WIND-ENERGY IN THE FUTURE ENERGY SYSTEM
- SCENARIOS AND SYSTEM PERSPECTIVE

4th International Workshop on System Engineering for Wind Energy 2017-09-13 at DTU

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DISPOSITION

1. Global outlook for windpower in the energy system (IEA, COP21)
2. European scenarios for windpower (ENTSO-E/G)
3. Offshore perspectives - North sea wind power hub (nswph)
4. Future windpower integration in the energy system (danish case)
5. Summing up
6. Questions and debate

GLOBAL OUTLOOK

GLOBAL CONTEKST – IEA WEO AND COP 21

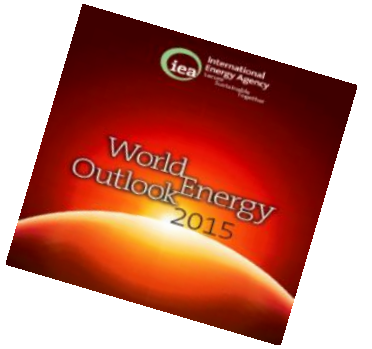
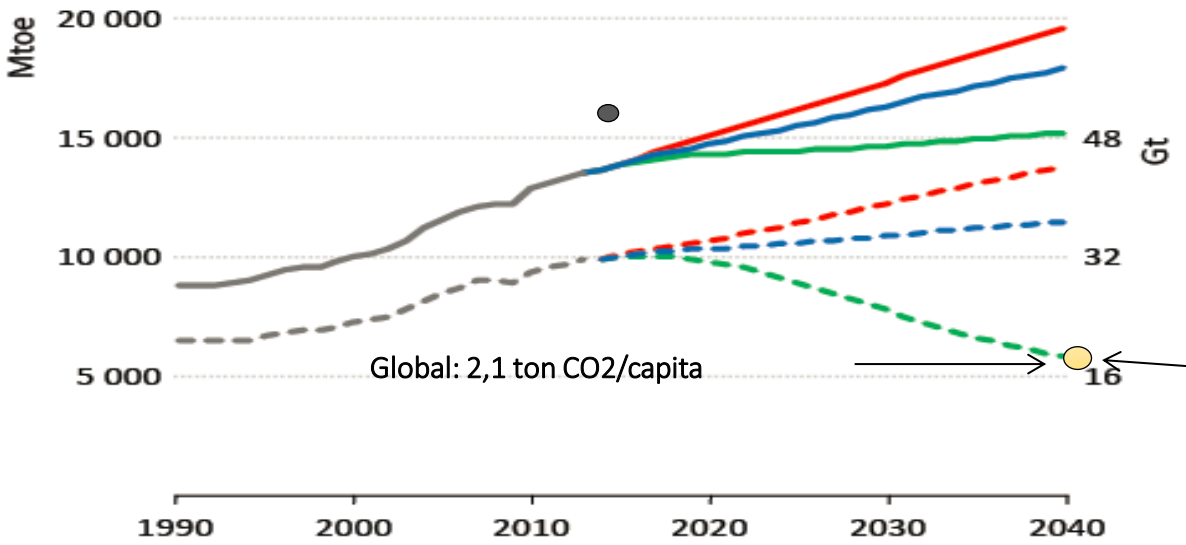


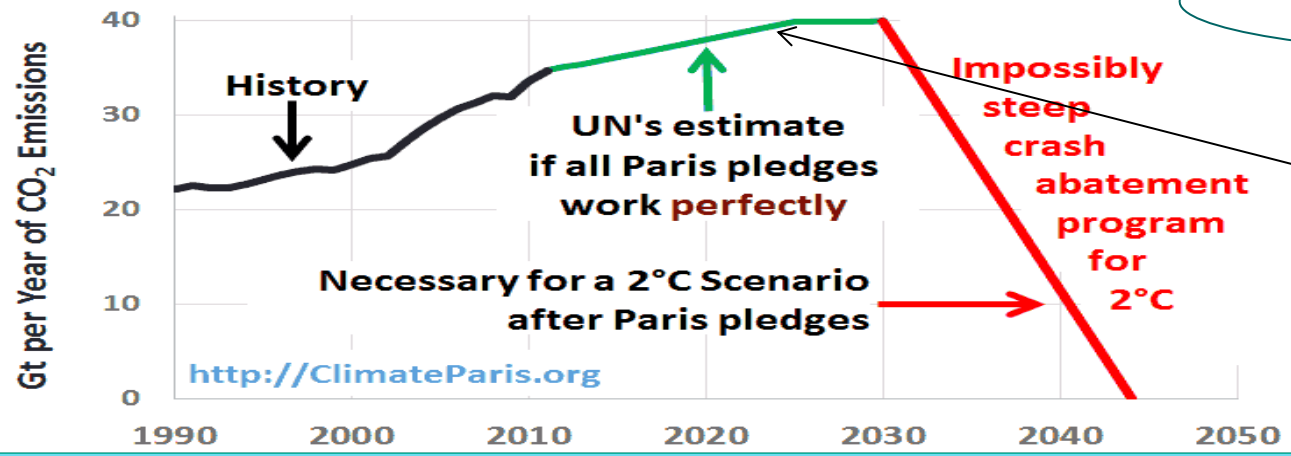
Figure 2.1 ▷ **World primary energy demand and CO_2 emissions by scenario**



IEA 450 PPM ≈

Mission Innovation
More global R&D

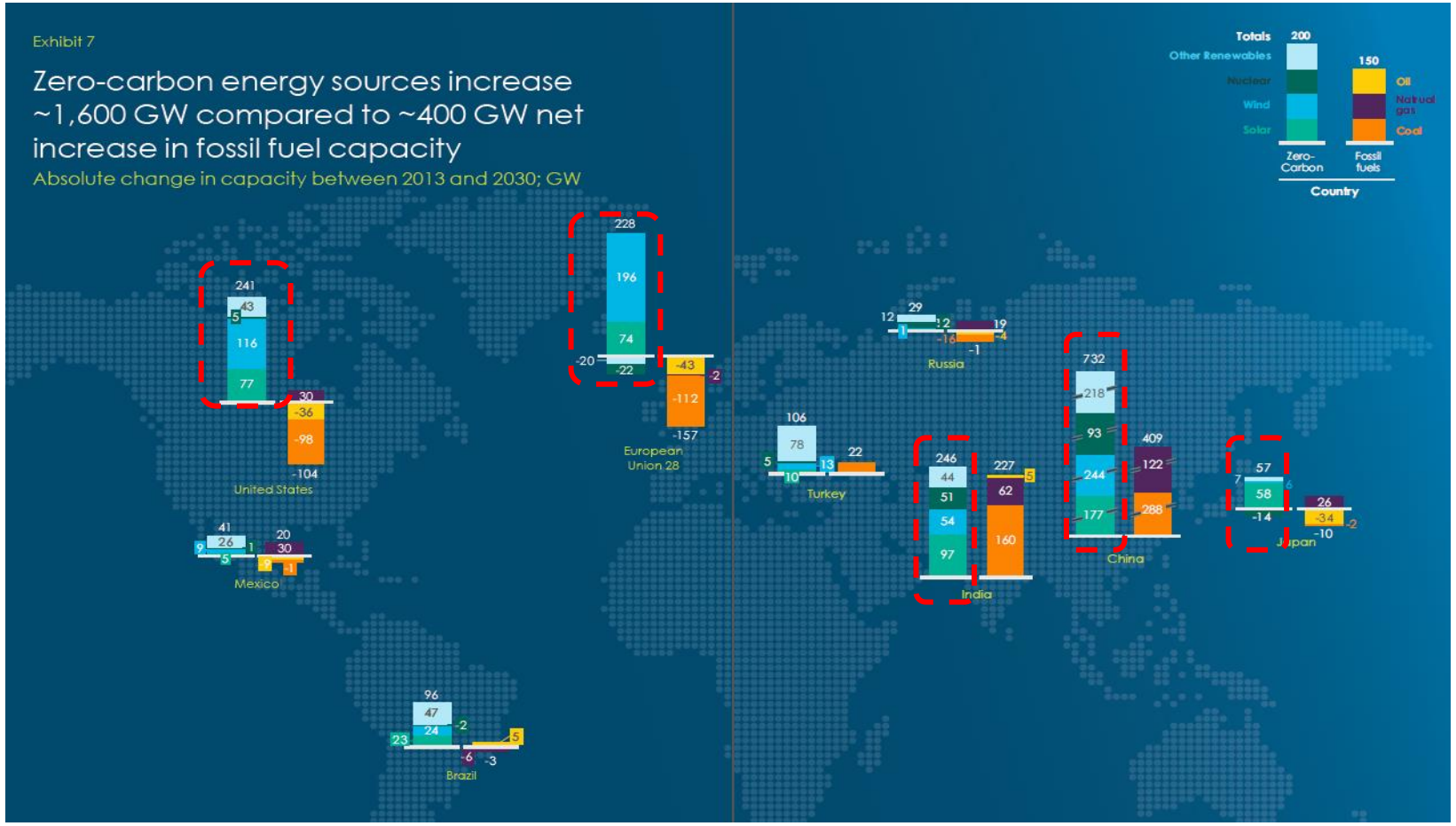
Target:
"Well below 2 degr."



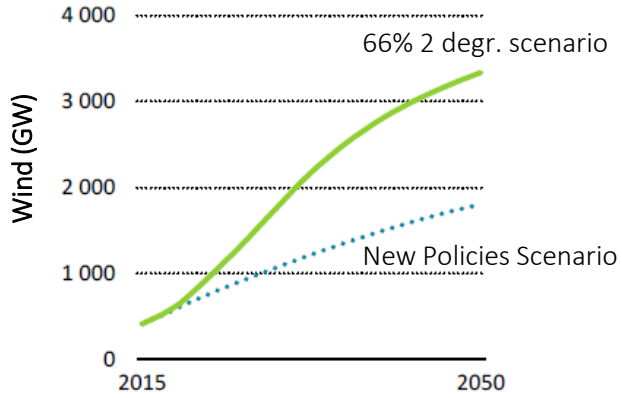
INDC's

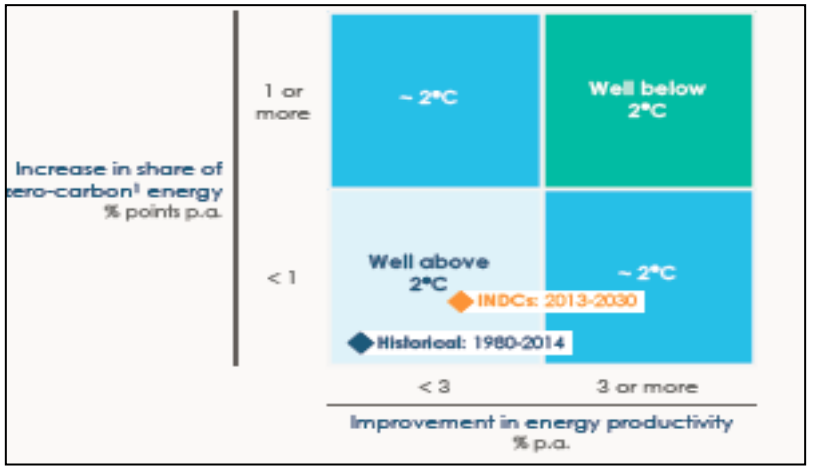
A tough challenge to realise Paris COP21 targets – significant CO2-reduction needed

GLOBAL PLANS (INDC'S) – SIGNIFICANT GROW IN WIND/SOLAR



Perspectives for the energy transition (IEA/IRENA)



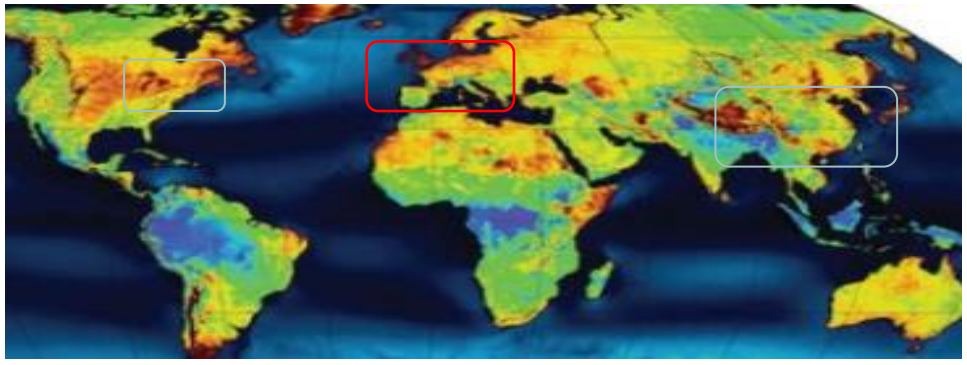


- INDC's does not lead to needed reduction in CO2 if "Well below 2 degr" should be realised
- Investment in more than 600 GW wind towards 2030 (INDC)
- But a need for even more wind, solar, RE-fuels and energy efficiency!

EUROPEAN SCENARIOS

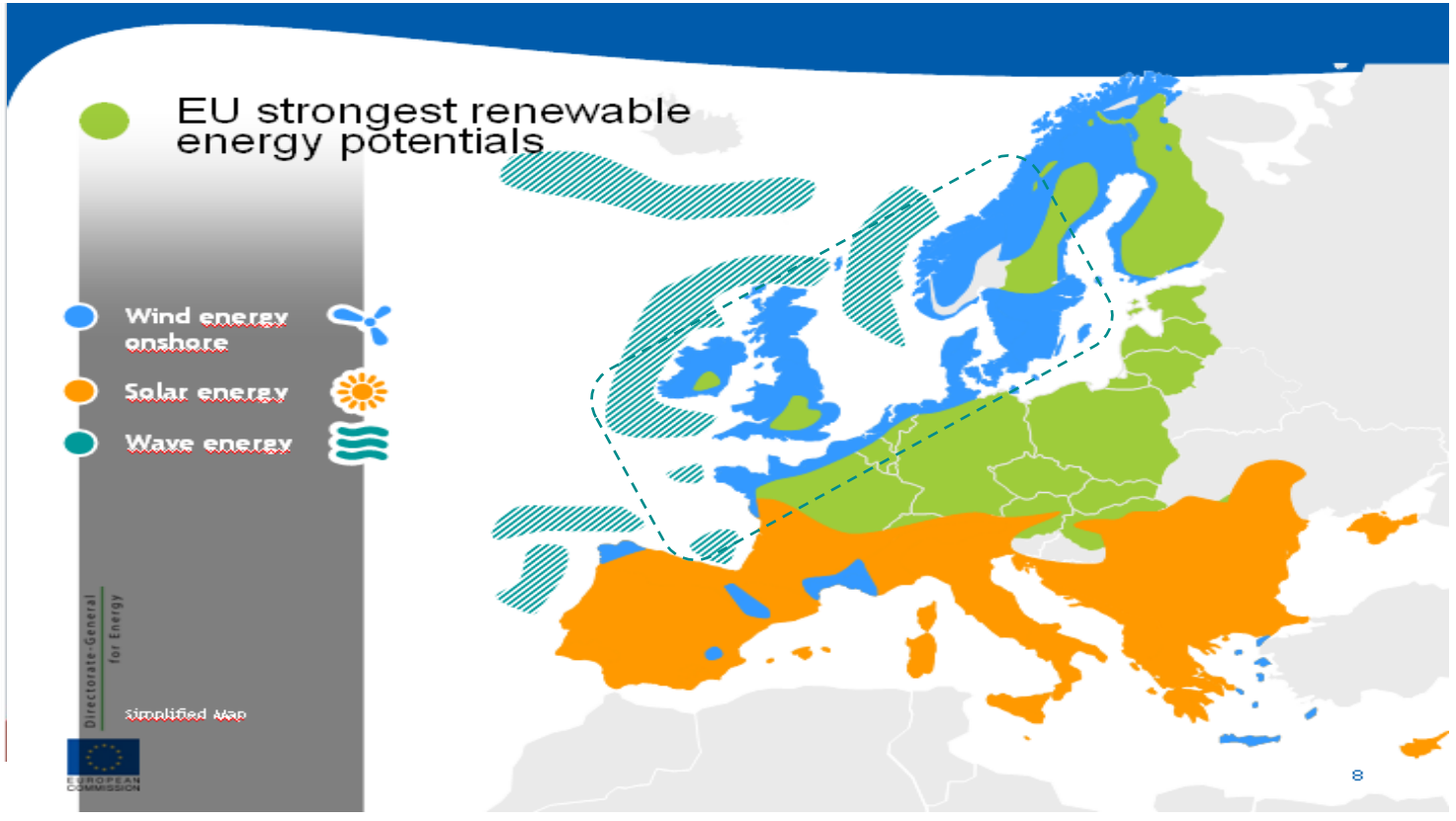
EUROPE – A CASE WITH WIND AND SOLAR MIX

Wind ressources



Solar ressources

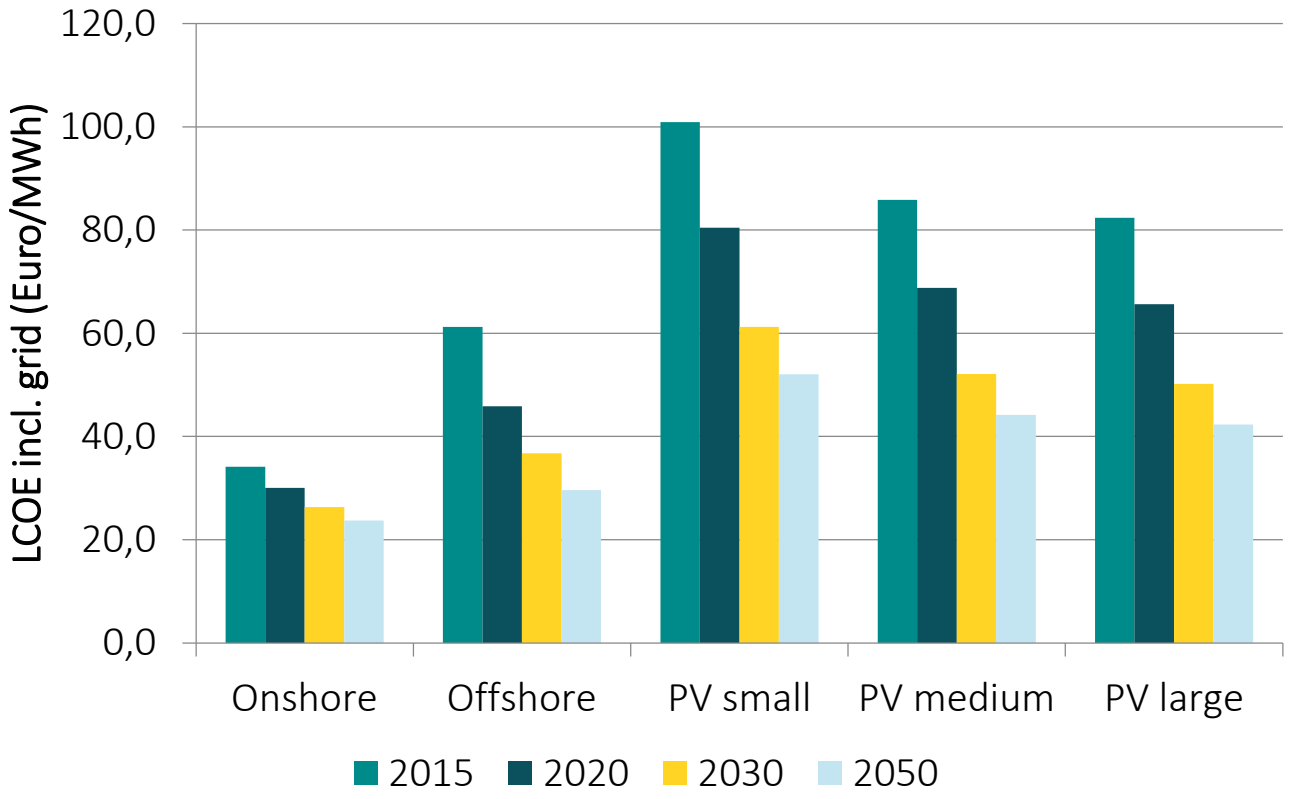
Population densities



Europe – A high population density region with a mix of wind and solar ressources

- *Europe a representative case for wind/solar system-integration*
- *North-sea area a high-wind area (offshore and onshore)*

TECHNOLOGY FORECAST – WIND AND SOLAR



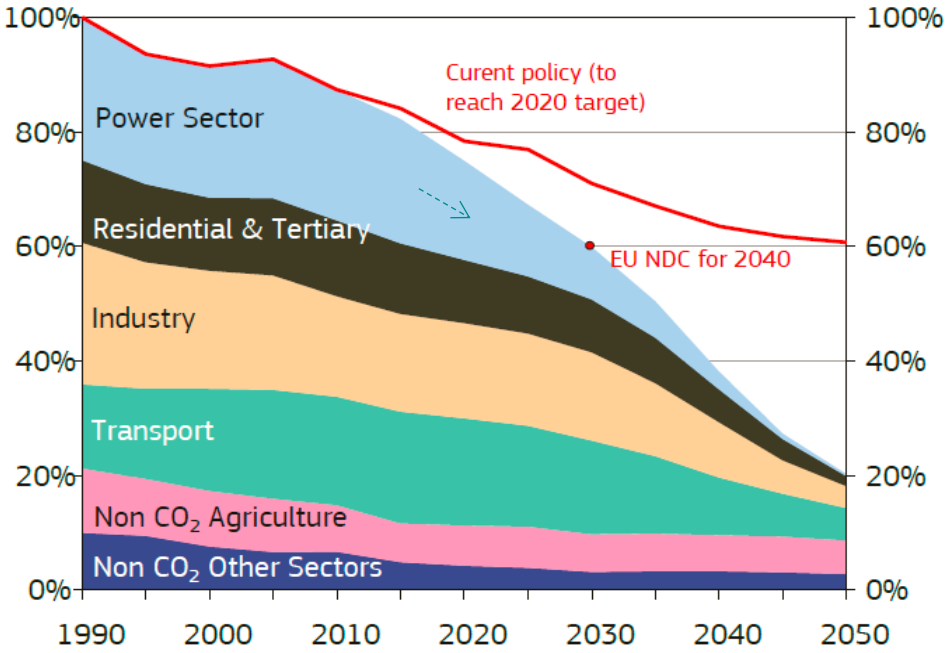
Wind and solar production profile based on Danish conditions

Socio-economic costs, on 4% discount and technical lifetime

Onshore wind very cost-effective if efficiently integrated

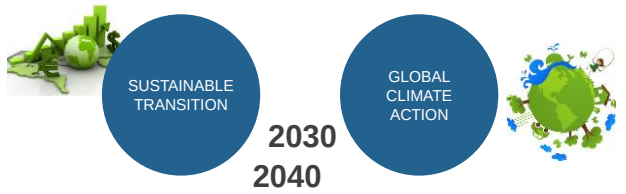
Offshore wind getting closer to onshore wind cost toward 2030

EUROPEAN TRANSITION AND ENTSO-E/G SCENARIOS



- *Target in set plan: 2030: 40% –2040: 60% –2050: 80%*
- Significant reduction of CO2 in power-sector
- Electrification of other sectors needed

ENTSO E/G Tyndp 2018 – Three scenarios defined!



GLOBAL CLIMATE ACTION (on track with EU targets)

- Strong international green framework
- EU on track with 2050 vision for CO2-reduction
- Moderate oil prices and very high CO2-prices (IEA 450 PPM)
- 50% electricity from wind/solar in 2040

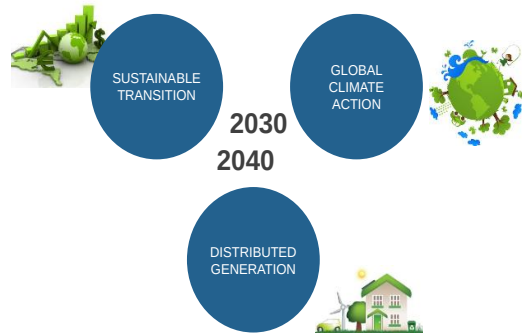
DISTRIBUTED GENERATION

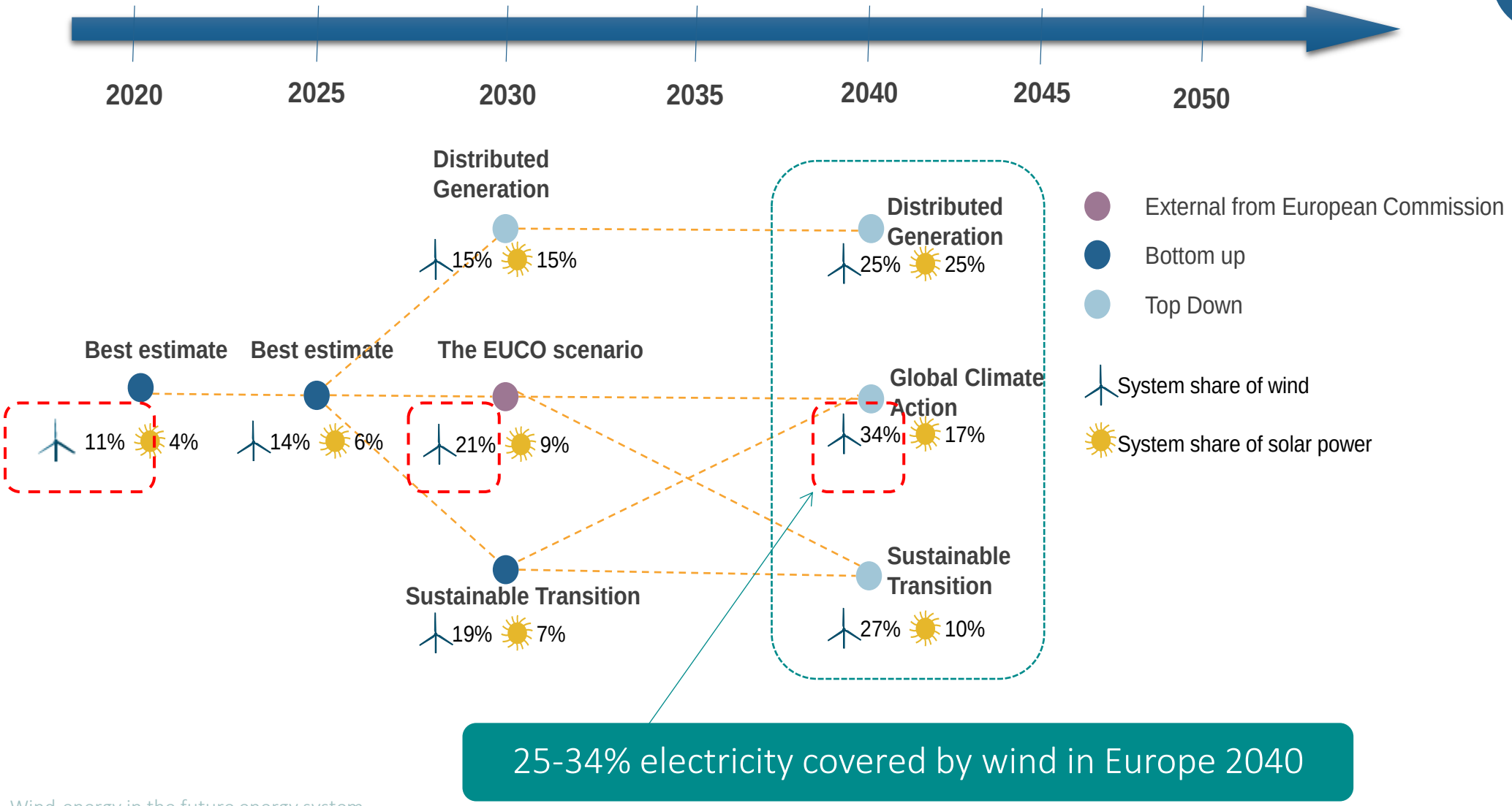
- High impact from ”local” prosumer solutions (PV/batteries)
- EU on track with 2050 vision for CO2-reduction
- High oil prices (IEA New policies) and high CO2 prices
- 50% electricity from wind/solar in 2040

SUSTAINABLE TRANSITION (almost on track with EU targets)

- EU not fully on track with 2050 vision for CO2-reduction
- Low oil/natural gas prices and moderate CO2-prices (IEA Low oil price scenario)

EUROPEAN TRANSISTION AND ENTSO-E/G SCENARIOS



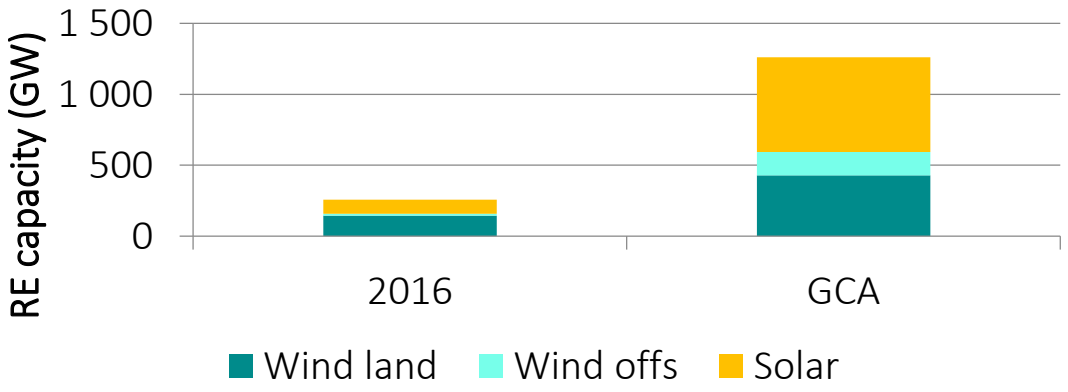


25-34% electricity covered by wind in Europe 2040

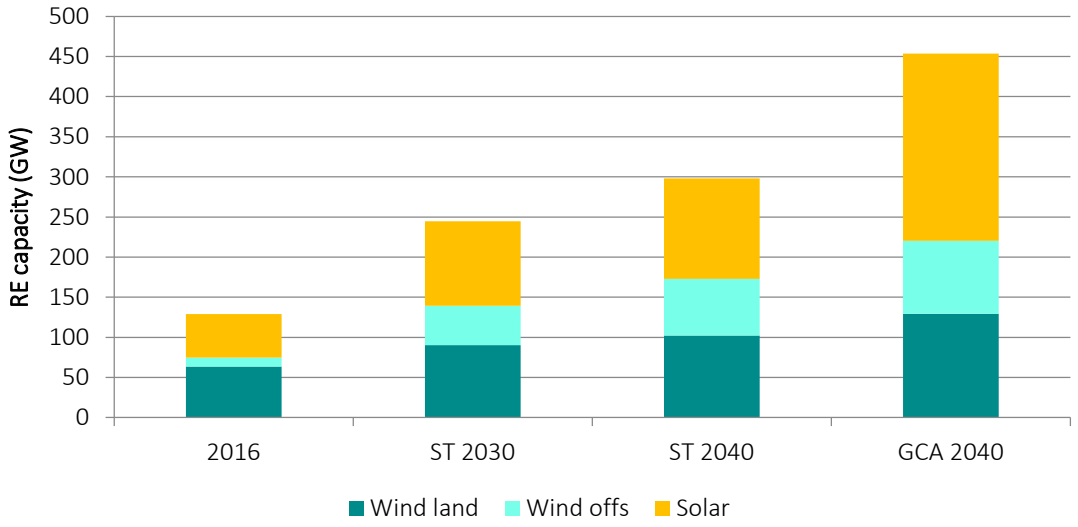
NORTH SEA AREA – HIGH WIND AREA

ENERGINET

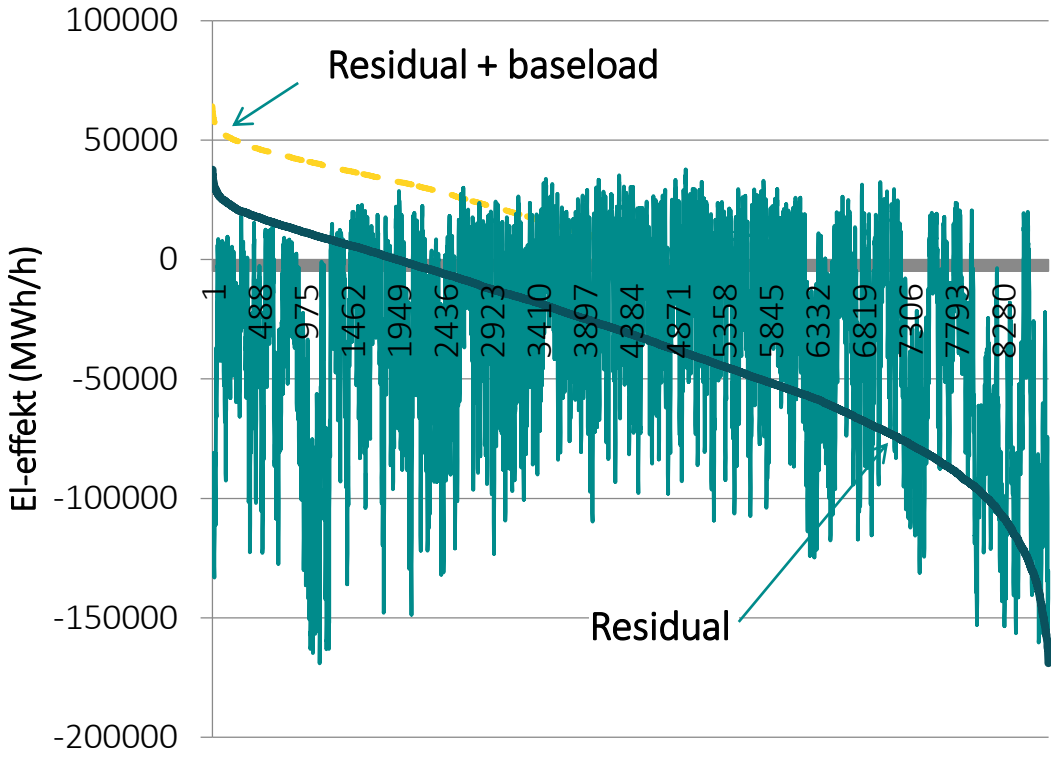
Wind/solar capacity in Europe



Wind/solar capacity in NorthSea region



Wind/solar power production minus consumption (DE,NL,GB,DK) in GCA 2040 scenario



A need to run the powersystem with a minimum of thermal base-load

A need for integration of RE-electricty in other sectors (P2G etc.)

DANISH PERSPECTIVES ON SYSTEM SUPPORT FROM DIFFERENT TECHNOLOGIES

	Generator >100 kV	Generator <100 kV	WT >100 kV	WT <100 kV	Classical HVDC	New HVDC	SVC/ STATCOM	Synch. comp
Inertia	++	+	(+)	÷	(+)	(+)	÷	++
Short circuit power	++	+	(+)	÷	÷	(+)	÷	++
Black start	(++)	(+)	÷	÷	÷	(++)	÷/(+)	÷
Continious voltage control	++	(+)	(+)	÷	÷	++	++	++
Dynamic voltage support	++	÷	++	÷	÷	++	++	++
Damping of system oscillations (PSS)	+	÷	(+)	÷	(++)	(++)	(+)	÷

++	*Large contribution*
+	*Minor contribution*
(+/++)	*Conditionally available*
÷	*Unavailable*

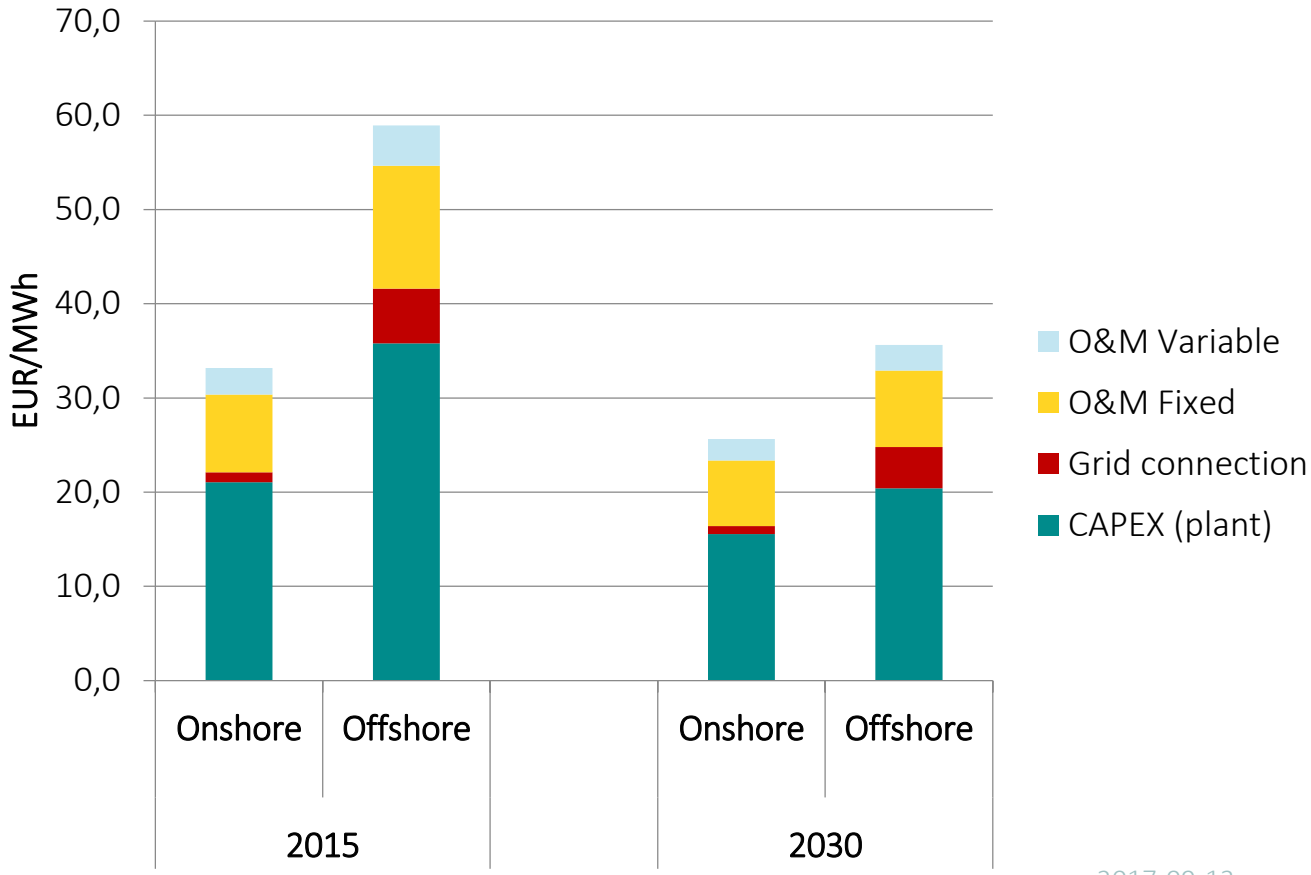
System development to use windpower for ancillary services essential

OFFSHORE PERSPECTIVES
- NORTH SEA WIND POWER HUB *(NSWPH)*

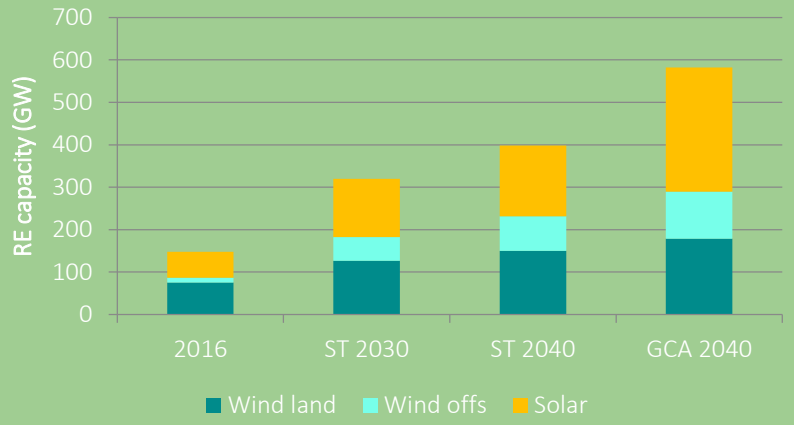
PRICE DEVELOPMENT: ROLE OF THE TSO

Comparison of future CAPEX for wind power – divided into the turbine and grid connection

A challenge is to keep up with the cost reductions on wind turbines, foundations etc.



NORTH SEA WIND POWER HUB



Paris climate agreement
80-95% CO_2 reduction in 2050

Needed in Europe in 2050
150 GW North Sea Wind

Regional cooperation is essential
Barriers:

- Subsidy schemes
- Focus on national sustainability goals

SOLUTION: NORTH SEA WIND POWER HUB

R&D project

Cooperation

- TSOs: TenneT Netherlands & Germany, Energinet.dk
- Partnerships other infrastructure operators

Studies done

- Dogger bank wind capacity
- Ecological Quick scan
- Ecological follow up studies
- Translate COP 21

Studies ongoing

- Concept business case - Market analysis
- Technical island conceptual design
- More to come!

SOLUTION: LOCATION

Shallow waters

Water depth has a significant impact on the development for offshore wind.

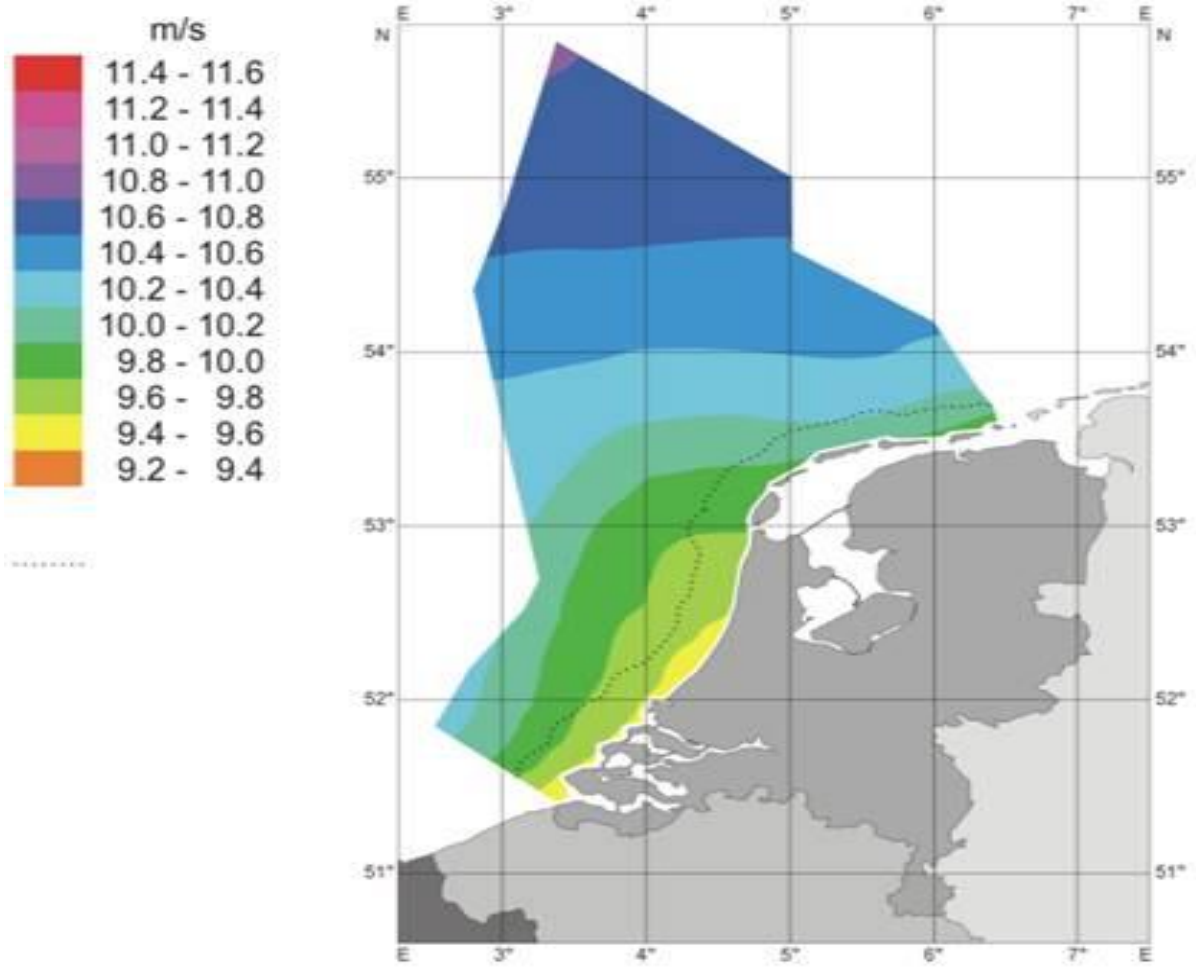
A development in shallow waters contributes significantly to cost reduction.

Wind conditions

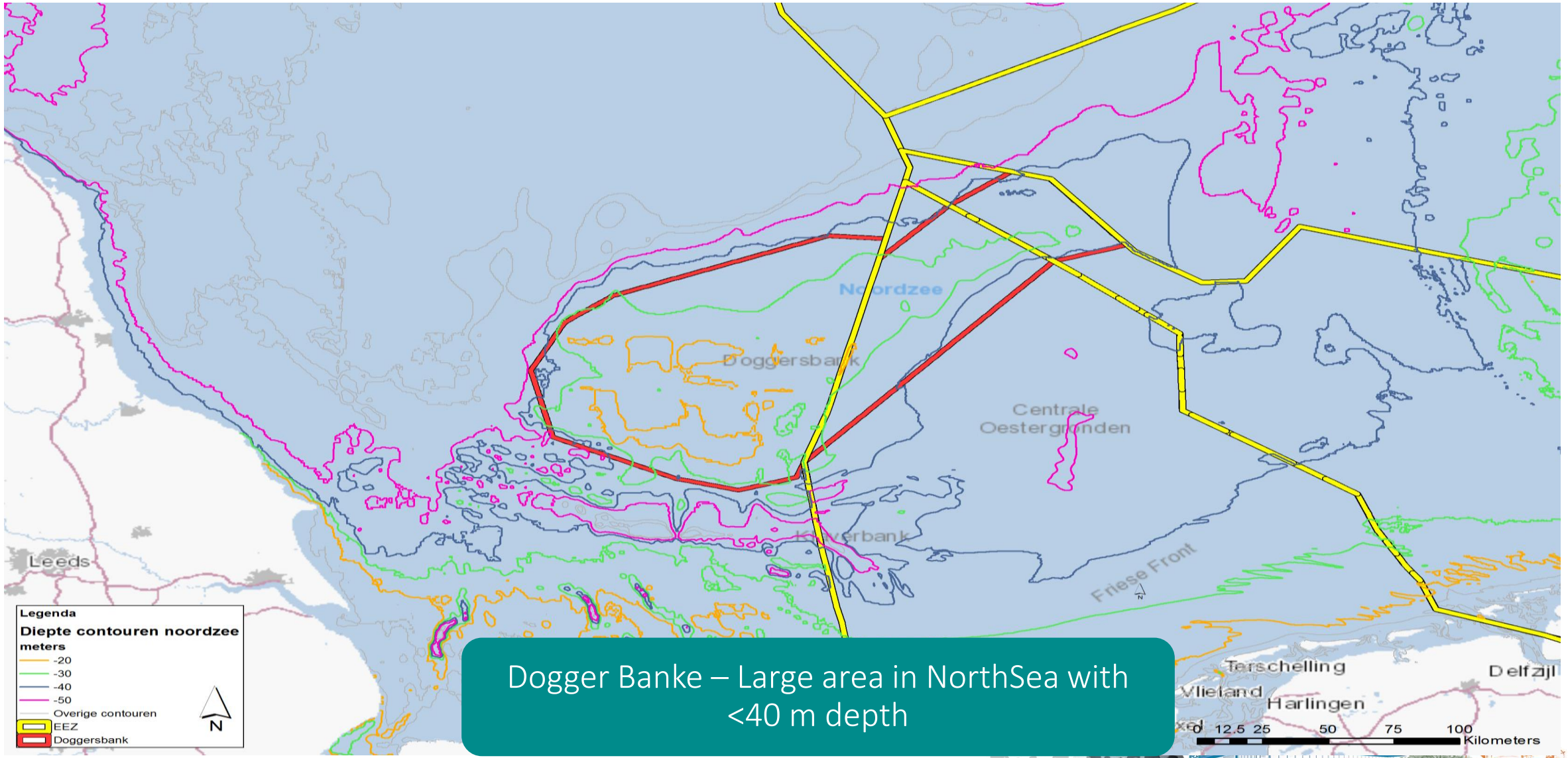
Wind conditions get better further at sea, which partially compensates the increase in cost for distance.

Central location

For a European coordinated roll-out, a central location is important.



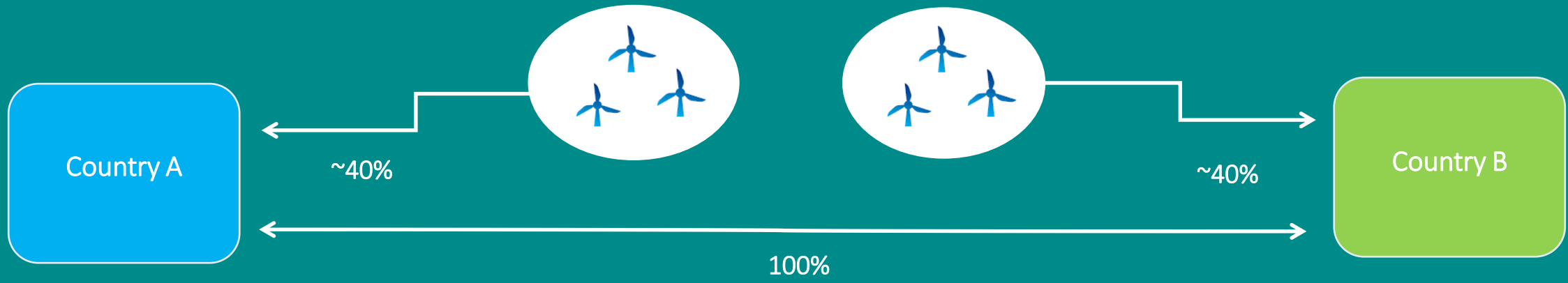
SOLUTION: LOCATION DOGGER BANKE

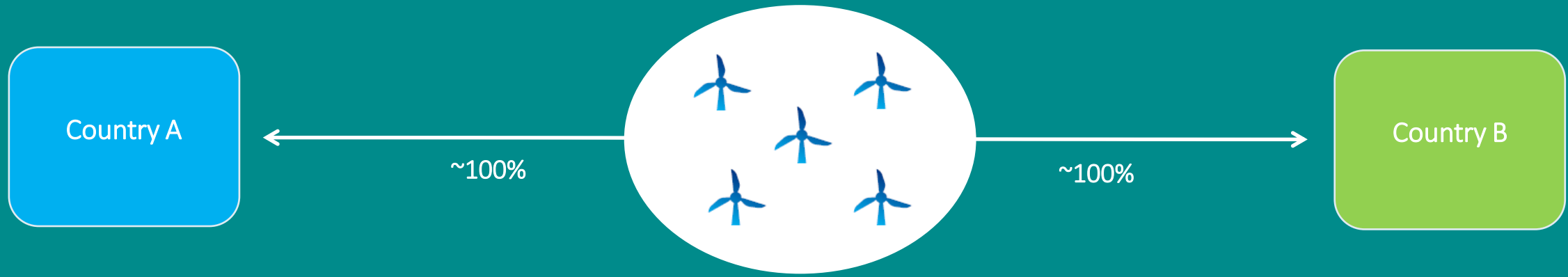


Dogger Banke – Large area in NorthSea with <40 m depth

SOLUTION: INFRASTRUCTURE

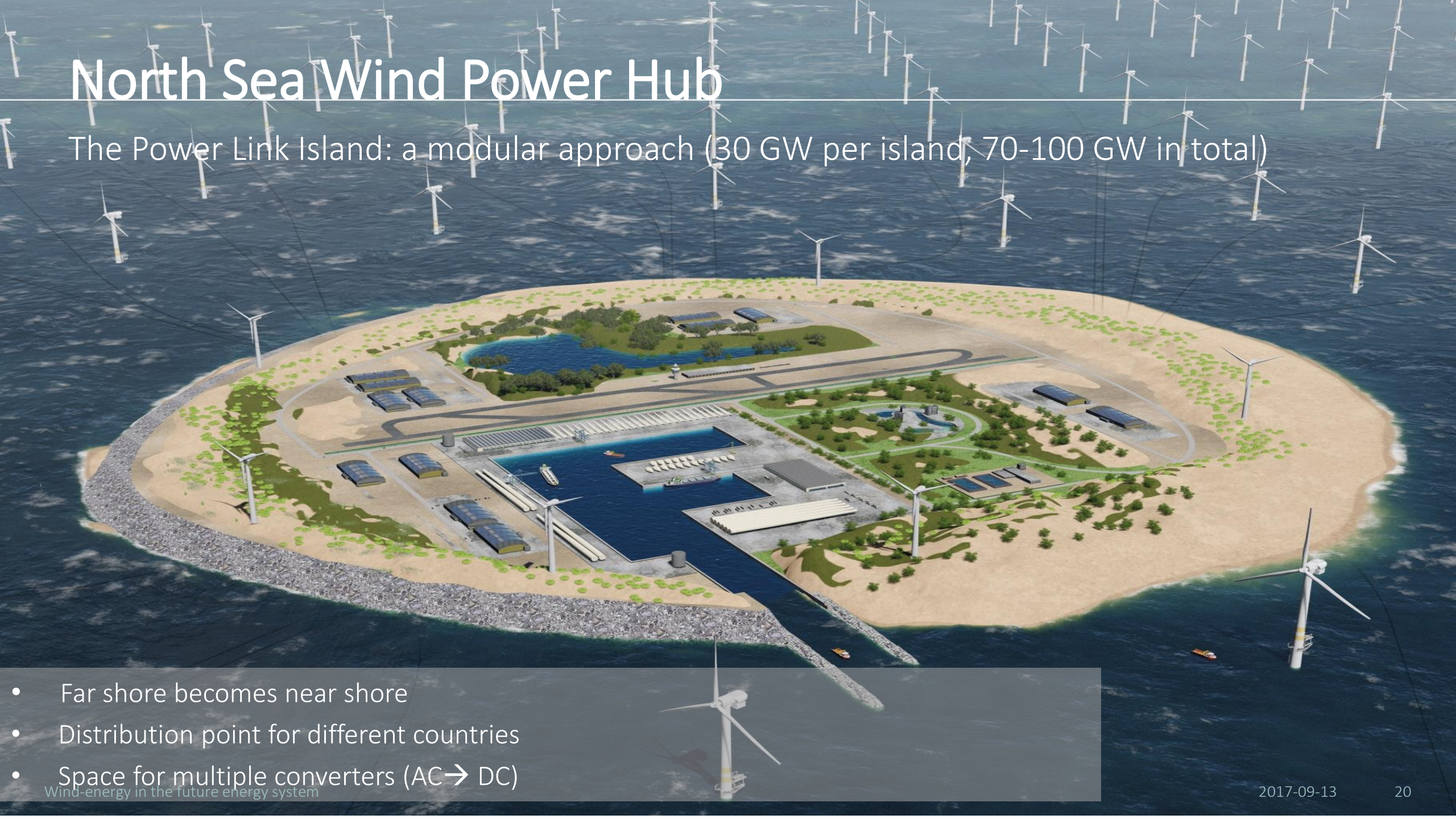
The *'wind-connector'*: offshore wind infrastructure and interconnector are one





North Sea Wind Power Hub

The Power Link Island: a modular approach (30 GW per island, 70-100 GW in total)



- Far shore becomes near shore
- Distribution point for different countries
- Space for multiple converters (AC→ DC)

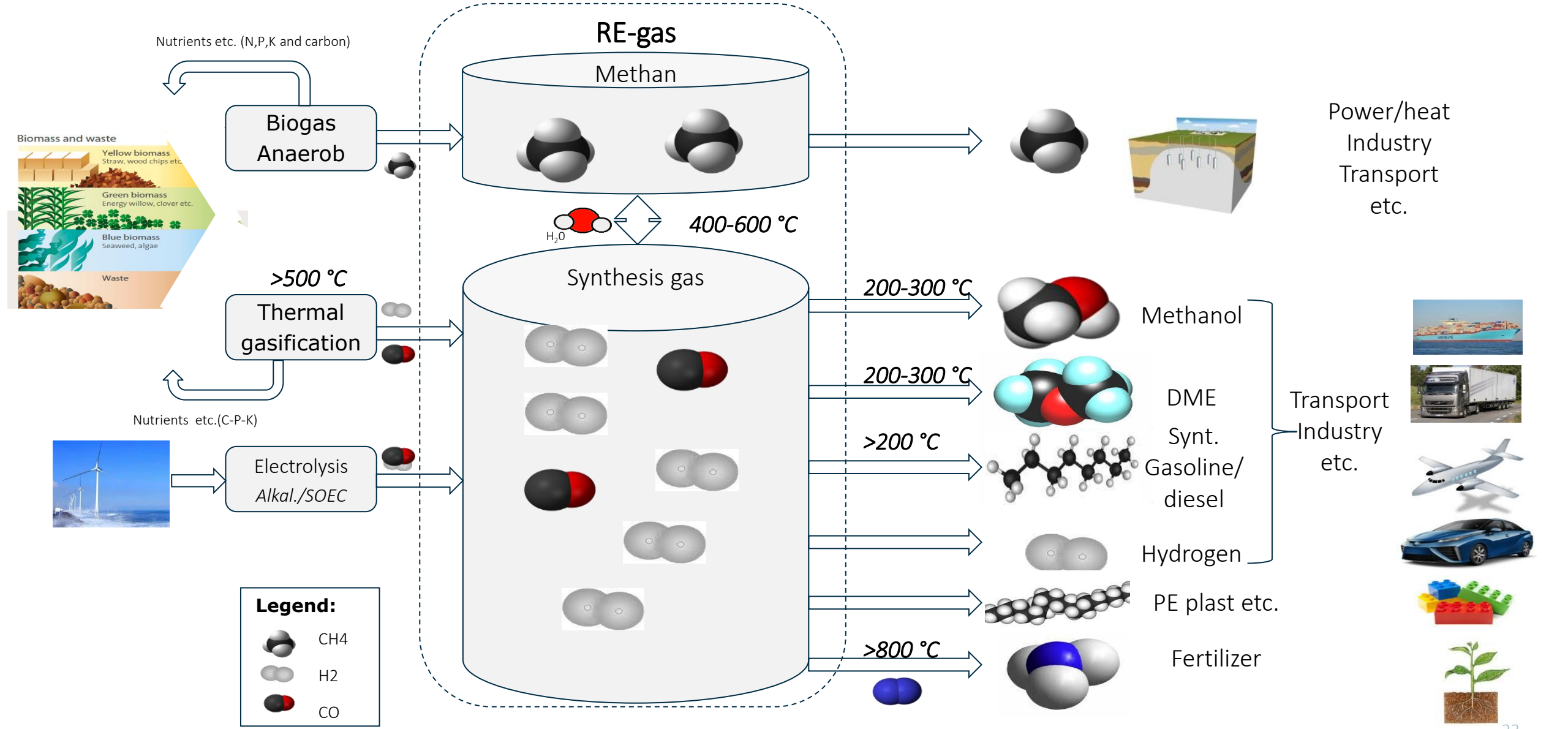
PERSPECTIVE: POWER TO GAS

Potential synergies

- After 2030 electrolysis is expected to be a mature technology for making green hydrogen
- Making green gas from the wind power source
- Onsite flexible consumption of wind power reduce transmission losses and optimize grid utilization
- Gas is much cheaper to transport over long distances than power
- Potential synergies with existing North Sea gas infrastructure?

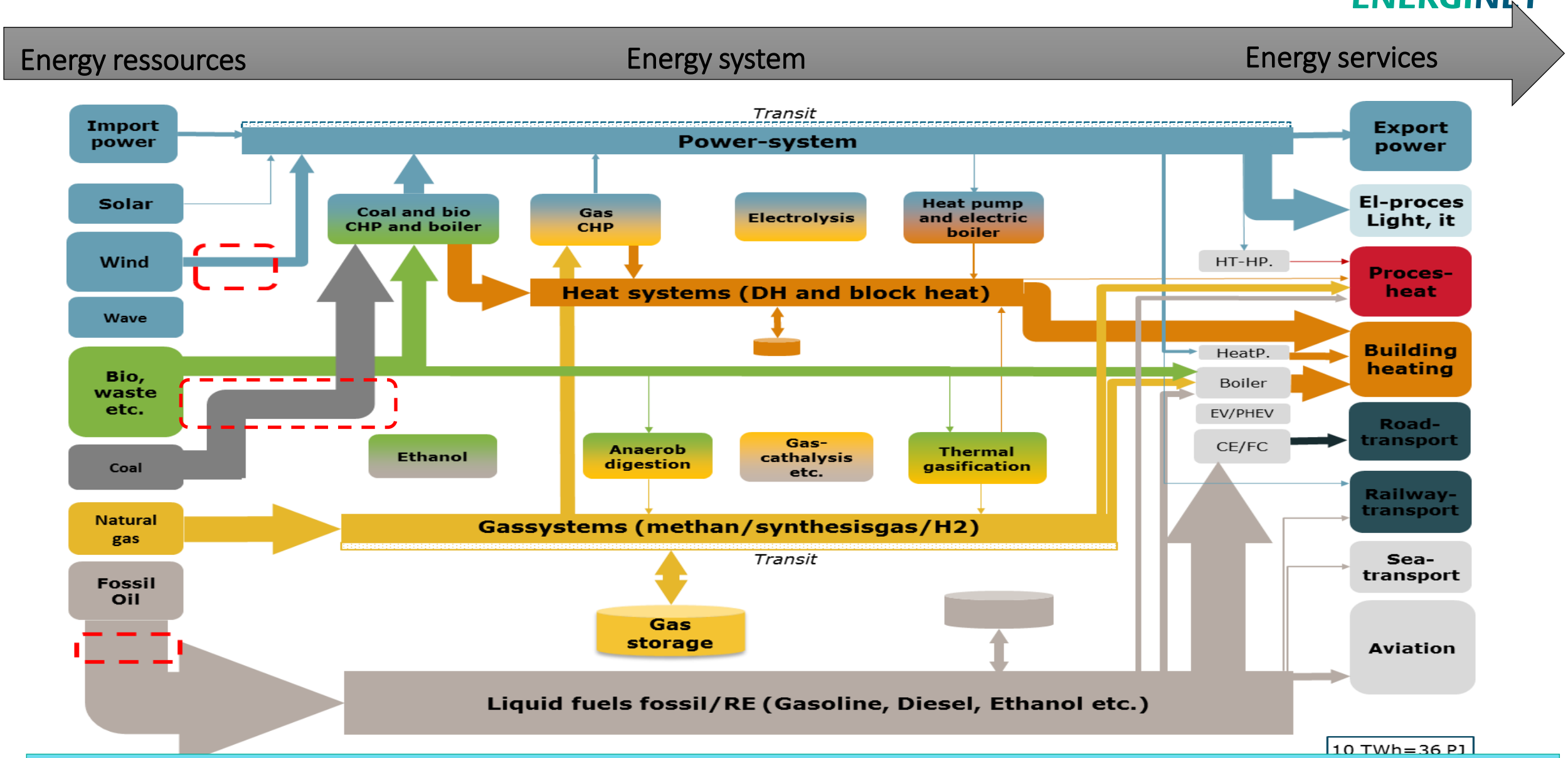
WINDPOWER INTEGRATION IN THE ENERGY SYSTEM - DANISH CASE

RE-GAS AS FEEDSTOCK FOR FUELS ETC.



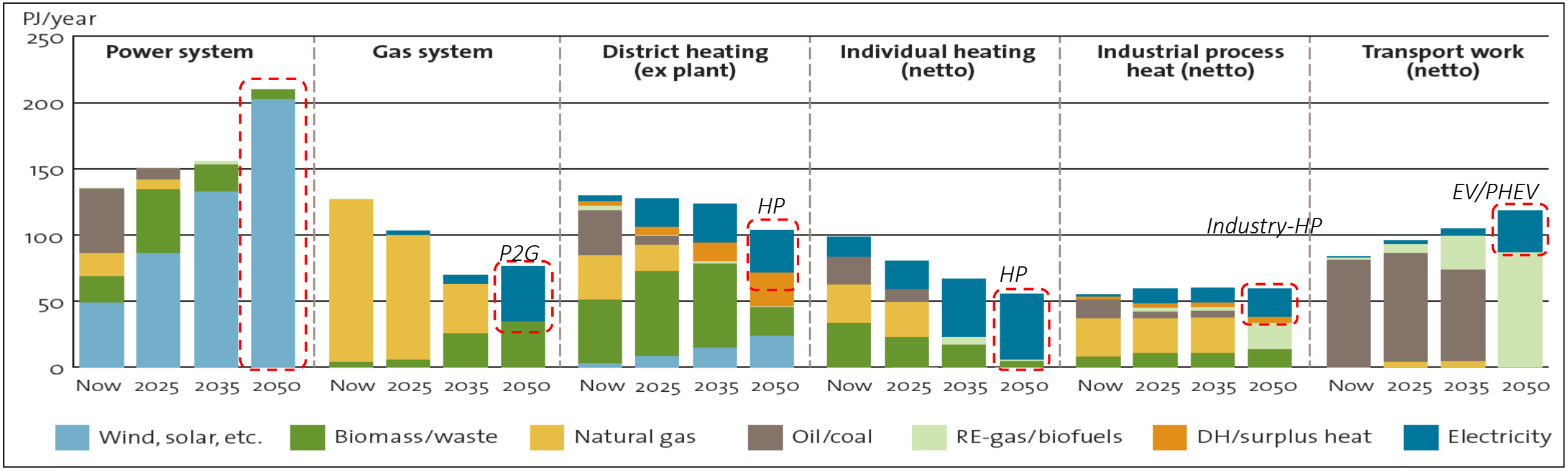
ANNUAL ENERGY FLOW IN ENERGY SYSTEM 2013

ENERGINET



Transport almost totally based on fossil oil
– wind and solar still quite a small part of total gross energy

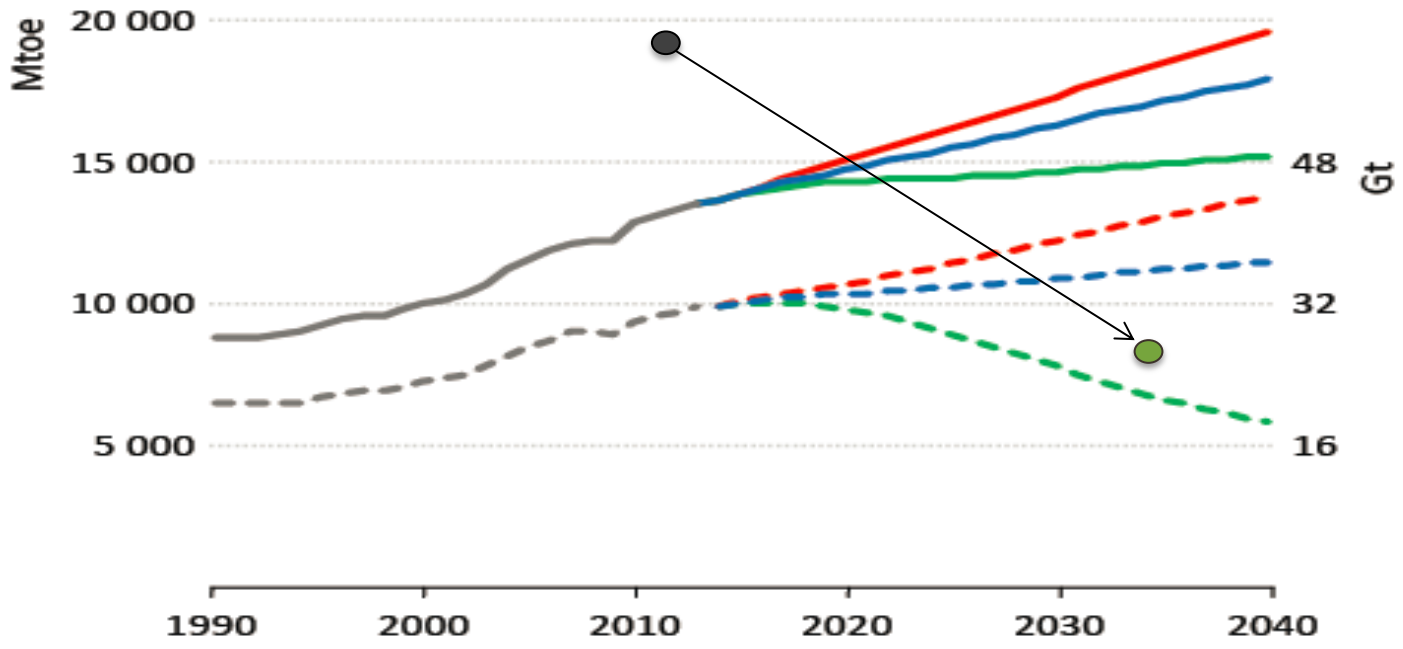
DENMARK – A SCENARIOS TOWARDS 2030-2050 - TOWARDS RE-BASED ENERGY SUPPLY IN 2050



2035 - Reference with fossil free power and heat stem

Import power
Solar
Wind
Bio, waste etc.
Natural gas
Fossil oil
Transit
Power-system
Bio CHP and boiler
Gas CHP/boiler
Electrolysis
Central Heat pumps
Export power
El-proces Light,it,cool

Figure 2.1 ▷ World primary energy demand and CO_2 emissions by scenario



Liquid fuels fossil/RE (Gasoline, Diesel, Ethanol, Methanol, DME etc.)

14 mio ton CO2

10 TWh=36 PJ

POST 2030 - FEASIBILITY STUDY 2035 – REDUCED FOSSIL OIL DEMAND

ENERGINET

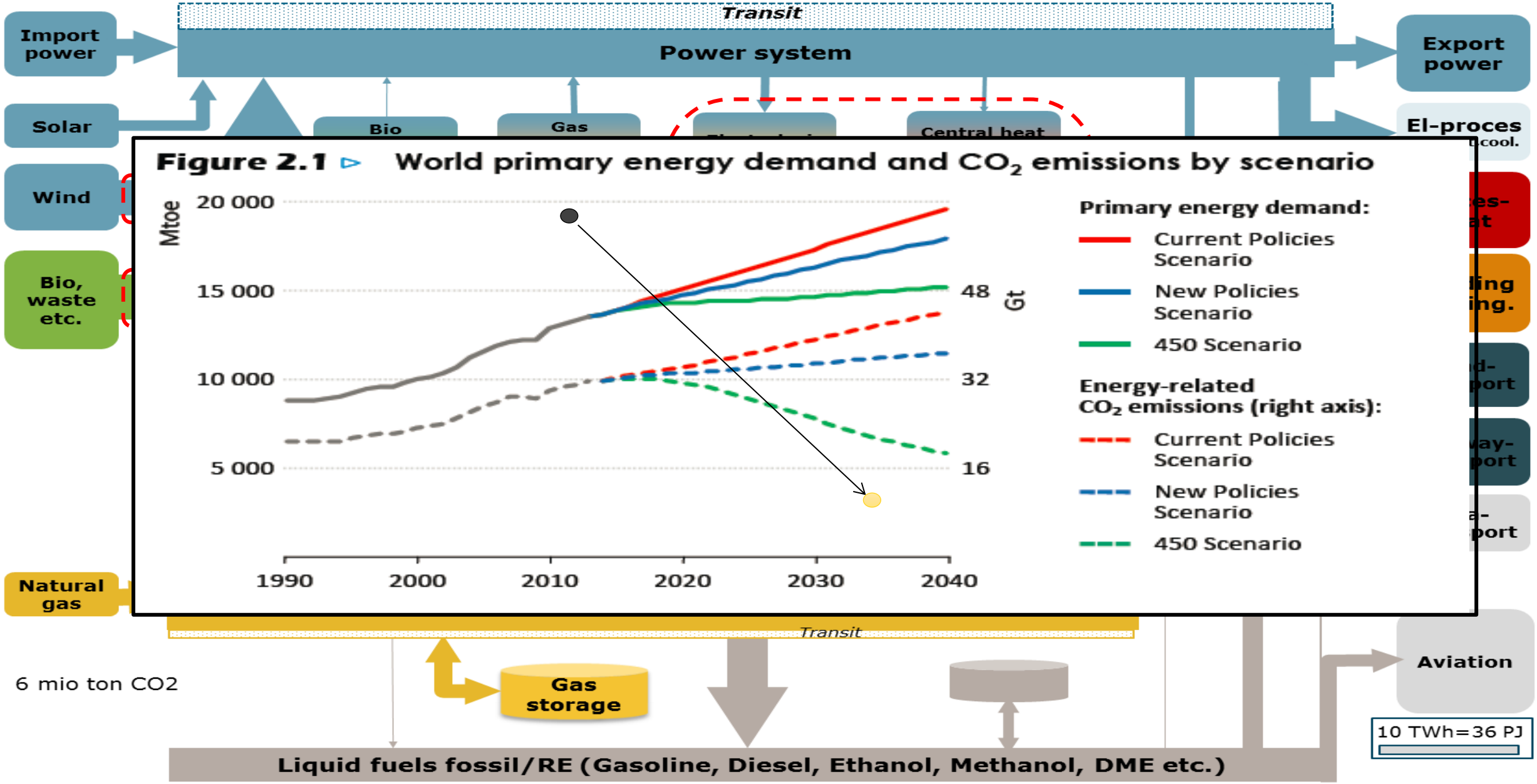
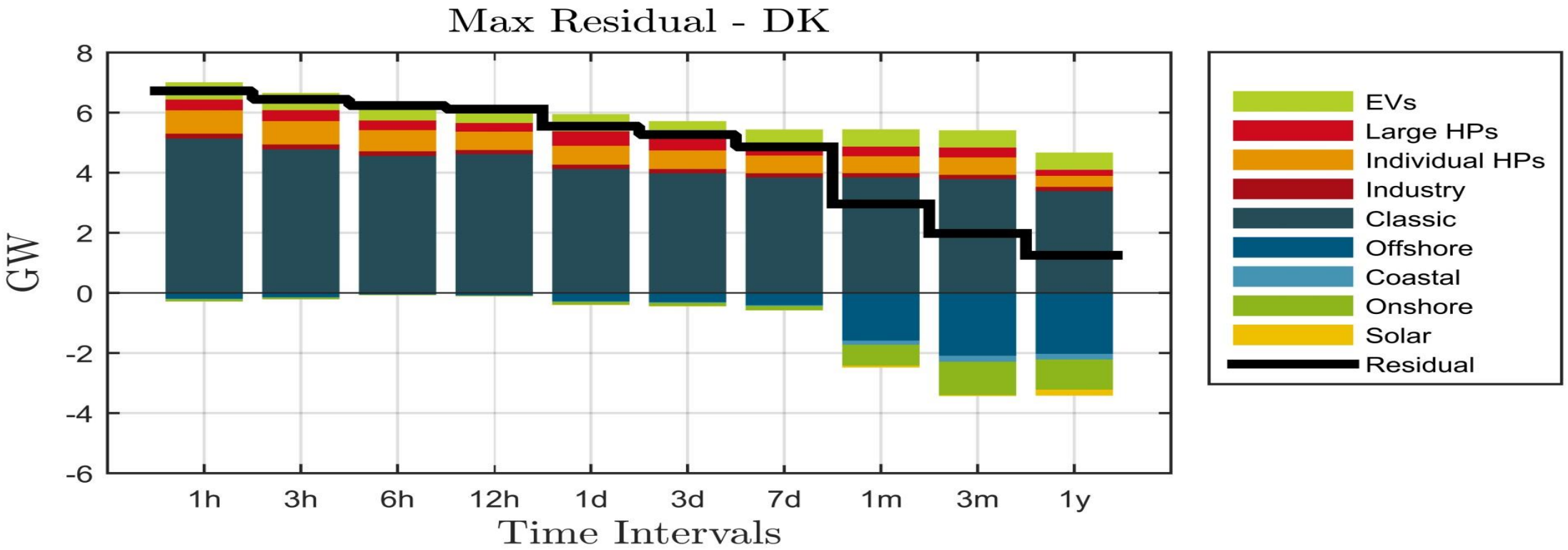


Figure 2.1 ▷ World primary energy demand and CO_2 emissions by scenario

Primary energy demand:
- Current Policies Scenario
- New Policies Scenario
- 450 Scenario

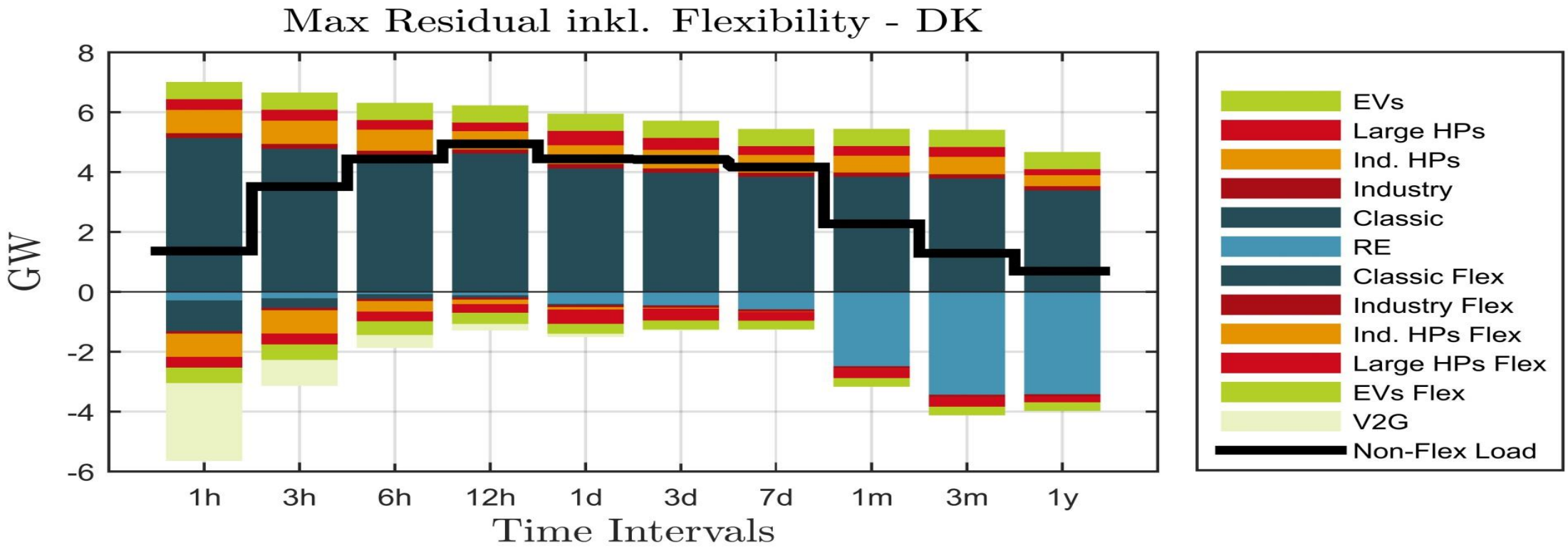
Energy-related CO_2 emissions (right axis):
- Current Policies Scenario
- New Policies Scenario
- 450 Scenario

MAX RESIDUAL LOAD IN PERIODS OF 1 HOUR TO 1 YEAR (2035 SCENARIO) (ANALYSIS BASED ON 10 YEAR DTU WIND TIME SERIES)



Residual load = Consumption – wind/solar

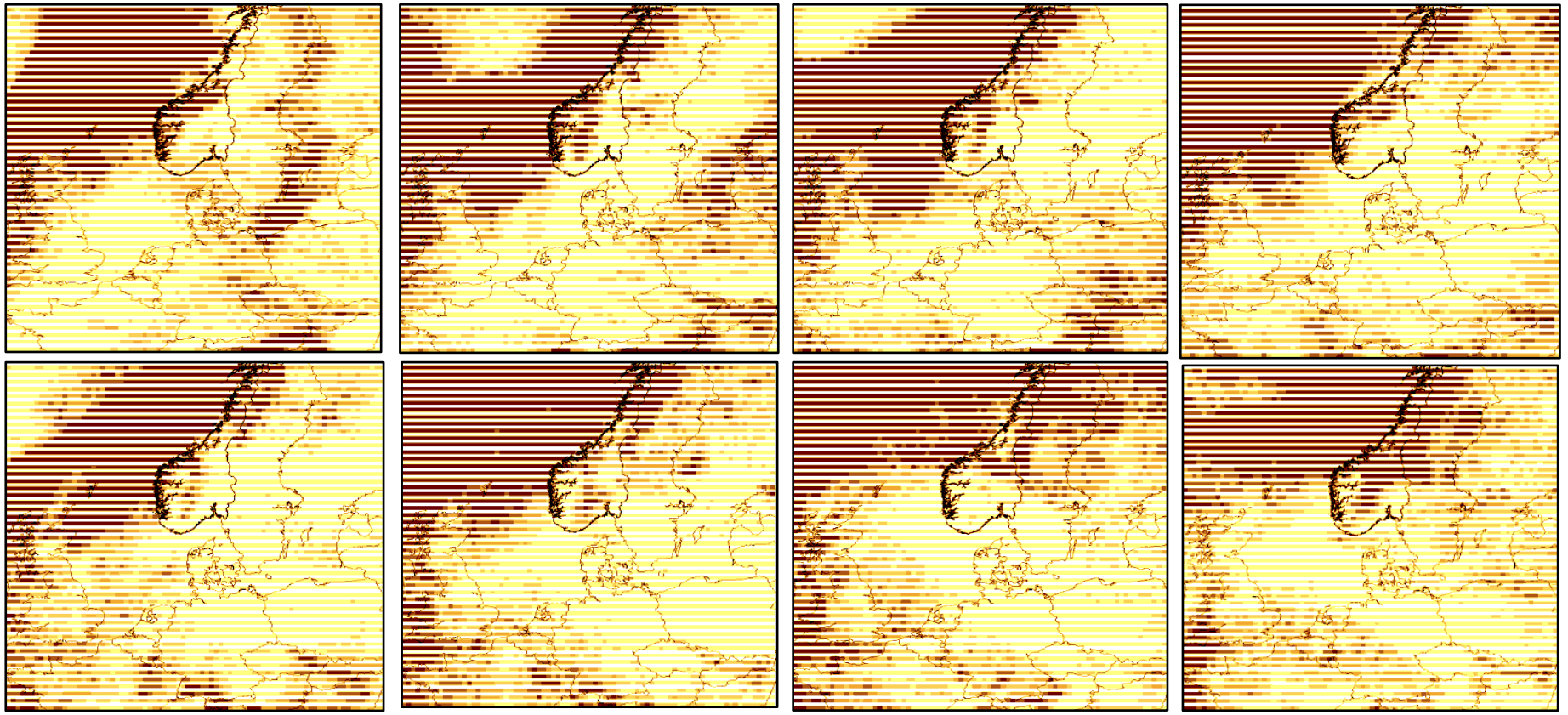
USE OF FLEXIBLE LOAD TO REDUCE PEAK DEMAND

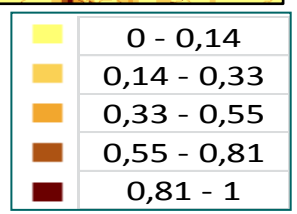


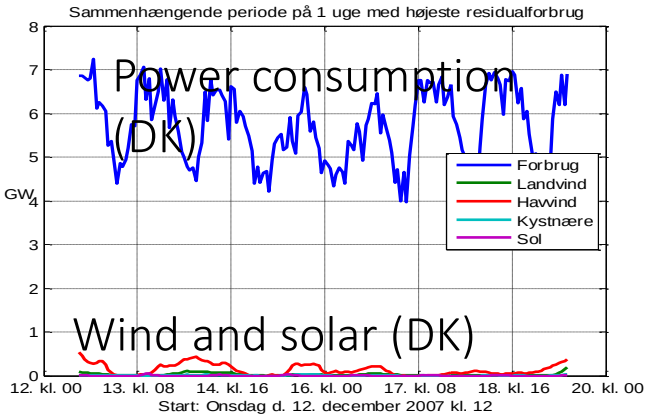
Now the max residual load is in a 12 hours period

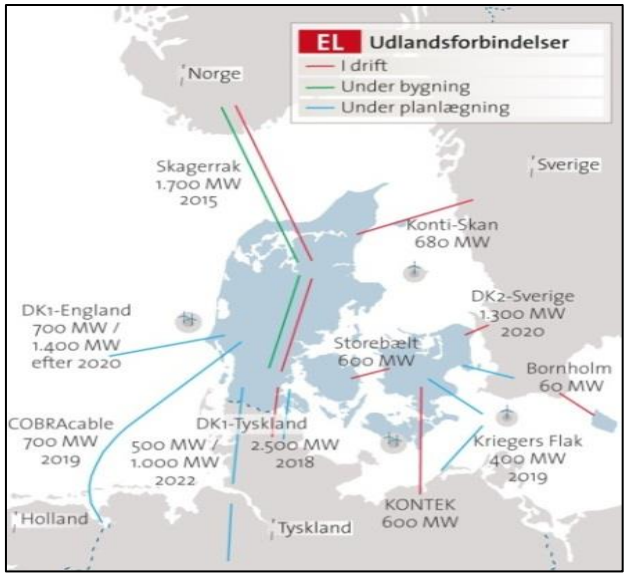
WINDPOWER IN NORTH SEA REGION IN A WEEK WITH ”WORST CASE I DK”

From 12/12 kl. 24.00 and 7 days ahead



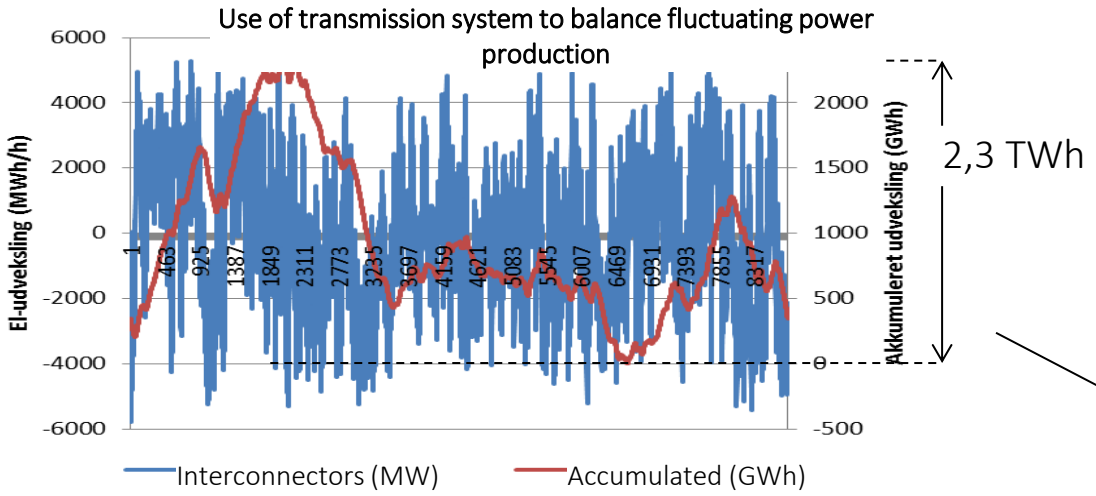




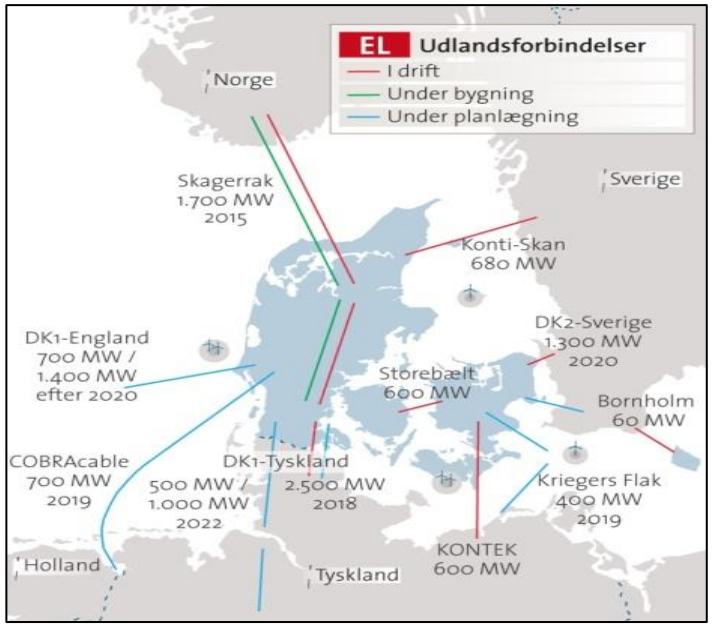


- *Essential to use the geographical spread of windpower*

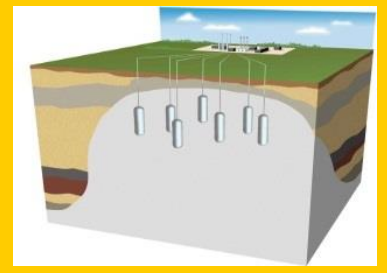
BALANCING THE POWER SYSTEM – COMBINATION OF MEANS

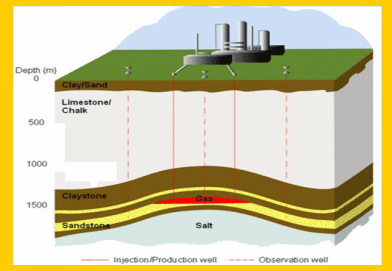


2,3 TWh



Gas storage (11 TWh methan-gas)
Energy input to power-to-gas





Transmission system:
Interconnectors yearly accumulated energy in 2035 (2,3 TWh)

District heat+storage

Indivi. heat pump
El- og plugin hybrid
case 2035

SUMMING UP

- The COP21 (Paris) agreement on CO2 reduction is very ambitios and there is need for very large amounts of wind-power to decarbonise the power system.
- All three European ENTSO-E/G scenarios indicate very large increase in wind- and solar power production for Europe
- The North-Sea region is expected to be highly dominated by wind and a strong grid and efficient integration with heat and gas-system (Power-to-gas) is essential for balancing the power-system
- Development of new cost efficient grid-connection solutions is a focus area in offshore windpower area (e.g. North Sea Wind Power Hub - NSWPH)
- A need for further development of windpower to deliver ancillery services (including virtual inertia) to operate the power system with a minimum of thermal power plants in periods with high wind and solar.
- A need for further development of Power-to-gas solutions to integrate large amounts of windpower in the energy system

Thank you for attention

Link: www.energinet.dk/energianalyser