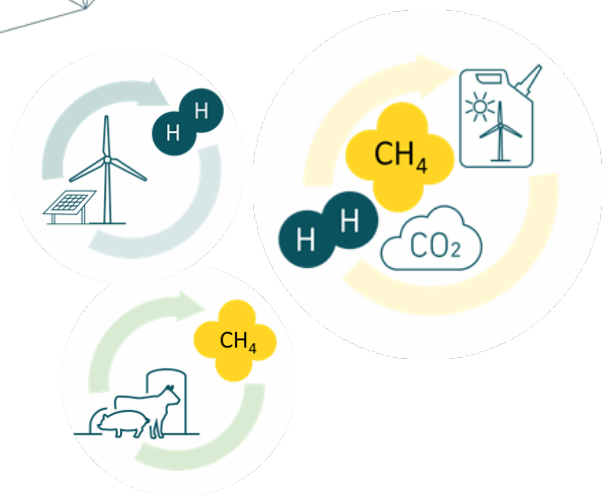
PtX & Sectorcoupled Infrastructure

IEA Green Fuels, Paris, October 21-22 2019

Martin Hartvig, M.Sc. Ph.D., Energinet, Gas System Development



Online title:

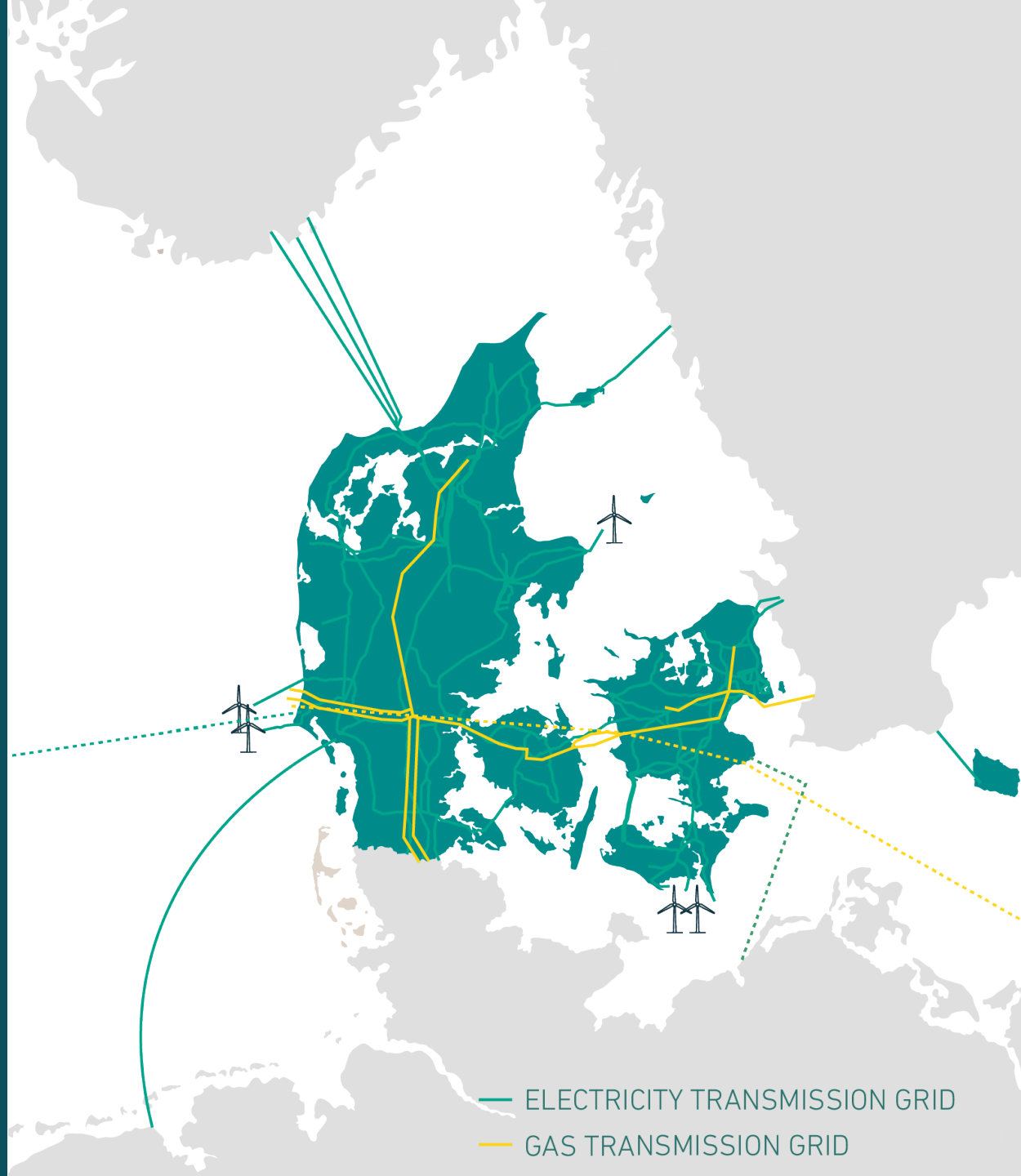
High pressure transmissions and low pressure distribution gas pipes - stranded assets or low cost, promising connection for new sources of gas

WE ARE WORKING FOR THE DANES

Energinet is responsible for ensuring that Denmark is supplied with gas and electricity.

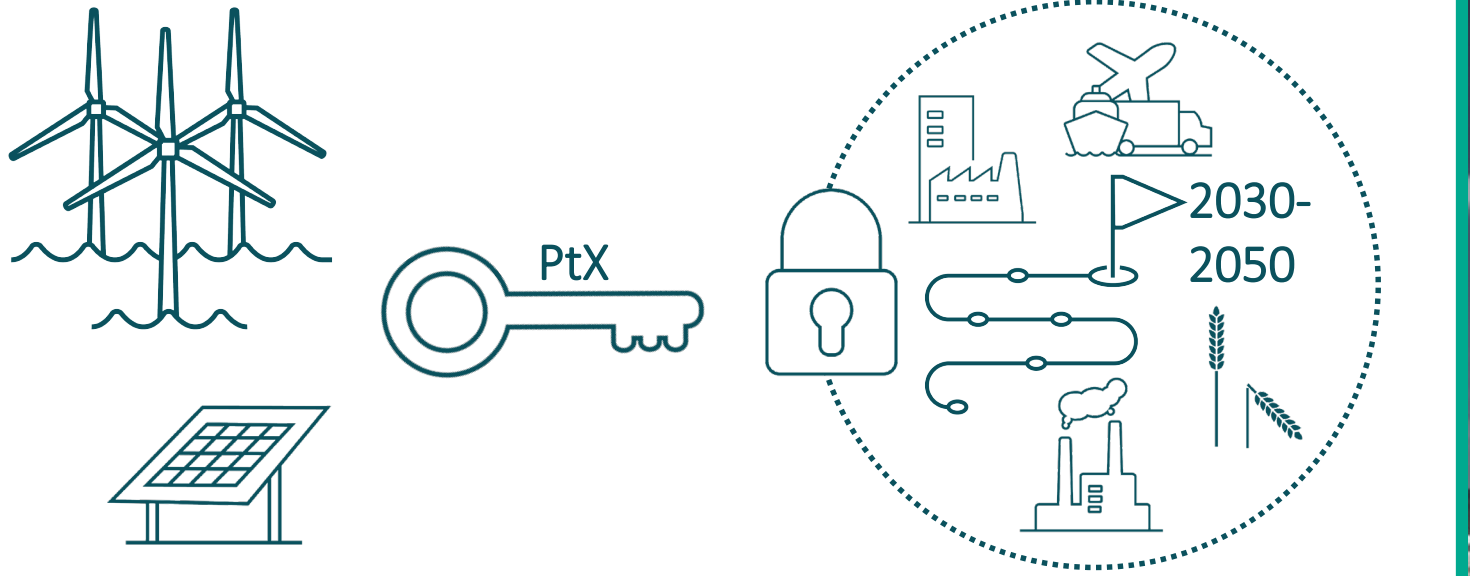
We safeguard society's interests as we move to a 100% green energy system.

We are owned by the Danish Ministry of Climate, Energy and Utilities.



Why?

DANISH GREEN TRANSITION



STATUS:

64% green electricity

34% green energy

10% green gasses

2030 TARGET:

100% green electricity

55% green energy

2050 TARGET:

100% green energy

GOVERNMENT GOAL:

70% reduction in CO2-emissions by 2030

How much PtX?

Large PtX potential

ENERGINET

~10GW electrolysis

Rough estimates based on current Danish consumption (+international shipping and aviation in DK). Varying degrees of electrification assumed. Not all conversion losses are included, so numbers should be regarded as preliminary.

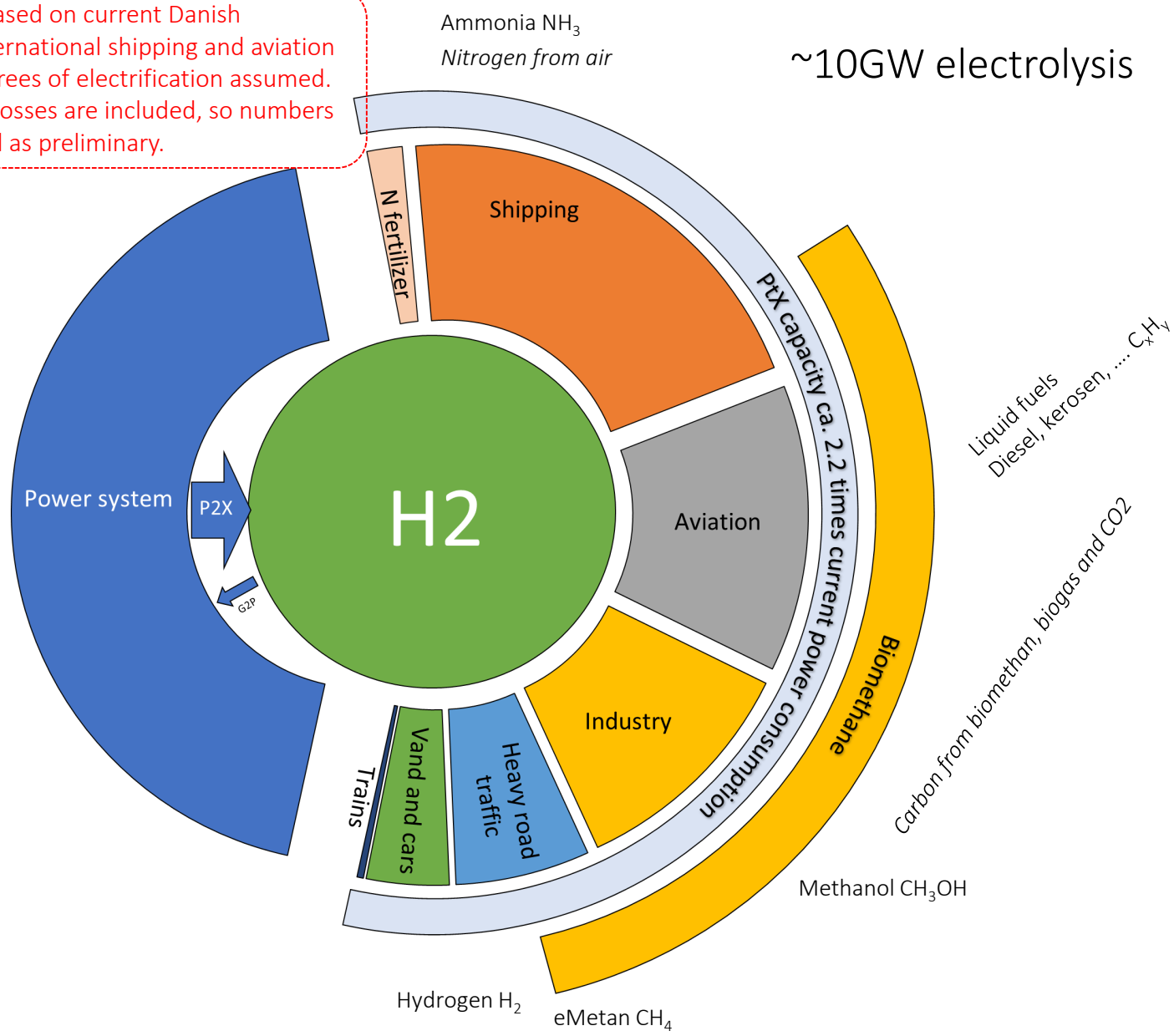
<u>Prerequisites</u>

- Denmark has cheap (LCOE) areas for opffshore wind
- Existing gas infrastructure (network and storage)

<u>Drivers</u>

- Transport: Non-electric consumption 1.7 times current DK power consumption
- Agriculture: CO2 + CH4 from biogas enables green hydcarbons (eFuels).
- Power system: Build out for +100% of needs?
- Export? In EU up to 1/4 of the energy use could be hydrogen

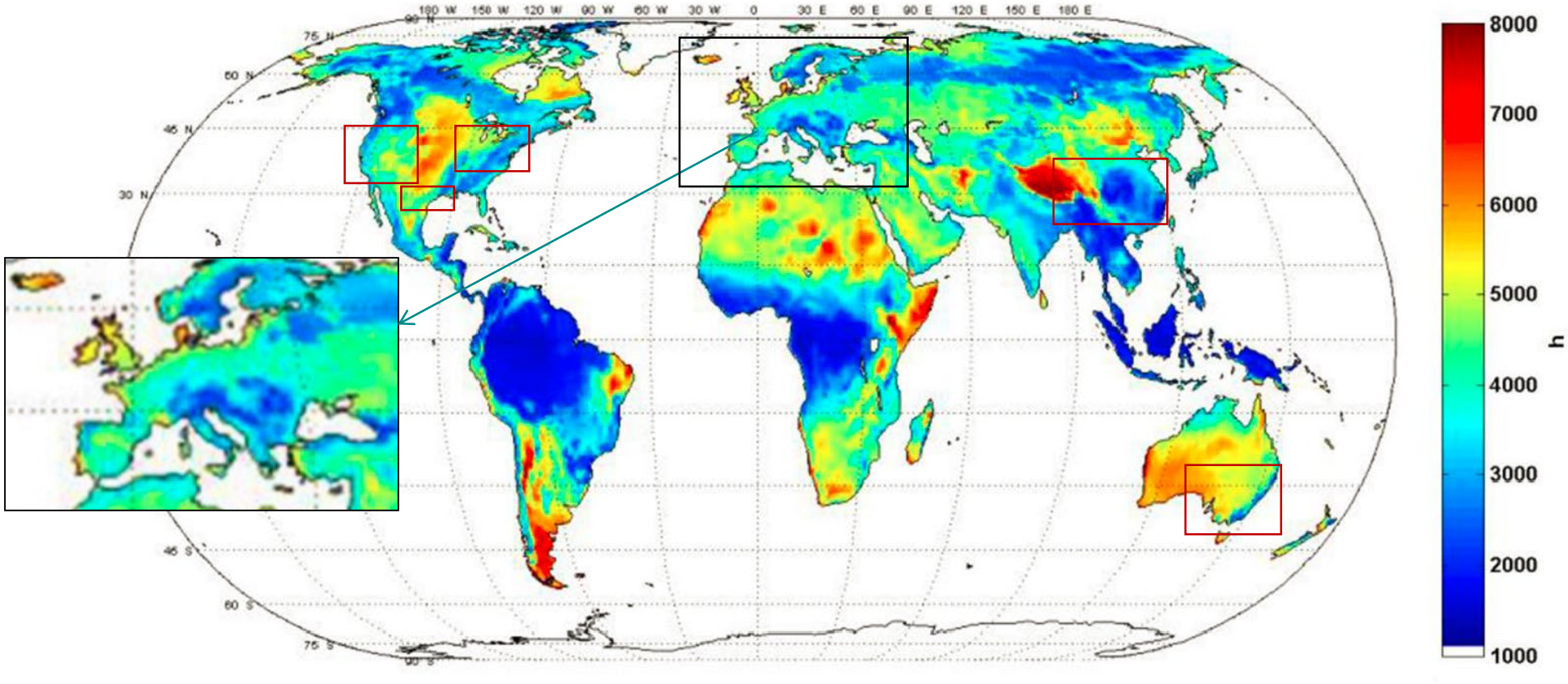
- District heating improves the business case



Is that feasible?

NORTH SEA WIND - GLOBAL PERSPECTIVE

Figure 15 **World's hybrid PV-Wind power plant cumulative full load hour map in 2030**



Source: Fasihi et al (2017).

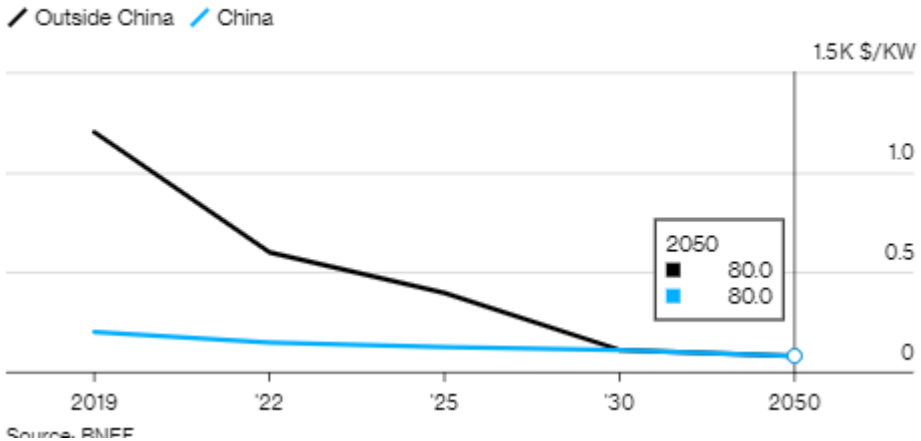
ELECTROLYSIS PV TRENDING?

ENERGINET

Bloomberg
NEW ENERGY FINANCE

China Model

The cost of alkaline electrolysis projects is set to plummet

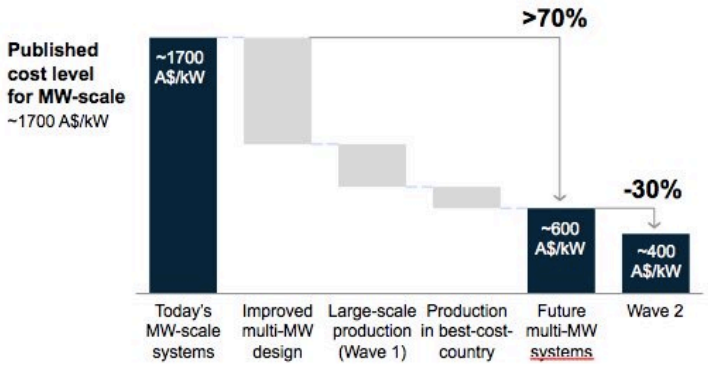


Source: BNEF

BloombergNEF	2019	2022	2025	2030	2050	
Outside China	1.200	600	400	115	80	$/kW
China	200	150	128	115	80	$/kW
Outside China	1,080	0,540	0,360	0,104	0,072	EUR/MW
China	0,180	0,135	0,115	0,104	0,072	EUR/MW

McKinsey & Company

Large-scale electrolyser systems are expected to decrease in CAPEX up to 70% by 2030



Industrialisation of large-scale electrolyser production will enable significant cost reductions

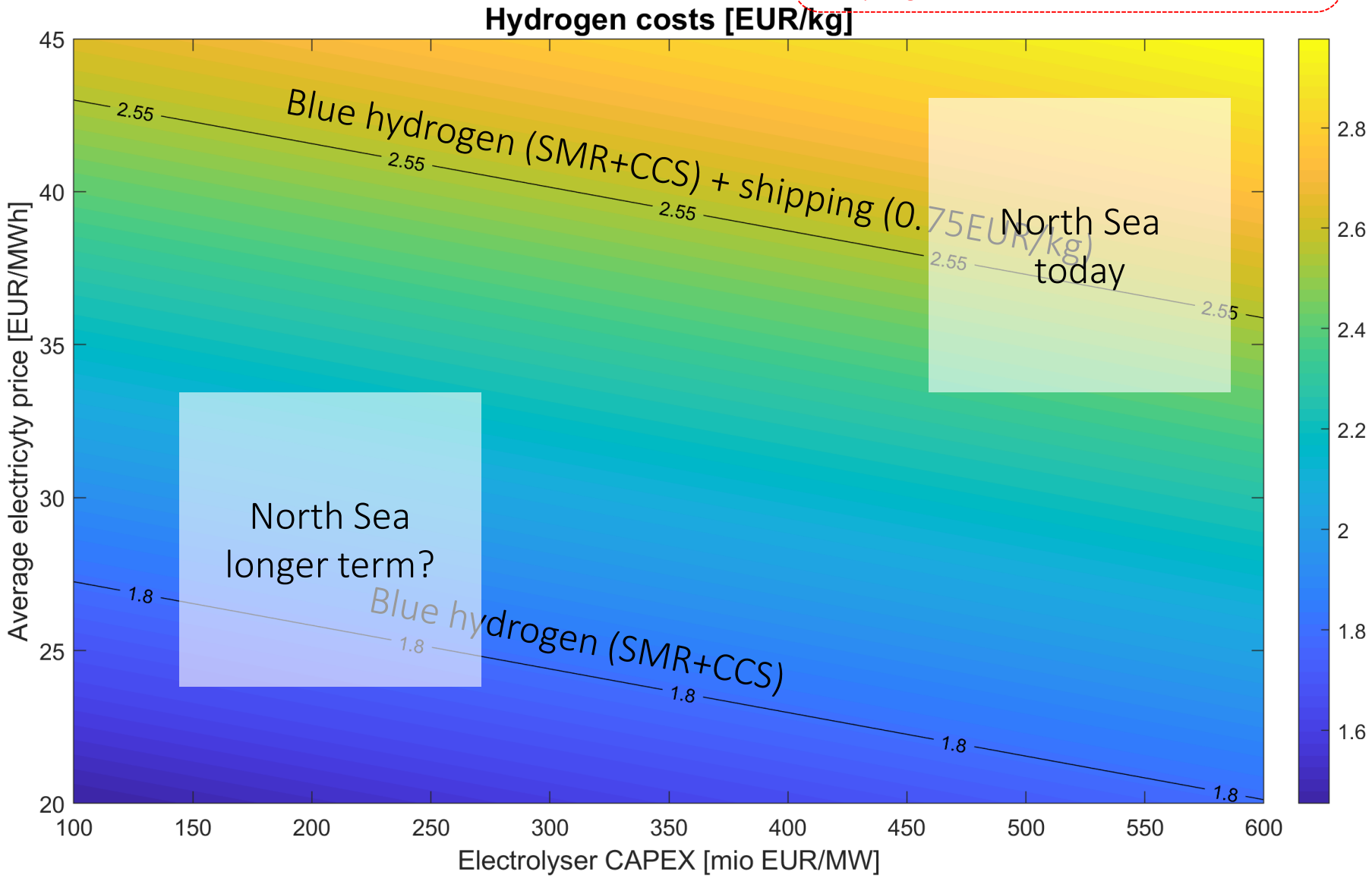
270USD

iea International Energy Agency

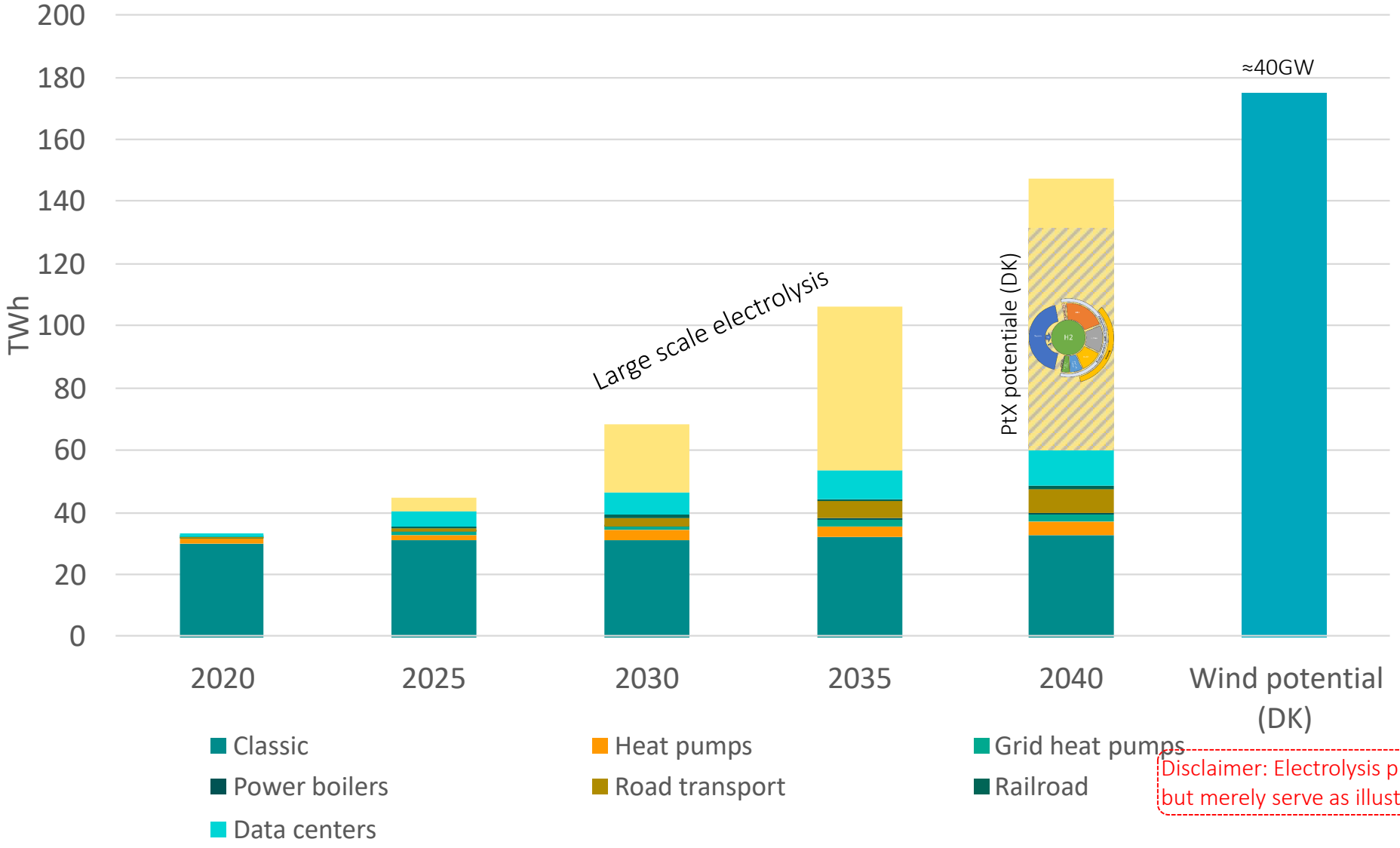
	Alkaline electrolyser			PEM electrolyser			SOEC electrolyser		
	Today	2030	Long term	Today	2030	Long-term	Today	2030	Long term
Electrical efficiency (%, LHV)	63–70	65–71	70–80	56–60	63–68	67–74	74–81	77–84	77–90
CAPEX (USD/kW_e)	500 – 1400	400 – 850	200 – 700	1 100 – 1 800	650 – 1 500	200 – 900	2 800 – 5 600	800 – 2 800	500 – 1 000

SHIPPING VS LOCAL PRODUTION?

Disclaimer: Rough estimates using intermediate values of heat for use in district heating. For this example 8000 hours of operation is assumed.
Shipping costs may be reduced, numbers hard to find.
Blue hydrogen costs are based on IEA 2019.

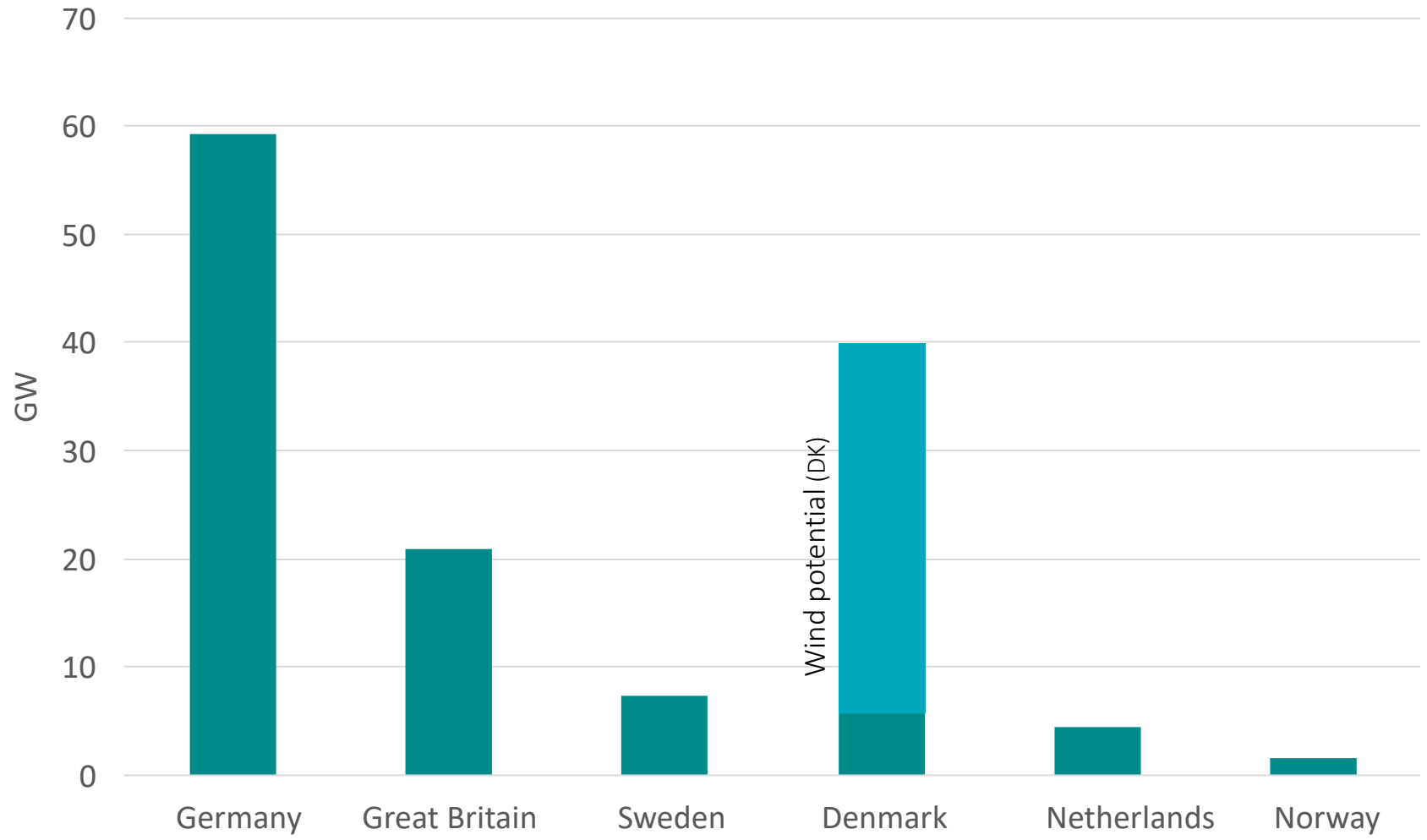


Development of power consumption (AF2019h) and wind & PtX potential



Disclaimer: Electrolysis prognosis not part of AF2019, but merely serve as illustration of a possible pathway

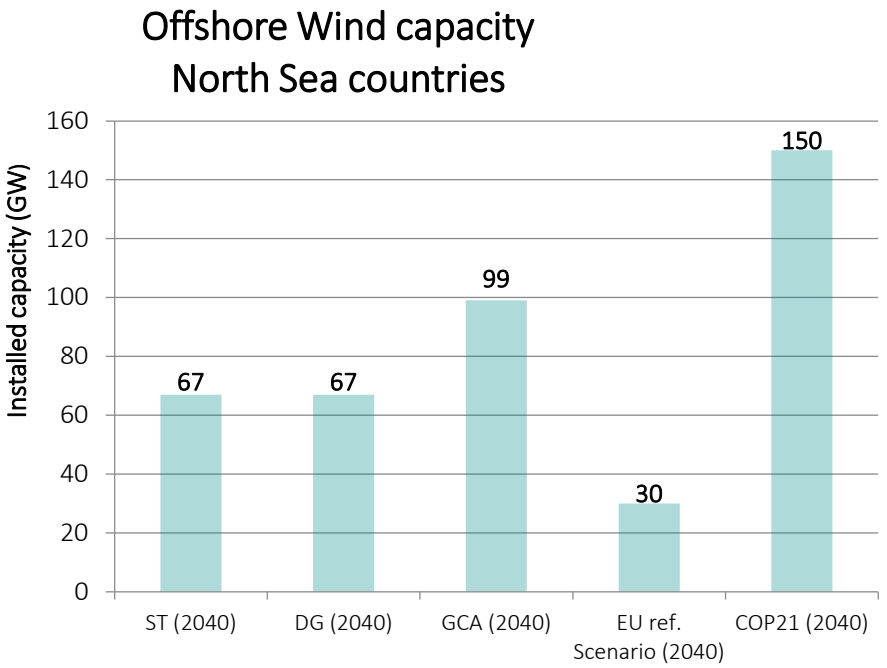
DK wind potential compared to today

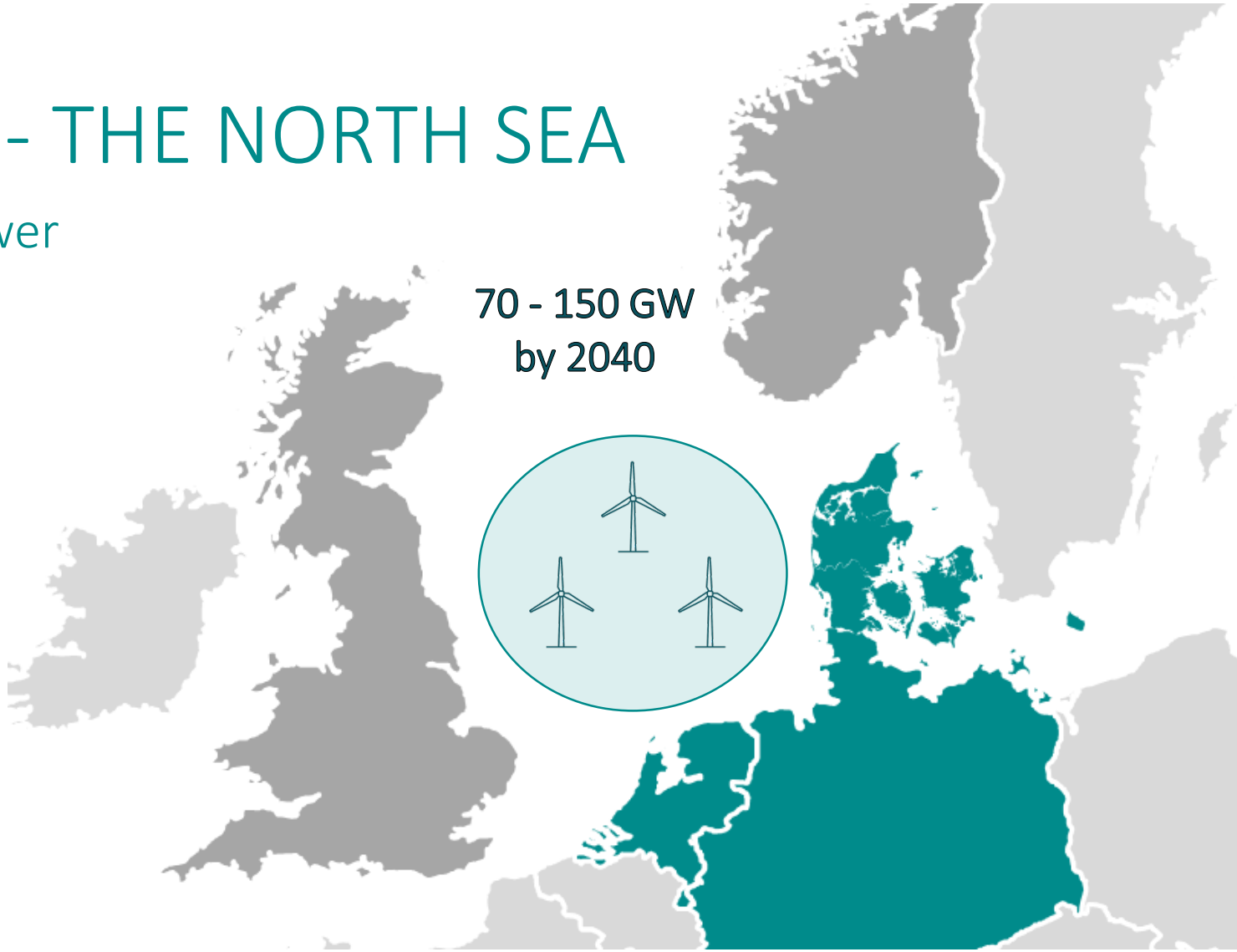


How do we get enough RE power production?

FUTURE SCENARIOS - THE NORTH SEA

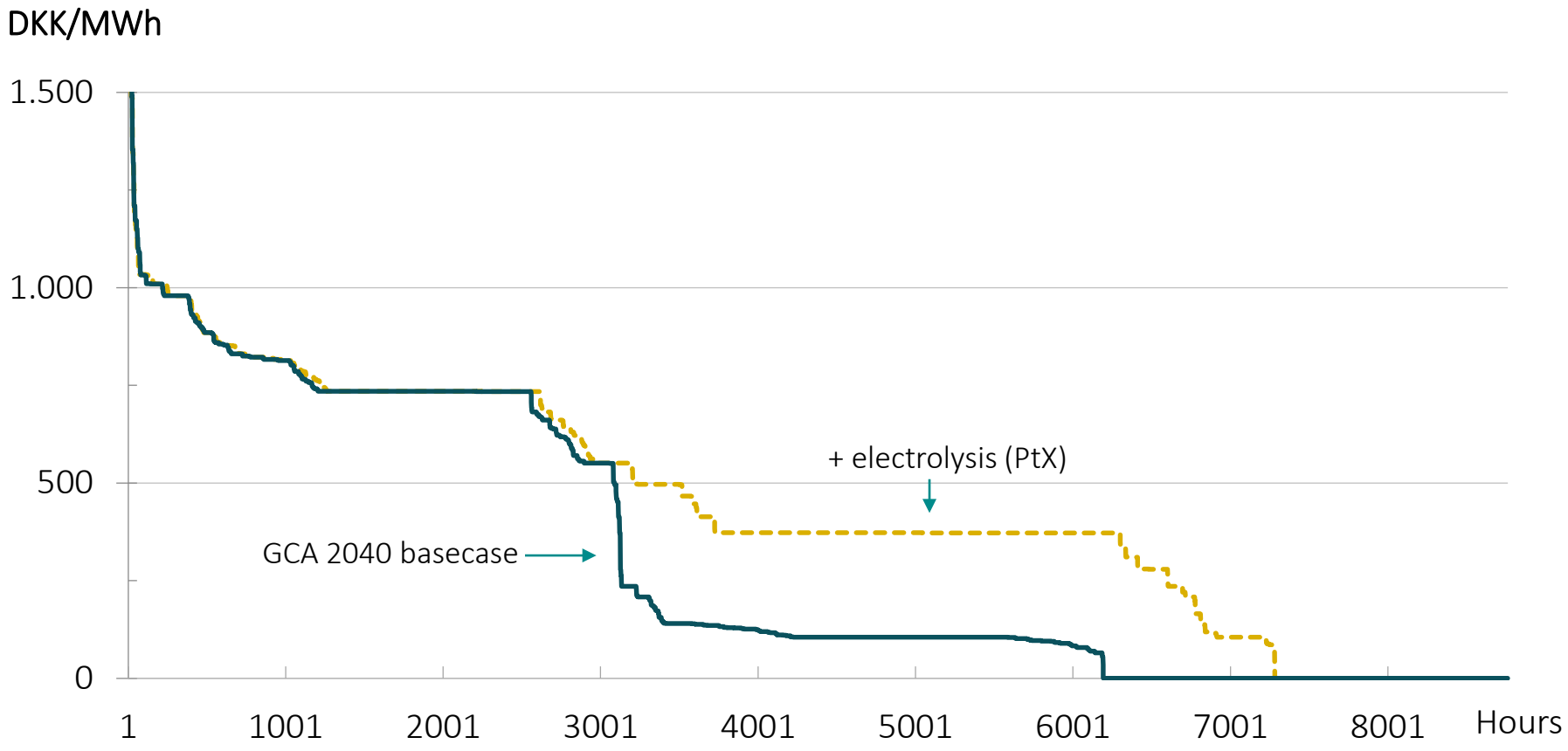
… High levels of offshore wind power





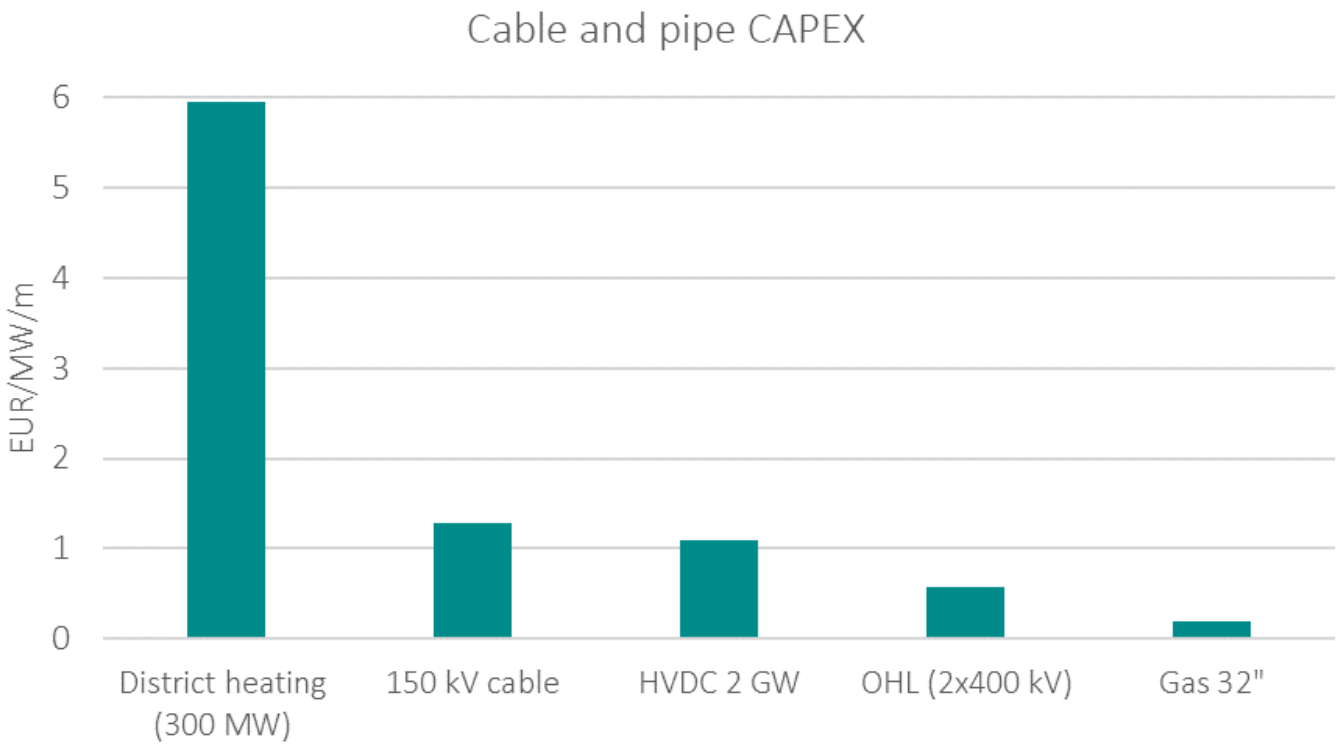
LARGE SCALE = WIND + ELECTROLYSIS SYNERGY

Large scale PtX is much more than curtailment!



How do we transport power for large scale PtX?

CAPEX for heat, power and H2 transport



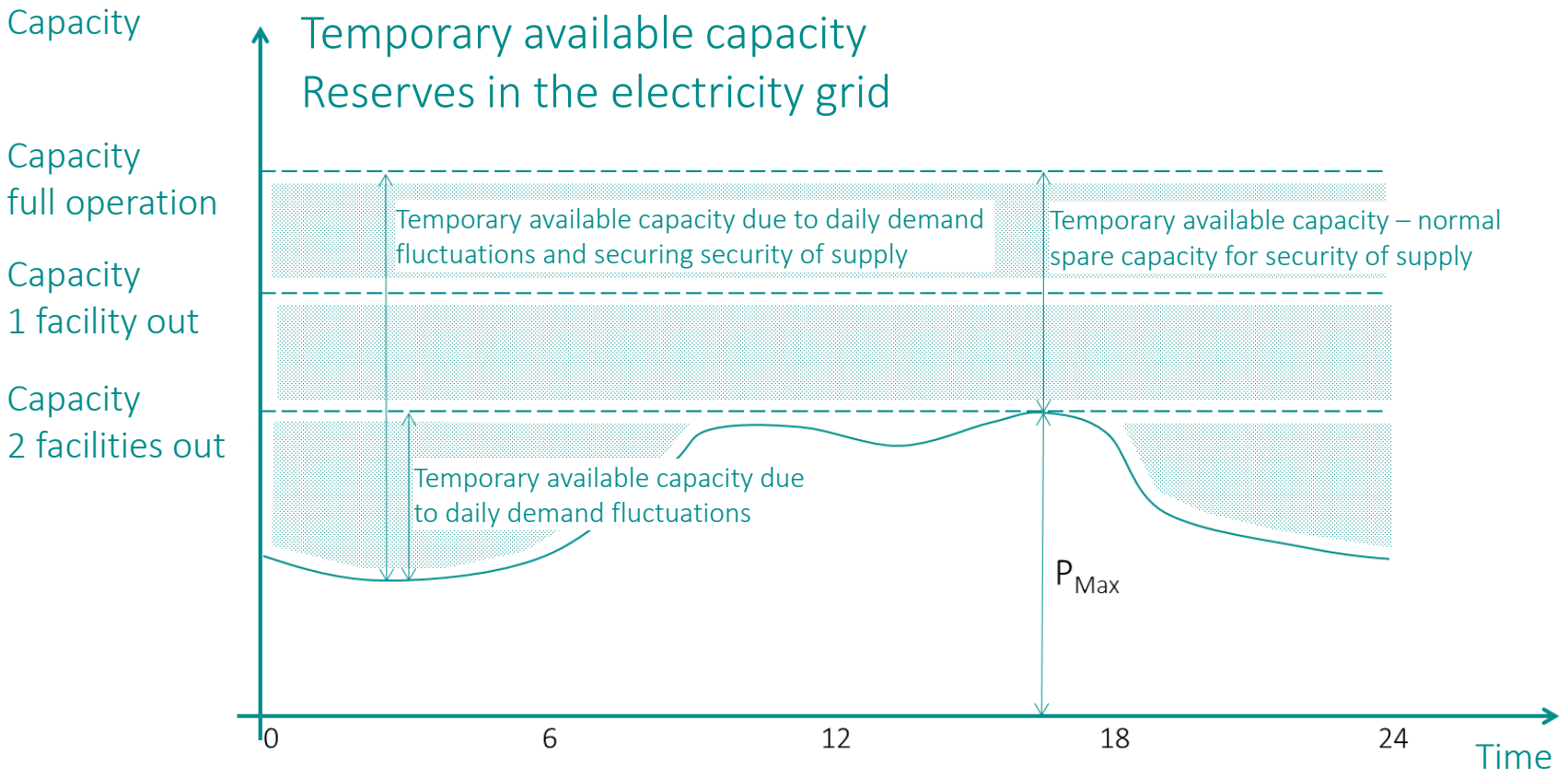
Numbers are excluding pumping stations, power regulation, AC/DC-DC/AC, compresser stations, meter and regulation, etc.



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CAPACITY IN THE DK TRANSMISSION GRID

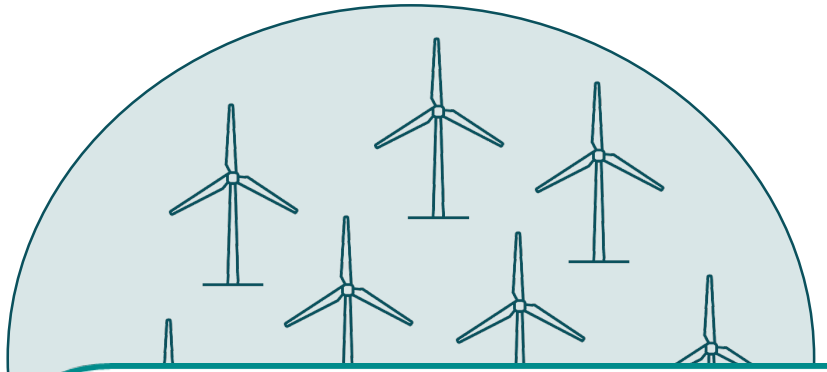
Most often there are plenty of available capacity in the grid, which give great possibilities for sector coupling, if it is made available and utilized for PtX – on flexibile terms and without guarantee.



Power Transport for **central** PtX

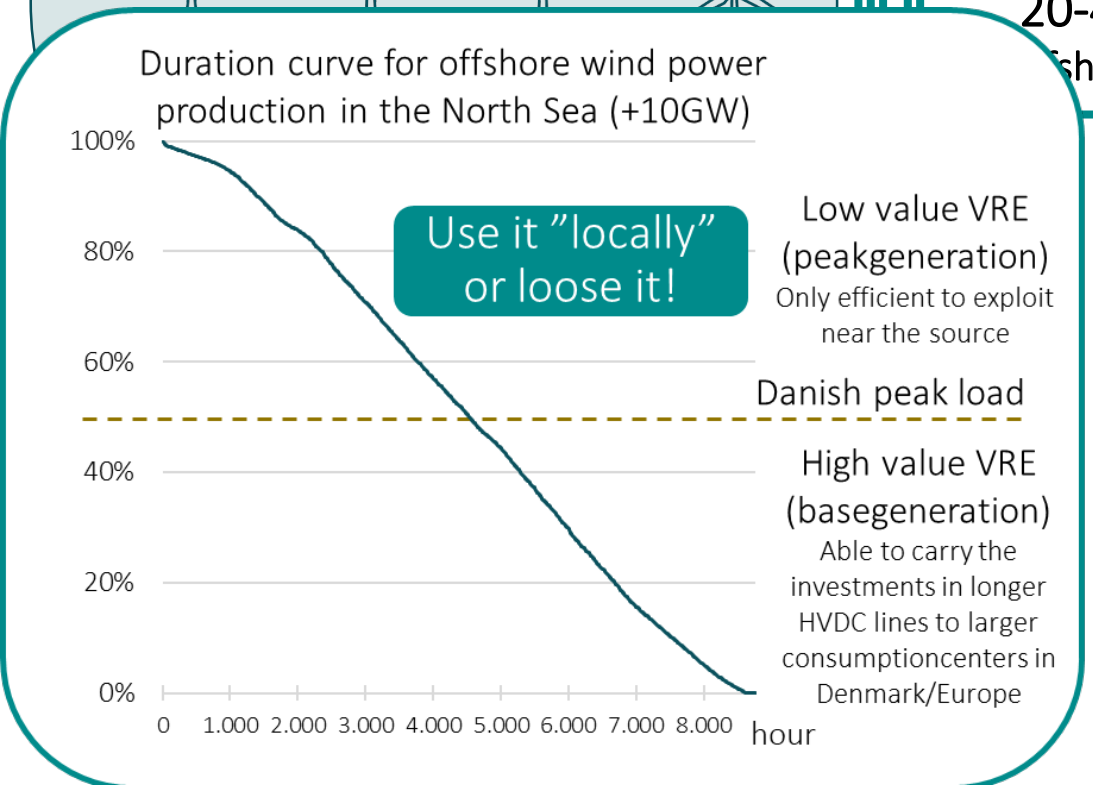
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NO COUNTRY (OR PRICE AREA) IS A COPPER PLATE





Potential of at least
20-40 GW
offshore wind



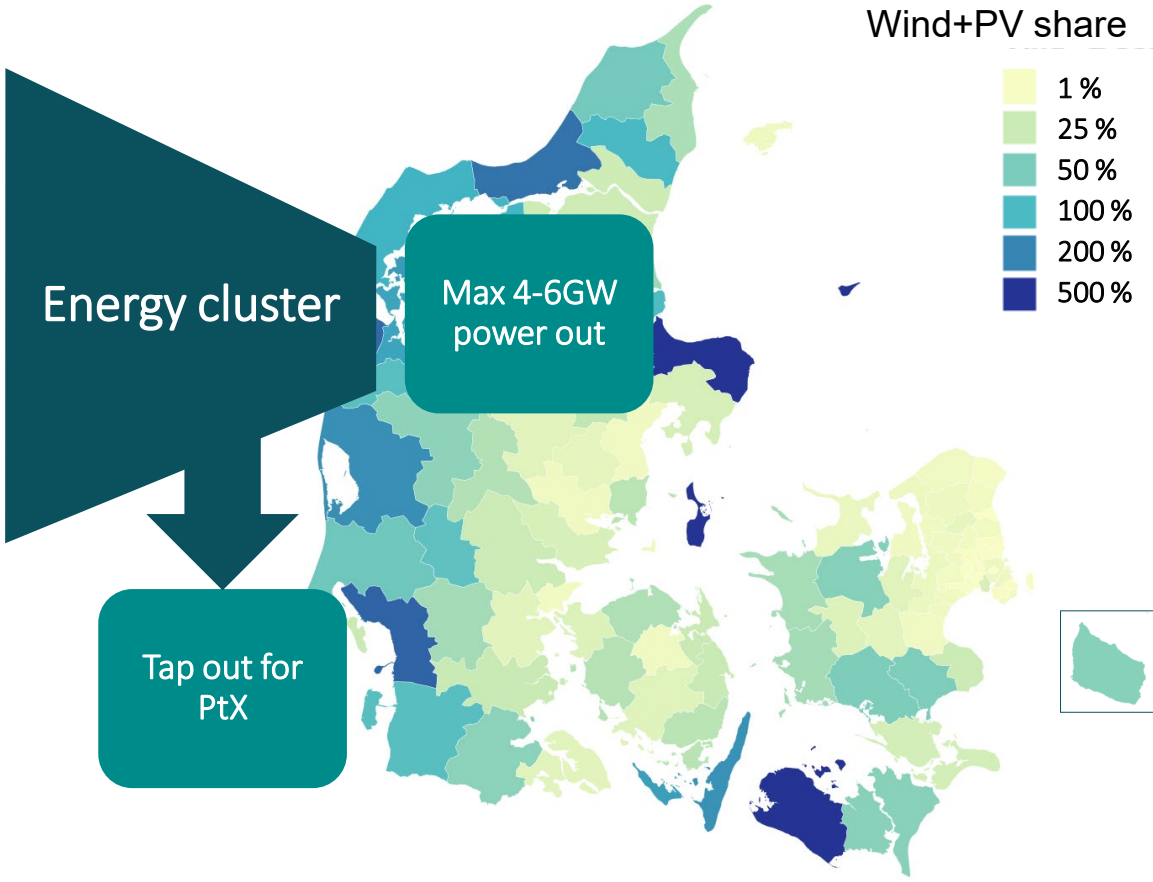
Energy cluster

Max 4-6GW power out

Tap out for PtX

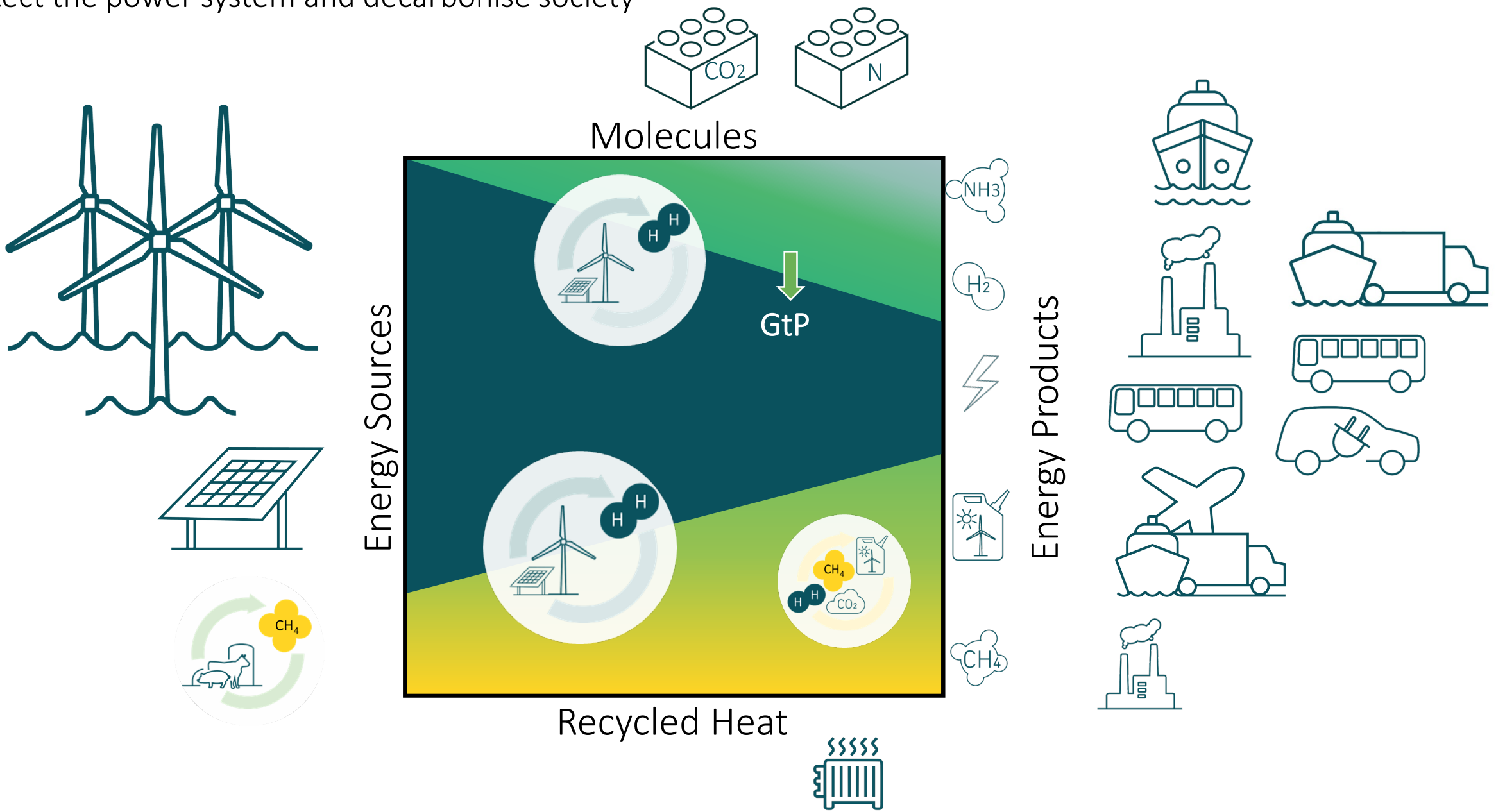
Wind+PV share at municipality level in Denmark (2017)

VRE production compared to gross power consumption



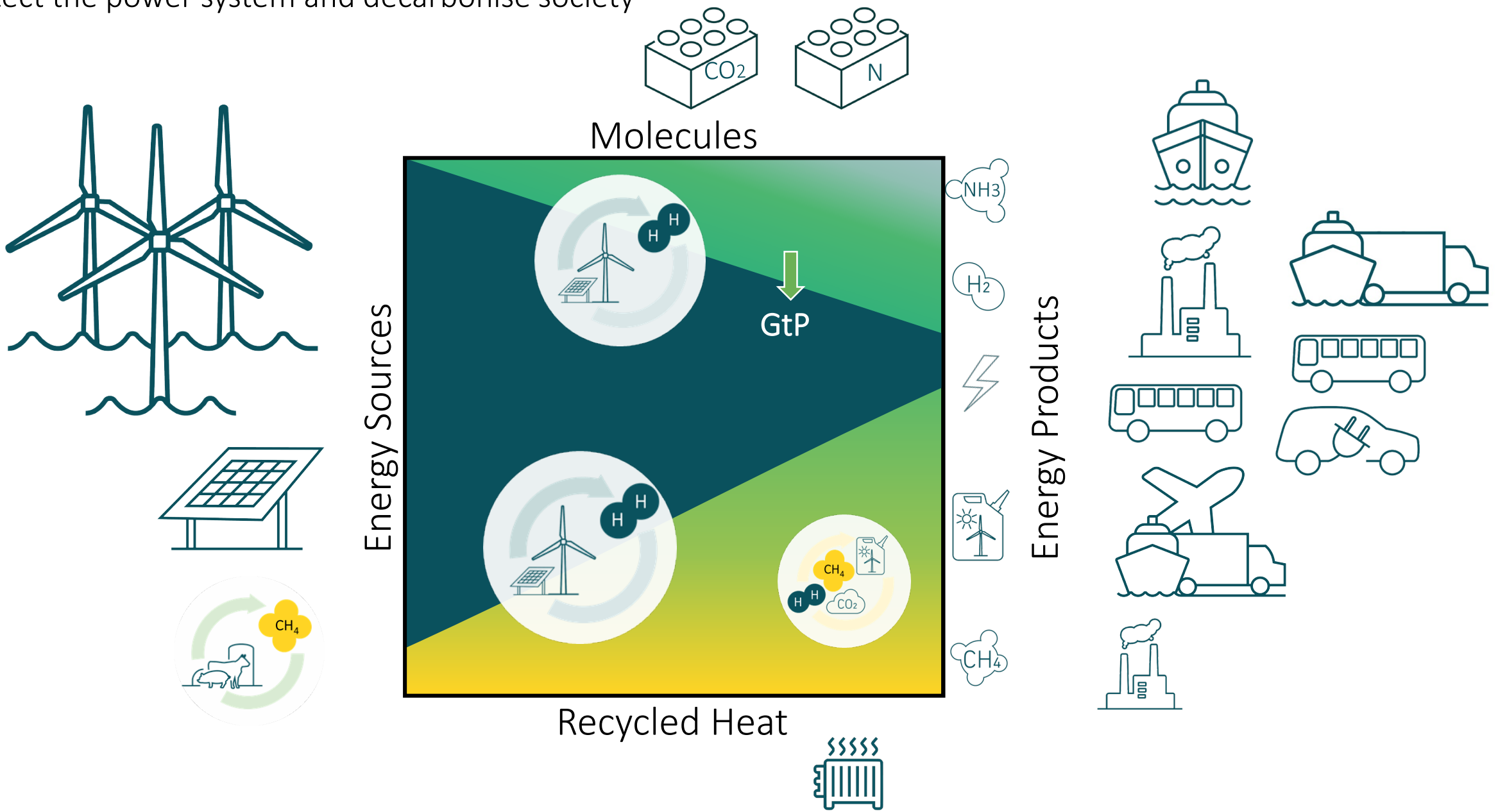
Energy cluster

Protect the power system and decarbonise society



Time goes….

Protect the power system and decarbonise society



Where do the first large amounts of H2 go?

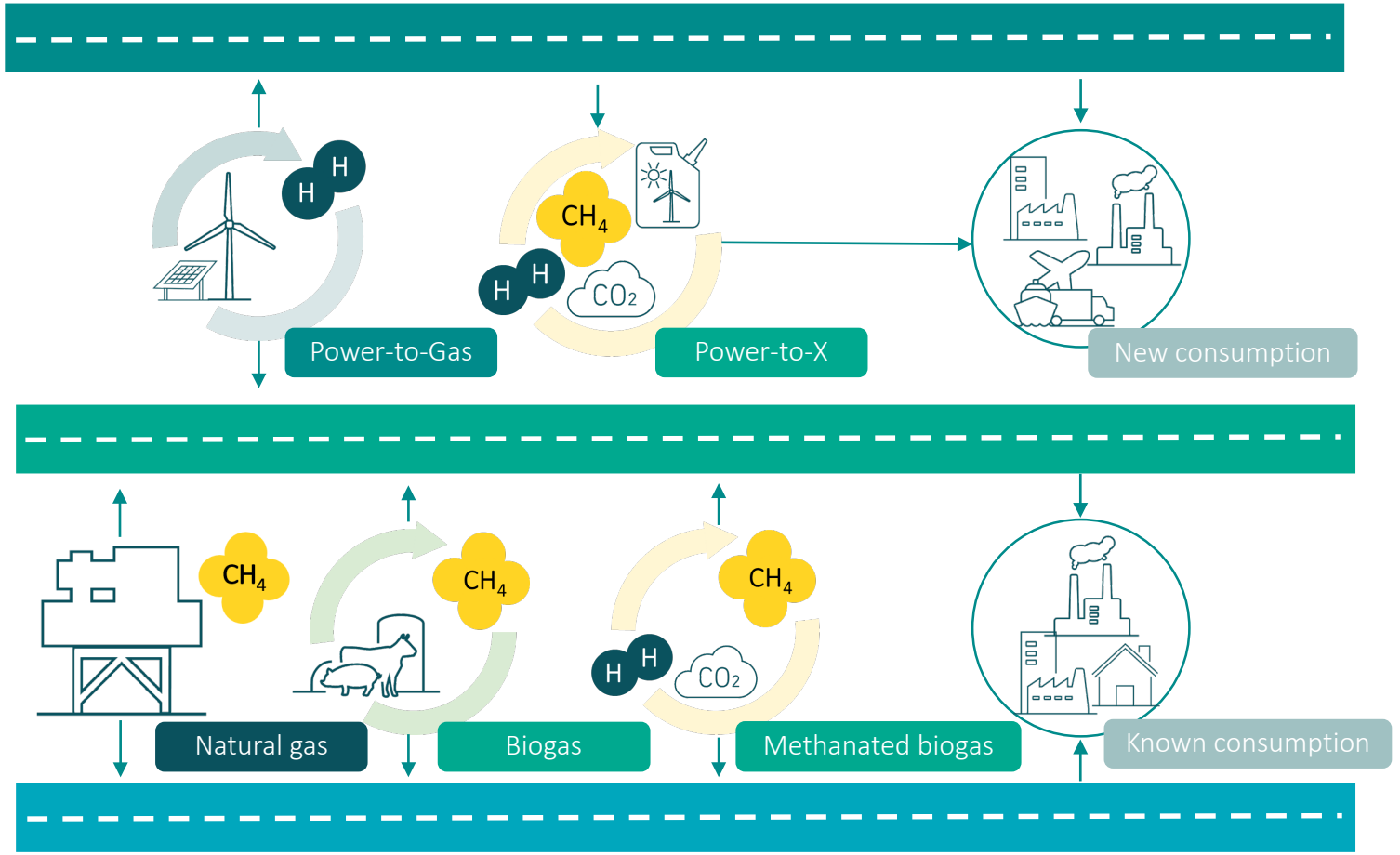
Routes for H2 in gas infrastructure

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H2 route

Mixing route

Methane route



Business-as-usual

Pros:
- Conservation of H2 value
- Potential for reduced costs in electricity infrastructure
- Large-scale storage of H2 in gas infrastructure for lowcost PtX

Cons:
- High costs for conversion and/or new H2 infrastructure
- No H2 demand today

Pros:
- BAU up to 10 % H2
- Stepping stone for H2 infrastructure

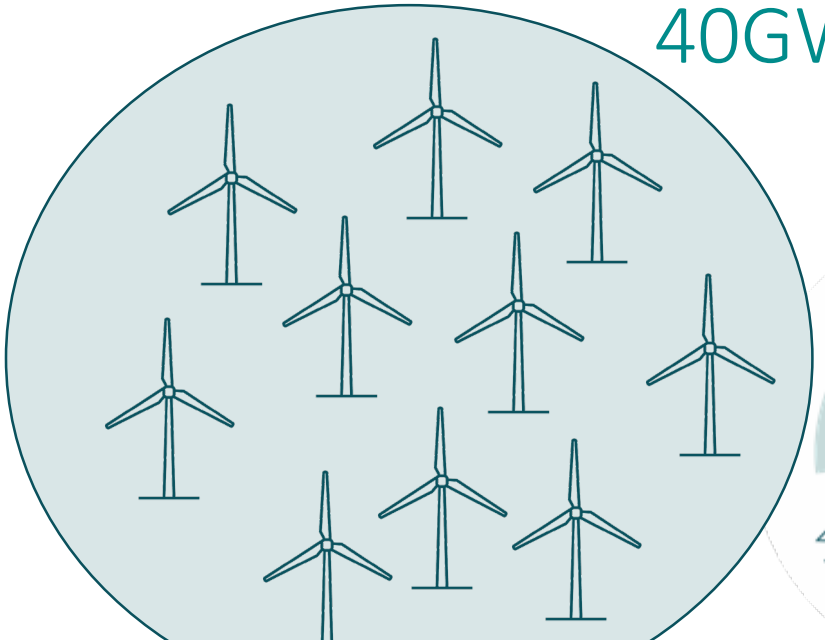
Cons:
- No pure H2 infrastructure to support large-scale PtX
- Varying H2 tolerance at consumer end
- Decreasing misxing potential due to decreasing consumption

Pros:
- BAU for TSO and gas consumers

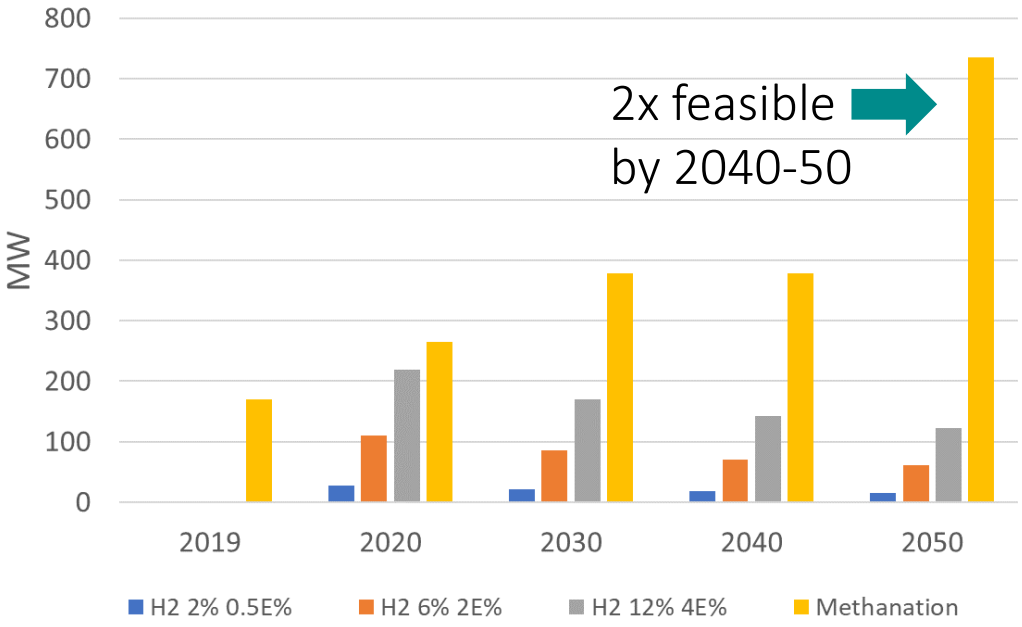
Cons:
- No pure H2 infrastructure to support large-scale PtX
- Decreasing consumption

How much?Decentral vs central

40GW

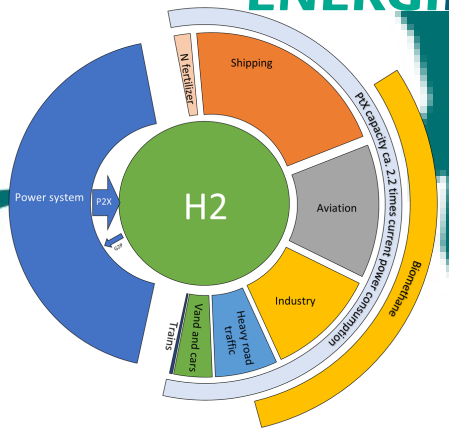


Possible electrolysis capacity



aalborgportland
CEMENTIR HOLDING

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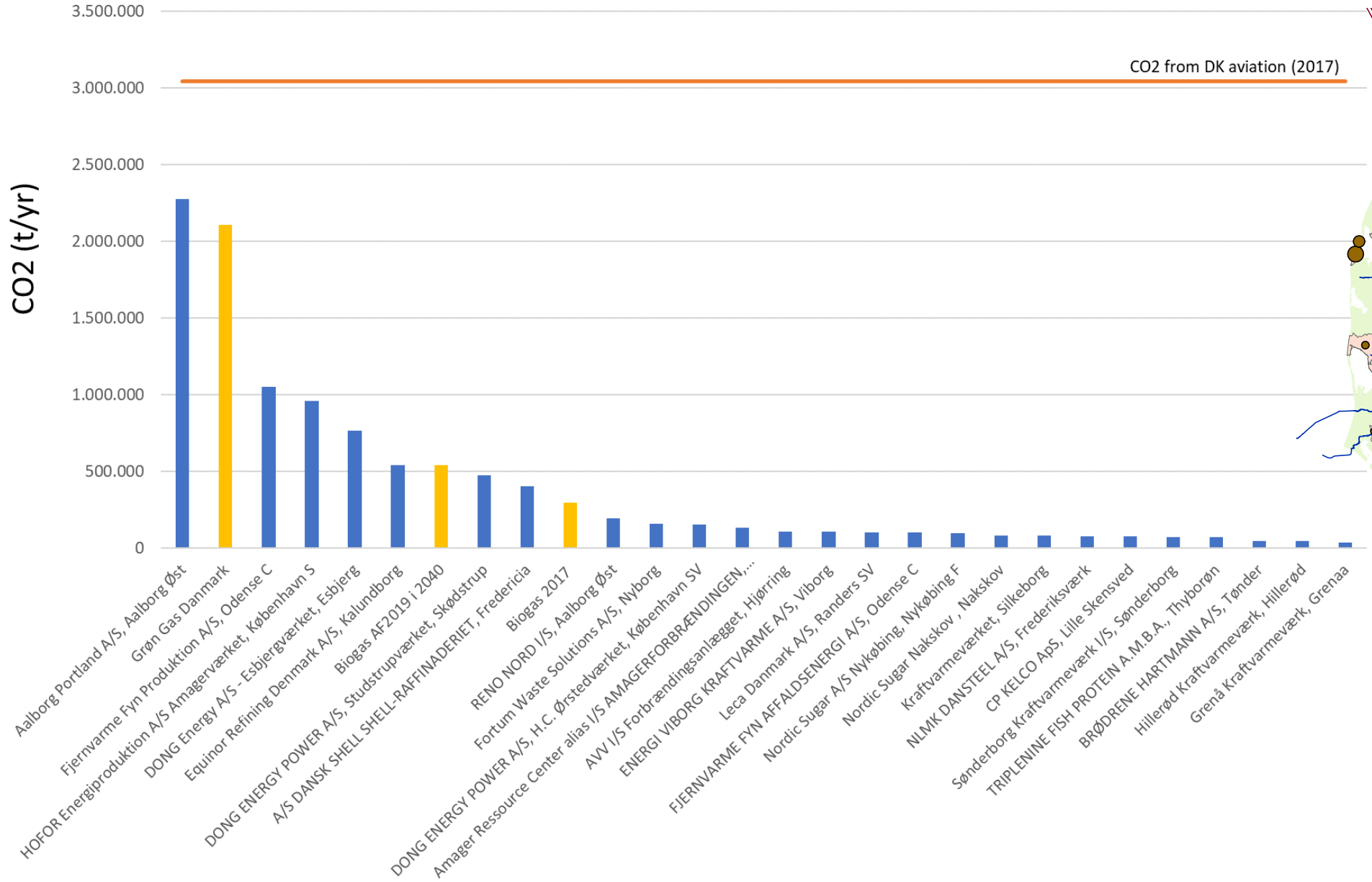


~10GW

Is there enough carbon?

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Top 25: CO2 point sources in DK (2017)



KEY MESSAGES

Ptx & Sectorcoupled infrastructure

- We can decarbonize 100% using PtX
  - Euroelectric: up to 60-65% can be directly electrified
- Wind & hydrogen synergy is much more than just simply curtailment
  - Use it ”locally” or loose it!
- North Sea region is a pricewise sweet spot
- H2 production = consumption
  - Challenge identical to historical natural gas build out
- Integrated planning infrastructure – team up!
  - Avoid excessive power infrastructure using pipes
  - Pipelines add storage and enables export
  - Central vs decentral H2 production
  - District heating networks: cheap heat and H2
  - Carbon, carbon, and carbon.
- Carbon is the scarcest resource
- Joint North Sea planning required (NSWPH)
  - Power and hydrogen and ? (NH3, …)



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