Power Transmission
– National and International Perspectives

Energy storage conference
–a must for successful conversion to green energy

ATV conference 2015-09-28 at DTU

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Energy Analysis
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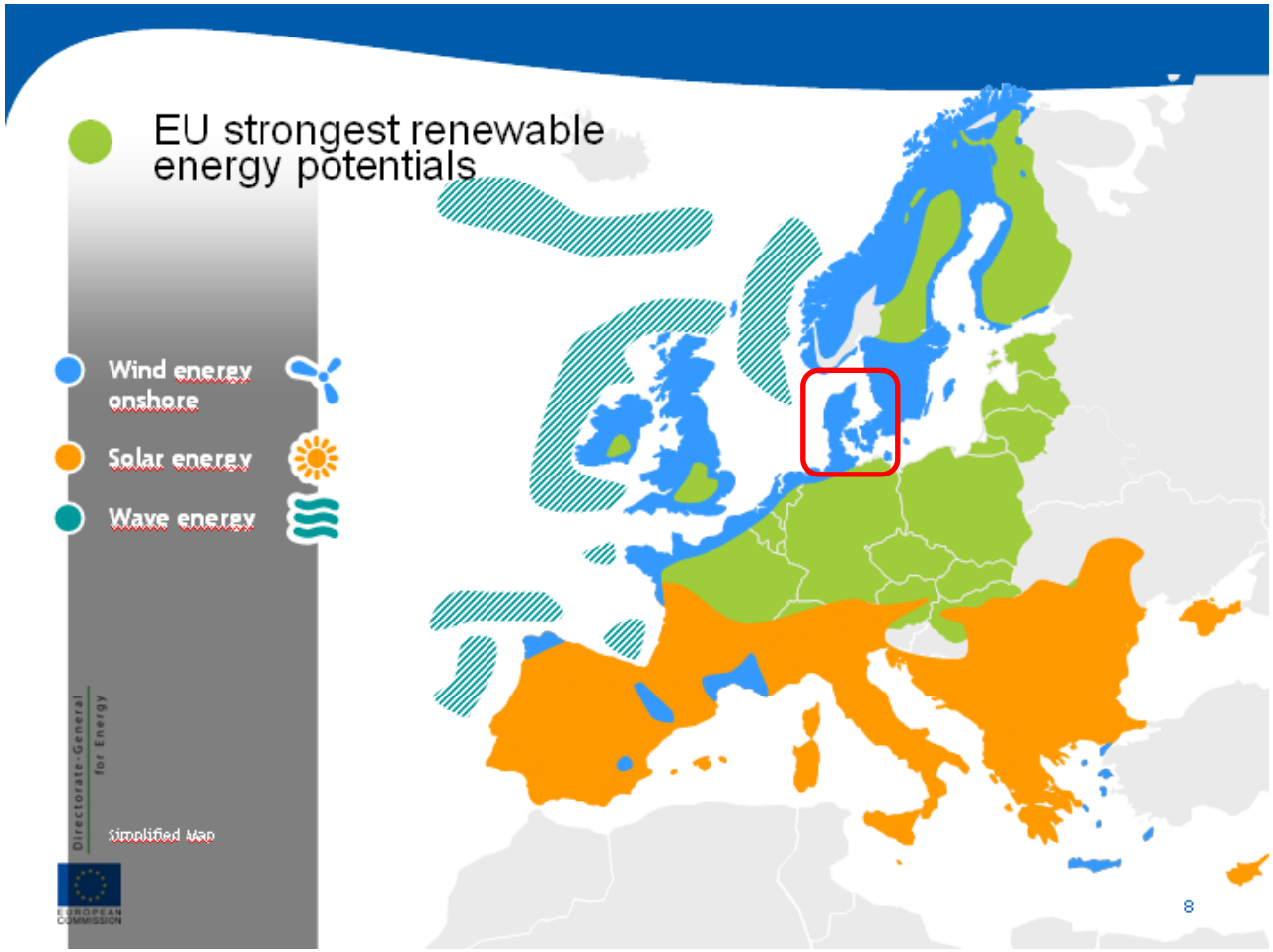
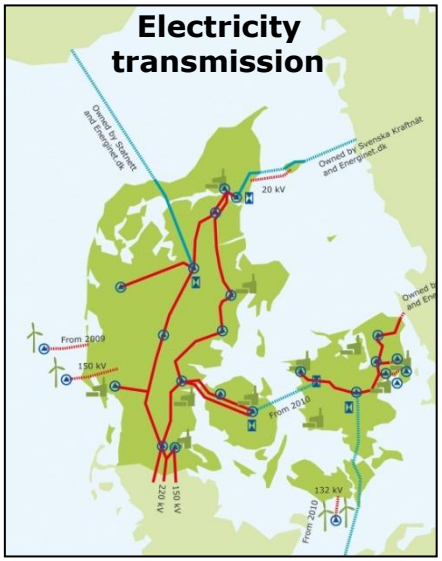
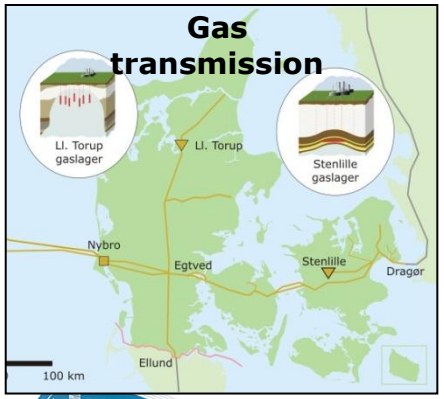
Denmark situated in a windpower area

Energinet.dk TSO for power and gas-systems in DK



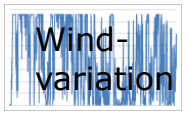


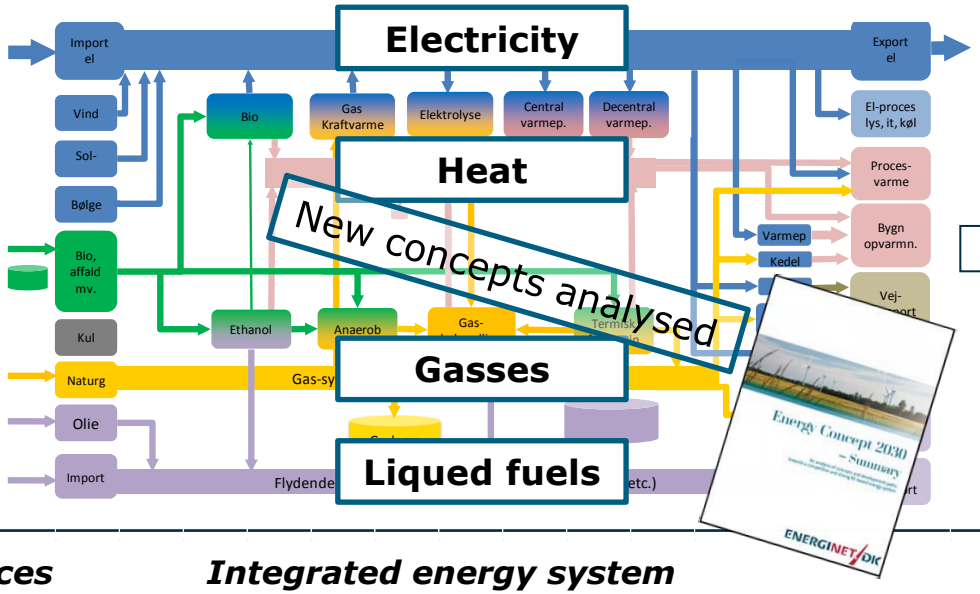


Energy system performance evaluated by simulation

Energy ressource → **Energy system** → **Energy service**

- Wind
- Solar
- Biomass
- Natural gas
- Fossil oil
- Coal
- Etc…





- Building heating
- Proces-heat
- Cooling
- Light, IT etc.
- Transport

Sustainable ressources

Integrated energy system
Robust, flexible and efficient

Minimised, low and stable costs

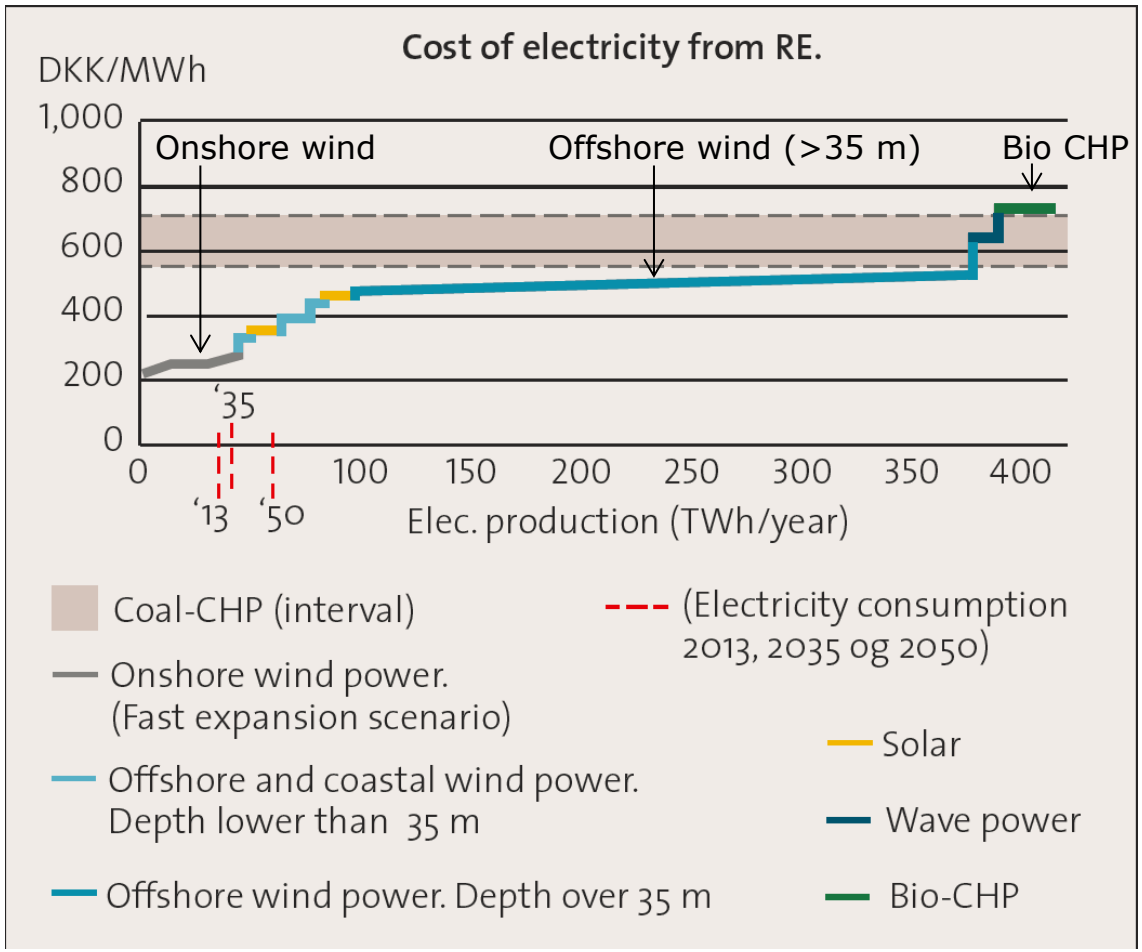
Total performance for system evaluated (economic and technical analysis)

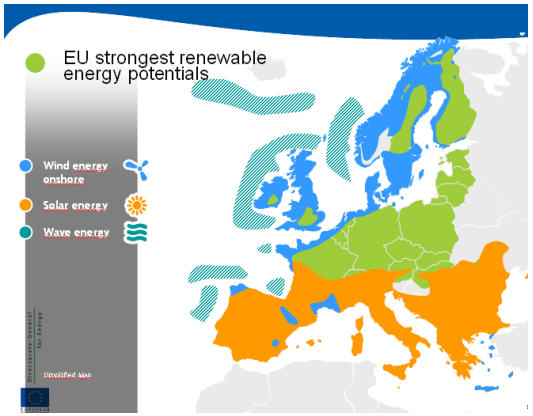
System property to "**damp**" step on ressource prices *(low β-faktors)*

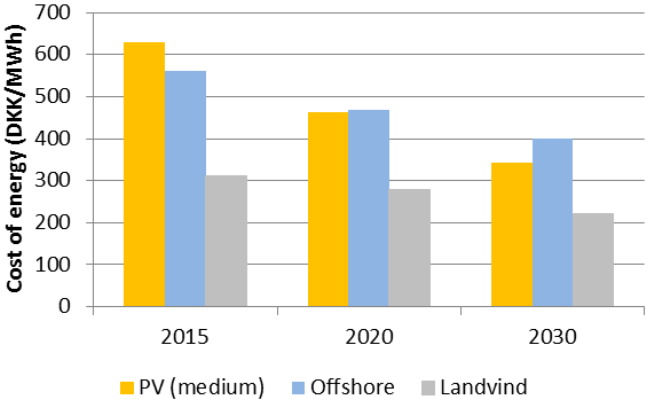
Price inkl. hedging = *Price excl. hedging + Price hedging*
= *Price exc. hedging + β_n x (Ressource price hedging– Ressource price excl. hedging)*

RE-electricity ressources DK

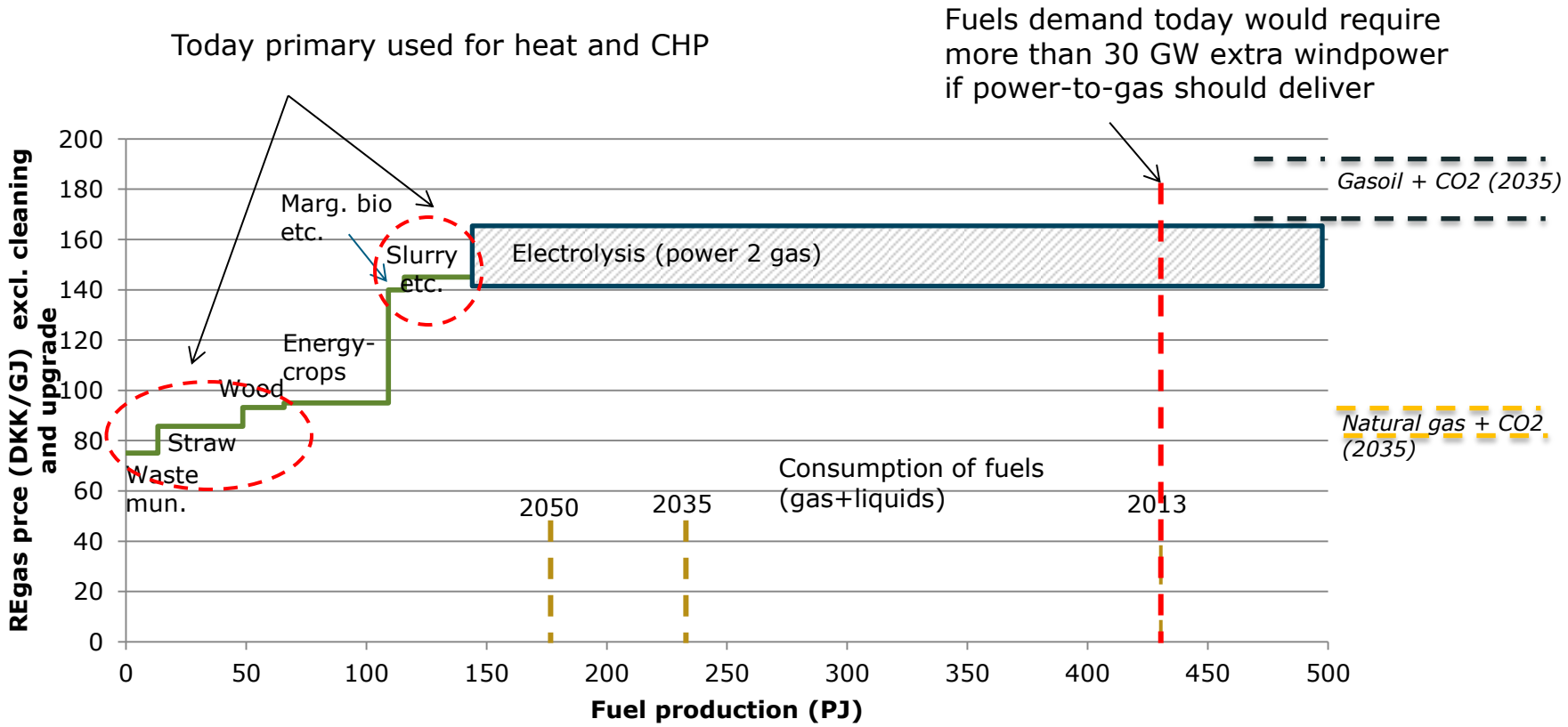
Socio-economic cost of energy 2030 excl. integration (LCOE)





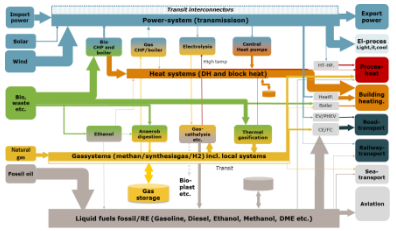


Ressources and cost for fuels
(2030 if all biomass is allocated to fuels)



A significant demand for fuels – electrification is needed to solve the "fuel" challenge

A scenario example towards RE-based energy supply



PJ/year

250
200
150
100
50
0

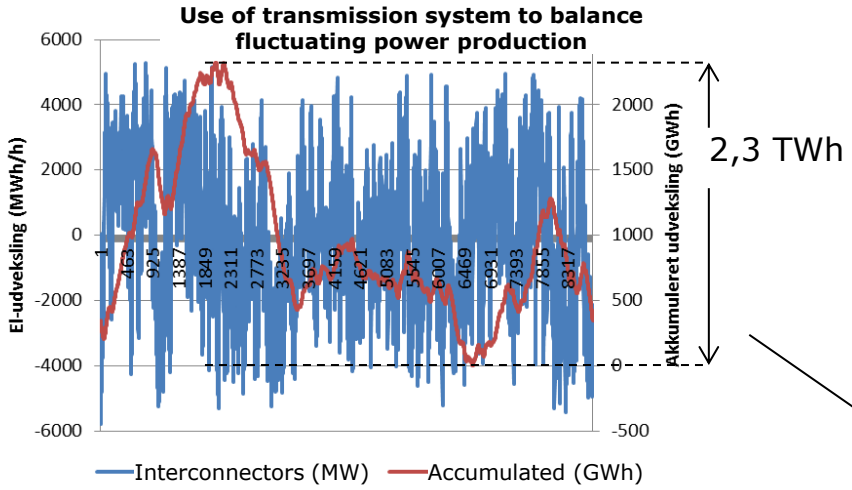
Power system | Gas system | District heating (ex plant) | Individual heating (netto) | Industrial process heat (netto) | Transport work (netto)

P2G
HP
HP
Industry-HP
EV/PHEV

Now 2025 2035 2050 | Now 2025 2035 2050 | Now 2025 2035 2050 | Now 2025 2035 2050 | Now 2025 2035 2050 | Now 2025 2035 2050

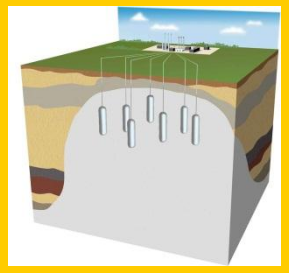
Wind, solar, etc. | Biomass/waste | Natural gas | Oil/coal | RE-gas/biofuels | DH/surplus heat | Electricity

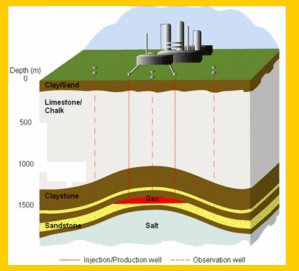
Use of transmission system to balance wind/solar



2,3 TWh

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



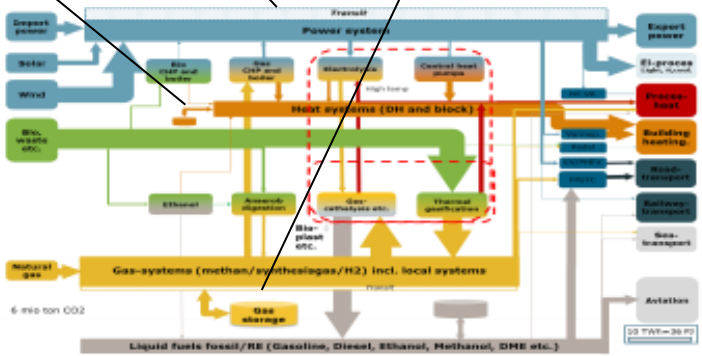


Transmission system:
Interconnectors yearly accumulated energy in 2035
(2,3 TWh)

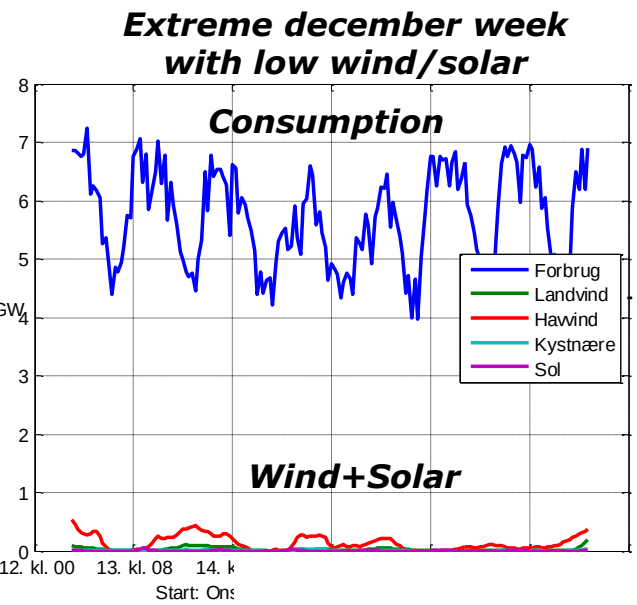
District heat+storage

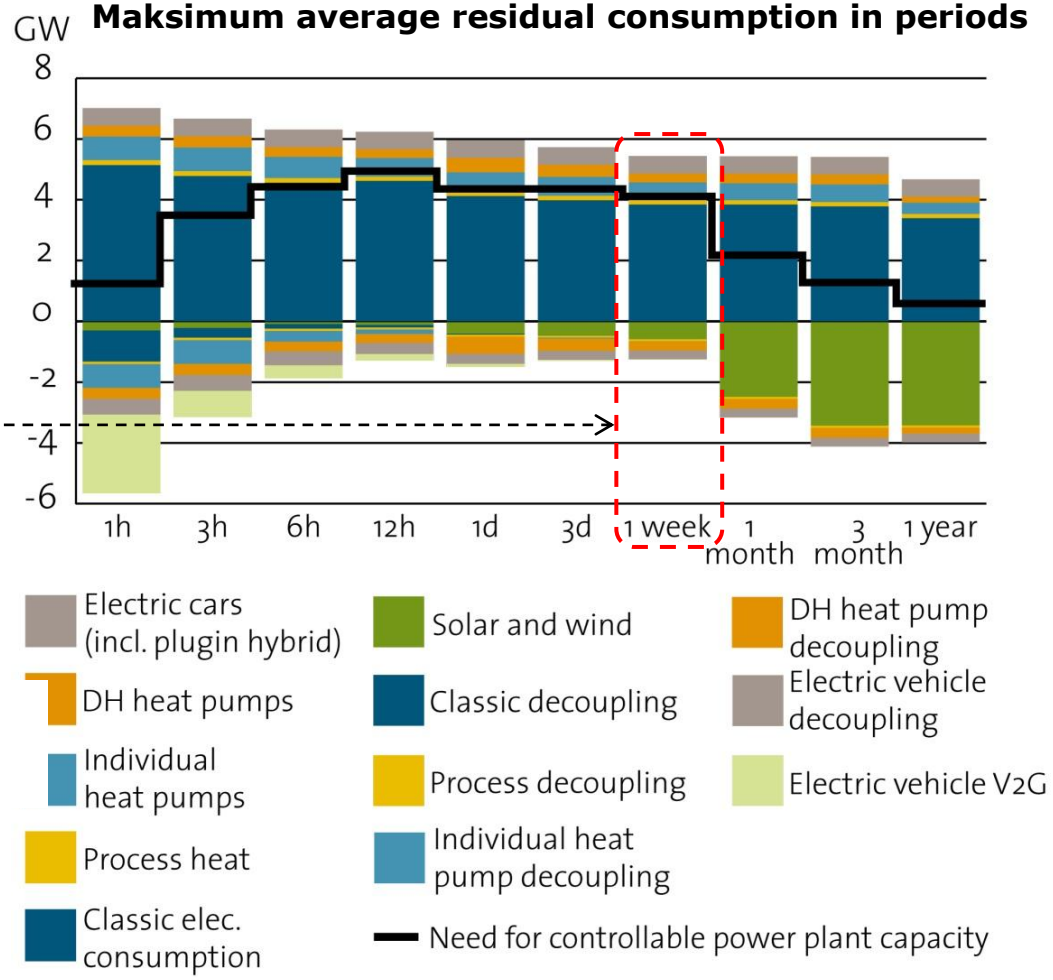
Indivi. heat pump

El- og plugin hybrid case 2035



Analysis of 10 years wind/solar data for DK and North Europe Used in scenario 2035

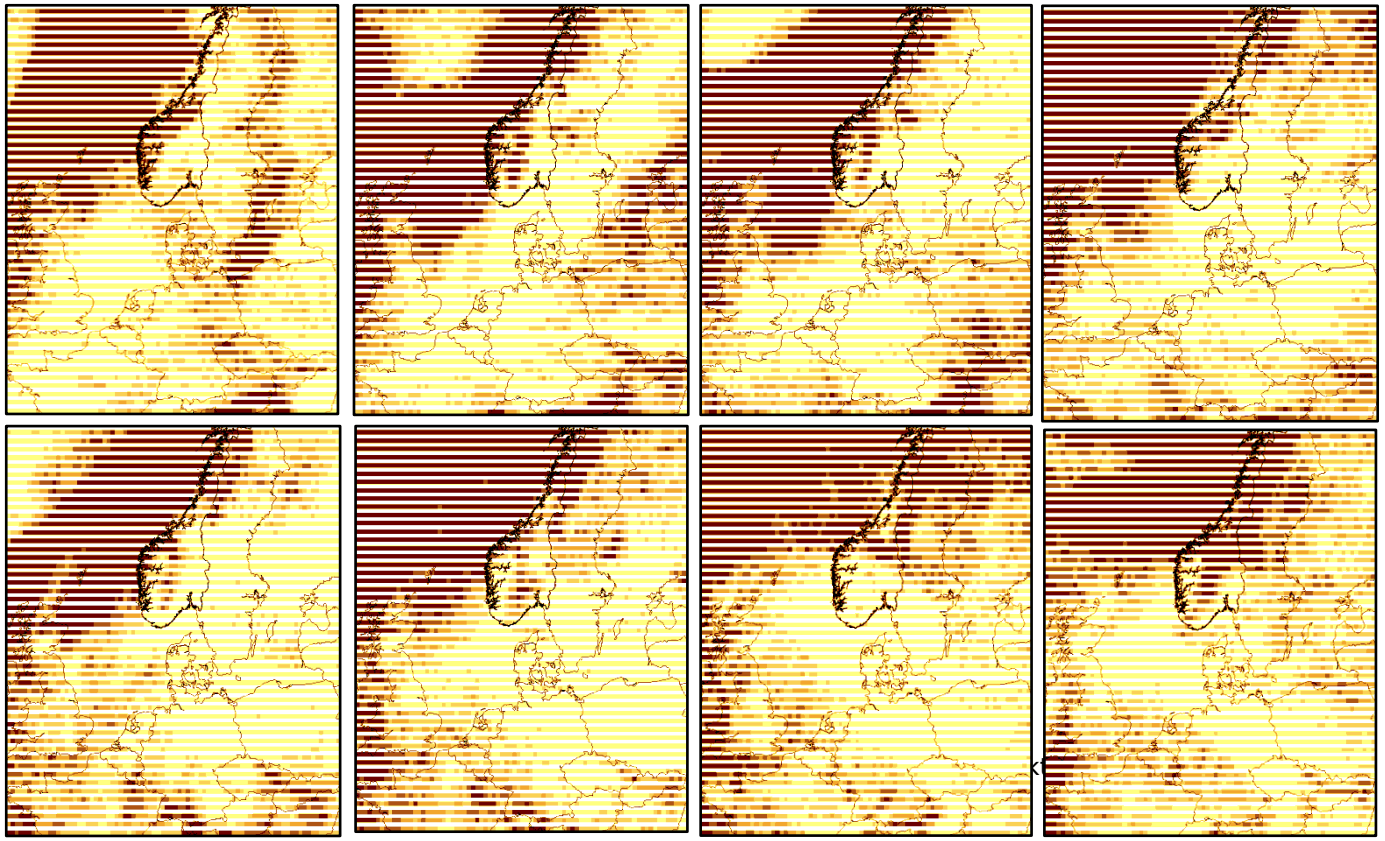




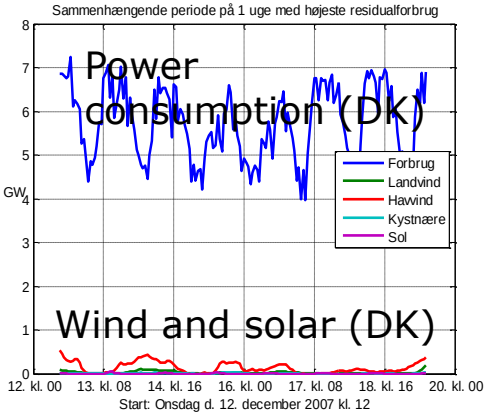
$$Residualconsumption = Consumption\ - wind\ - solar\ - (wave)$$

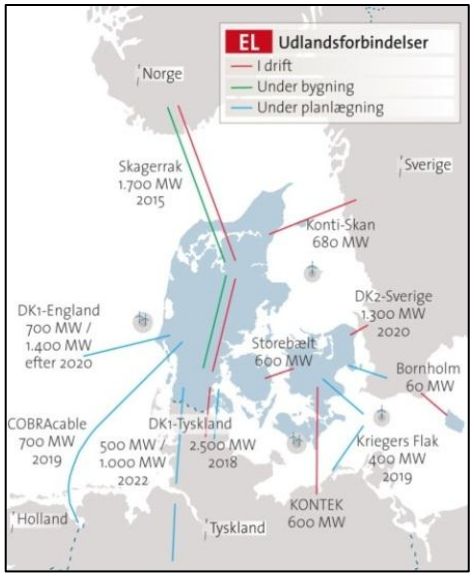
Windpower in North sea region in a week with ”Worst case i DK”

Wind intensity index from 12/12 kl. 24.00 and 7 days ahead



	0 - 0,14
	0,14 - 0,33
	0,33 - 0,55
	0,55 - 0,81
	0,81 - 1

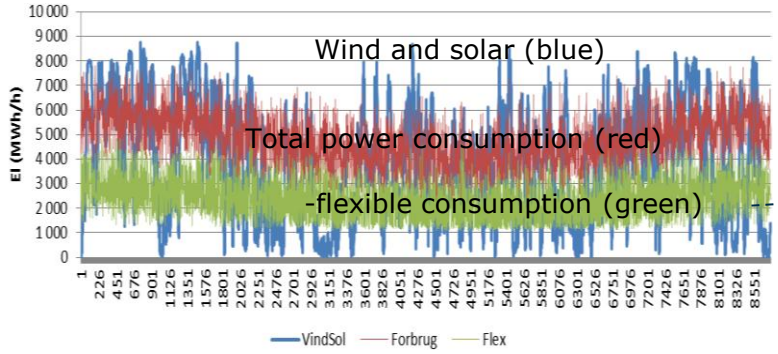




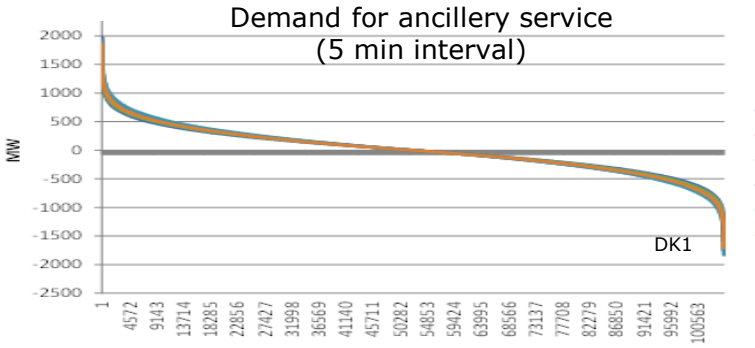
- *Essential to use the geographical spread of windpower*

Flexible consumption as ancillary service and grid backup (n-1)

Flexible consumption analysed as grid reserve (n-1)

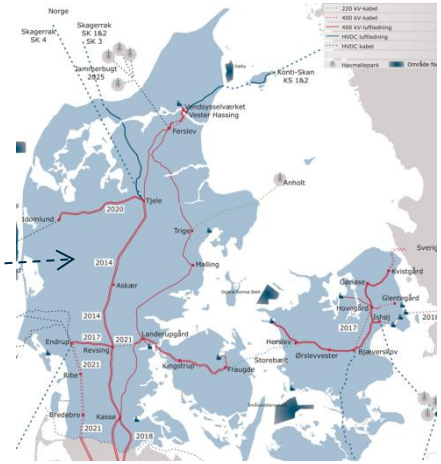


Flexible consumption as ancillary service



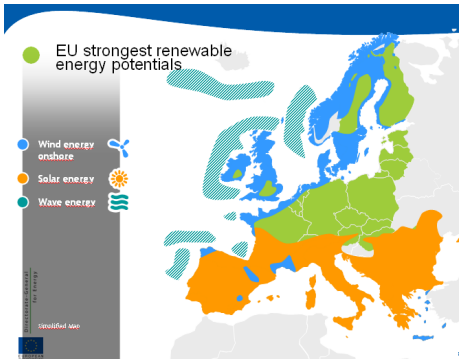
Flexible consumption as grid reserve can increase the use of transmission (long horizon solution)

Flexible consumption as grid reserve



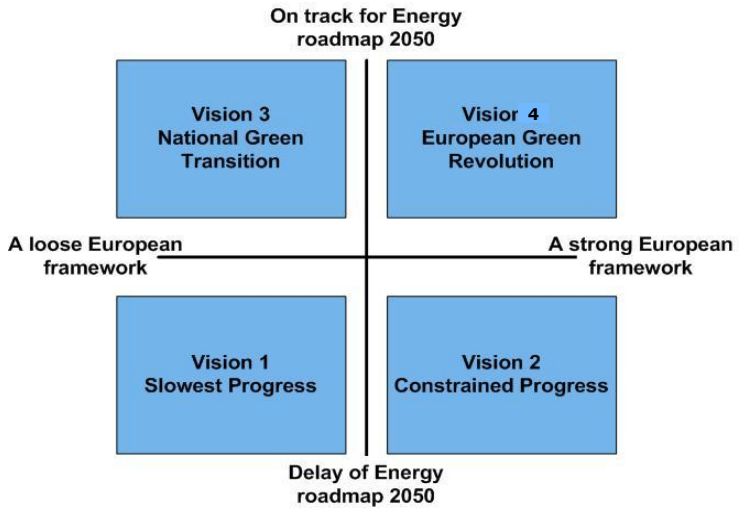
- Flexible consumption also essential as:
  - Grid reserve (TSO/DSO)
  - Ancillery services
  - Intraday balancing

European Scenario Framework in the analysis

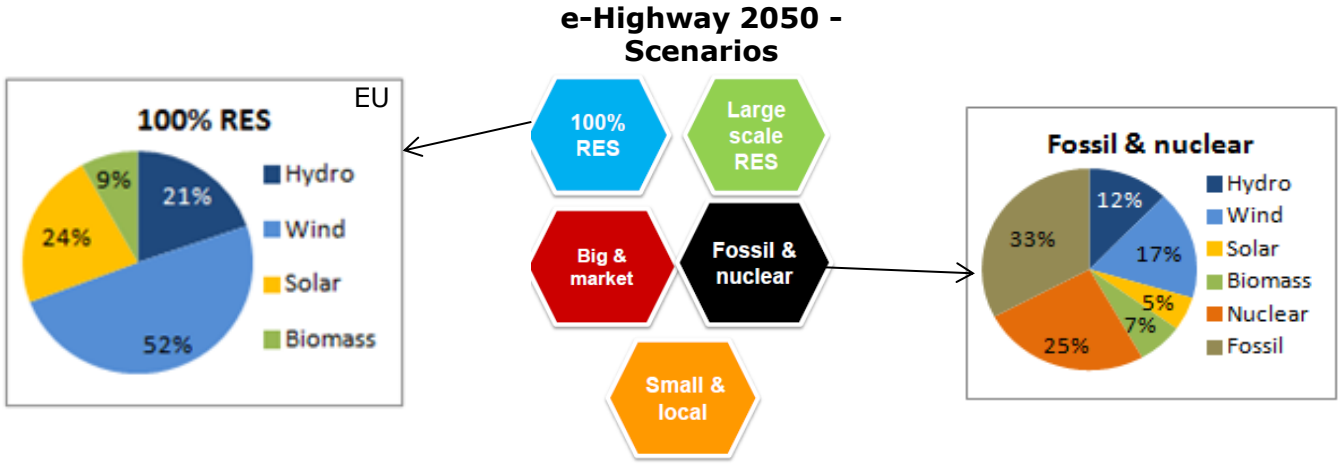


ENTSO-E Visions

2030



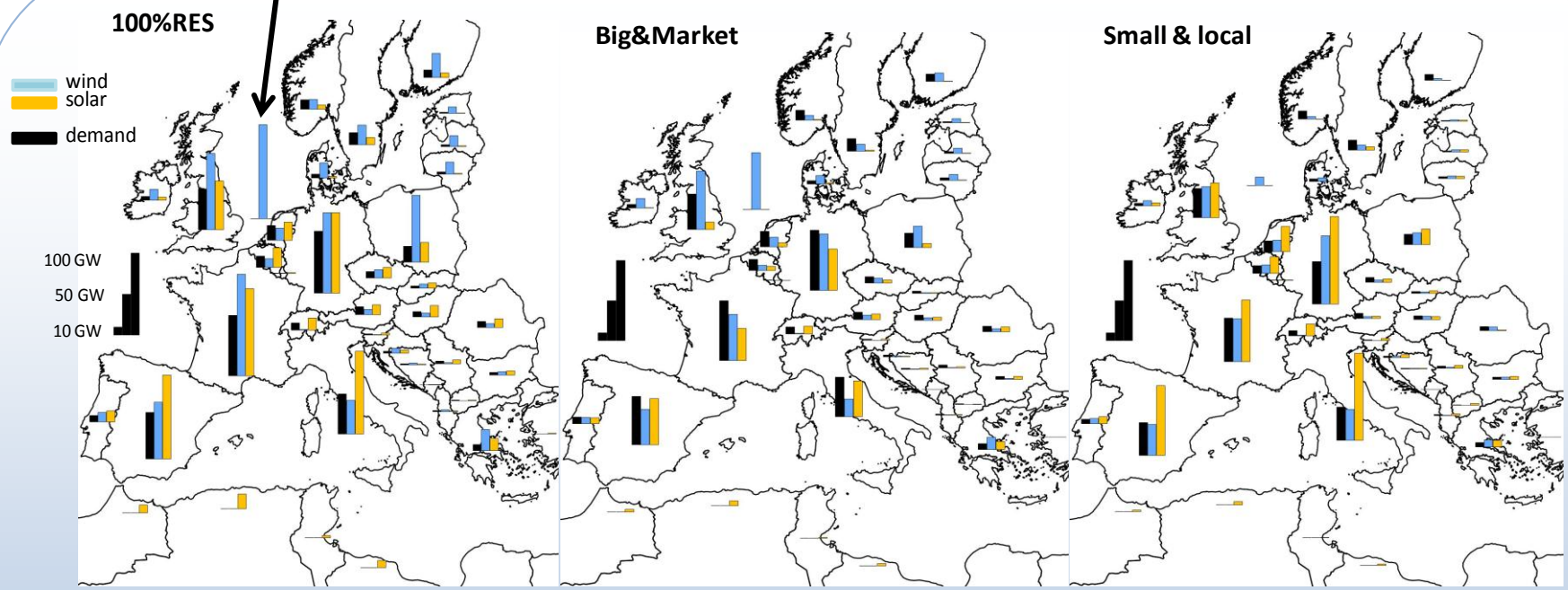
2050



A framework of international scenarios used to evaluate robustness of strategic choices

Wind and solar in European eHighway scenarios towards 2050

Obs: More than 100 GW wind-power in North Sea region!
A need for transmission grid to integrate RE in Europe

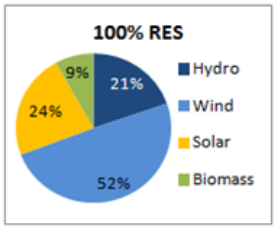


The figure shows the average demand for three scenarios in 2050, in comparison to the installed RES capacities (solar and wind). With significant amount of renewables, the RES generation capacities exceed the average demand. As a result, during period of high RES generation, it is necessary either to export, either to store, or to curtail the generation.

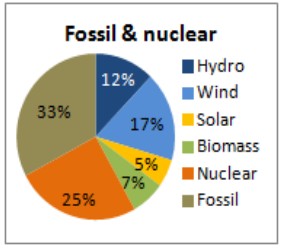
Source: Final draft eHighway scenarios

European transmission grid reinforcement towards 2050
An example from eHighway scenarios

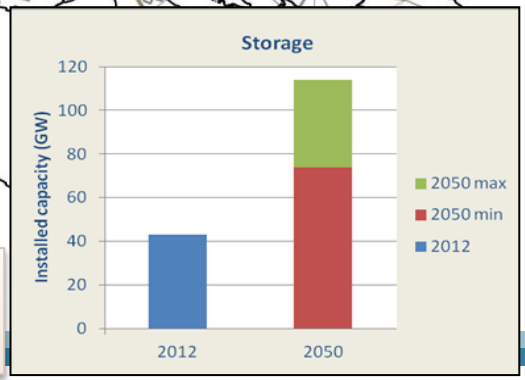
100% RES electricity



Fossil & nuclear



>100 GW windpower installed in North Sea region!



- *More transmission to integrate wind- and solar*
- *A need for more storage capacity (hydro etc.)*

Summing up…

The vision is to make the total energy system in DK independent of fossil fuels, and to make it competitive with a fossil reference

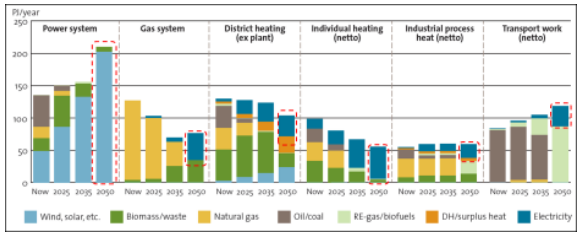
A high degree of electrification and much more wind- and solar will be essential in DK

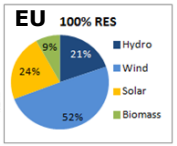
A strong transmission grid is essential for balancing huge amount of fluctuating wind- and solar.

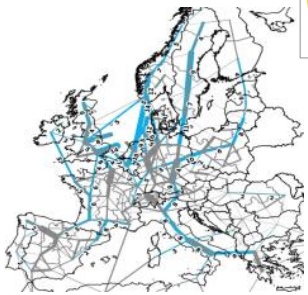
Flexible demand (EV/HP/P2G) can enhance use of transmission (grid-reseve n-1) and ancillary service

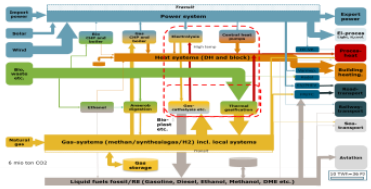
There is a high need for fuel production from biomass and P2G. A need to integrate power/gas/fuel/heat to solve this challenge.

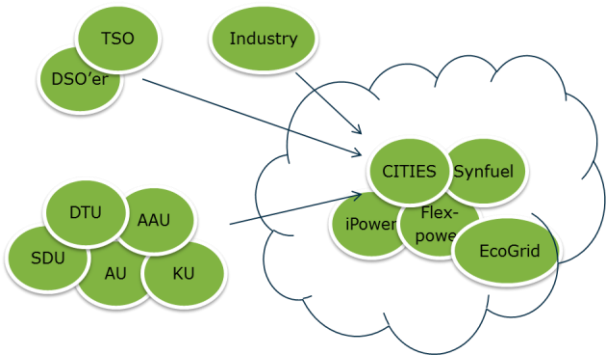
A need for cooperation between Universities, Industry and Utilities (TSO/DSO) in RD&D projects to pave the way for the energy system development

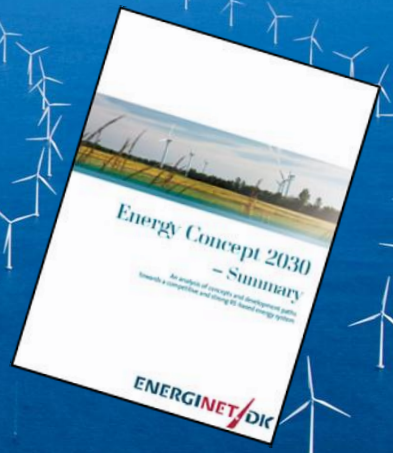












Thank you for attention

Link: www.energinet.dk/energianalyser