Transitions to renewable energy systems – the case of Denmark and EU

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Climate Thursdays, SDU, Online, October 3rd, 2024

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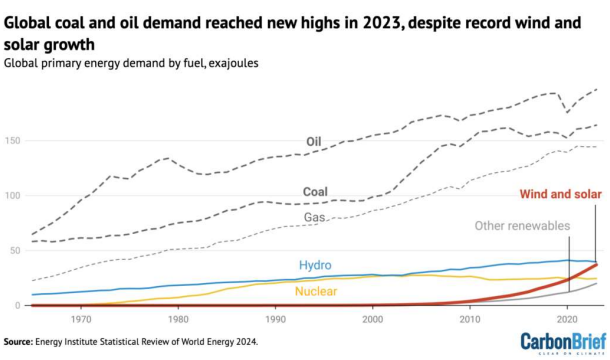
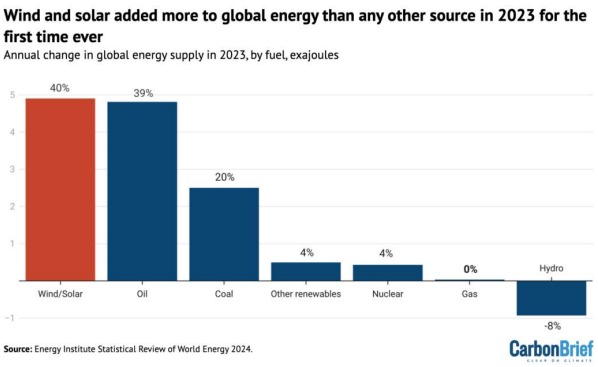
Global primary energy supply

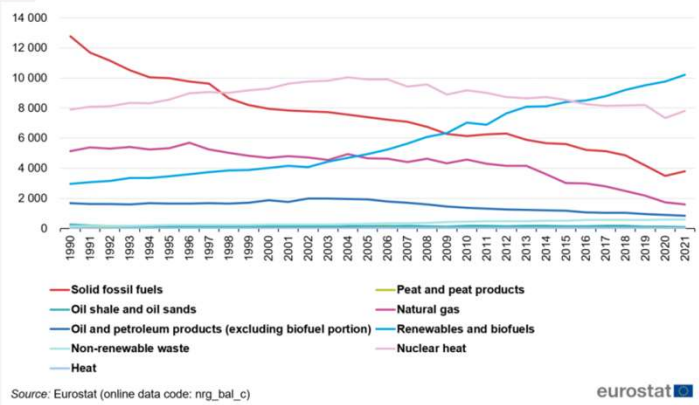


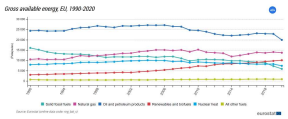


2

Increased dependency of Natural gas 2000-2022

- EU successes before the war:
  - Increased renewable energy
  - Higher energy efficiency (Sligthly)
- EU Failures :
  - Diversification of the gas markets – instead of a natural gas exit plan
  - No improvements in security of suply.





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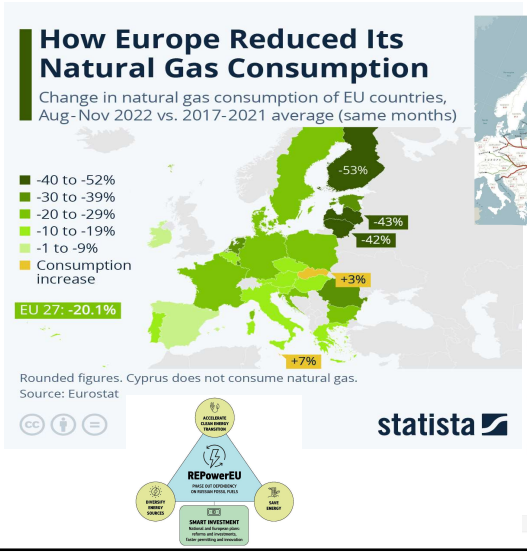
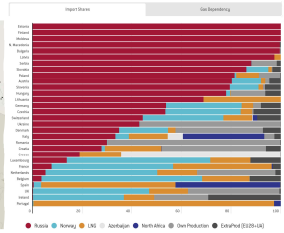
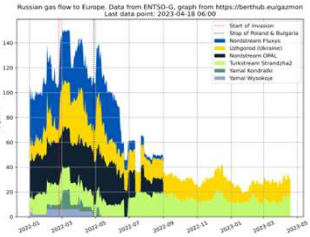
Risk: Ministries, citizens and (politicians) thinks the natural gas price will be perminently low







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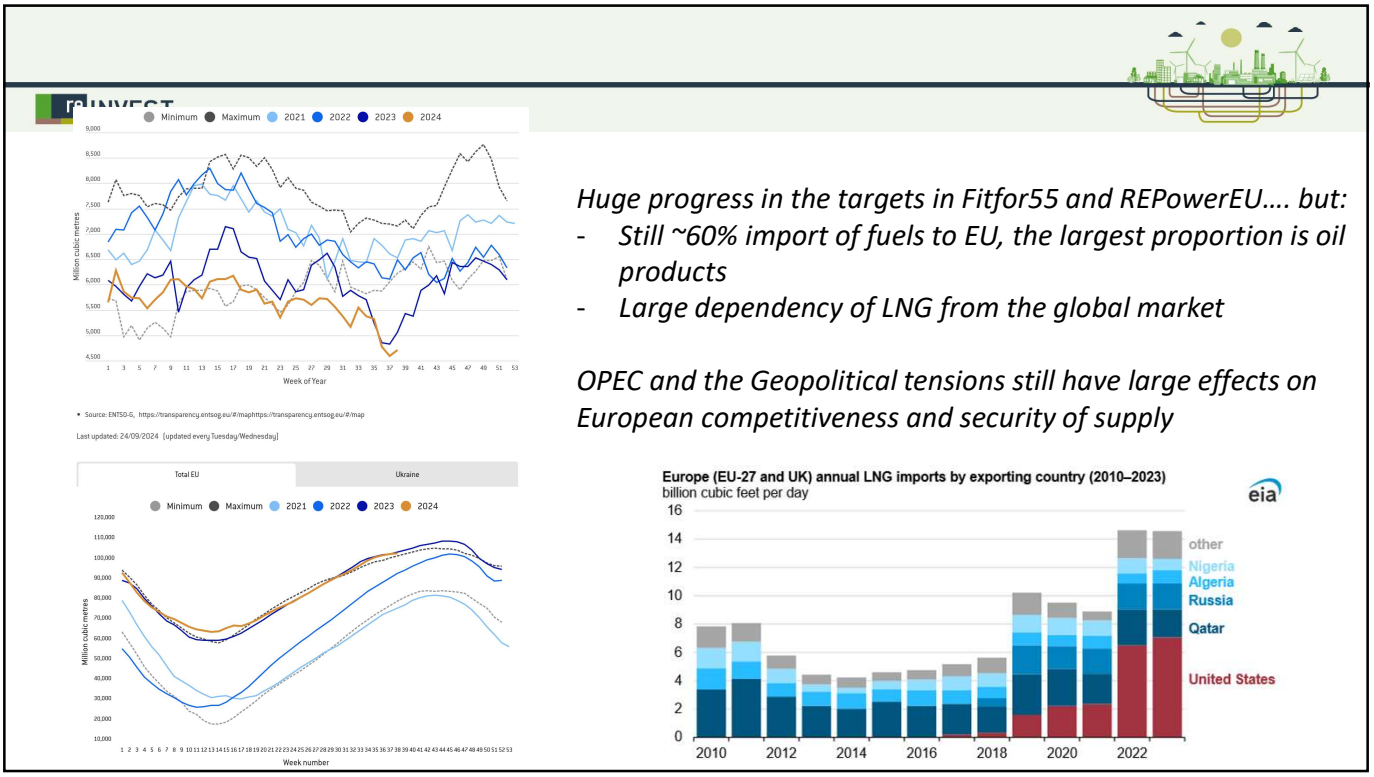
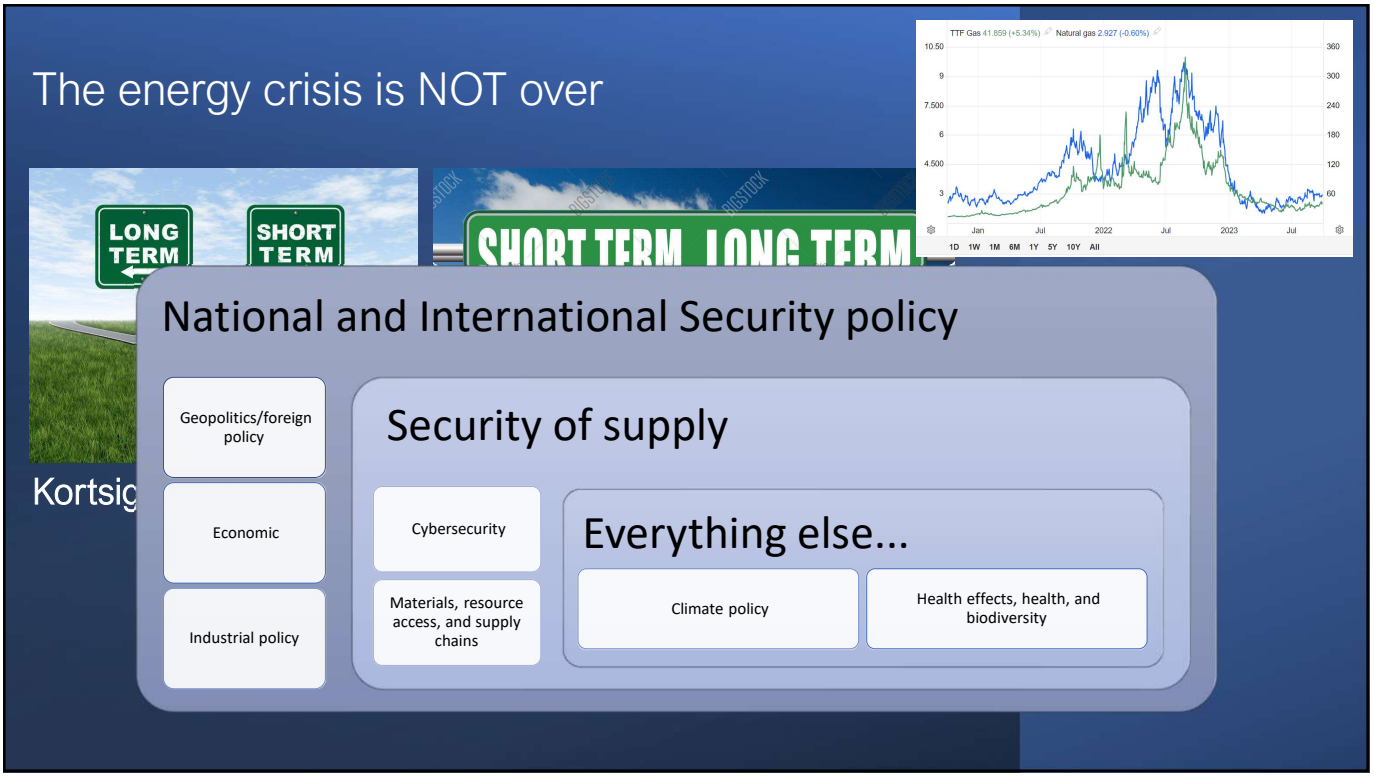

Minimum Maximum 2021 2022 2023 2024
Million cubic metres
Week of Year
Total EU
Ukraine
Minimum Maximum 2021 2022 2023 2024
Million cubic metres
Week number
Huge progress in the targets in Fitfor55 and REPowerEU…. but:
- Still ~60% import of fuels to EU, the largest proportion is oil products
- Large dependency of LNG from the global market
OPEC and the Geopolitical tensions still have large effects on European competitiveness and security of supply
Europe (EU-27 and UK) annual LNG imports by exporting country (2010–2023)
billion cubic feet per day
eia
other
Nigeria
Algeria
Russia
Qatar
United States
2010 2012 2014 2016 2018 2020 2022

5


The energy crisis is NOT over
LONG TERM
SHORT TERM
SHORT TERM LONG TERM
TTF Gas 41.859 (+5.34%) Natural gas 2.927 (-0.60%)
National and International Security policy
Geopolitics/foreign policy
Economic
Industrial policy
Security of supply
Cybersecurity
Materials, resource access, and supply chains
Everything else...
Climate policy
Health effects, health, and biodiversity

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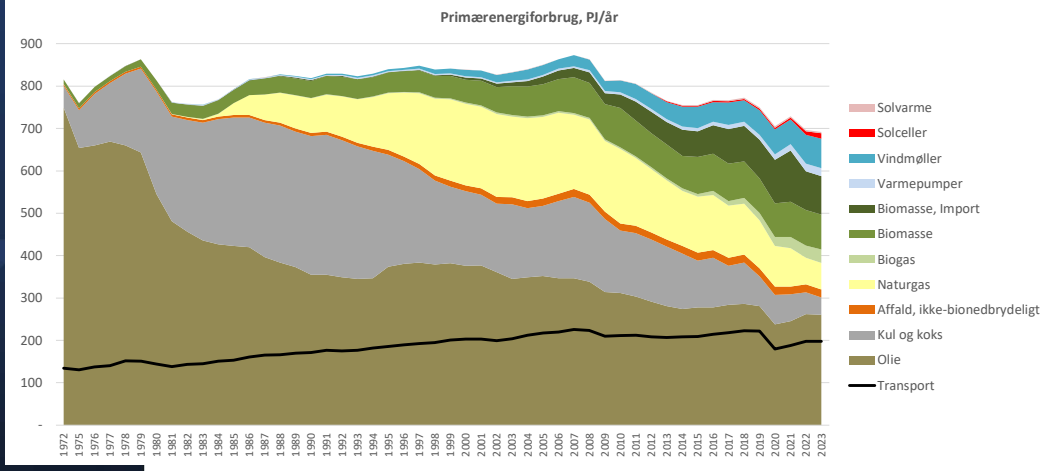
Primary energy supply in Denmark

Successes:
- Building improvements
- District heating
- Wind turbines
- System level energy efficiency

Biggest culprits:
- Transport
- Too little energy efficiency
- Our self-sufficiency rate



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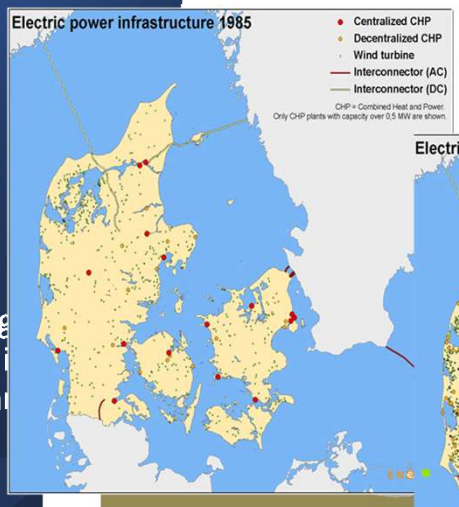
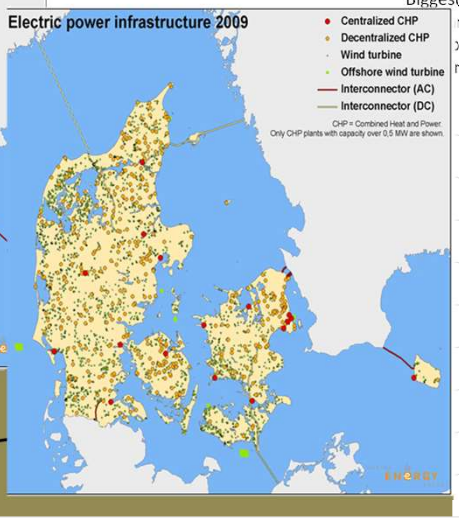
Primary energy supply in Denmark





Successes:
- Building improvements
- District heating
- Wind turbines
- System level energy efficiency

Biggest culprits:
- nsport
- little energy efficiency
- self-sufficiency rate

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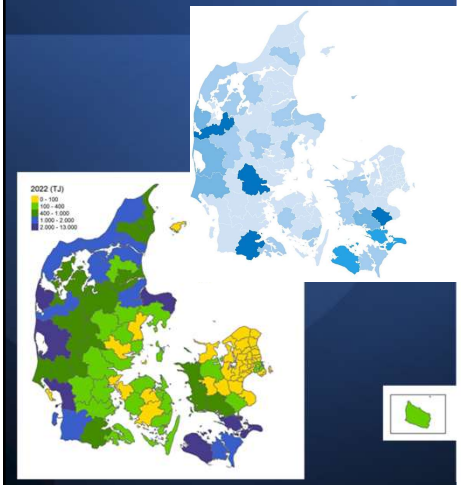
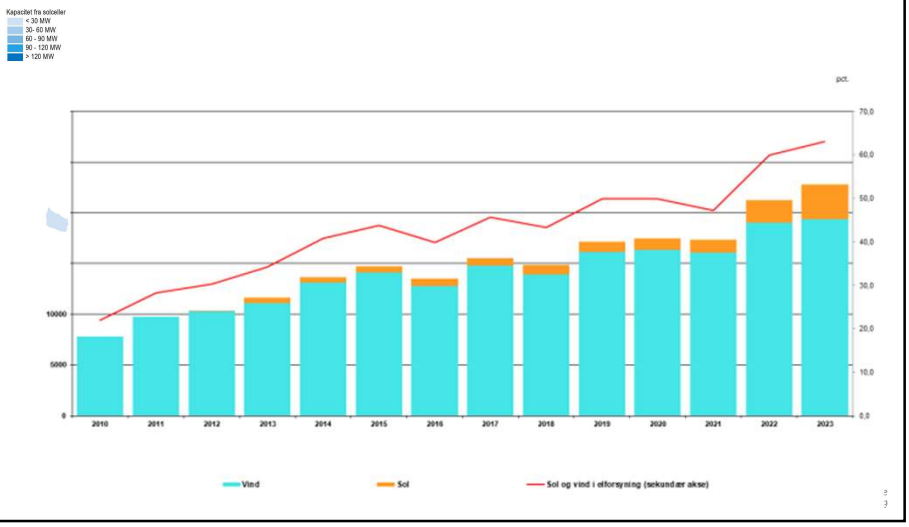
Energistyrelsen

Wind power and solar PV share in the Danish electricity mix

– 63% in 2023



Danish "boom" in wind power and PV



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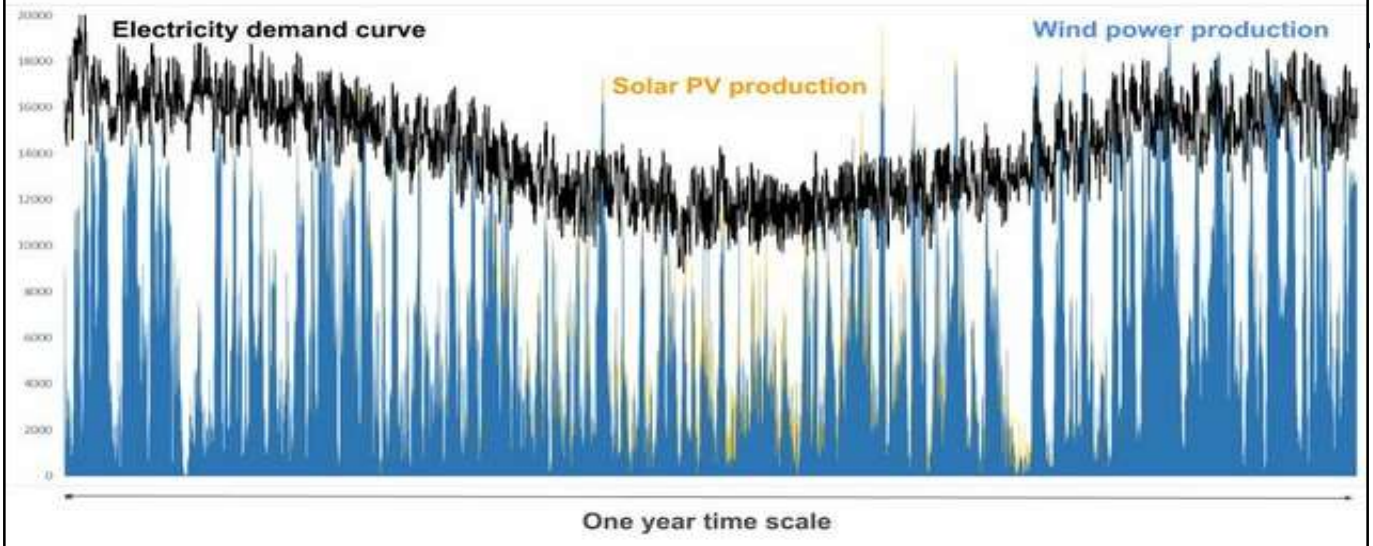

The power grid is more challenged by solar than wind – there is a need for a balance between wind and solar shares as well as the placement of solar in relation to consumption.

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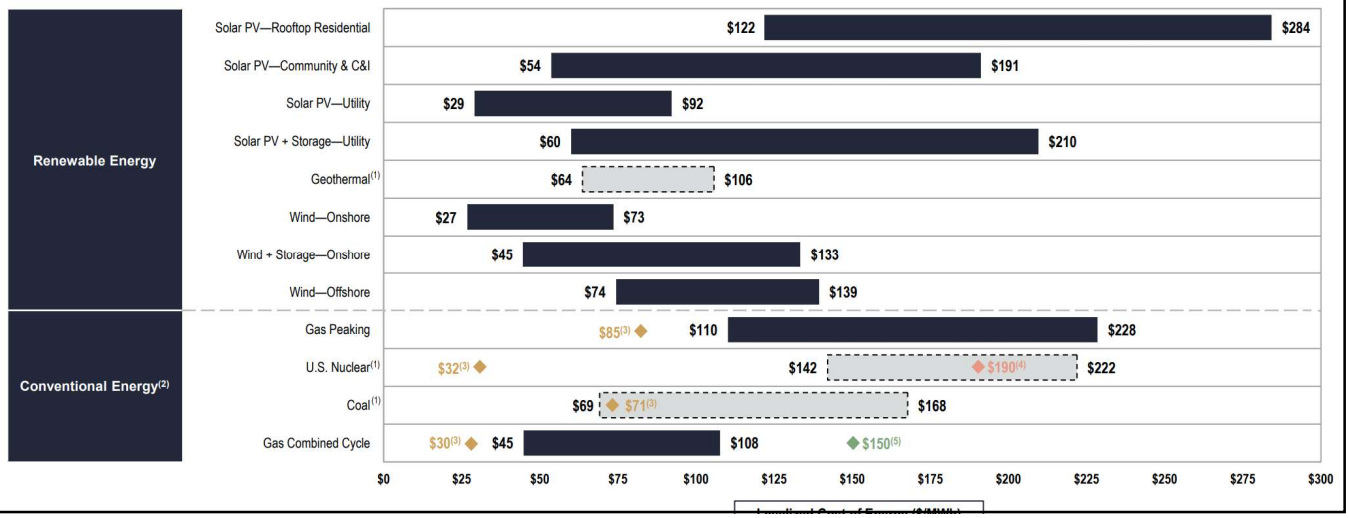
Lazard: Levelized Cost of Energy Comparison
—Version 17.0



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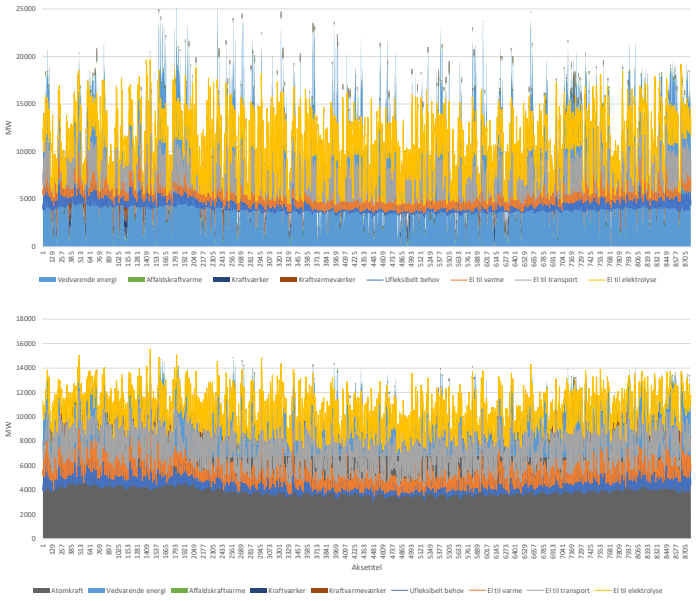
Hourly Balance Between Electricity Production and Electricity Demand

Electricity from Renewable sources

- Varying sources cause electricity production to fluctuate hour by hour.
- Sector coupling, flexible consumption, and energy storage ensure high utilization of renewable energy.
- For a few hours, there will be a need for peak reserve load production from a power plant or electricity exchange. (below 10% of the hours over a year)

Electricity from Nuclear Power plants

- Investment costs mean that nuclear power must operate at a high capacity factor
- Sector coupling, flexible consumption, and energy storage ensure stable, high production from nuclear power plants.
- There will be a need for peak reserve load production when the total demand exceeds nuclear power capacity.
- The electricity costs and system costs are larger.



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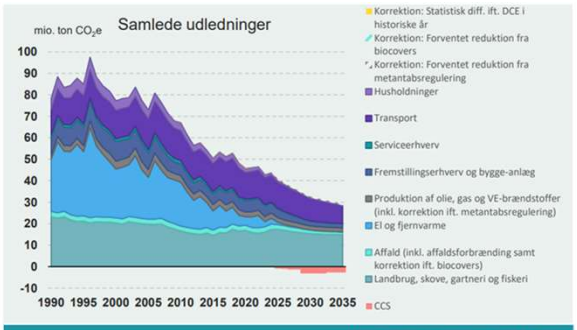
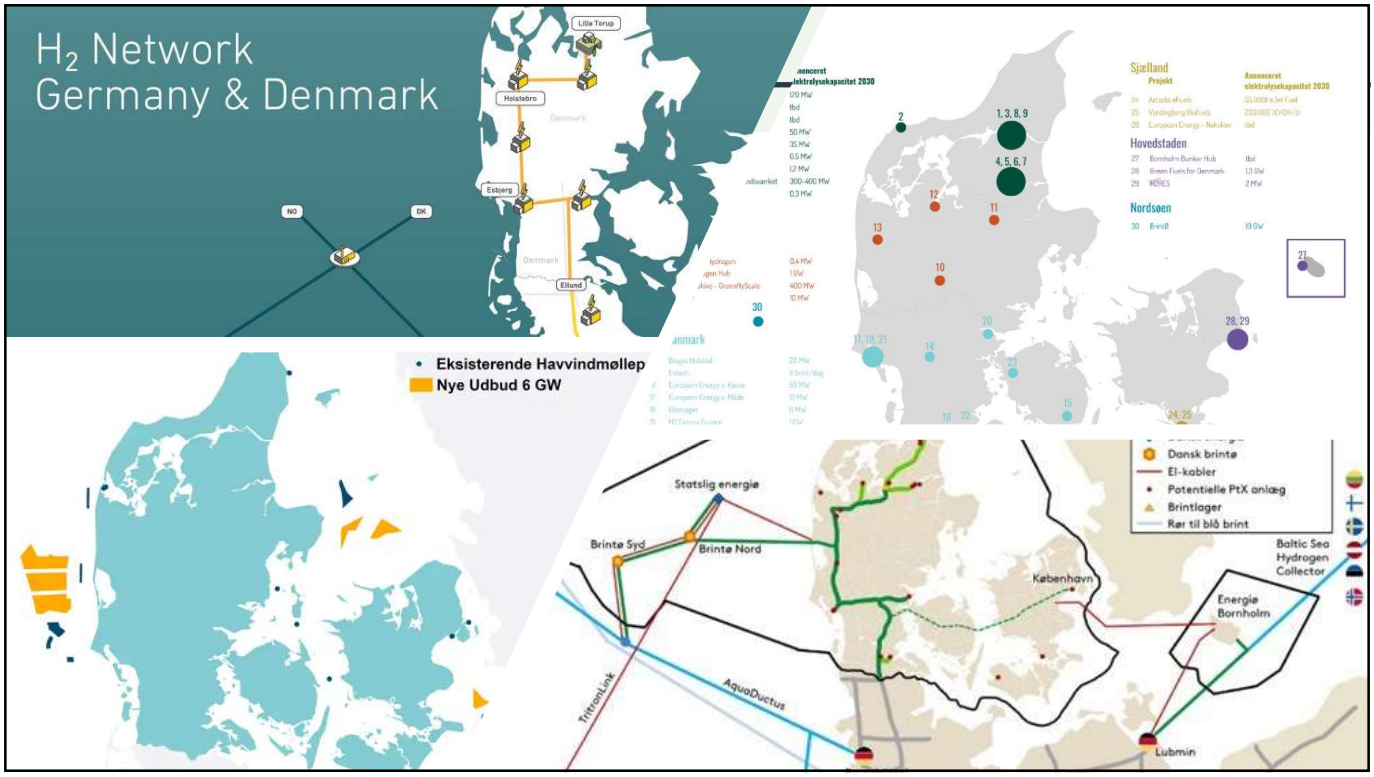
The Danish Climate Goals for Energy, Transport, Industry, Agriculture, and Energy Goals

Political Goals in Denmark
- 2021: Energy crisis starts
- 2025: Aim for a 50-54% reduction - In one year
- 2030: Aim for a 70% reduction - In almost 6 year
- 2045: Aim for climate neutrality - In 21 years
- 2050: Aim for "climate positivity" - In 26 years



	1990	2021	2025	2030	2035
KF22 samlede nettoudledninger (mio. ton CO_2e)	78,0	45,5	41,4	33,6	30,2
KF23 samlede nettoudledninger inkl. partielle korrektioner*	**78,4**	**46,2**	**39,7**	**28,9**	**25,8**
Klimalovens reduktionsmål ift. KF23 (mio. ton CO_2e)			36,1-39,2	23,5	
KF23 manko ift. reduktionsmål (mio. ton CO_2e)			**0,5-3,7**	**5,4**	

13



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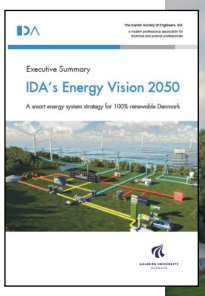
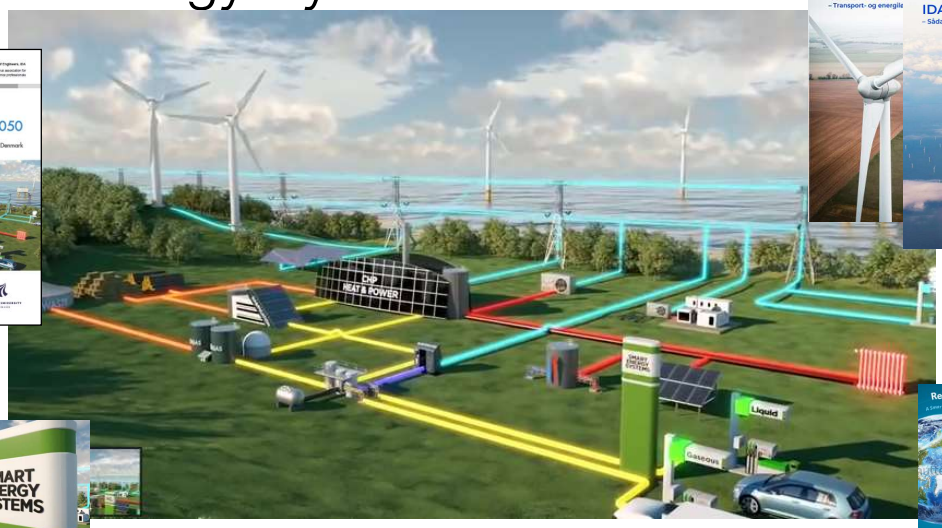
Smart Energy Systems





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Unit Investment Costs for Energy Storage

1. Thermal Cheaper at All Scales

Electricity → Thermal

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Unit Investment Costs for Energy Storage

1. Thermal Cheaper at All Scales

Electricity → Thermal

2. Bigger is Better i.e. Cheaper

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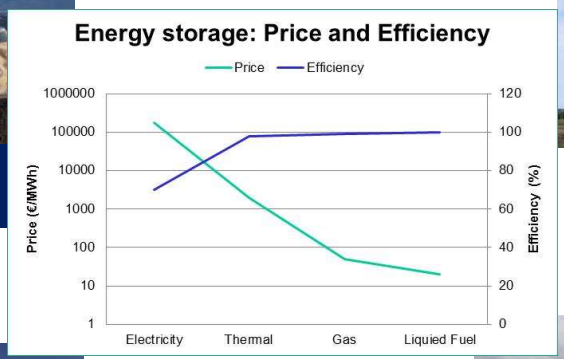
ENERGY STORAGE

PUMP HYDRO STORAGE
175 €/KWH



THERMAL STORAGE
1-4 €/KWH

NATURAL GAS UNDERGROUND STORAGE
0.05 €/KWH

OIL TANK
0.02 €/KWH

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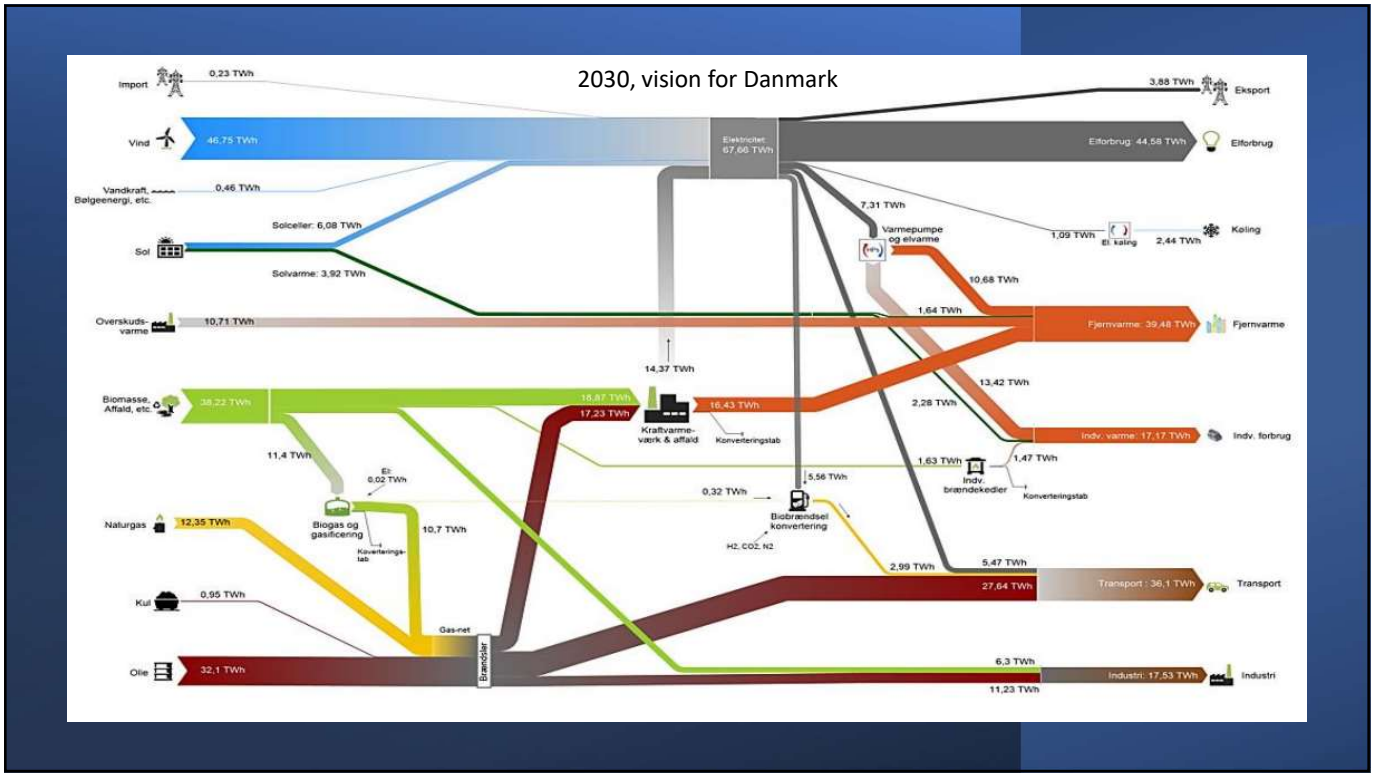

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Heat Roadmap Europe
2050
A low-carbon heating and cooling strategy

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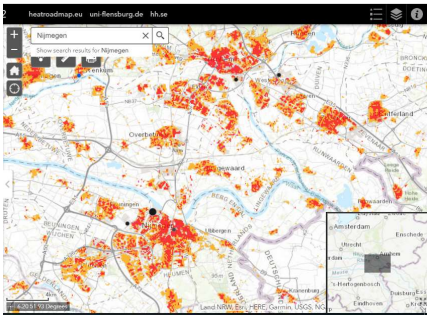
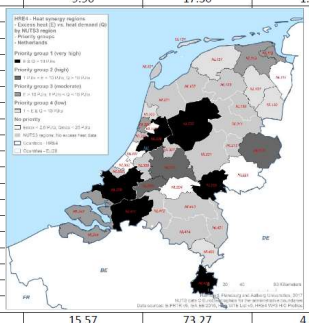
Heat synergies map - Netherlands



- Heat demands: 296 PJ/y
- Excess heat: 560 PJ/y
- District heating share: 6%
- Renewable energy in heating: 3%
- Not a Technical barrier to improve energy efficiency?

NUTS3 Regions	Heat demand [PJ/a]	Excess heat [PJ/a]	Excess heat ratio [-]
NL111	3.83	0.20	0.05
NL112	1.22	11.32	9.28
NL113	9.90	17.30	1.75
NL121			25
NL131			92
NL132			55
NL213			48
NL224			08
NL225			09
NL226			40
NL230			99
NL310			12
NL322			16
NL323			.27
NL325			05
NL326			05
NL332			05
NL337			09
NL339			06
NL33A			39
NL341			.41
NL342			78
NL411	15.57	73.27	4.71
NL422	5.96	8.10	1.36
NL423	15.28	39.67	2.60
Grand Total	**295.84**	**559.23**	**1.89**



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WP2: Pan-European Thermal Atlas: www.heatroadmap.eu

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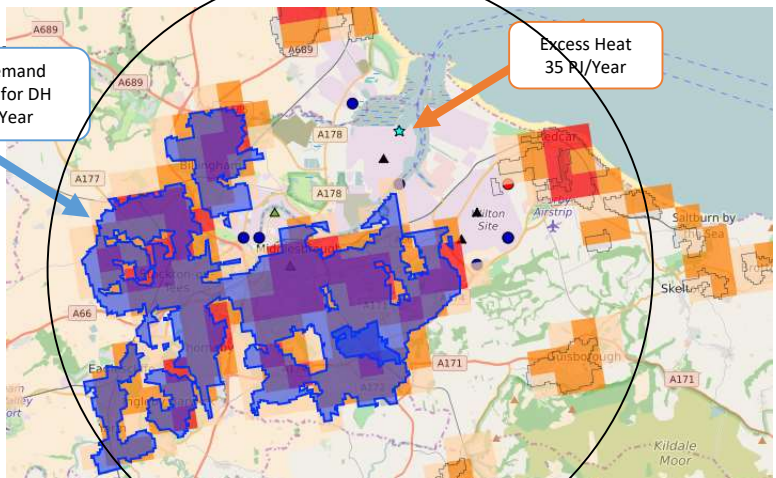
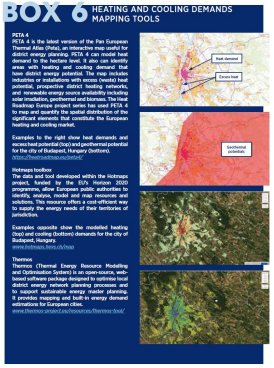
Case





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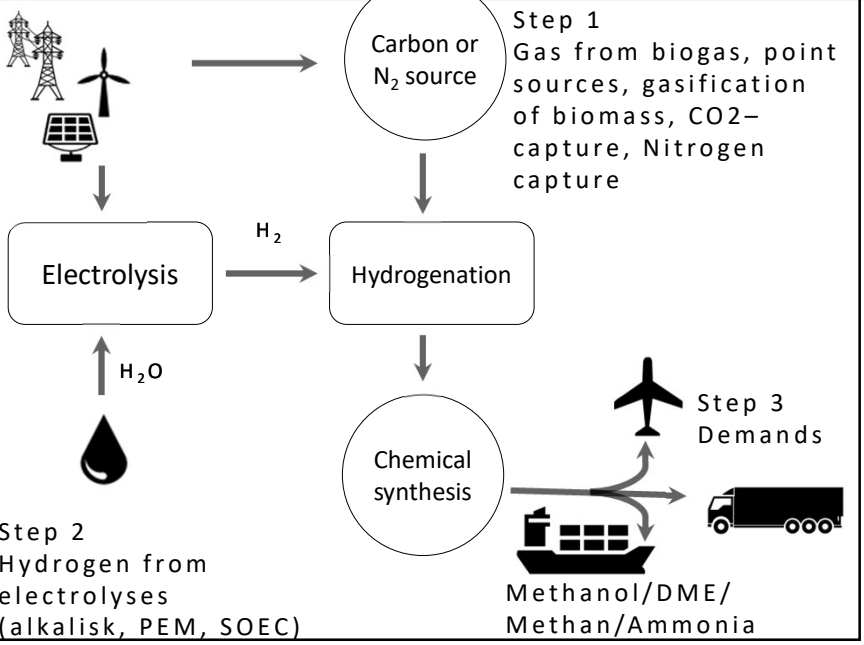
reINVEST Innovation Fund Denmark eUDP @BrianVad

HANDLINGSPLAN FOR STORSKALA ANVENDELSE AF ELEKTROLYSE I DANMARK

- Mature technologies – and immature technologies (TRL – levels)
- The combination is complex
- The up-scaling is complex
- Everything has to be tested



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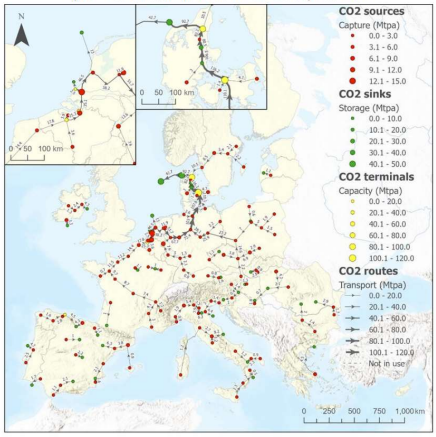
New (useless) JRC report on CO2 capture (JRC = EU's knowledge center for energy)

Figure 1. Potential CO_2 transport network in 2050 according to scenario C1



Source: JRC, 2024

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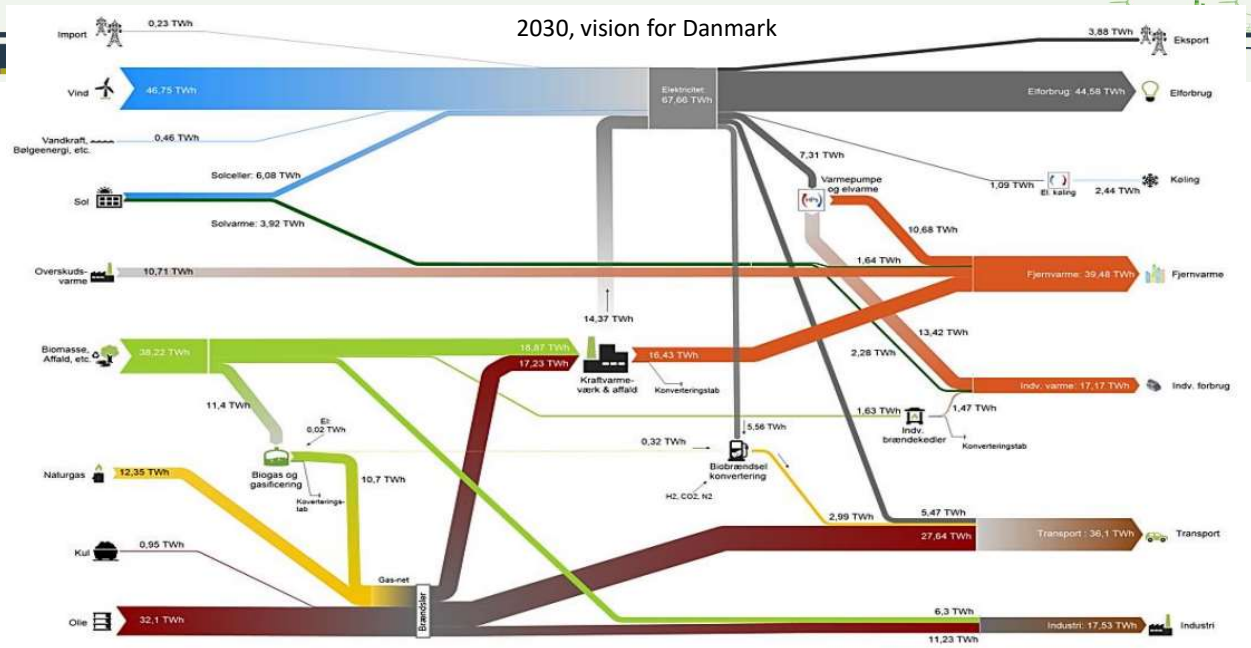

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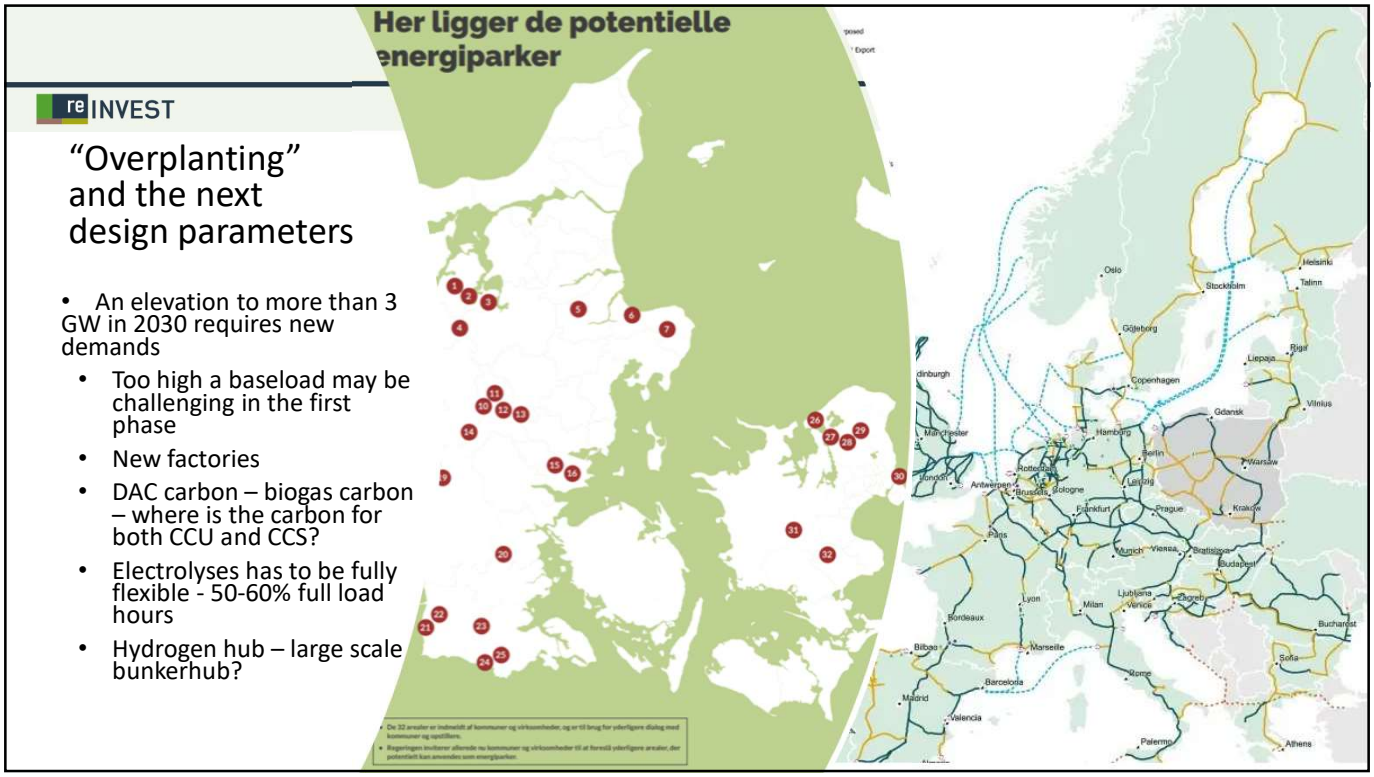
Her ligger de potentielle
energiparker
reINVEST
"Overplanting" and the next design parameters
• An elevation to more than 3 GW in 2030 requires new demands
• Too high a baseload may be challenging in the first phase
• New factories
• DAC carbon – biogas carbon – where is the carbon for both CCU and CCS?
• Electrolyses has to be fully flexible - 50-60% full load hours
• Hydrogen hub – large scale bunkerhub?

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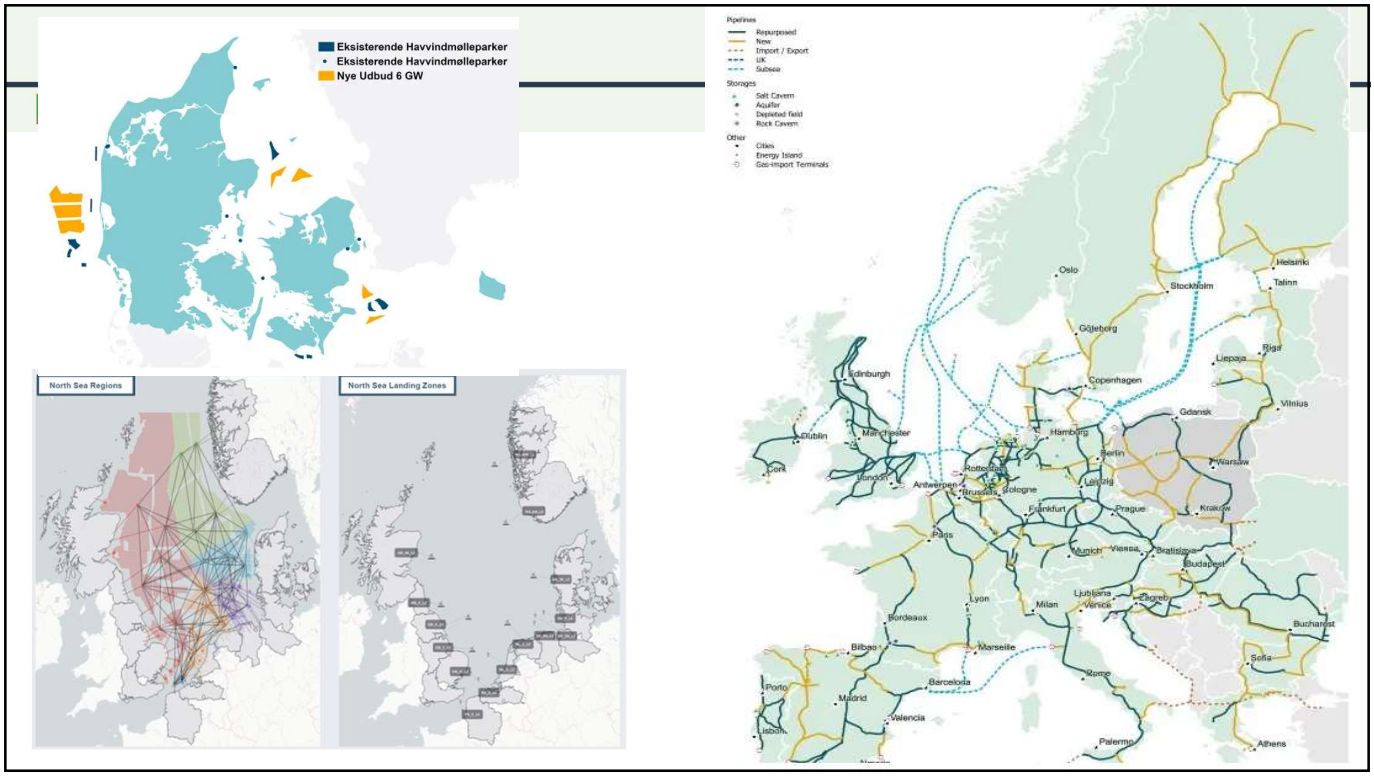
Eksisterende Havvindmølleparker
Eksisterende Havvindmølleparker
Nye Udbud 6 GW
North Sea Regions
North Sea Landing Zones

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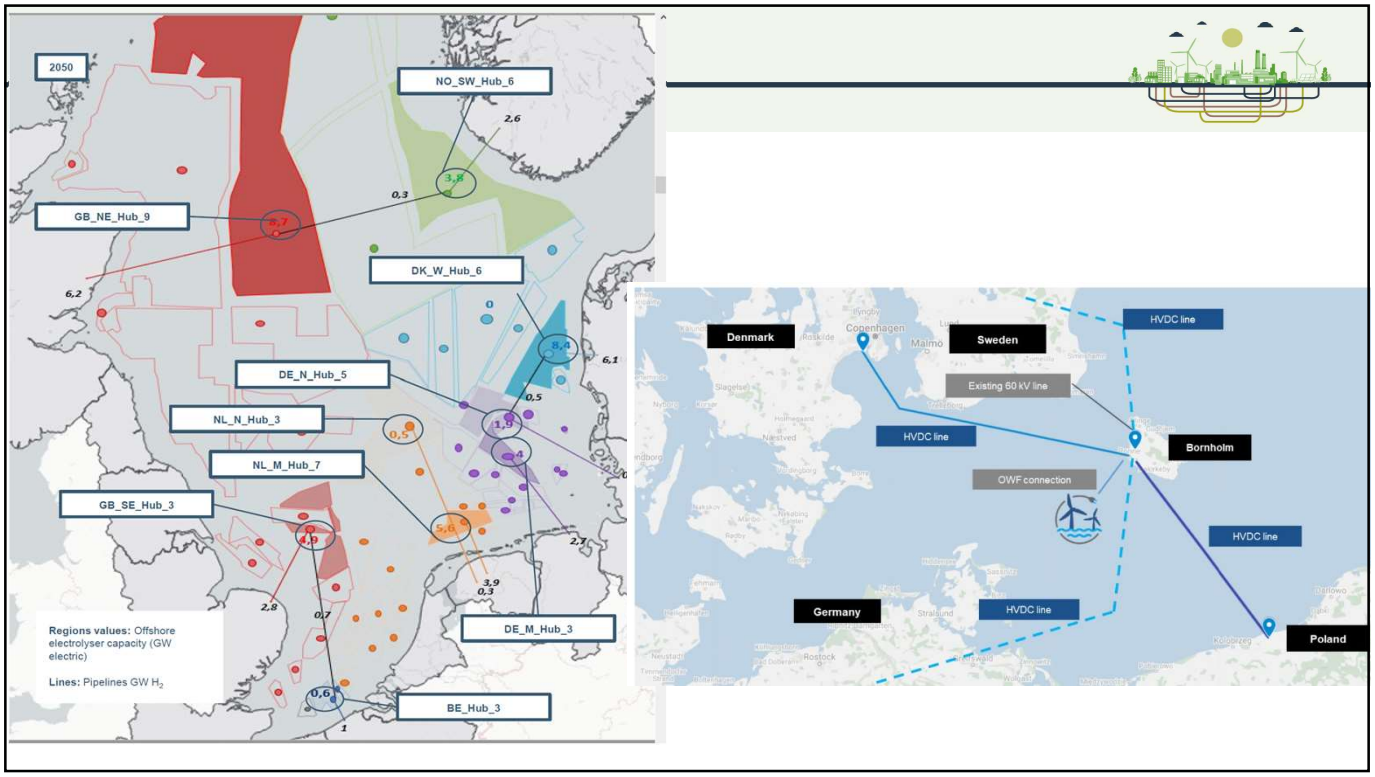
2050
NO_SW_Hub_6
GB_NE_Hub_9
DK_W_Hub_6
DE_N_Hub_5
NL_N_Hub_3
NL_M_Hub_7
GB_SE_Hub_3
DE_M_Hub_3
BE_Hub_3
Regions values: Offshore electrolyser capacity (GW electric)
Lines: Pipelines GW H2
Denmark
Sweden
Germany
Poland
Bornholm
HVDC line
Existing 60 kV line
OWF connection

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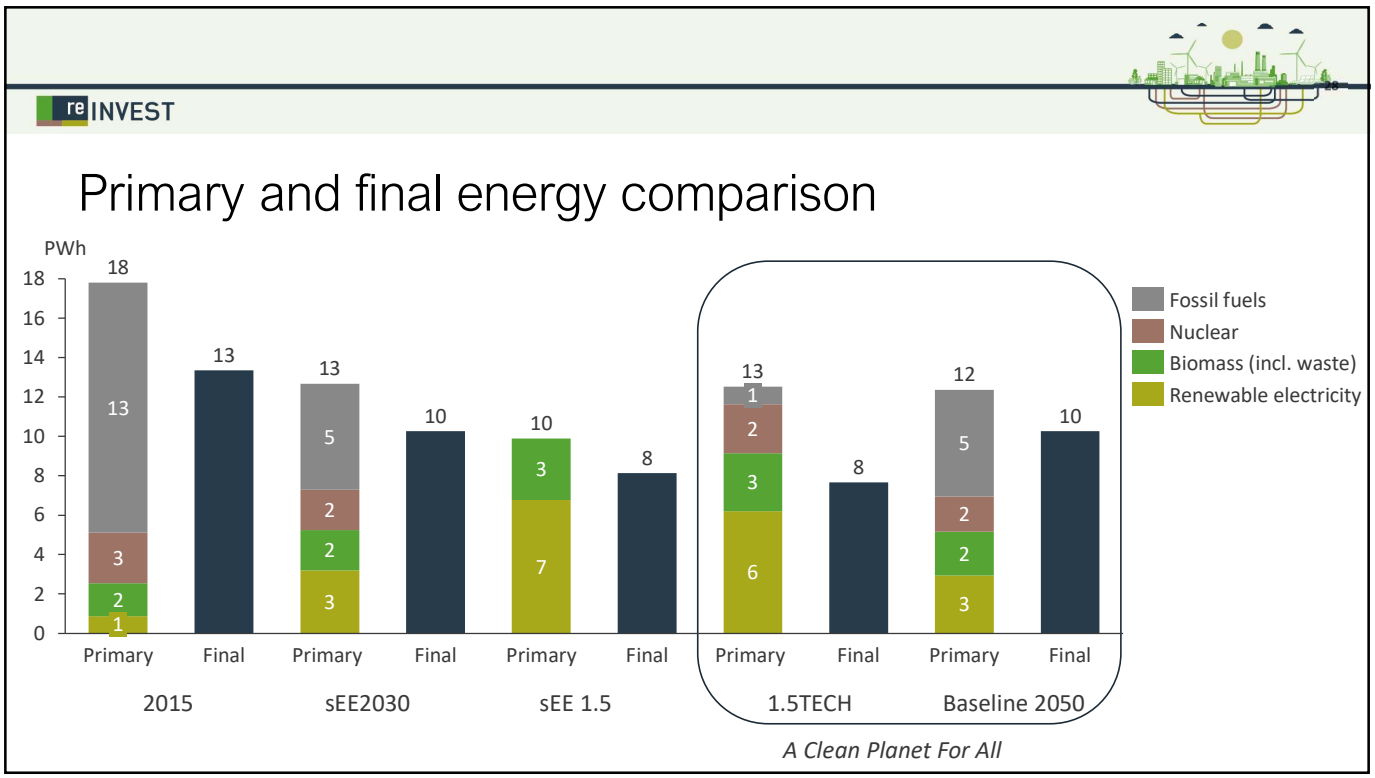
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Primary and final energy comparison
PWh
Fossil fuels
Nuclear
Biomass (incl. waste)
Renewable electricity
Primary
Final
2015
sEE2030
sEE 1.5
1.5TECH
Baseline 2050
A Clean Planet For All

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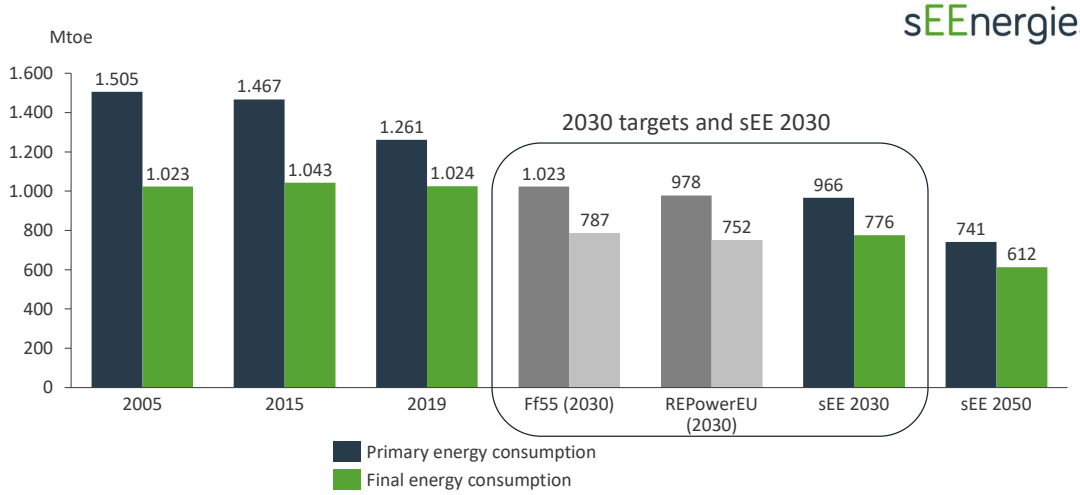
Primary and final energy consumption EU27

sEEnergies



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