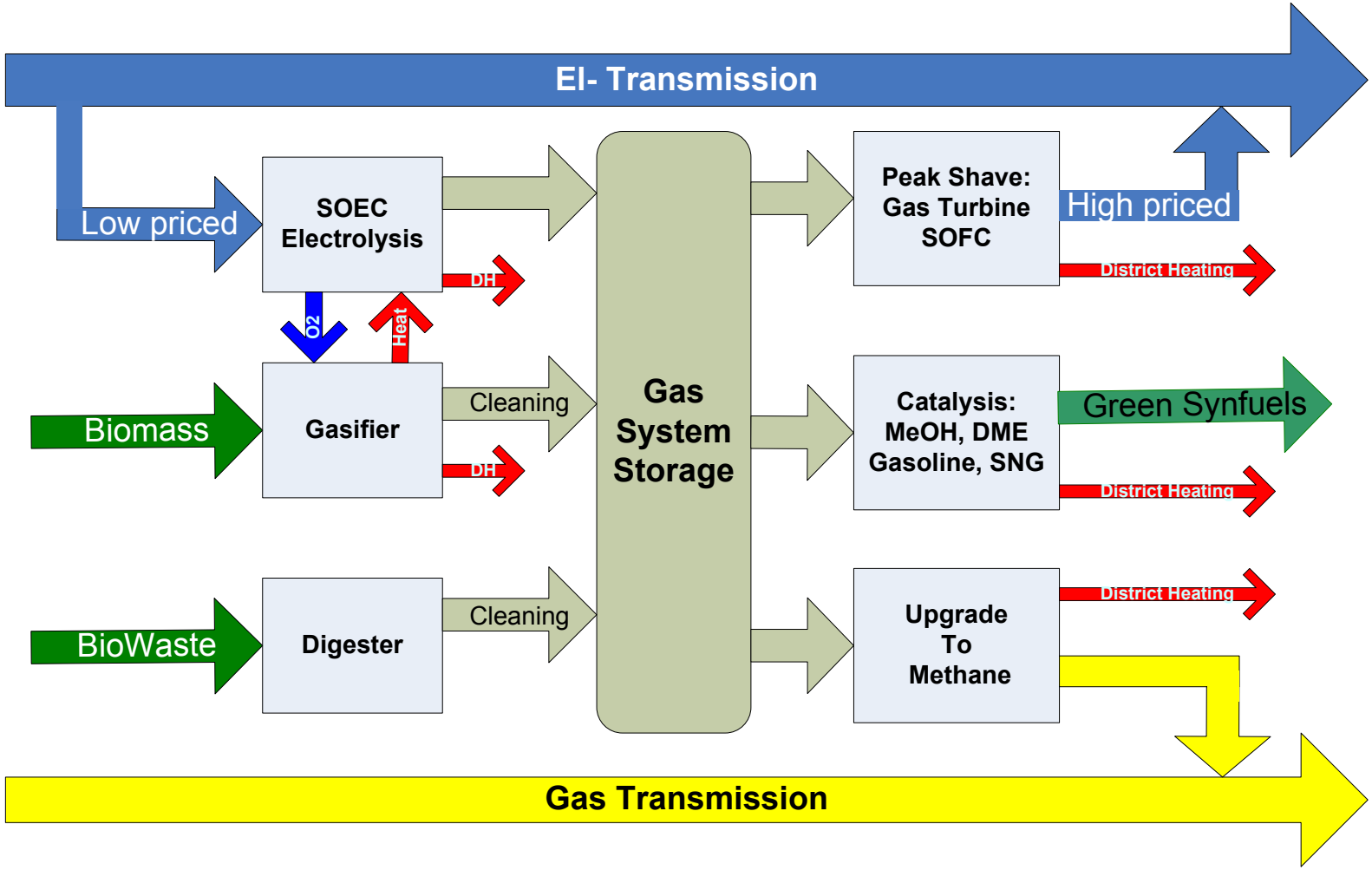
Wind power is often reason for imbalances



Source ENERGINET.DK

HALDOR TOPSOE

Energinet.dk's vision for fossil fuel free Denmark in 2050 – The Wind Scenario



HALDOR TOPSØE

Storage of Wind Energy

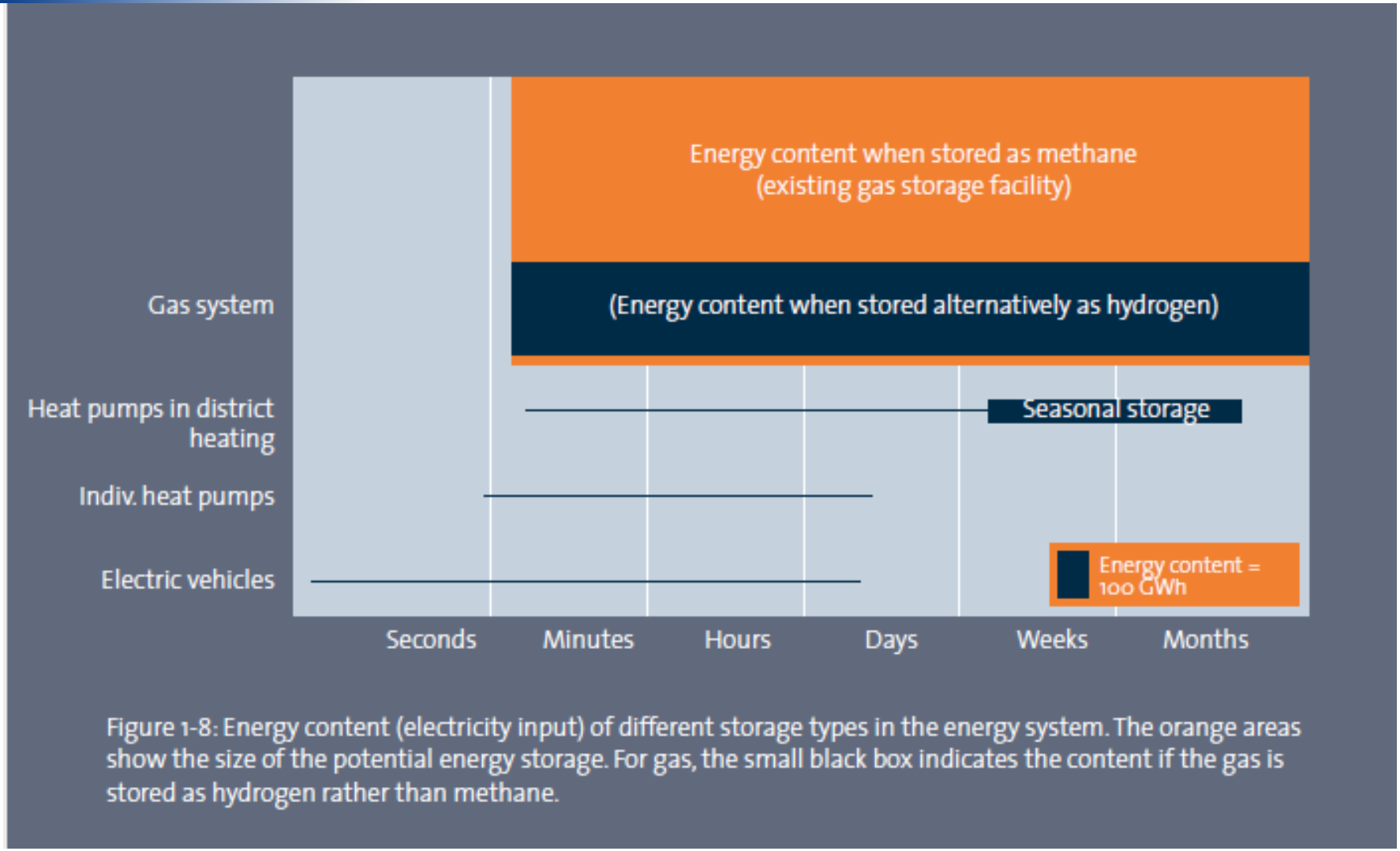


Figure 1-8: Energy content (electricity input) of different storage types in the energy system. The orange areas show the size of the potential energy storage. For gas, the small black box indicates the content if the gas is stored as hydrogen rather than methane.

Energinet.dk development track

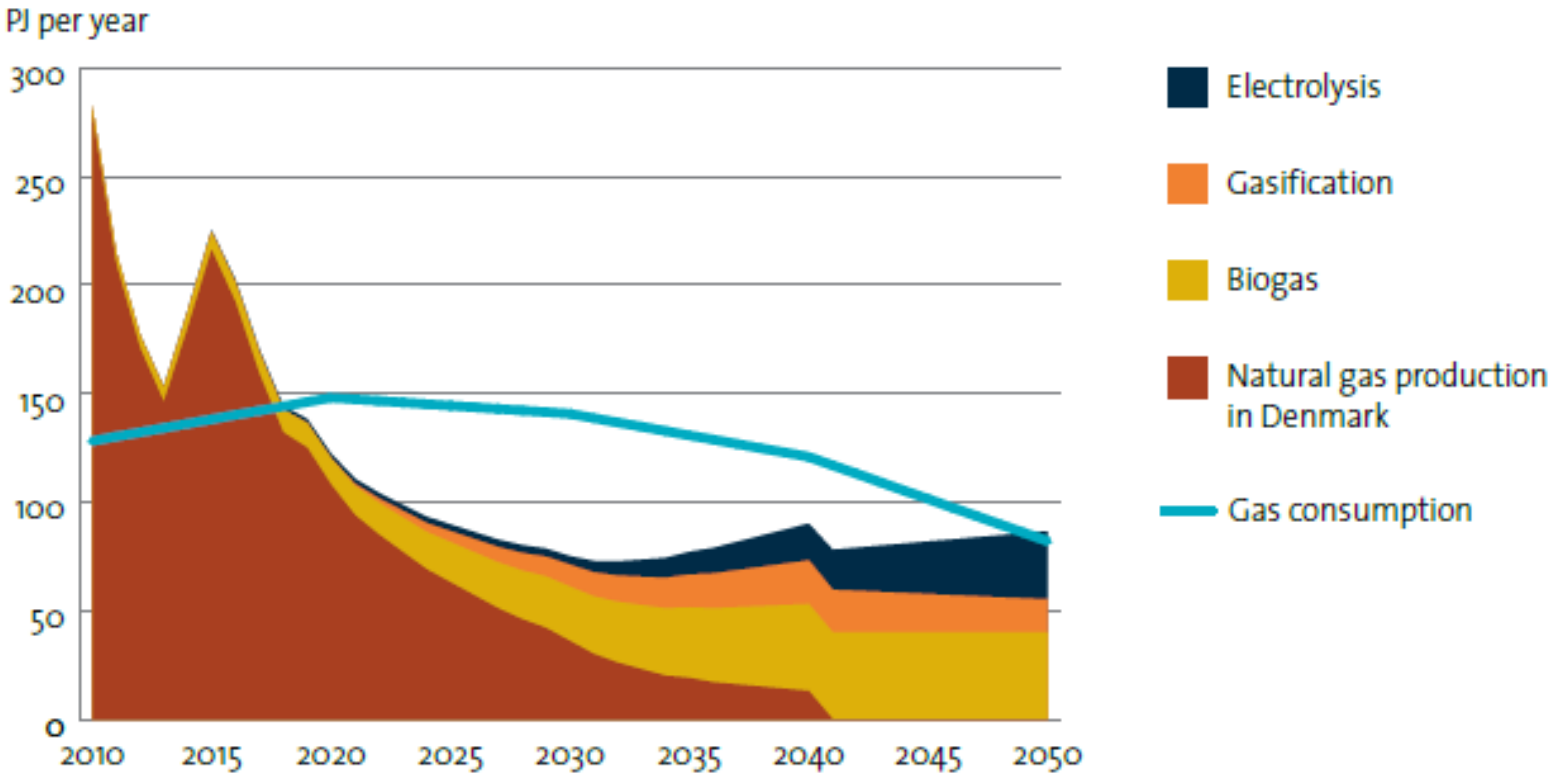
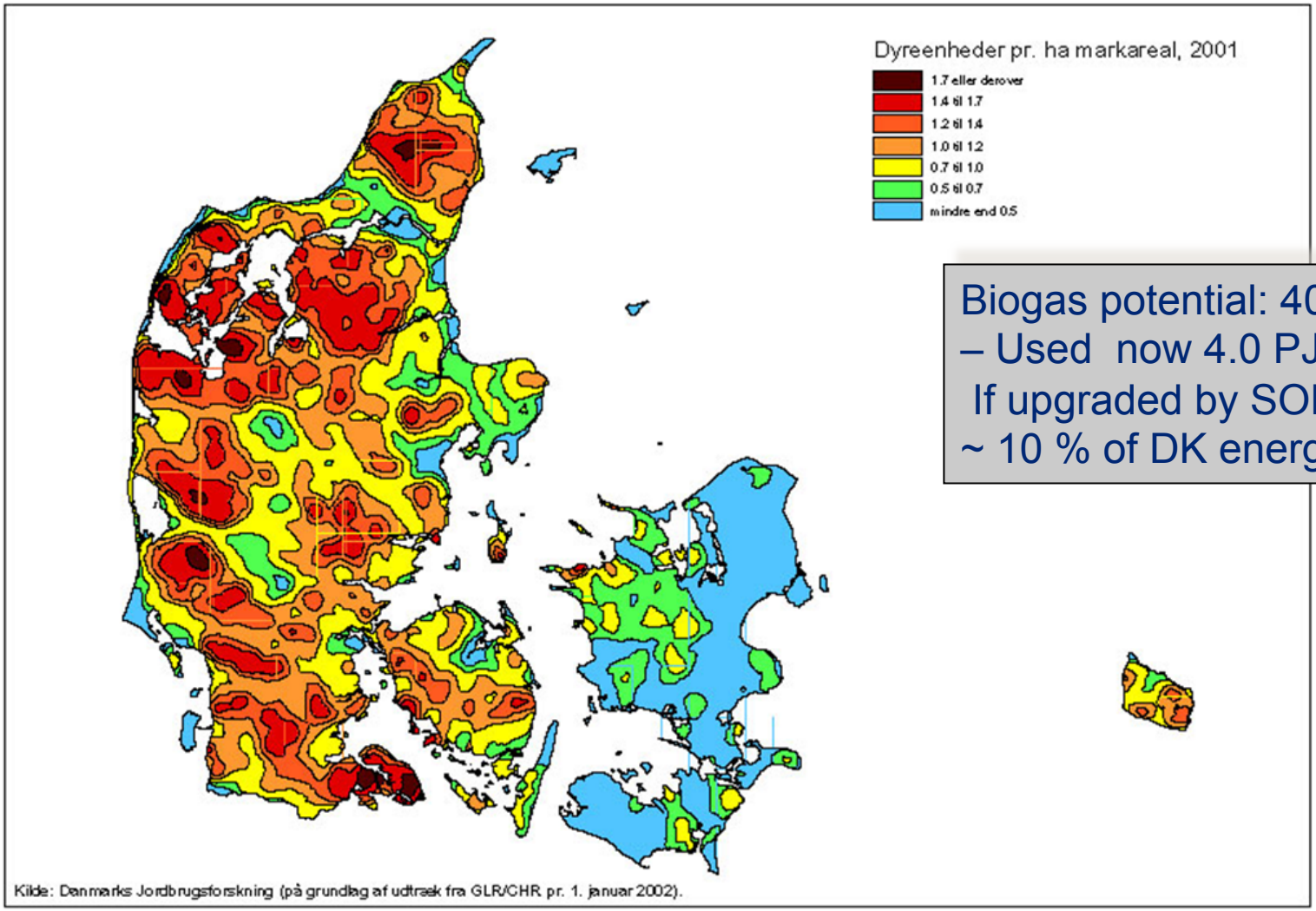


Figure 1-10: Production and consumption of gas until 2050 in Energinet.dk's development track (wind power track).

Biogaspotential in Denmark



Biogas potential: 40 PJ
– Used now 4.0 PJ
If upgraded by SOEC: 67 PJ
~ 10 % of DK energy

SNG

RESEARCH | TECHNOLOGY | CATALYSTS

HALDOR TOPSØE

Biogas upgrade

$$CH_4 + CO_2 + 3H_2O + El \rightarrow 2CH_4 + H_2O + 2O_2$$

If all biogas in Denmark was upgraded =

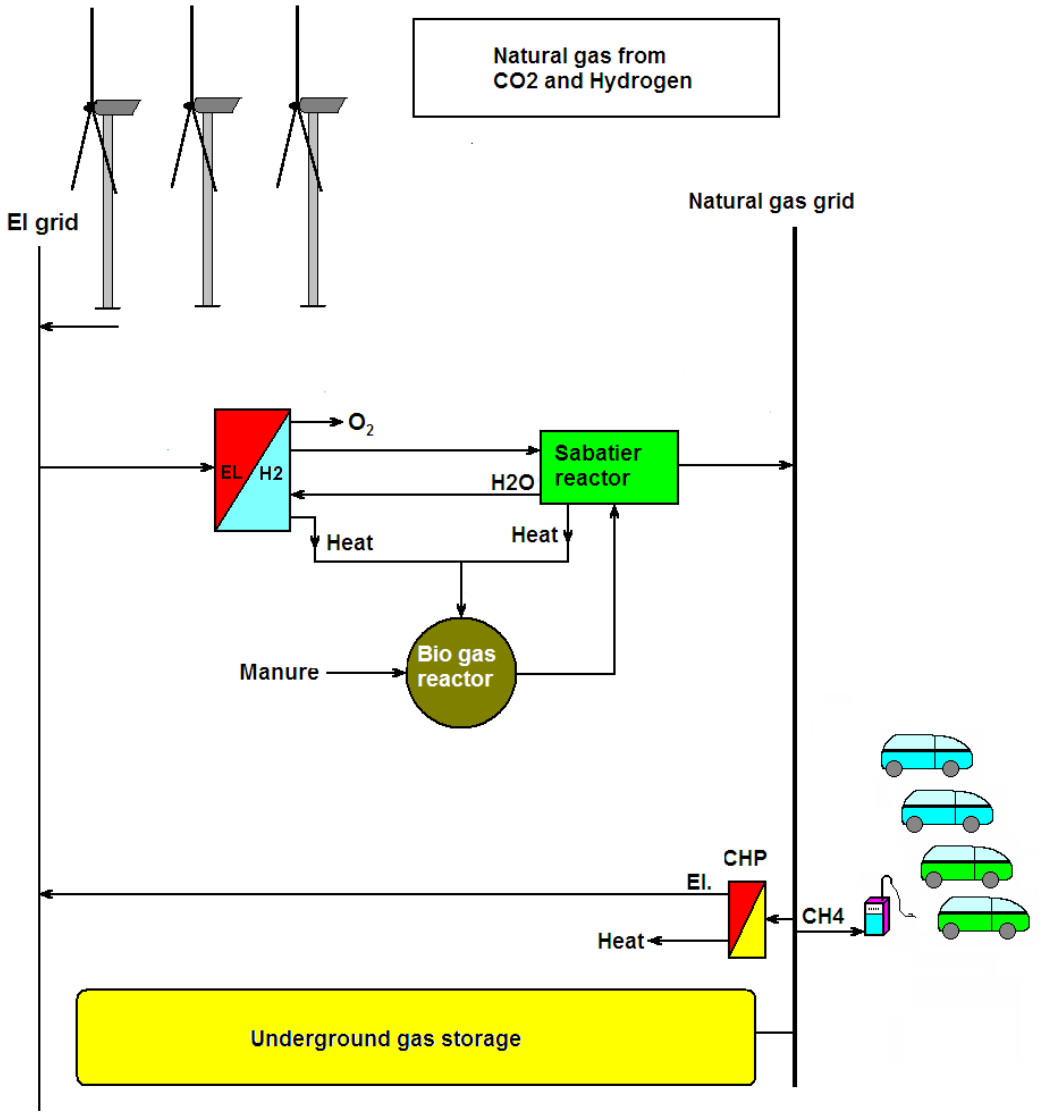
- 10 % of energy
- 1 ton CO_2 saved percapita

HALDOR TOPSØE

Biogasopgrading
Feasibilityproject sponsered by

midt
regionmidtjylland

Planning of demo
Experimentel verification
of Biogas clean up



HALDOR TOPSØE
CATALYSING YOUR BUSINESS

DTU

AGRO BUSINESS PARK

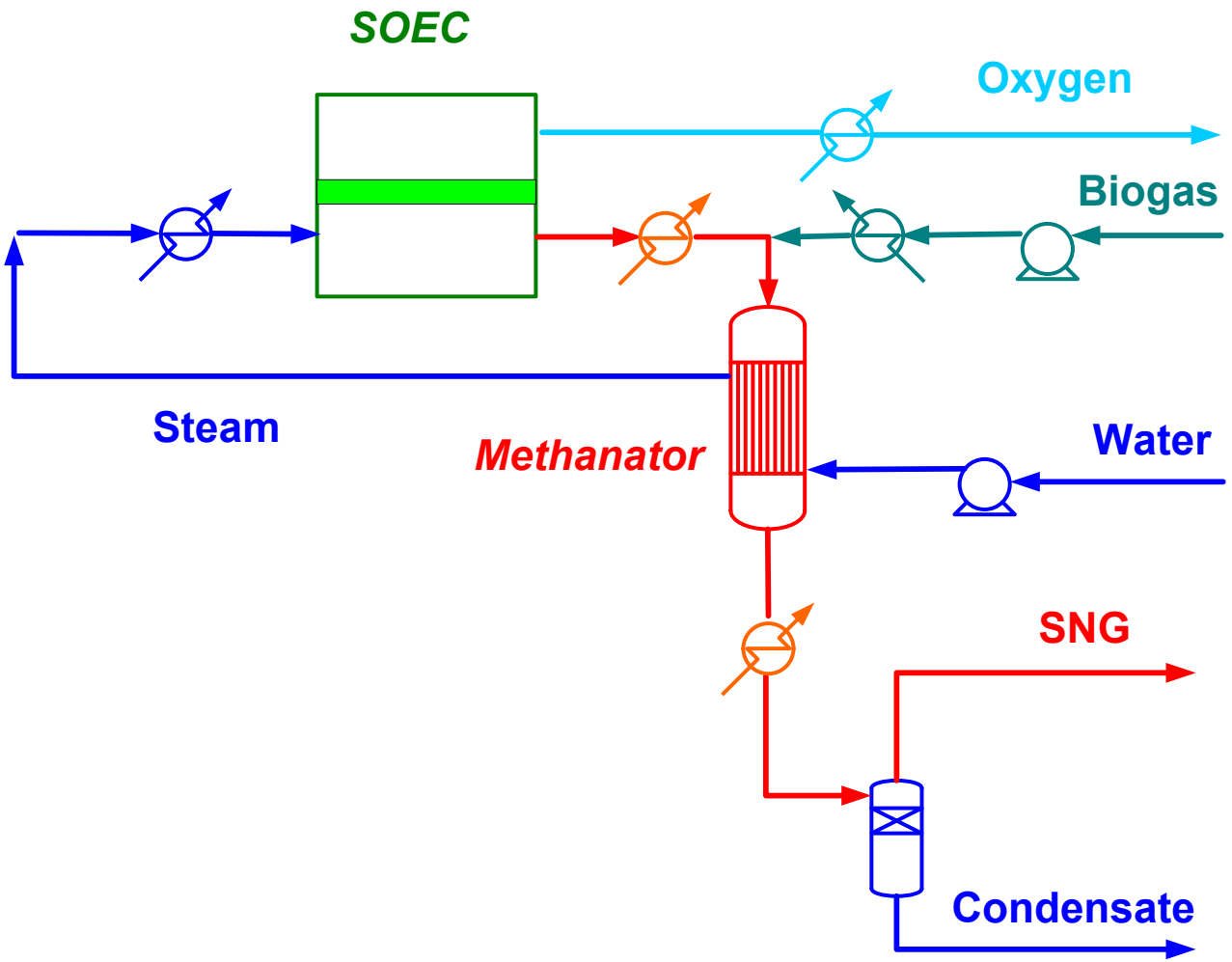
HMN NATURGAS

HIRC
Hydrogen Innovation & Research Centre

GREENHYDROGEN.DK
alkaline electrolyser systems

PlanEnergi

Biogas to SNG via SOEC and methanation of the CO_2 in the biogas



Typical specification for substitute natural gas (SNG)

	Mole%
CH_4	94 - 98
CO_2	0.2 – 3
H_2	0.1 – 2
CO	<100 ppm
N_2 + Ar	1 - 3
HHV, KJ/Nm^3	37,000 - 40,000

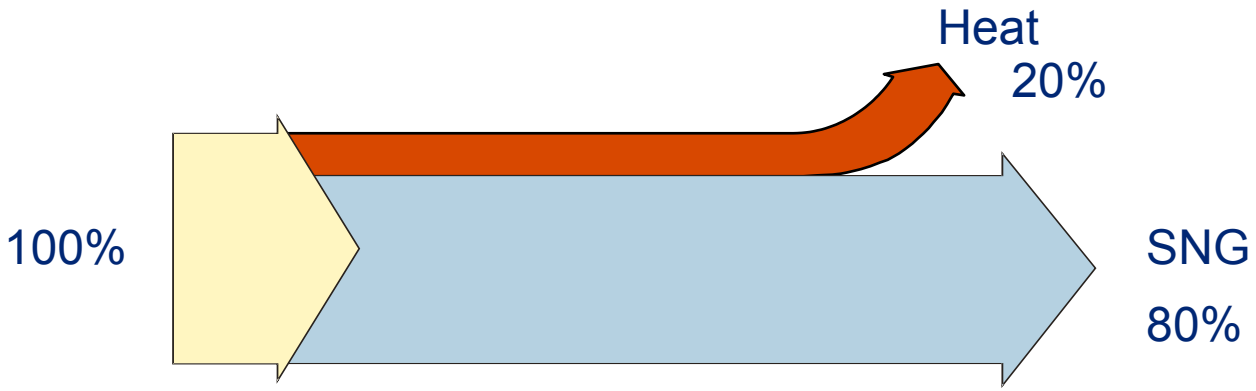
SNG Technology

- Methanation generates a lot of heat

$CO + 3H_2 \leftrightarrow CH_4 + H_2O$ $(-\Delta H_0 298 = 206\ kJ/mol)$

$CO_2 + 4H_2 \leftrightarrow CH_4 + 2H_2O$ $(-\Delta H_0 298 = 165\ kJ/mol)$

$CO + 3H_2$		=	CH_4	$+ H_2O$
Syngas		=	SNG	+ heat
Energy:	100%	=	80%	+ 20%

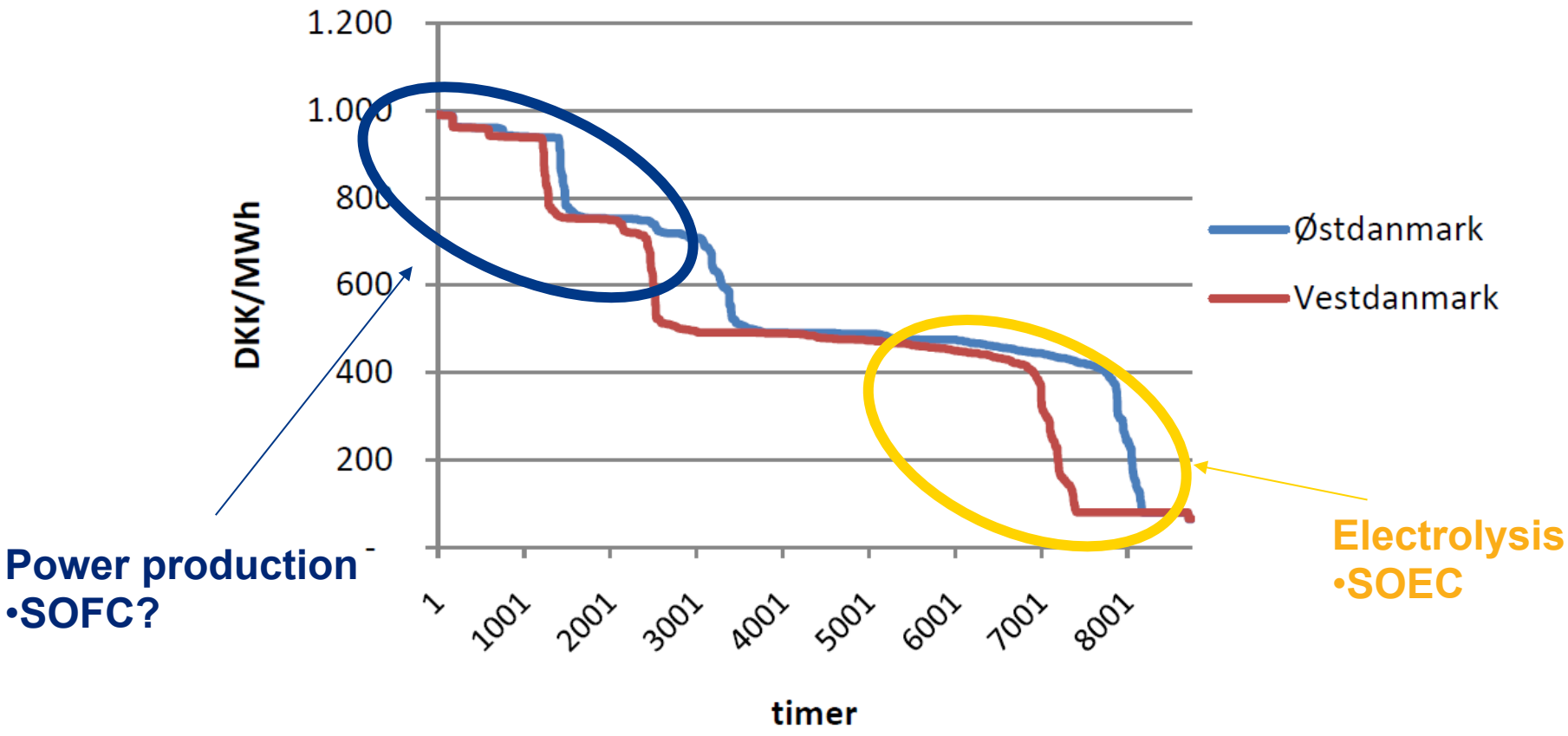


Topsøe methanation technology:

- Extremely active catalyst
- Stable at operating temperature up to 700°C
- More than 45,000 demonstration hours
- Up to 48,000 NM^3/day SNG

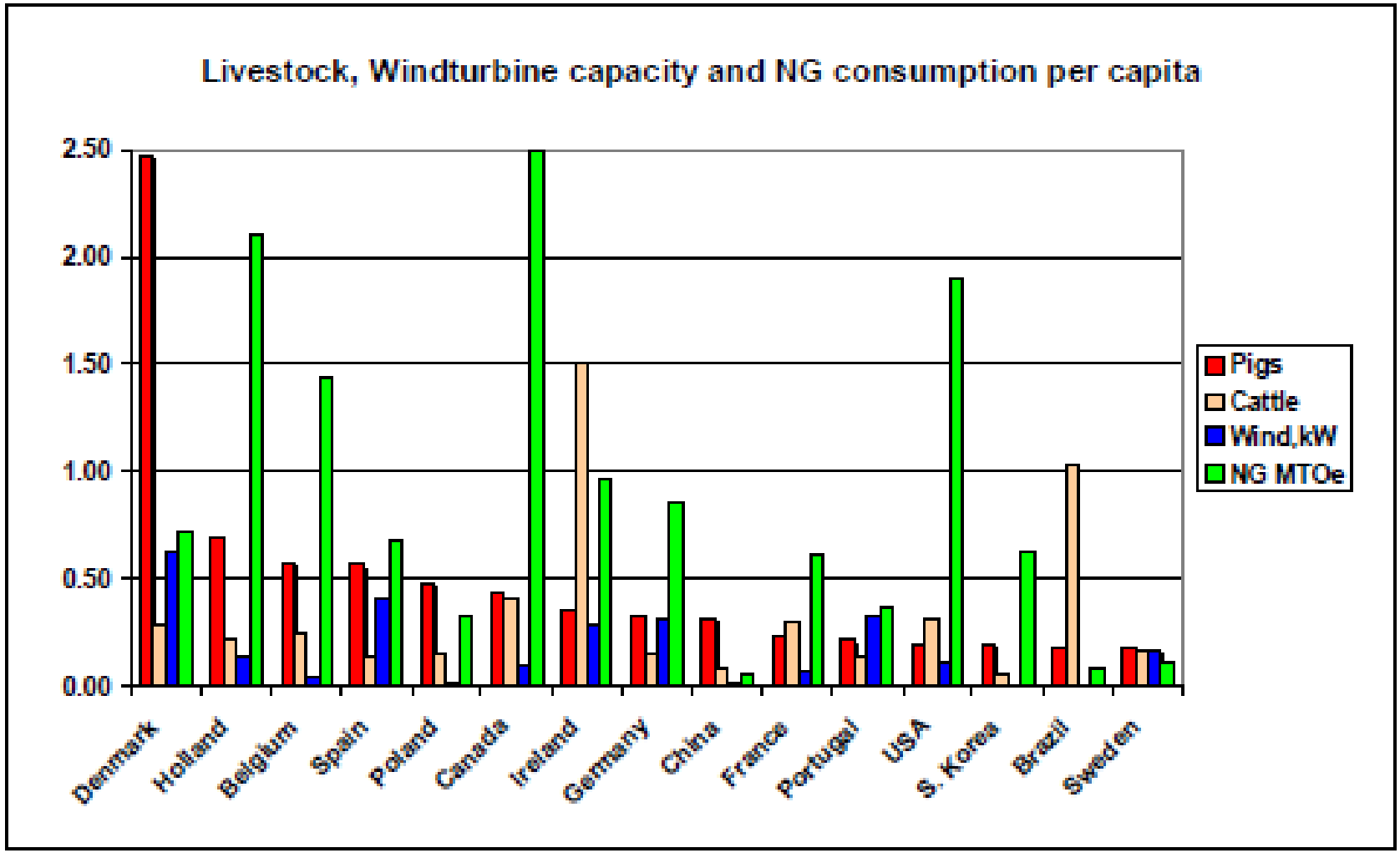
HALDOR TOPSØE

Fluctuating electricity prices



Figur 22: Varighedskurve for elpriser beregnet med Balmorel for det ambitiøse fremtidsbillede i 2050.

Business case



Key numbers
Denmark (2008)

- Final energy consumption: 673 PJ
- Biogas potential: 40 PJ
- If upgraded by SOEC: 67 PJ ~ 10 %
- NG used for power plants: 73 PJ
- NG used in household, industry and service: 76 PJ
- Saved CO_2 ~ 1 MT/capita