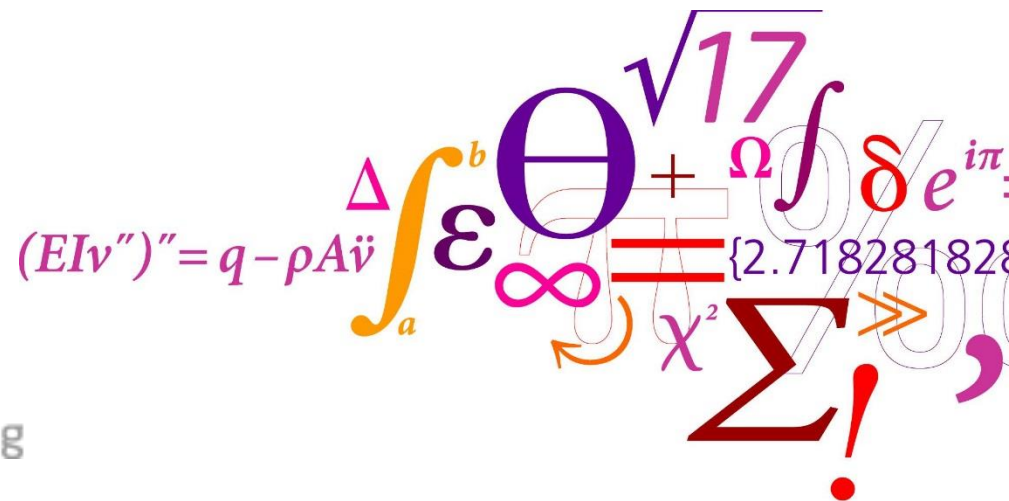


Industrial excess heat and district heating in Denmark

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Webinar Climate Recon 2050

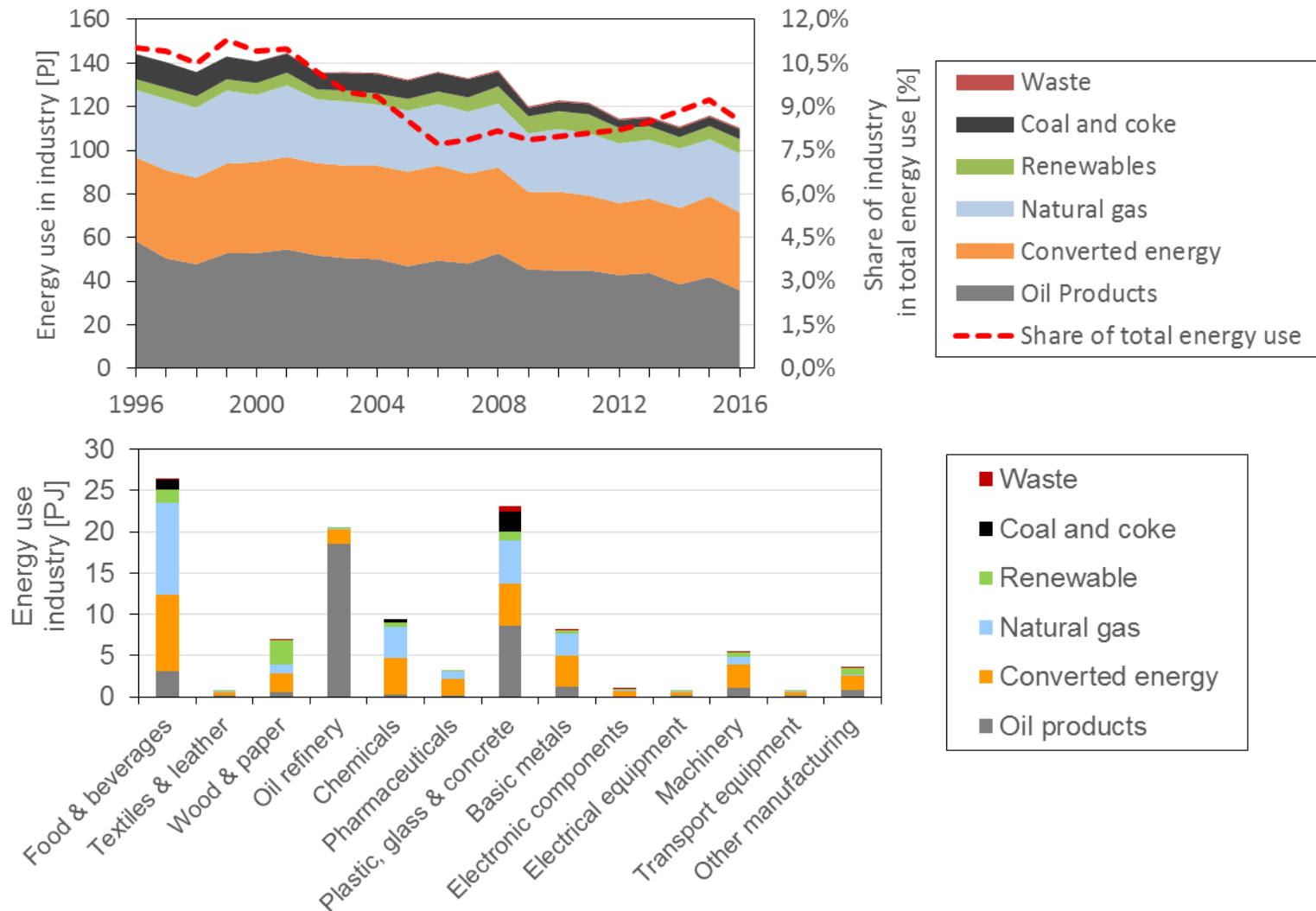
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Agenda

- Excess heat from the industry
- Utilization of excess heat
- Mapping of energy use and excess heat in Denmark
- Approach to excess heat utilization and case studies

Energy use in the Denmark



Introduction

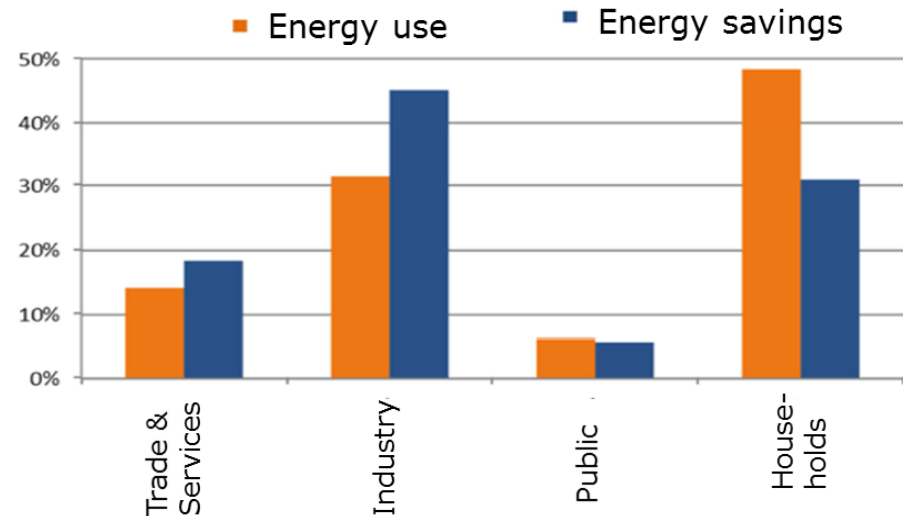
Motivation

- Process heat characteristics in the industry
- Availability of excess heat
- Recovery technologies
- Potential for excess heat recovery

Approach

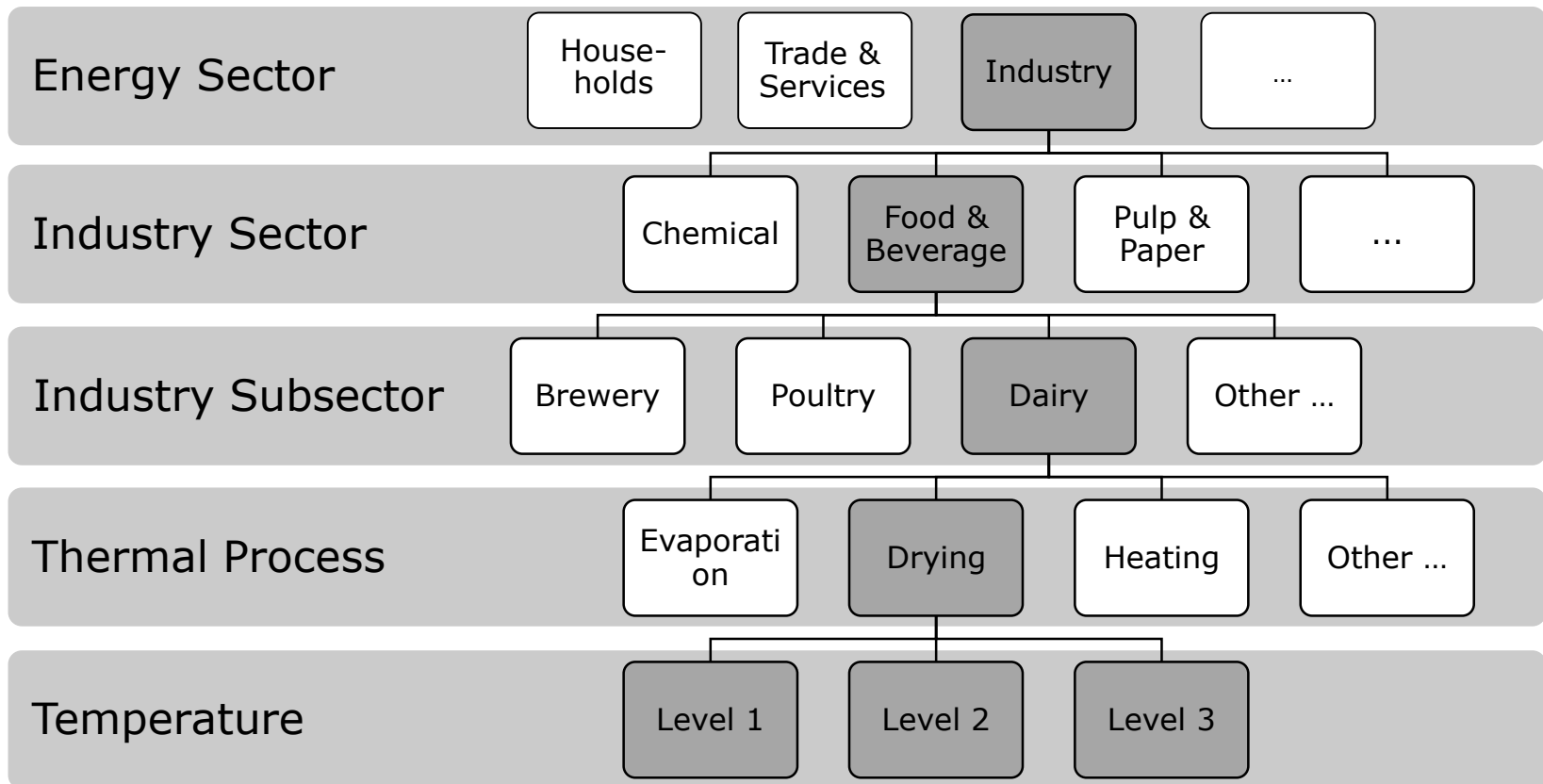
- Excess heat potential by temperature for the industry sector
- Spatial, temporal and economic analysis of EH for external utilization
- Assessment of heat pump requirements for DH

Share of 2015 Energy use and savings



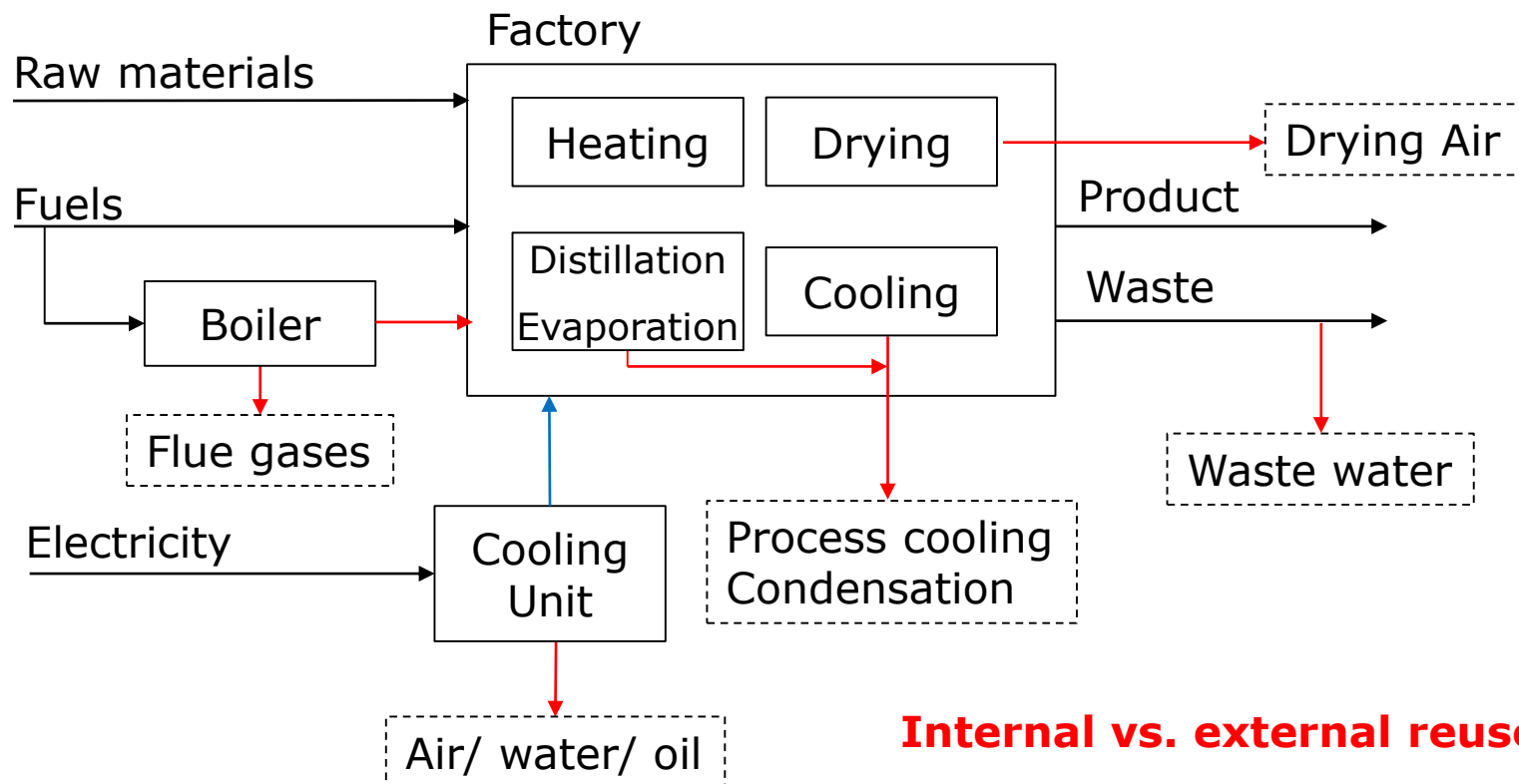
Method

Structure for energy use



Origin of industrial excess heat

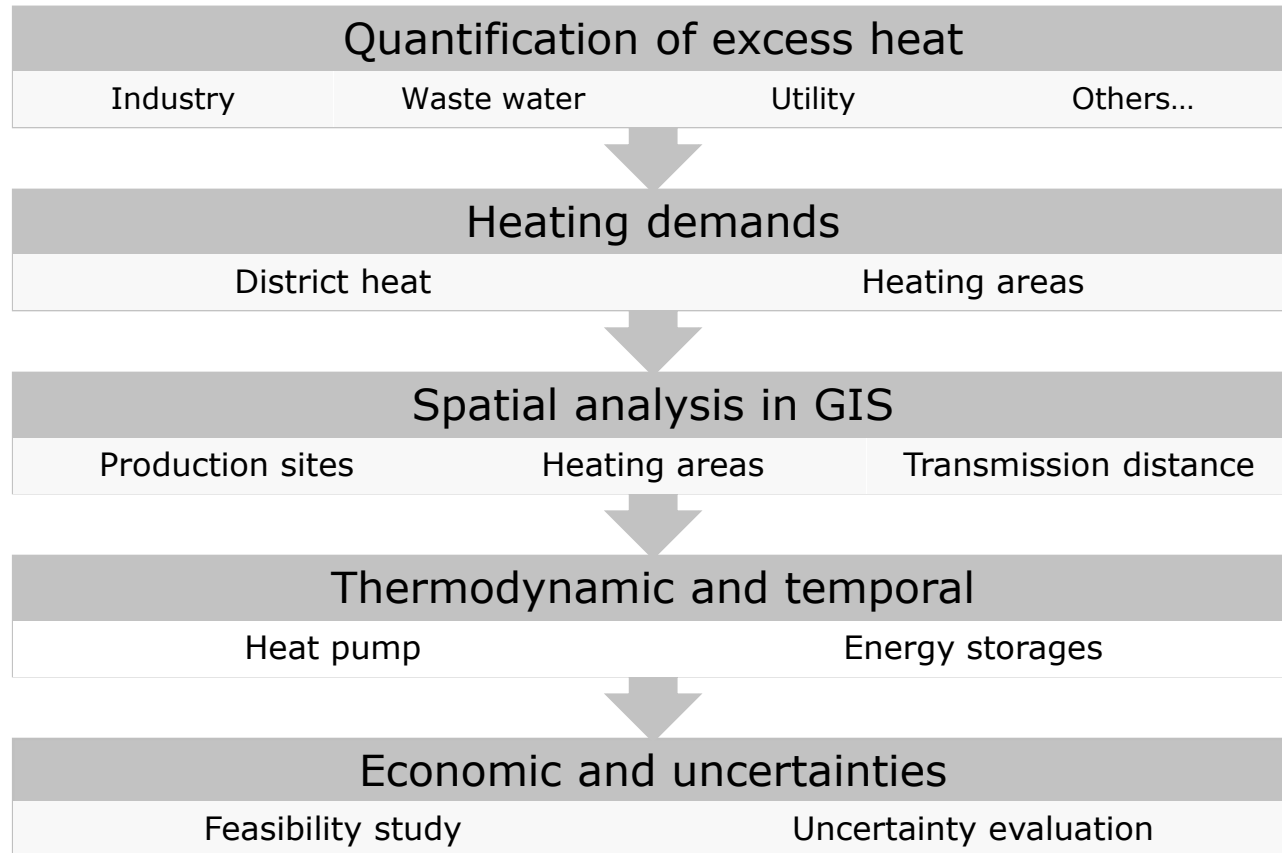
- Where does industrial excess heat come from?



Internal vs. external reuse
Energy efficiency vs. excess heat

Method

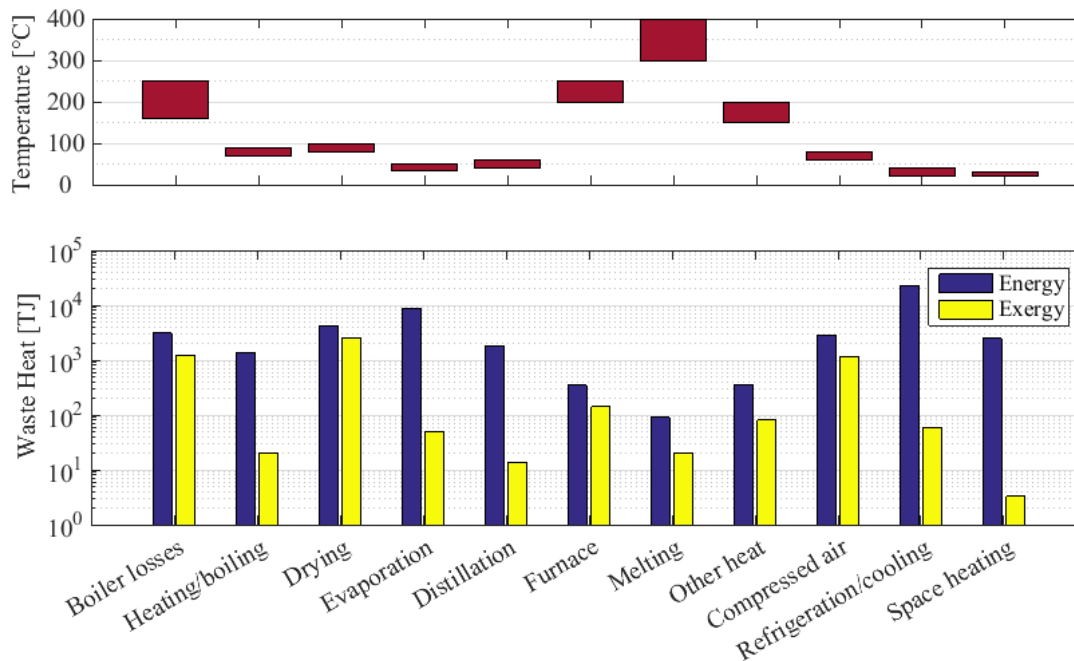
Excess heat for district heat



Quantification of excess heat

Industrial excess heat in Denmark

- Total of 212 PJ of excess heat per year
- 23% of excess heat from industry and 28% from utility
- Total excess heat in manufacturing industry 22.6 PJ/year

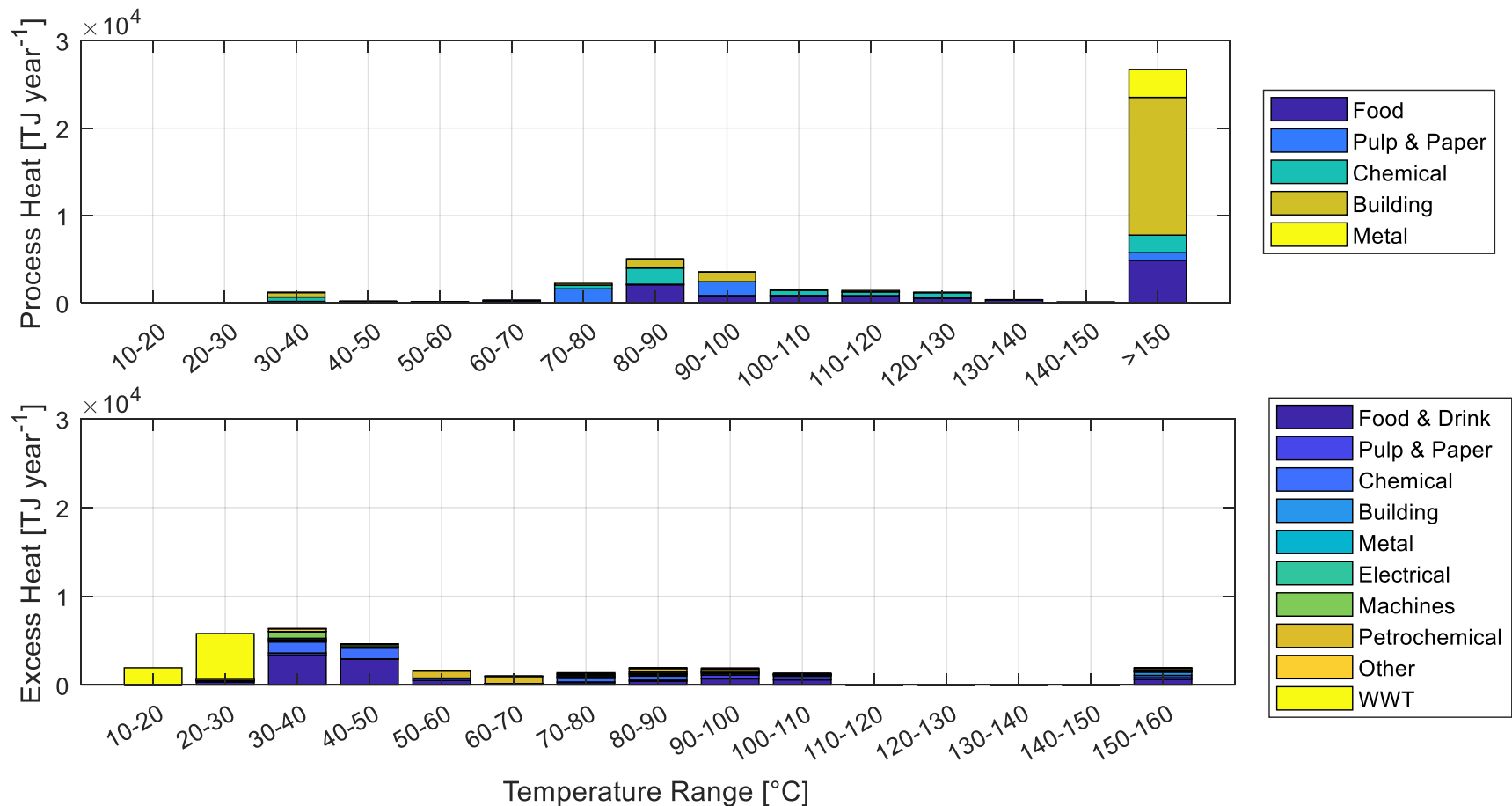


- Drying, Evaporation and refrigeration main excess heat sources
- Highest temperatures from furnaces, boilers and melting operation

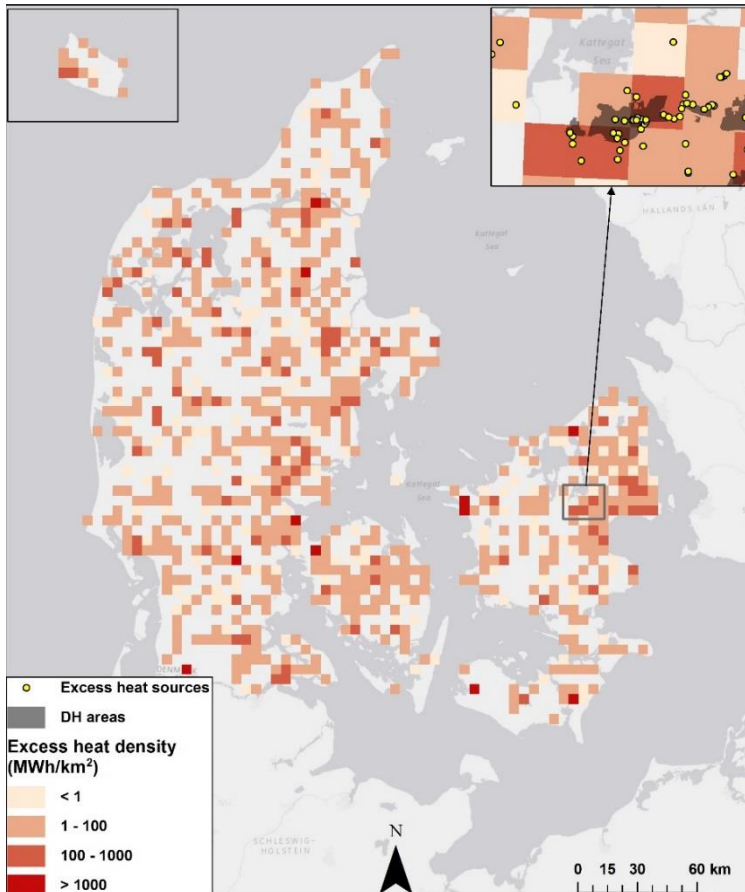
Bühler F., Holm FM., Huang B., Andreasen JG. & Elmegaard B. (2015). Mapping of low temperature heat sources in Denmark. in Proceedings of ECOS 2015.

Process and excess heat in Denmark

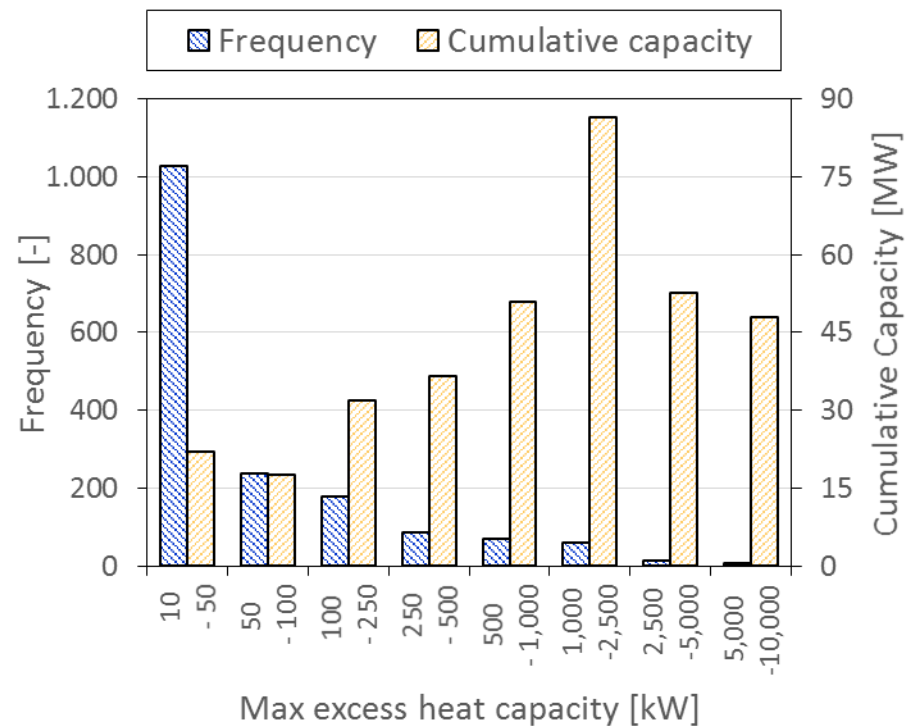
Internal utilization potential, source of excess heat and requirements for heat pumps.



Spatial analysis of excess heat in Denmark



Spatial and temporal analysis of the 22 largest manufacturing industries with 2584 production units.

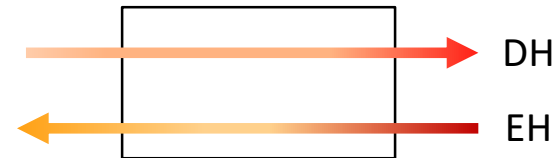


Bühler F., Petrovic S., Karlsson K.B. & Elmegaard B. (2017). Industrial excess heat for district heating in Denmark. *Applied Energy*. 205. 991-1001.

Utilisation of industrial excess heat

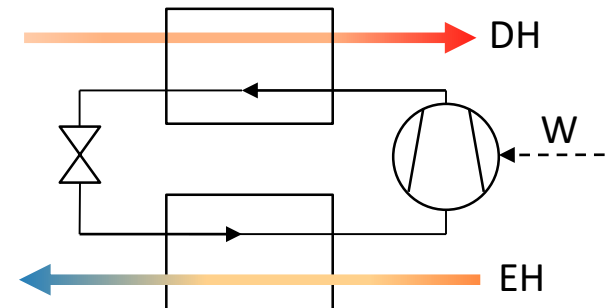
- Direct utilization

- DH supply temperature $<$ EH temperature $+ \Delta T$
- ΔT between 5 K to 15 K
- DH return temperature 50 °C \rightarrow EH temperature $>$ 55 °C
- Minimum EH temperature



- Heat pump

- DH supply temperature $>$ EH temperature $+ \Delta T$
- $COP_h = \text{Useful heat output} / \text{Electricity input}$
- Obtainable COP_h 3 – 5
- Often $COP_h + COP_c$



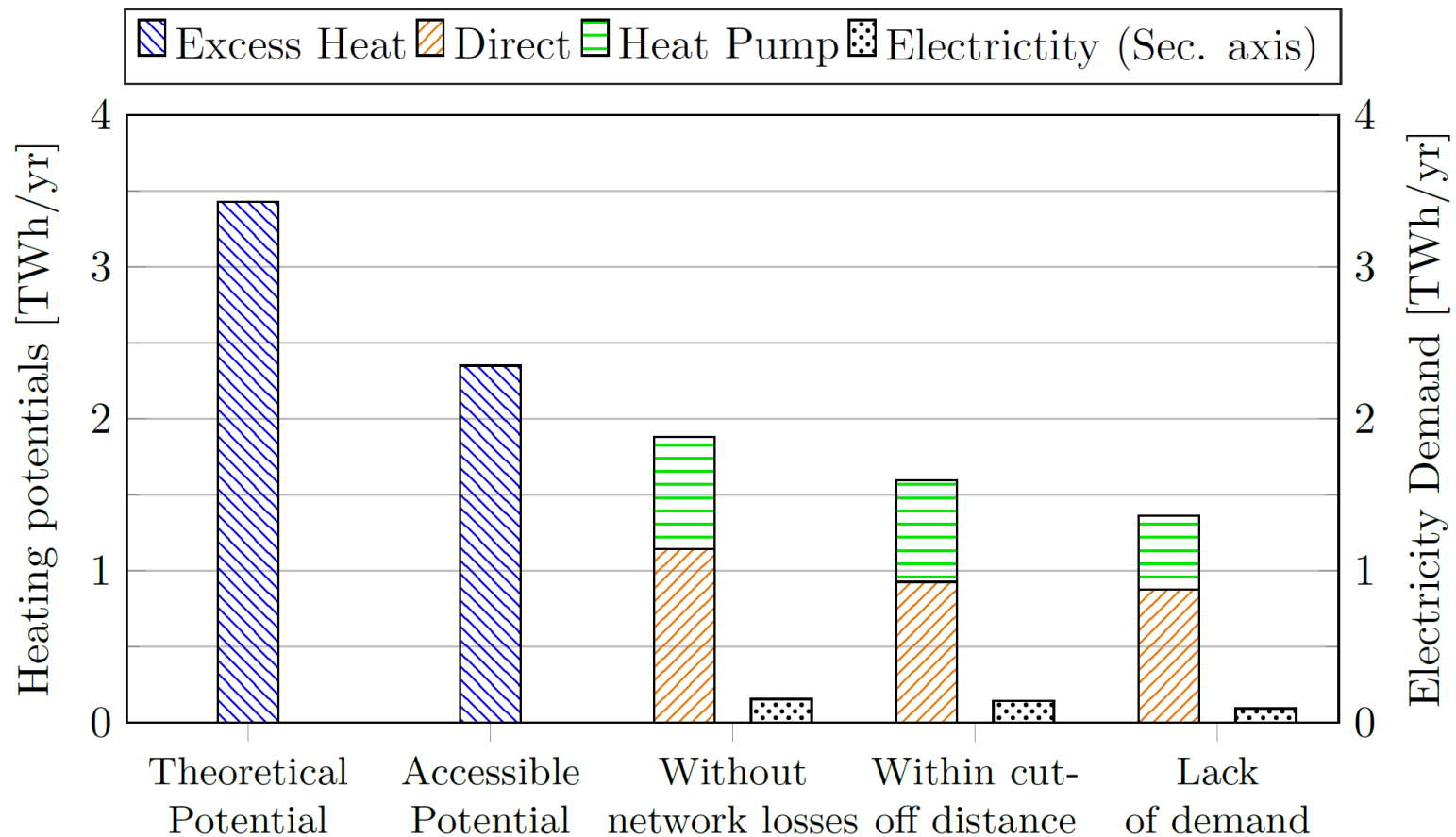
- Combination of direct heat transfer and heat pump

- Absorption Chillers

- EH source 100 °C to 170 °C \rightarrow COP_c of 0.7 to 1.0

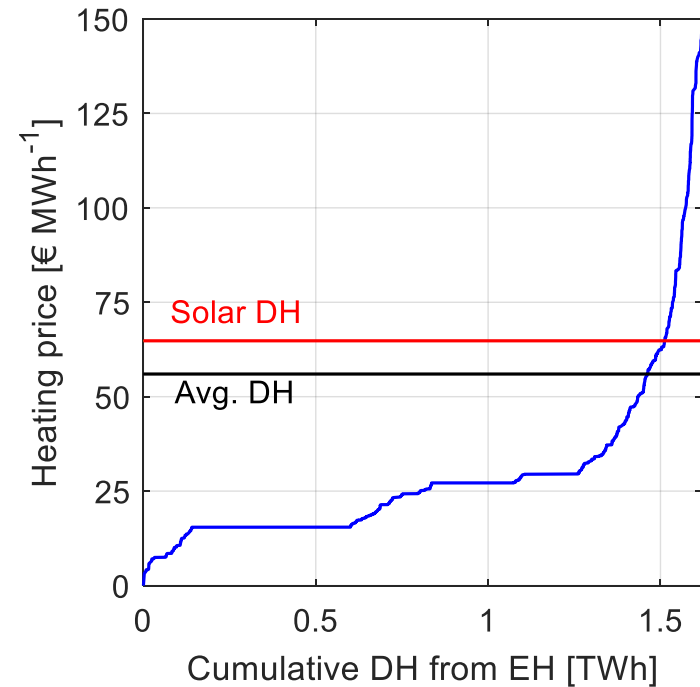
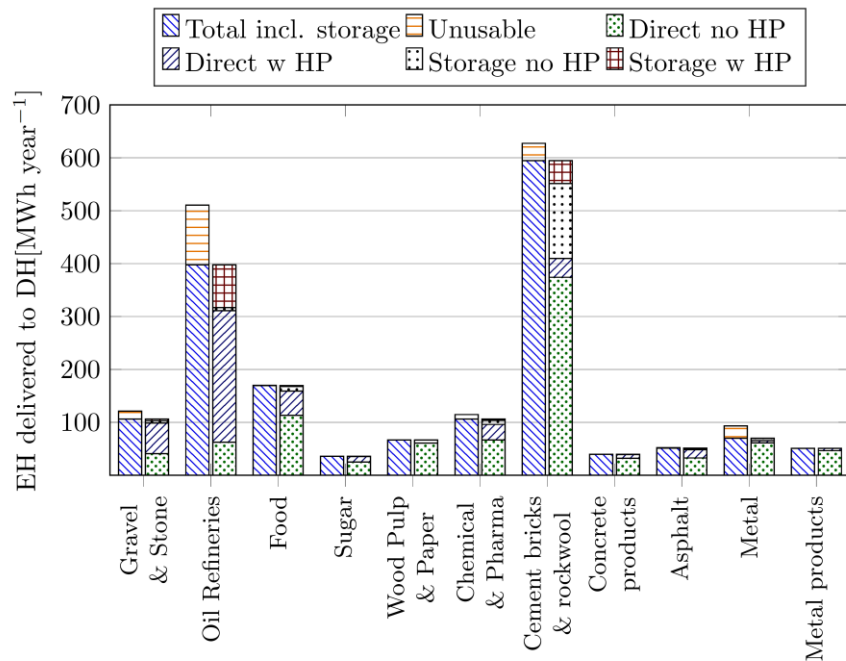
- Electricity generation using ORC

From theoretical to practical potential



Bühler F., Petrovic S., Karlsson K.B. & Elmegaard B. (2017). Industrial excess heat for district heating in Denmark. Applied Energy. 205. 991-1001.

Thermodynamic and economic analysis



- Requirement of energy storages
- Useable excess heat
- Requirement and performance (COP) of heat pumps

- Socio-economic analysis of heating price
- Investment in transmission, heat pumps, heat exchanger

Bühler F., Petrović S., Holm F. M., Karlsson K., & Elmegaard B. (2018). Spatiotemporal and economic analysis of industrial excess heat as a resource for district heating. *Energy*, 151, 715-728.

Evaluation of case studies

Case 1

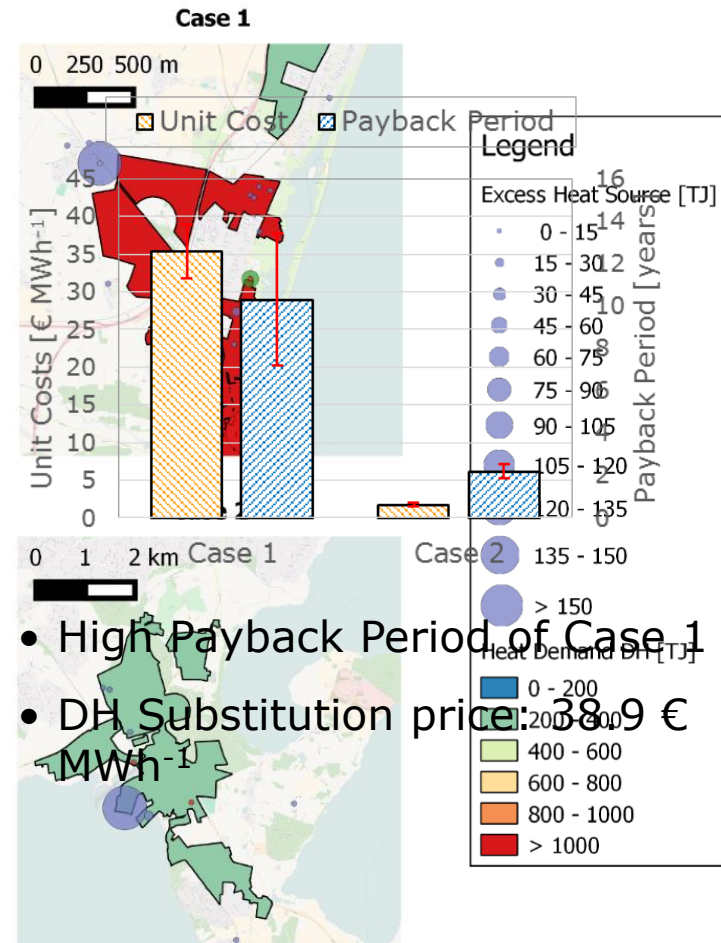
Excess heat to district heat with a heat pump

- Chemical company
- 80 °C heat from distillation
- 170 m to next DH network
- 90 °C supply/ 60 € MWh⁻¹

Case 2

Excess heat to district heat without heat pump

- Metal processing
- 180 °C from off gasses
- 20 m to next DH network
- 80 °C supply



Bühler F., Petrovic S., Ommen T., Holm F., Pieper H., & Elmegaard B. (2018). Identification and Evaluation of Cases for Excess Heat Utilisation Using GIS. *Energies*, 11(4).

Summary and conclusion

- Quantification of excess heat primarily from the manufacturing industry shows there is a considerable potential
- Use of excess heat needs to be carefully evaluated
- Excess heat can be an important source for District heating
- Regional difference based on “industry profile”

Thank you for your attention!

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