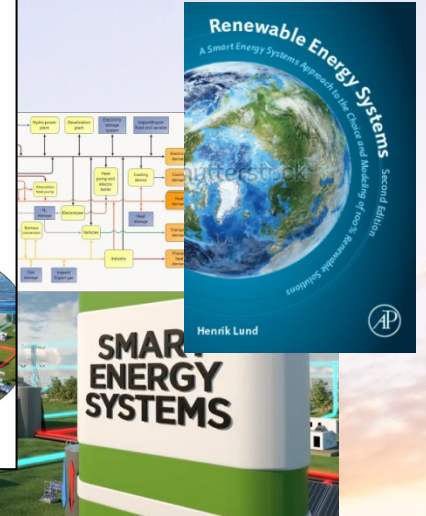


BUILDING A LOW-CARBON ISLAND ECONOMY CONFERENCE 2022

Thursday 27 October 2022 Comis Hotel, Mount Murray

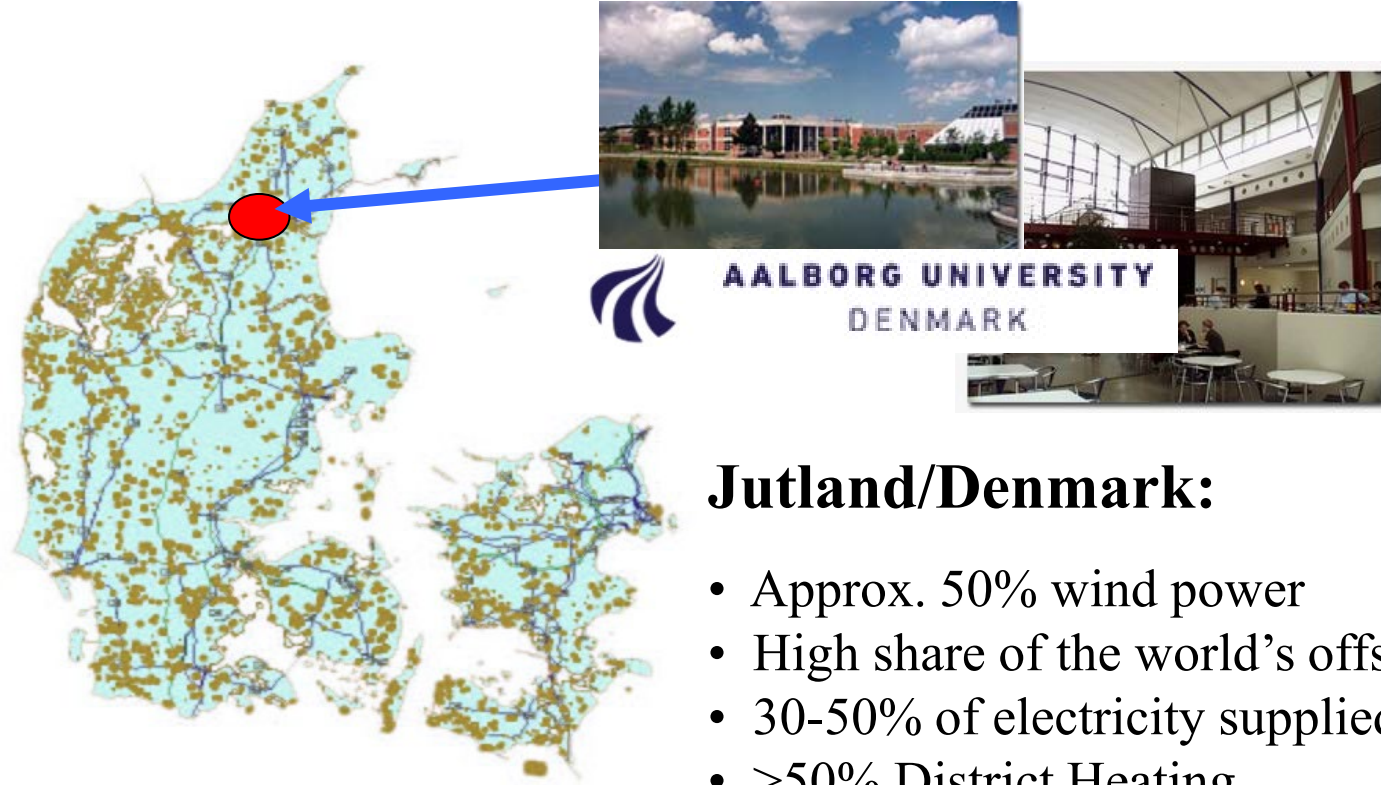


A Small Nation's Guide to the Energy Transition

Professor Henrik Lund
Aalborg Universitet



Aalborg University, Denmark

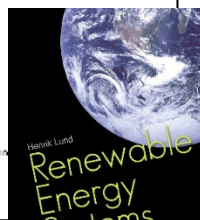
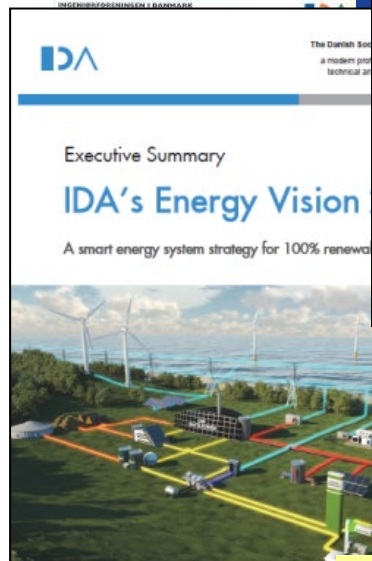
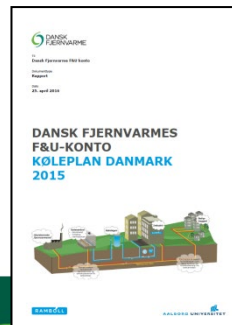


Jutland/Denmark:

- Approx. 50% wind power
- High share of the world's offshore power
- 30-50% of electricity supplied by CHP
- >50% District Heating
- > 30% Biogas in the natural gas supply

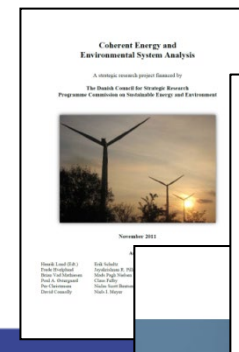
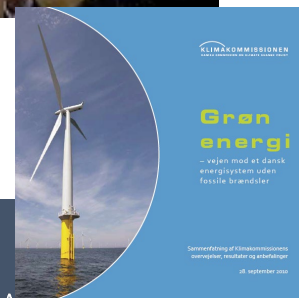


The long-term Objective of Danish Energy Policy



Prime minister 16 November 2008:
"We will free Denmark totally from fossil fuels like oil, coal and gas"

POWER TO THE PEOPLE
09 06 09



Expressed by former Prime Minister Anders Fogh Rasmussen in his opening speech to the Parliament in 2006 and in several political agreements since then:

To convert to 100% Renewable Energy

Prime minister 16 November 2008:
"... position Denmark in the heart of green growth"

SYSTEMPERSPEKTIV 2035

Perspektiver for effektiv anvendelse af vedvarende energi i det danske energisystem på længere sigt

Marts 2018

2019 New Government and agreement: 70% reductions in Greenhouse gases by 2030

Climate Law and Action plan:

1. Energy savings in among others public buildings
2. National Strategy for Sustainable buildings
3. Strategy for electrification of transport, industry and society in general
4. More funds for green research and demonstration projects
5. Assessment of Danish and North Sea countries mutual expansion of offshore wind
6. Investigation of energy island of 10 GW wind before 2030
7. Support afforestation (new forest)
8. Climate adoption via coordination of coastal protection



Politik, frekædet mellem Socialdemokratiet, Radikale Venstre, SF og Enhedslisten:

Retfærdig retning for Danmark

Folketingsvalget 2019 har givet Danmark en historisk mulighed for at sætte en ny politisk retning.

Vi skal gå videre i kampen mod klimakrisen. Danmark skal markant hæve ambitionerne for klima, miljø og natur og påtage sig det internationale lederskab for den grønne omstilling. Folketinget kan blive det grønne parlament i verden, der ikke kun gør noget, men som gør det, der skal til for at leve op til Paris-afkølen.

Vi skal styrke vores velfærd igen. Så Danmark bliver verdens bedste land at være bopæl i, så der bliver mere tid til omsorg i sundhedsvæsenet, og så alle kan se frem til en tryk og værdig alderdom. Velfærd giver lige muligheder og frihed til forskellighed.

Vi skal bekæmpe den stigende ulighed. Så vi igen bekræfter at styrke den samfundsmodel, der har gjort Danmark til et af de mest ulidsfulde og trygge lande i verden. Hverken fattigdom eller gældighed hæver hjemme i vores land, og vi har muligheden for at tage et opgør med begge dele.

Vi skal tage et opgør med centraliseringen af Danmark. Så der er udvikling, muligheder, arbejdspladser og velfærd i hele landet. Det har en værdi i sig selv, at beslutninger træffes tæt på dem, der vedst. Danmark er for lille til store forskelle.

Vi skal sætte på uddannelse. Så vores unge kan udfordre og udfordres sig så meget, som de kan – og så bliver ny generation går en bedre fremtid i møde end den forrige. I et velfærdssamfund som det danske skal det ikke være en baggrund, der afgør, hvilke muligheder man har i livet.

Vi skal fremme integrationen. Så vi kan leve sammen, selvom vi er forskellige. Med respekt for hinanden og de demokratiske spilleregler vi bygger vores samfund på. I Danmark er alle frie og ligestillede.

Vi skal løfte et ansvar for verden. Så Danmark er et land, der hjælper mennesker i nød. Som ulykter om de internationale konventioner, åbner arbejder for FN's verdensmål og engageret indgår i forpligtende internationale fællesskaber. Danmark skal være et åbent land, hvor vi lever af vores udbyr til resten af verden.

Vi tror på, at politik betyder noget. At vi kan løse de sædte problemer i stedet for at føle trykkeløshed. Så vi sammen kan sætte en ny og progressiv retning for Danmark. Forventningerne er store. Ikke så kan indføres på én gang, og forventningen er, at der bliver en ansvarlig økonomisk politik, der sikrer gode rammebetingelser for erhvervslivet. Vi har en unik mulighed for at gå i gang med at realisere de håb, valgene har til et nyt politisk fælleskab.

Det er på den baggrund, at partier, med et flertal af mandater i Folketinget, har peget på Mette Frederiksen (S) som kongelig undersøger med henblik på at danne en regering, der skal sikre en ny politisk retning for Danmark.

Som forudsætning for etablering af en sådan regering er Socialdemokratiet, Radikale Venstre, SF og Enhedslisten enige om "en politisk frekædet", der medfører, at en ny regering er forpligtet til at tage en række initiativer, der samlet set vil betyde en ny politisk retning for Danmark. Initiativerne skal udformes i løbet af regeringsperioden og gennem et bredt samarbejde med Folketingets øvrige partier. En ny regering vil endvidere respektere alle gældende forlig.

Side 1



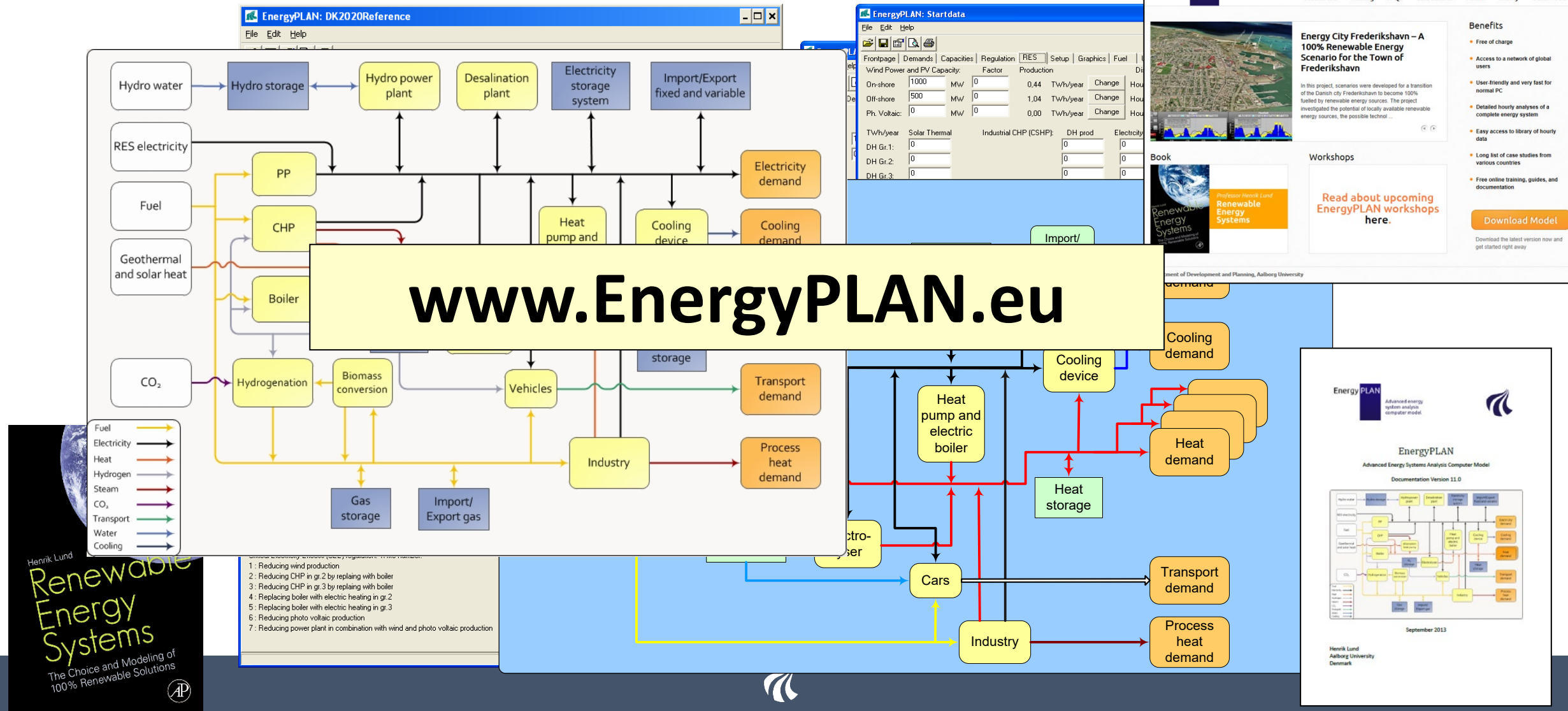
100% Renewable Energy 2050

A fully decarbonized society 2050

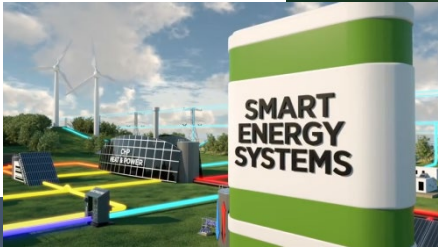
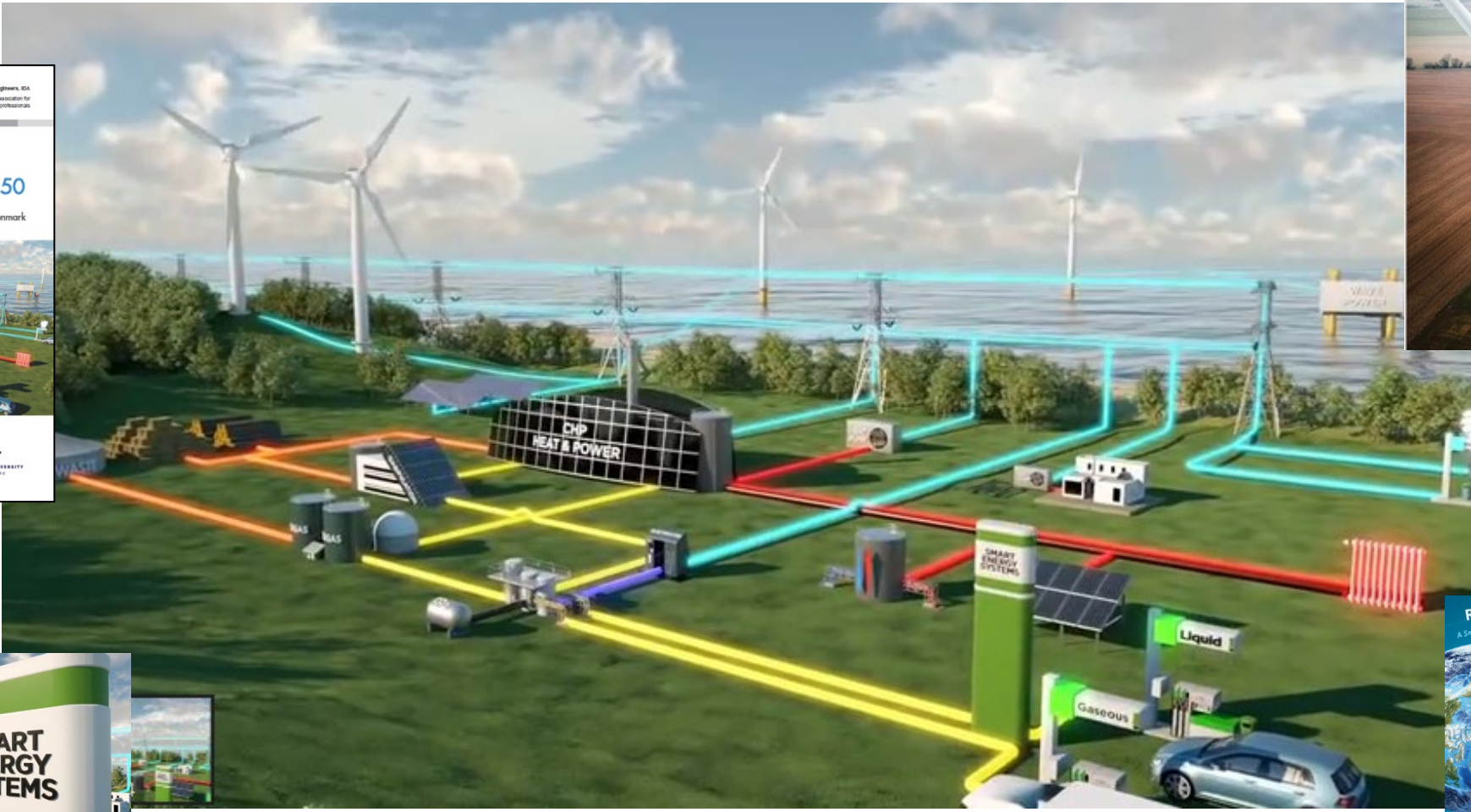
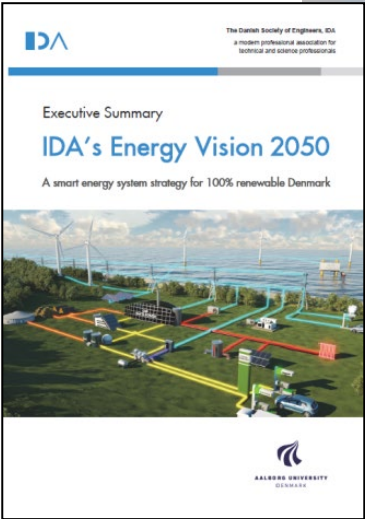
..... but how...???!?



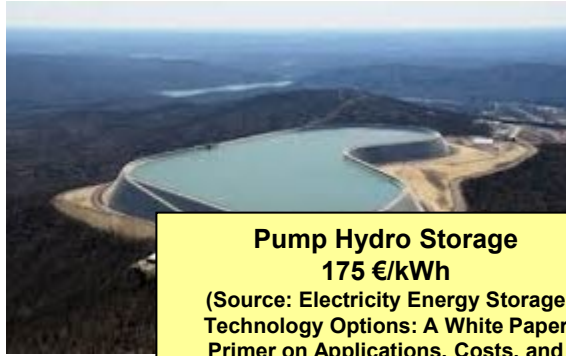
Energi System Analyse Model



A Holistic Smart Energy Systems Approach



Energy Storage



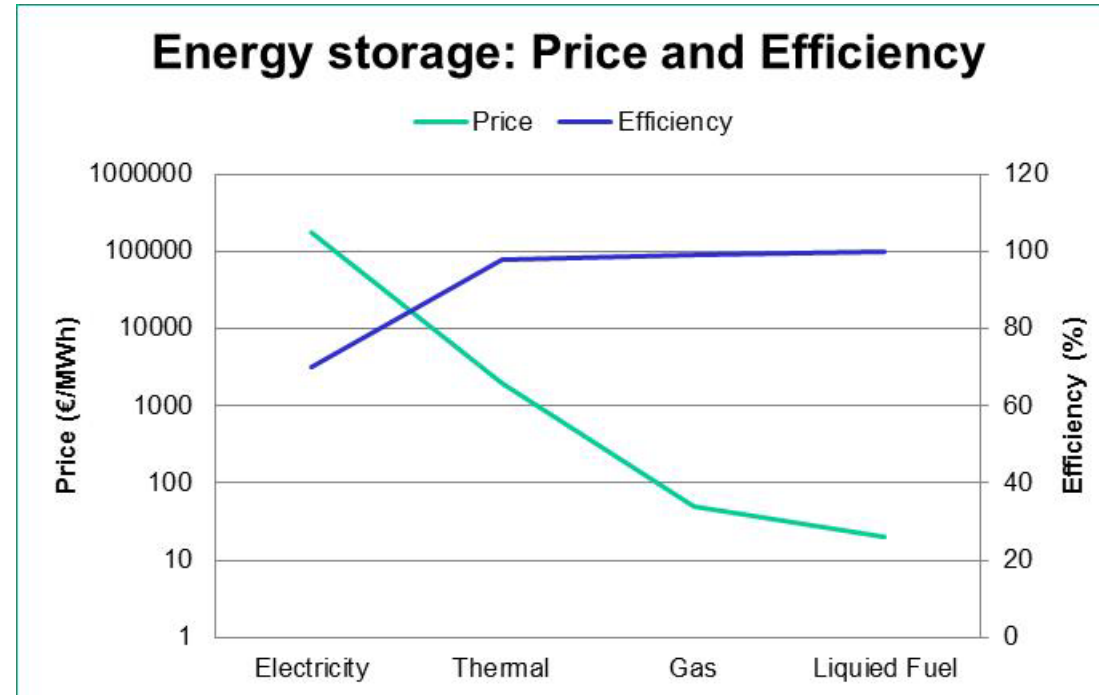
Pump Hydro Storage
175 €/kWh

(Source: Electricity Energy Storage Technology Options: A White Paper Primer on Applications, Costs, and Benefits. Electric Power Research Institute, 2010)



Natural Gas Underground Storage
0.05 €/kWh

(Source: Current State Of and Issues Concerning Underground Natural Gas Storage. Federal Energy Regulatory Commission, 2004)



Thermal Storage
1-4 €/kWh
(Source: Danish Technology Catalogue, 2012)



Oil Tank
0.02 €/kWh
(Source: Dahl KH, Oil tanking Copenhagen A/S, 2013: Oil Storage Tank. 2013)

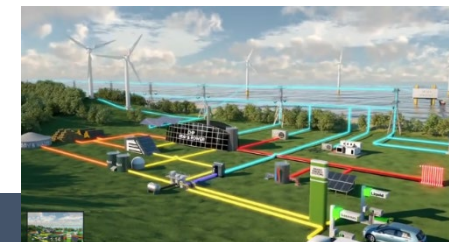
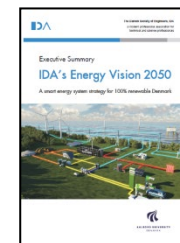


IDAs Climate Response: In a European context

Denmark should fulfill its objective of renewable energy and CO2-reductions in a way, so it fits well into a context in which the rest of Europe - and the world - will do the same.

Therefore:

- Denmark should include the Danish share of ***international aviation and shipping*** even though it is not included yet in the UN way of calculating the Danish CO2 emissions.
- Denmark should not exceed our share of ***sustainable use of biomass*** in the world.
- Denmark should make our contribution in terms of ***flexibility and reserve capacity*** to integrate wind and solar into the ***European electricity supply***.



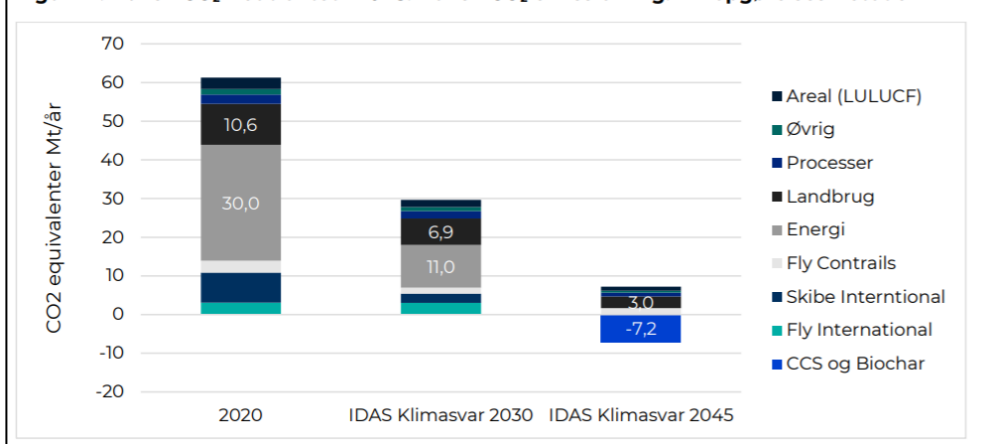
IDA's Climate Response 2045

How Denmark Can Become Climate Neutral

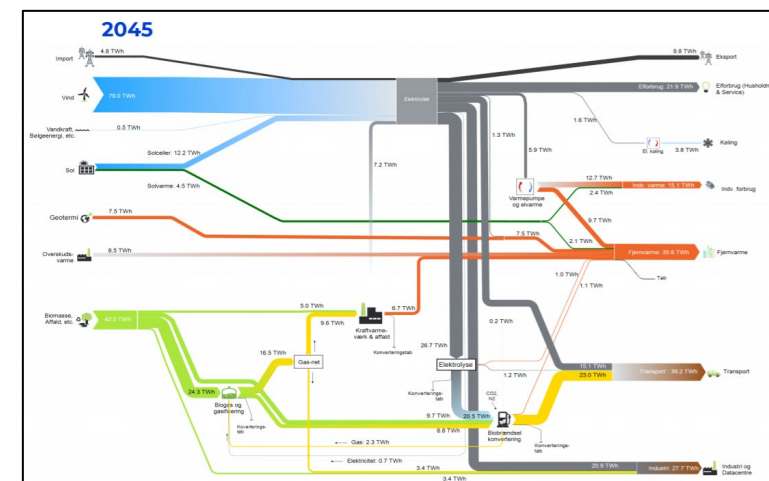
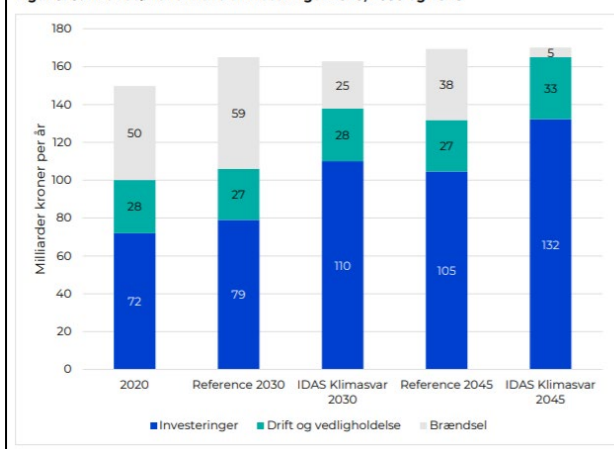
- Include Danish Share of International Aviation and Shipping
- Within the Danish share of Global Sustainable Biomass resources
- Reach the 2050 climate neutral goal already in 2045
- Coordinated with actions within agriculture, LULUCF and processes



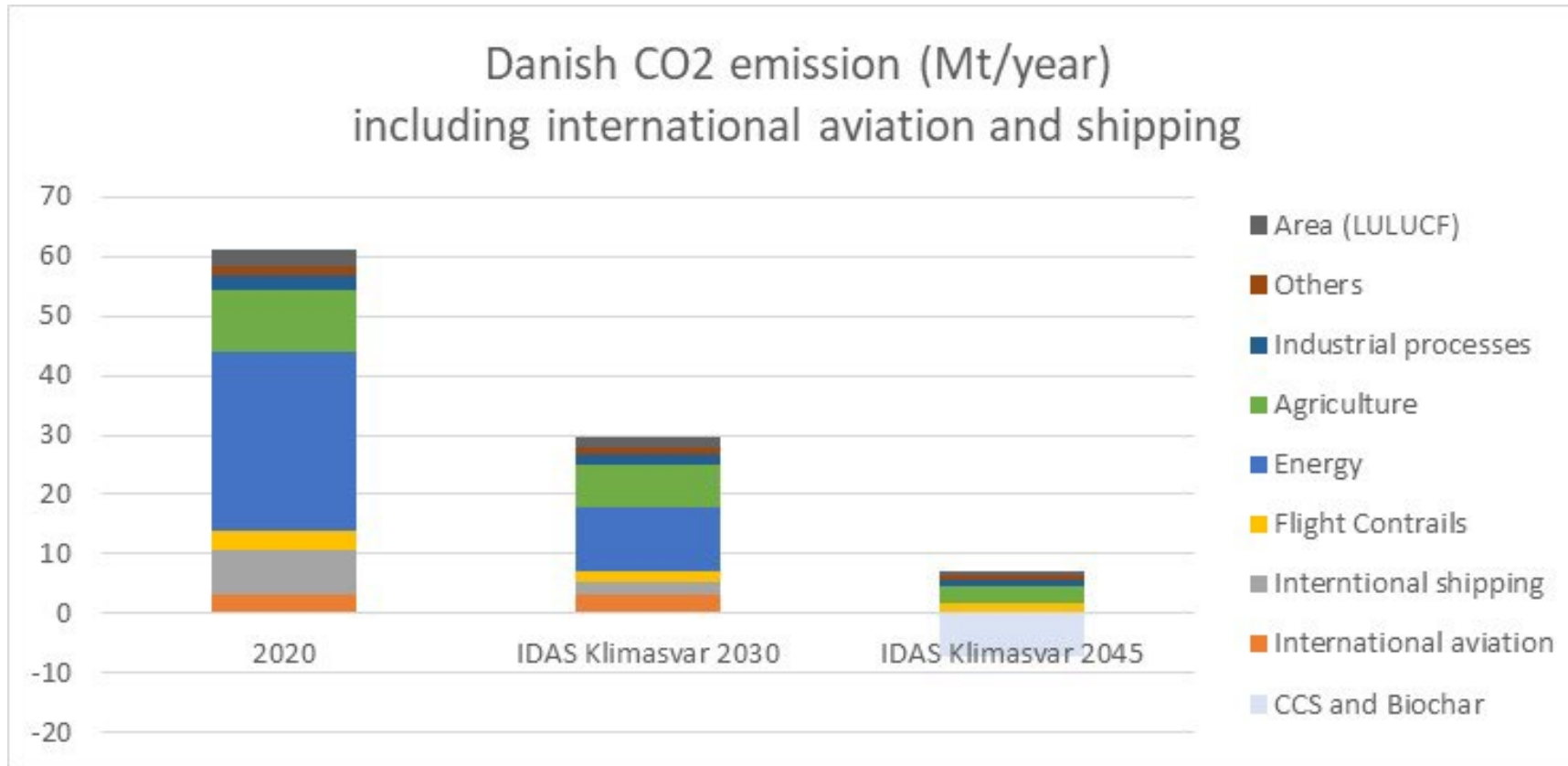
Figur 1B. Dansk CO₂-neutralitet i 2045. Dansk CO₂ emission iflg. FN-opgørelsesmetoden



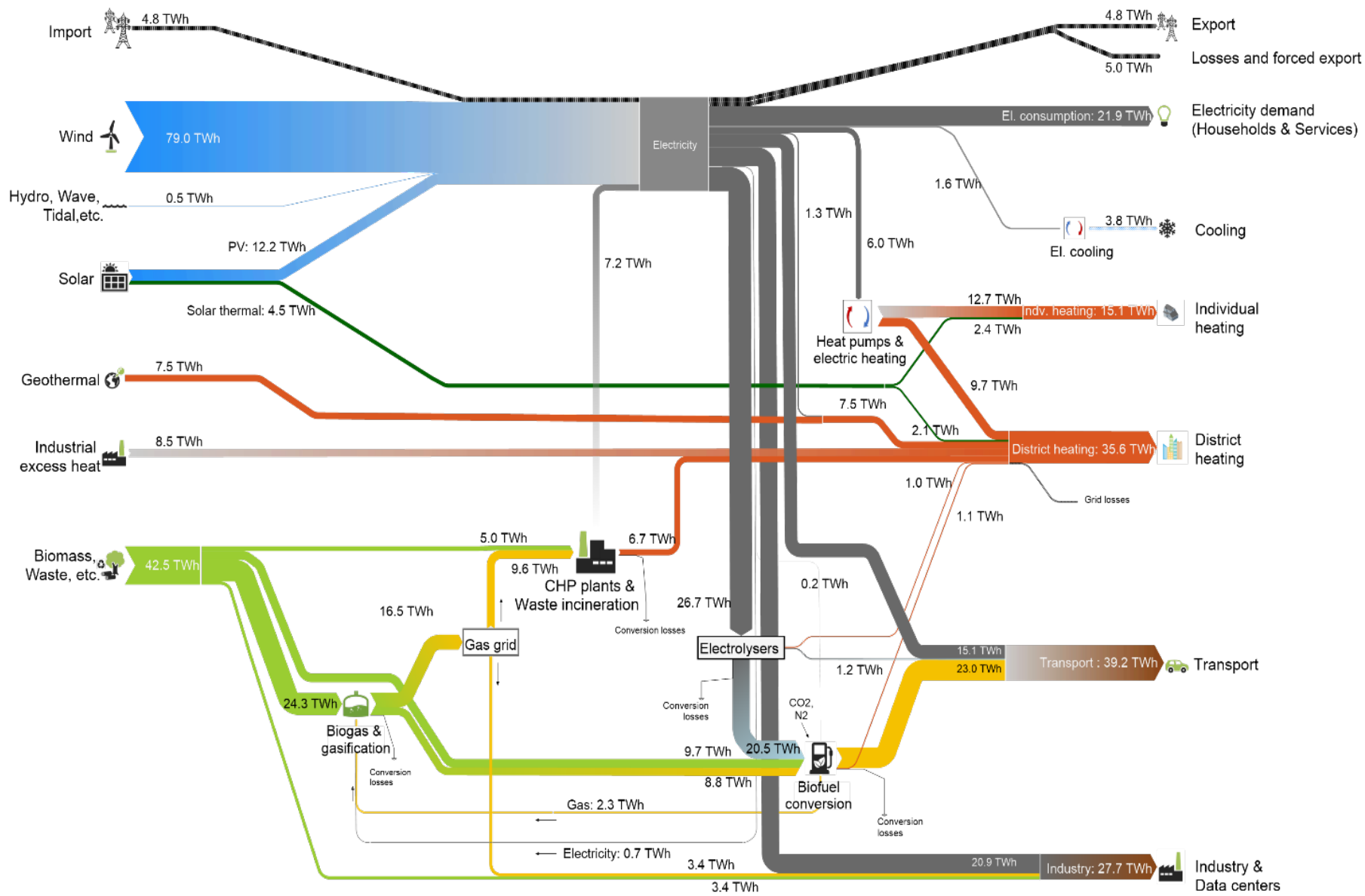
Figur 3. Samfundøkonomiske omkostninger 2020, 2030 og 2045



A fully decarbonized Denmark 2045



2045



VARMEPLAN DANMARK 2021
En Klimaneutral Varmeforsyning



Heat Plan Denmark 2021



Varmeplan Danmark 2021

Brian Vad Mathiesen, Henrik Lund, Steffen Nielsen, Peter Sorknæs, Diana Carolina Moreno Saltos og Jakob Z. Thellufsen

Aalborg Universitet

Why Heat Plan Denmark 2021?

How can the heating sector best support the political goals?

- 70% reduction in greenhouse gases by 2030
- Climate-neutral Denmark in 2050

Key questions:

- Where is the balance between heat savings and heat supply?
- Where should there be district heating and where should it be individual?
- What should the individual heat supply be based on?
- Where should the district heating come from?
- What are the innovative challenges e.g. 4th generation district heating, smart meters, digitization, power2X, data centers, geothermal, etc.
- How does the heating sector best help in terms of flexibility in the entire energy supply?



VARMEPLAN DANMARK 2021 **En Klimaneutral Varmeforsyning**



Four main points

- **Energy savings in the building stock are important.** A good balance between energy savings and renewable energy must be achieved to have low costs and low fuel consumption. This means that a continued focus on energy renovation in buildings is important to implement savings of 32-36%.
- **District heating should be expanded to cover 63-70% of the heat market** as individual natural gas and oil-fired boilers are phased out in existing urban areas and as new urban areas emerge. Outside the district heating areas, the heat should come from **individual heat pumps** supplemented by solar thermal. This combination provides the most energy efficient and flexible solution.
- In district heating, a **targeted focus should be placed on a transition to 4th generation district heating** with lower temperatures. It provides the lowest cost and most efficient use of geothermal heat, waste heat, and large heat pumps.
- In future low-carbon energy systems there is **great potential for utilizing geothermal and waste heat** from industry, data centers, and Power-to-X. These opportunities should be exploited.



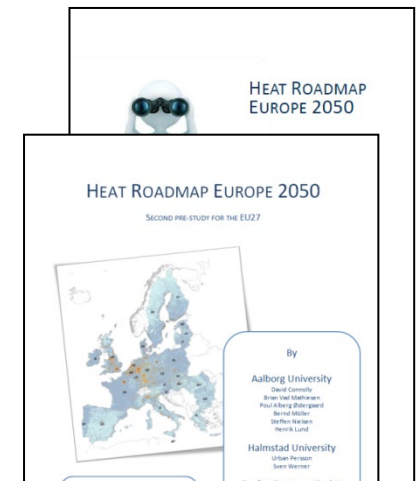
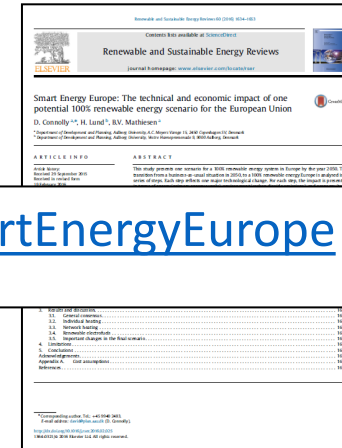
www.henriklund.eu

More information:

<https://www.energyplan.eu/book2/>

www.energyplan.eu/SmartEnergyEurope

www.4DH.dk



www.heatroadmap.eu

www.energyplan.eu/smartenergysystems/



Energy System Analyse Model

www.EnergyPLAN.eu

www.EnergyPLAN.eu