SYSTEM INTEGRATION OF HEAT AND ELECTRICITY – HOW?

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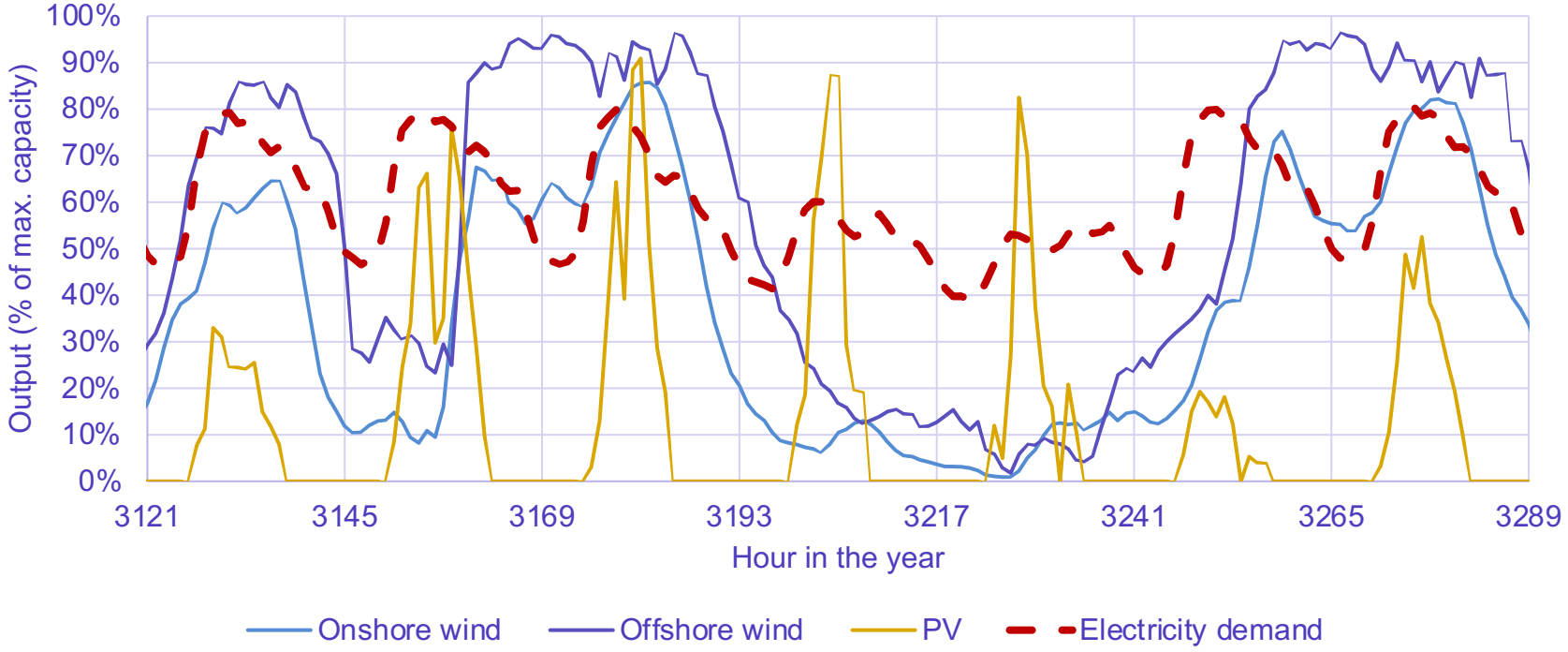
Example of production distributions of variable renewable electricity



Principle example based on Danish distributions

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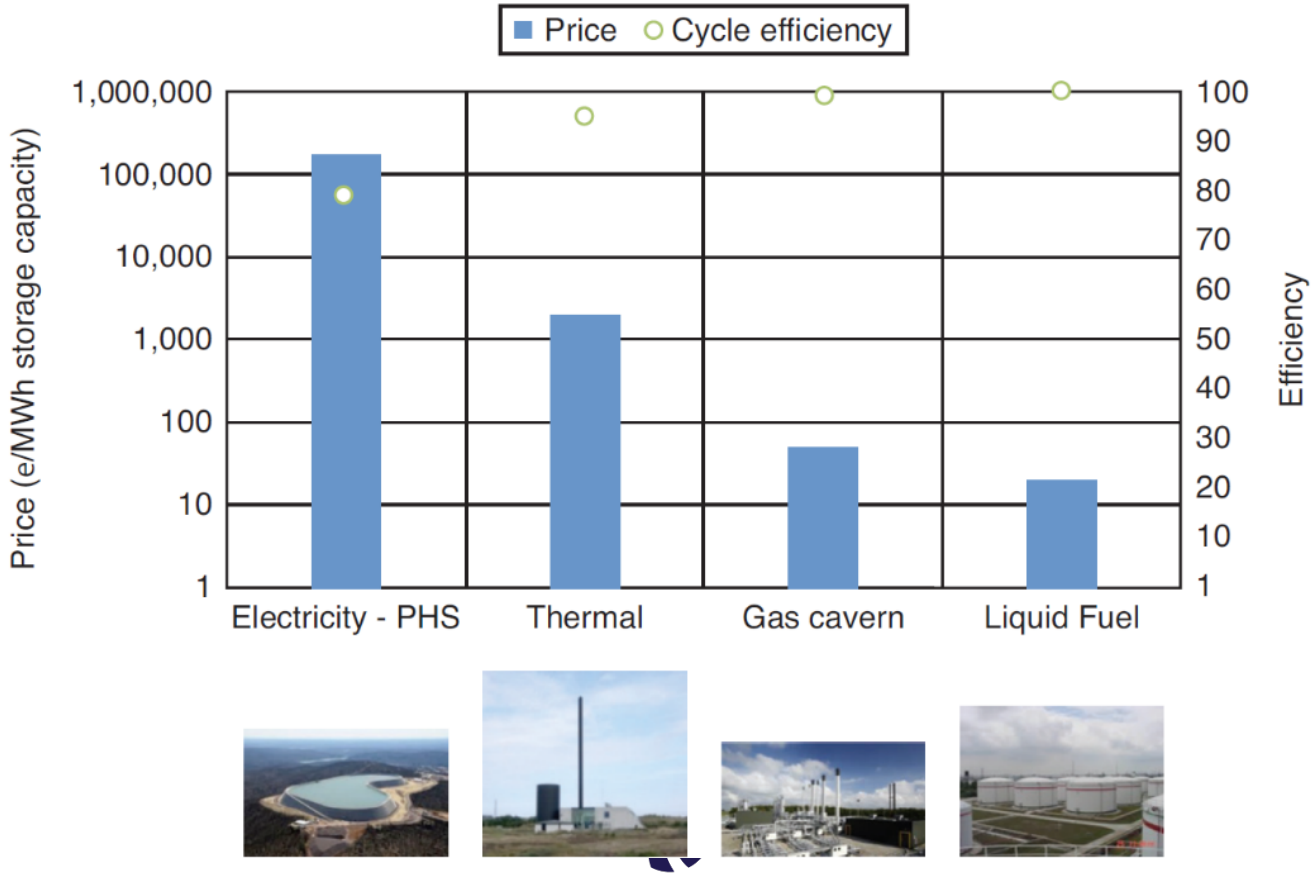
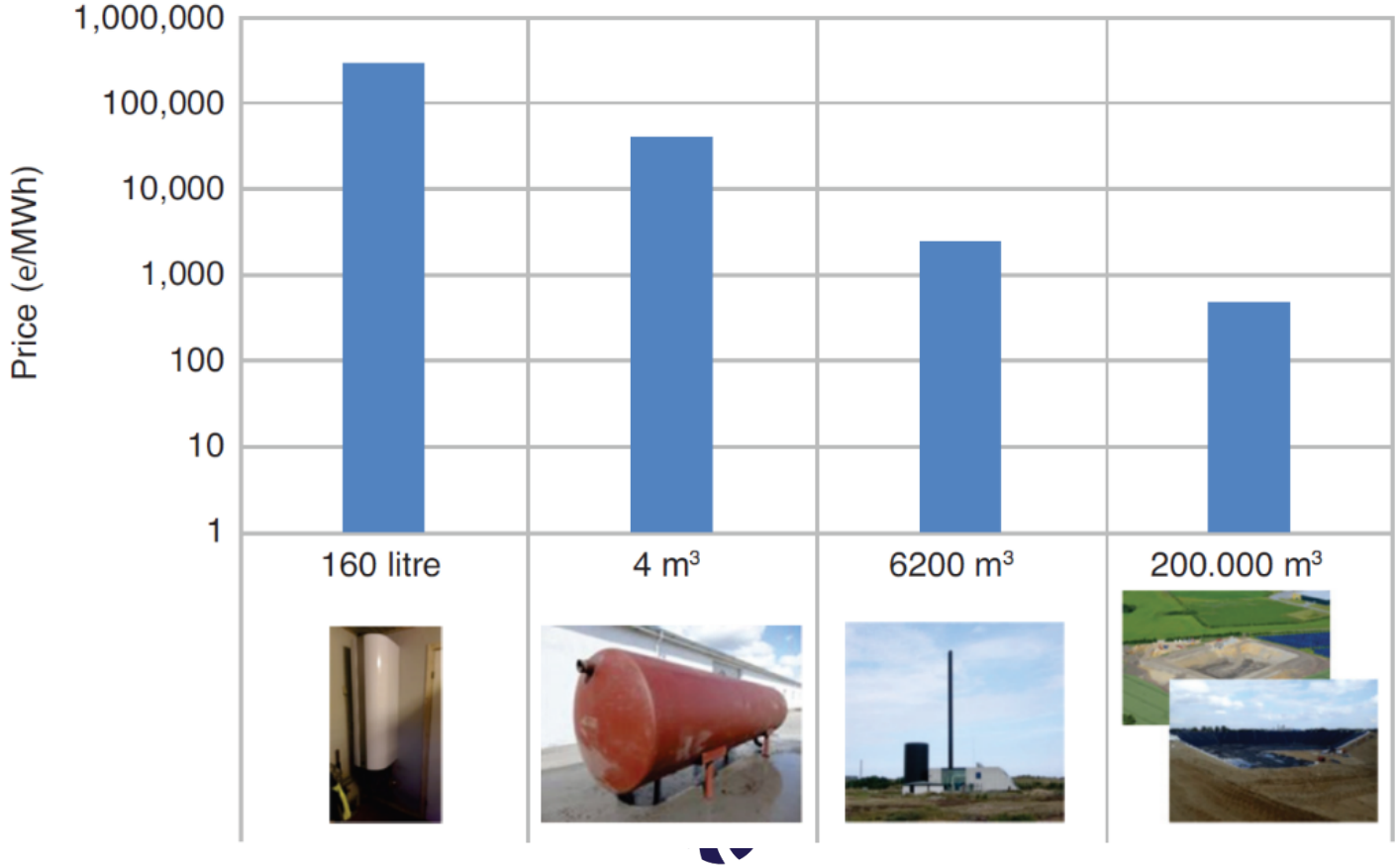
Energy storages in renewable energy systems – costs and efficiencies



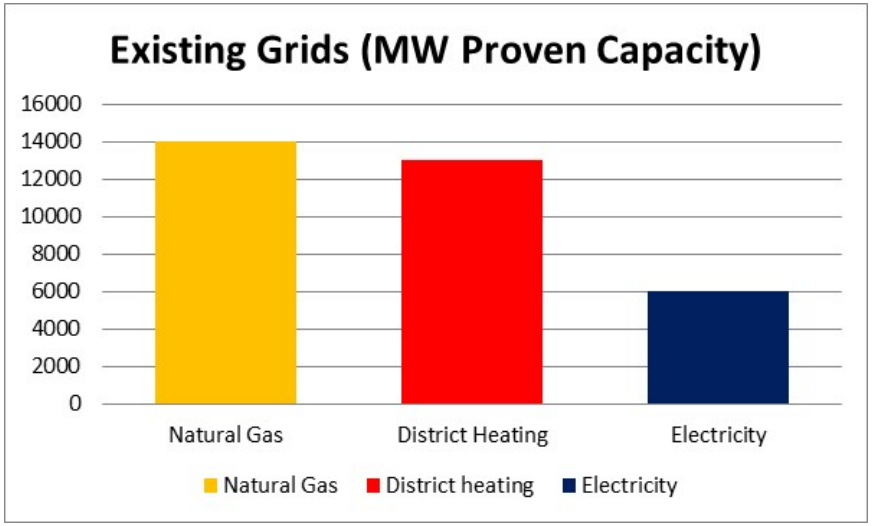
Lund H, Østergaard PA, Connolly D, Mathiesen BV. Smart energy and smart energy systems. Energy 2017;137:556–65. doi:10.1016/j.energy.2017.05.123.

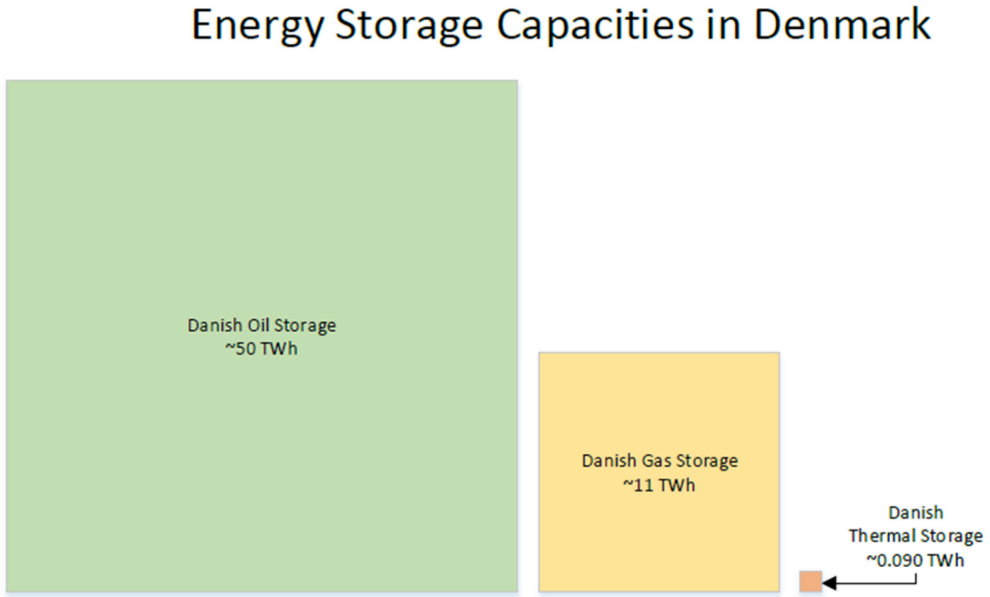
Costs of different thermal energy storage systems



Lund H, Østergaard PA, Connolly D, Mathiesen BV. Smart energy and smart energy systems. Energy 2017;137:556–65. doi:10.1016/j.energy.2017.05.123.

Also a question of best utilizing existing grids and storages





Lund H. Renewable heating strategies and their consequences for storage and grid infrastructures comparing a smart grid to a smart energy systems approach. Energy 2018;151:94–102. doi:10.1016/J.ENERGY.2018.03.010.

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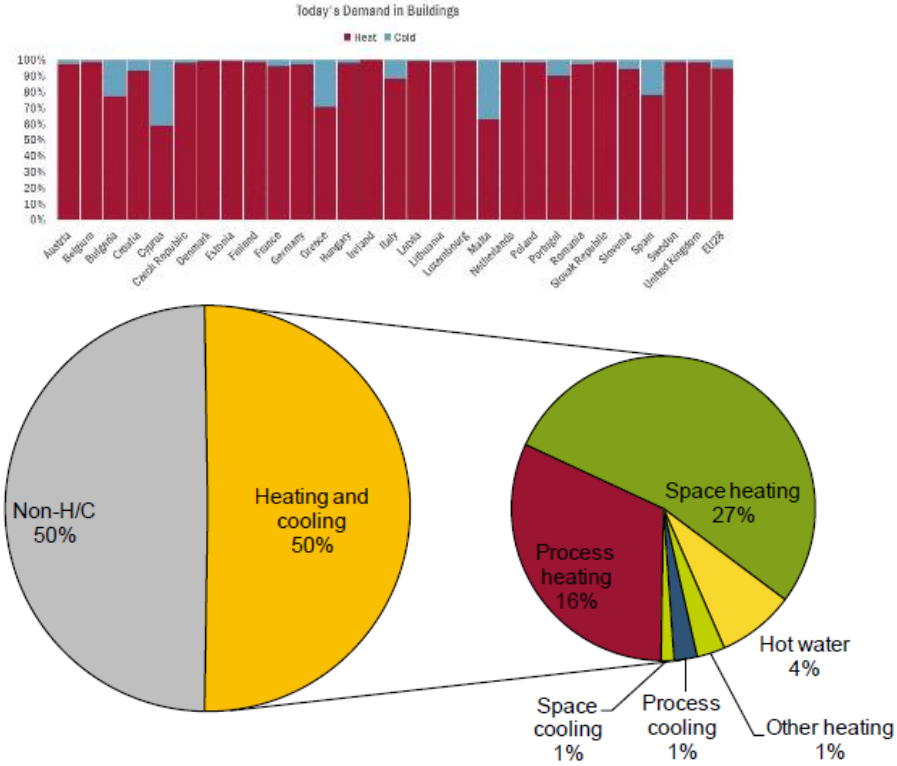
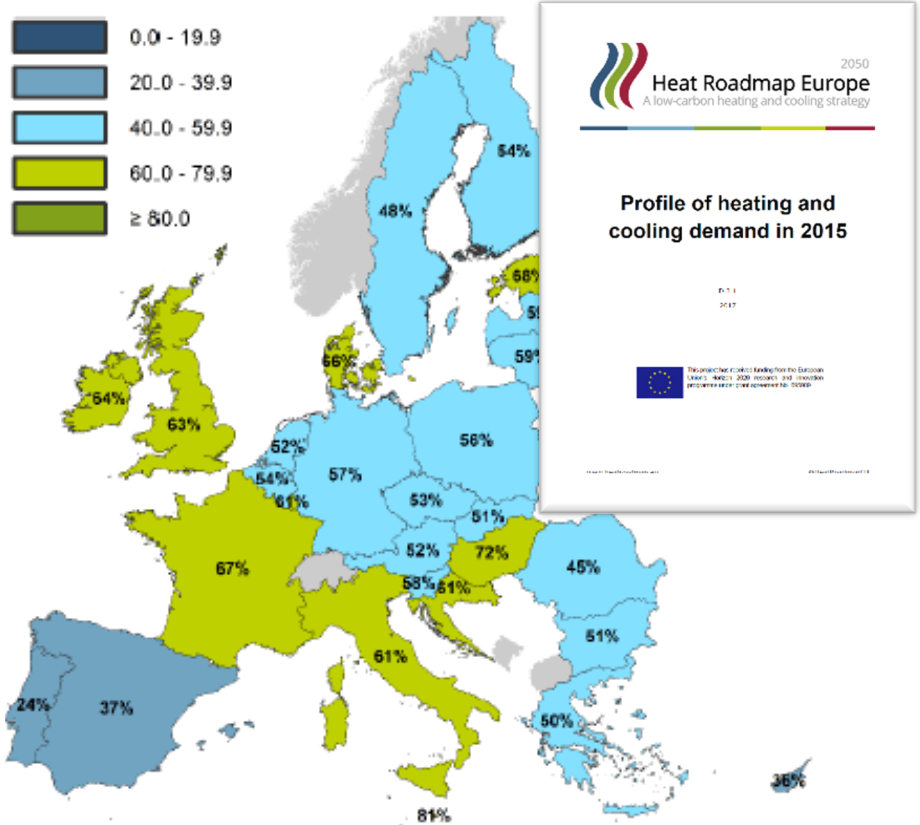
Heating is key to the energy system



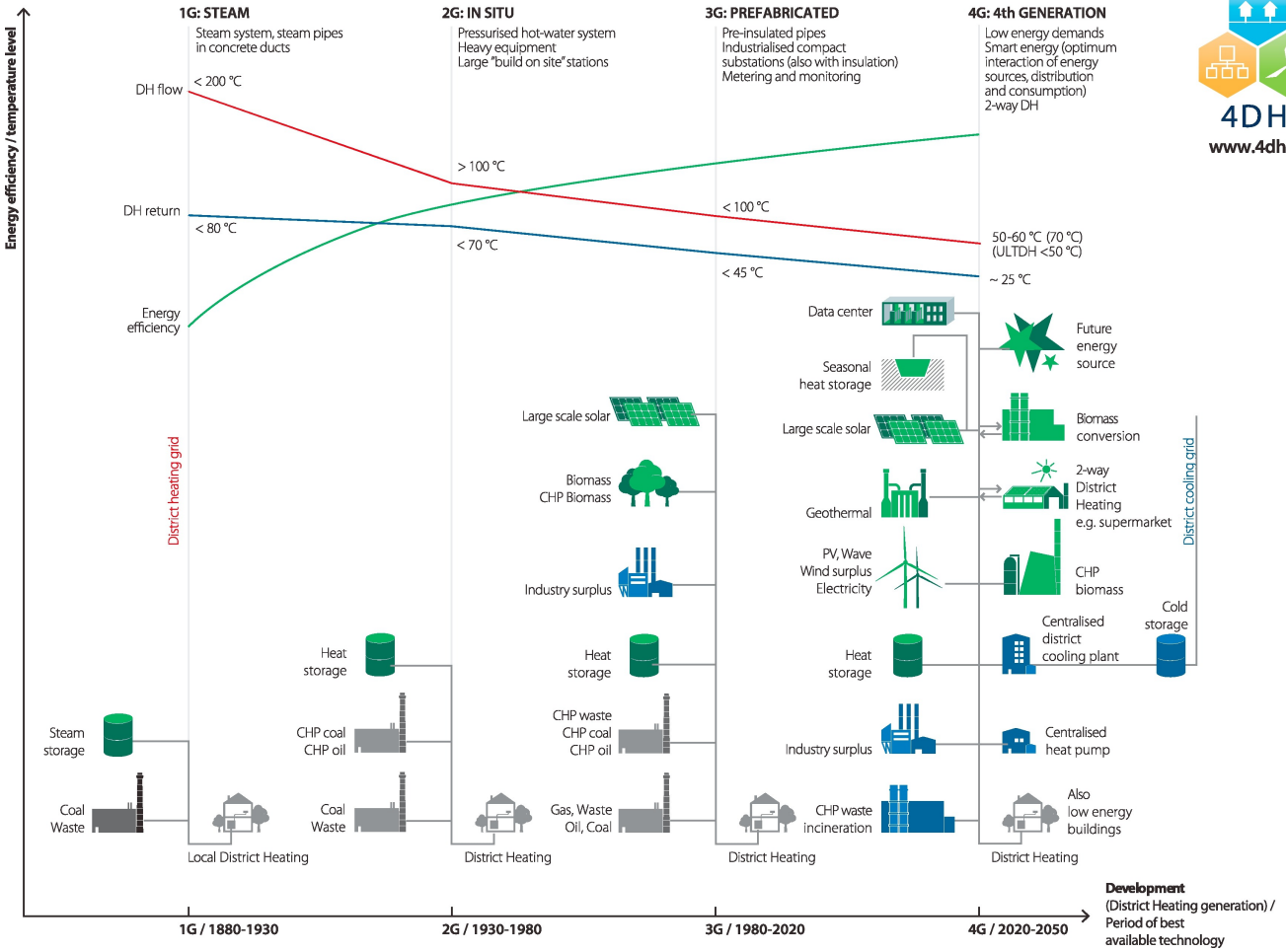
Heating and cooling demand in 2015 in the EU28 by end-use compared to total final energy demand



Heating and cooling demand in 2015 in the EU28 by end-use compared to total final energy demand

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No. 695989.

The four generations of district heating



4DH
www.4dh.dk

Lund H, Østergaard PA, Chang M, Werner S, Svendsen S, Sorknæs P, et al. The status of 4th generation district heating: Research and results. Energy 2018;164:147–59. doi:10.1016/J.ENERGY.2018.08.206.

Smart Energy Systems approach

- **Smart Electricity Grids**

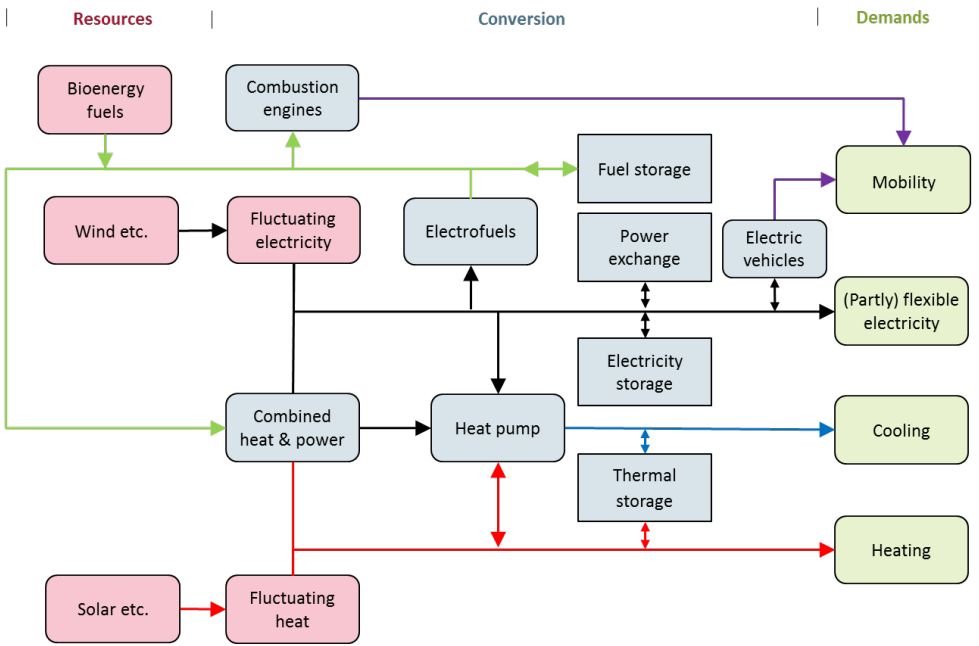
Connecting flexible electricity demands, heat pumps and EV to the intermittent renewable resources such as wind and solar power.

- **Smart Thermal Grids** (District Heating and Cooling)

Connecting the electricity and heating sectors, thermal storage to be utilised for creating additional flexibility and heat losses in the energy system to be recycled.

- **Smart Gas Grids**

Connecting the electricity, heating, and transport sectors, enabling gas storage to be utilised for creating additional flexibility. If the gas is refined to a liquid fuel, then liquid fuel storages can also be utilised.



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For more on Smart Energy Systems:
http://www.energyplan.eu/smartenergysystems/

Direct and indirect electrification

Direct electrification

E.g.:

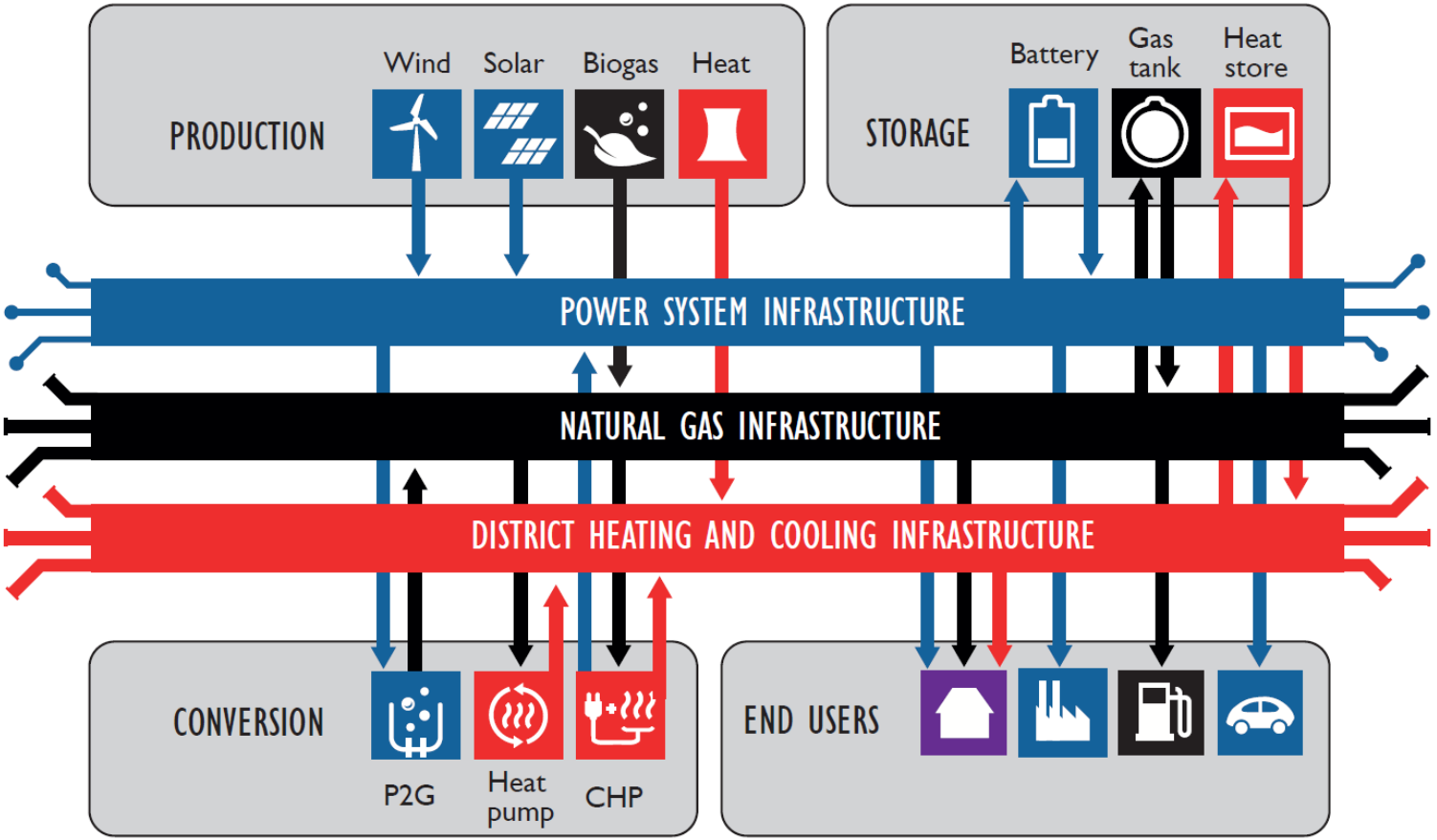
- Heat pumps
- Electric boilers

Indirect electrification

E.g.:

- Utilised excess heat from electrofuel production
- Utilised excess heat from electrified industrial processes

IEA DHC Annex TS3: Hybrid energy networks



For more on the IEA DHC Annex TS3: https://www.iea-dhc.org/the-research/annexes/2017-2021-annex-ts3-draft

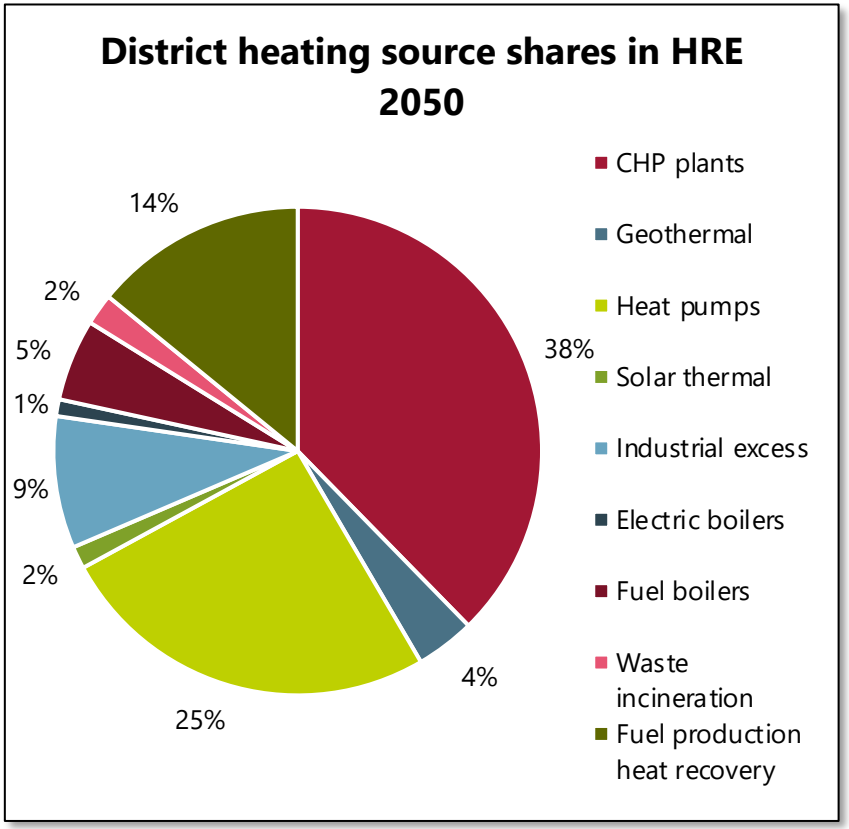
Heat Roadmap Europe 4 – District heating

Purpose of Heat Roadmap Europe 4:

- Creating scientific evidence to support long-term energy strategies at local, national, and EU level for the transition to a low-carbon energy system
- Quantifying the impact of various alternatives for addressing the heating and cooling sectors
- 14 countries with largest heating demands in EU

Some results related to DHC:

- Use electrification of key sectors
  - **Heat pumps and chillers are key!**
- Use flexibility and synergies to enable further decarbonisation
  - Better use of variable RES
  - Better use of grid capacity
  - Avoid peak capacity
- CHPs operate to the electricity markets and 'pair' with large heat pumps



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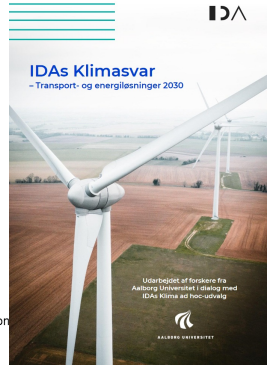
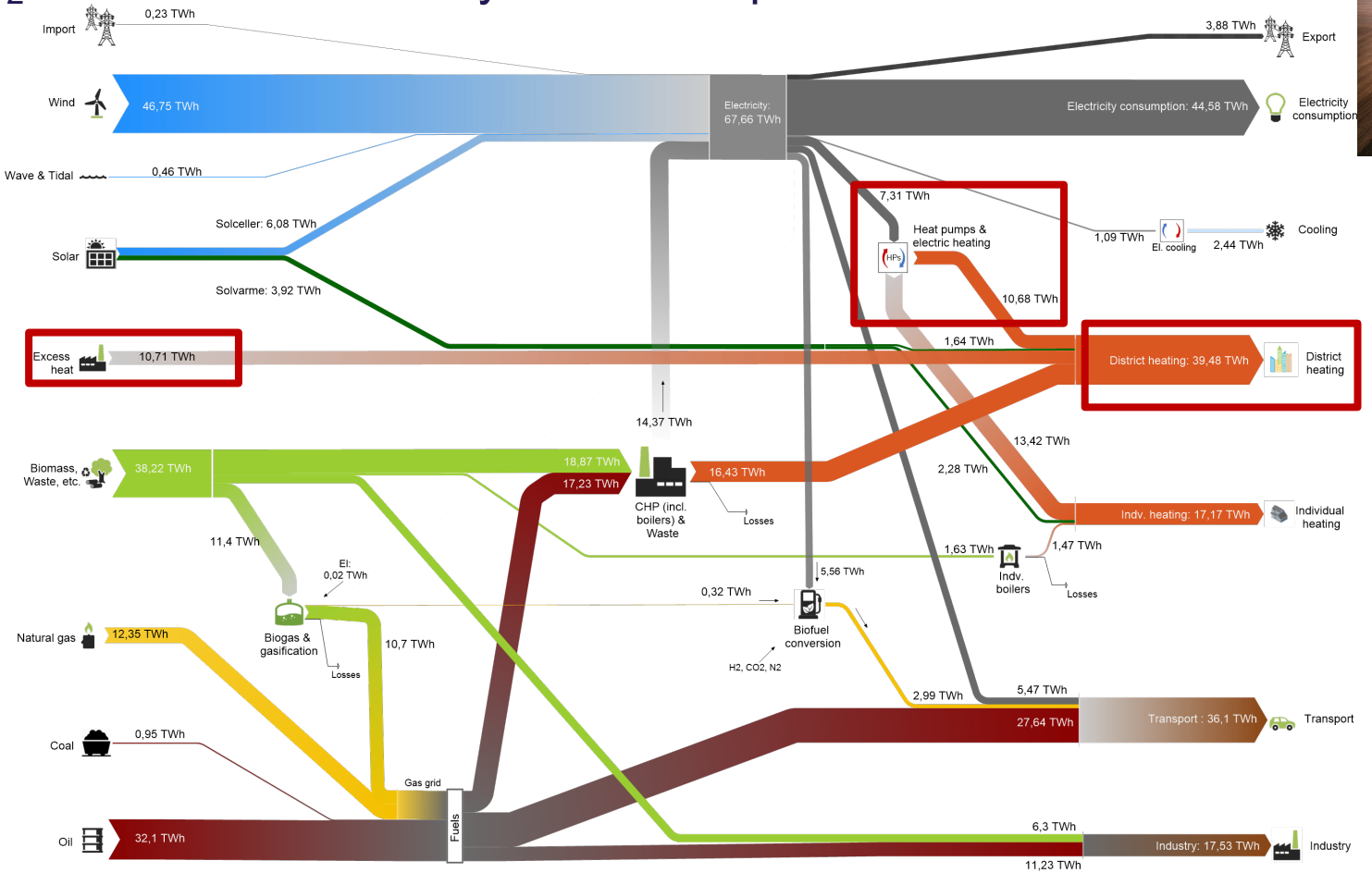
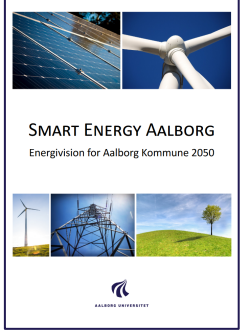
”IDAs Klimasvar” – Reduction of the Danish energy sector’s CO_2-emissions in 2030 by ~80% compared with 1990-levels

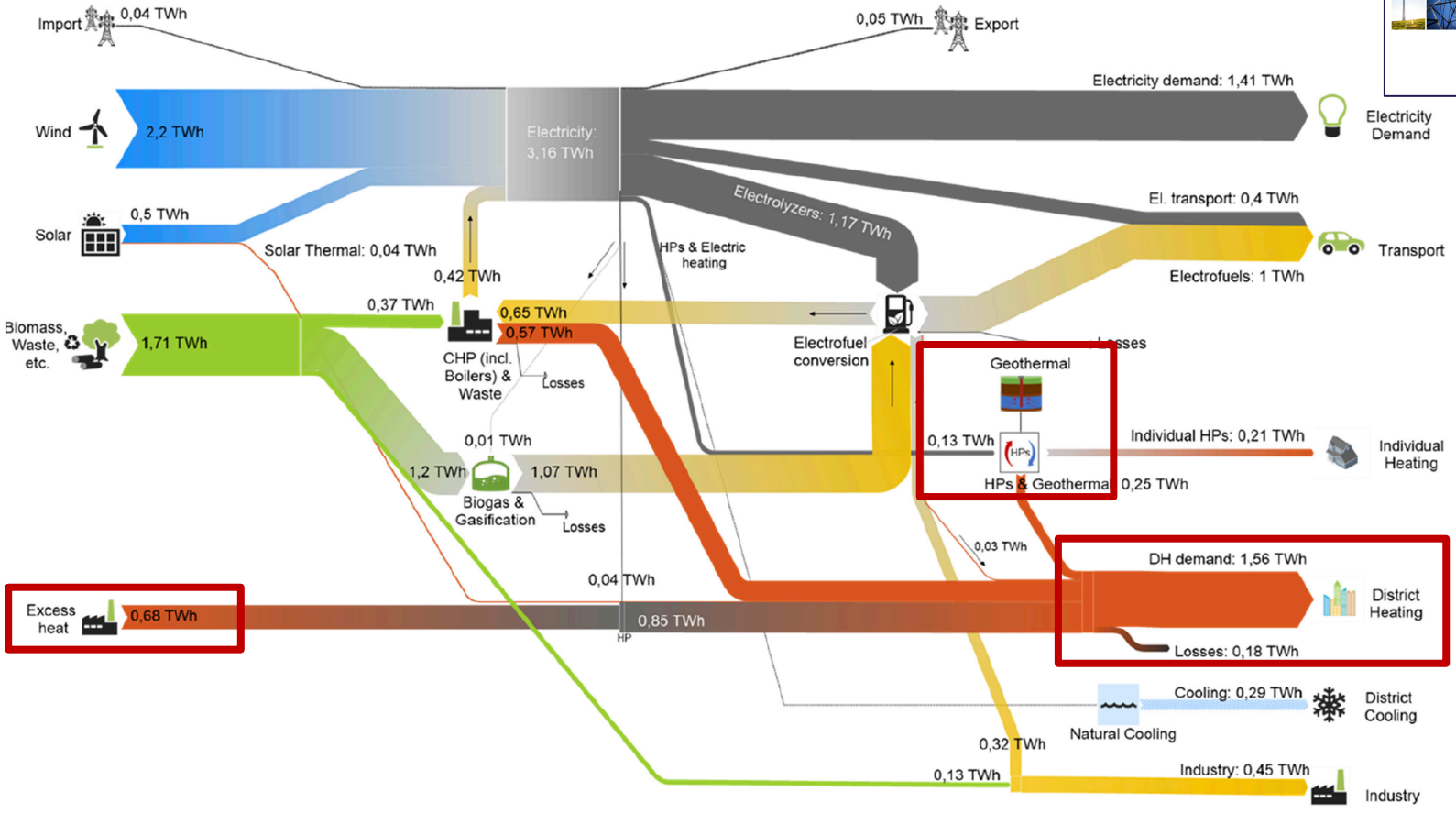




https://vbn.aau.dk/da/publications/idas-klimasvar-transport-og-energil%C3%B8sninger-2030

A 100% renewable energy system scenario for Aalborg Municipality, Denmark





Thellufsen JZ, Lund H, Sorknæs P, Østergaard PA, Chang M, Drysdale D, et al. Smart energy cities in a 100% renewable energy context. Renew Sustain Energy Rev 2020;129:109922. doi:10.1016/j.rser.2020.109922.

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