Heat pumps for district heating and industry in Denmark

Status, perspectives and ongoing developments

28.08.2019 – ICR Montreal – Workshop on industrial HPs

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Agenda

- Danish energy system and political targets
- Status
  - Overview of industrial heat pump installations
  - Heat pumps in district heating
  - Heat pumps in industrial applications
- Perspectives and ongoing developments
  - Potential of industrial heat pumps in the Danish industry
  - Improving the operation of large-scale heat pumps
  - Exploiting flexibility of large-scale heat pumps
- Conclusions

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Energy system and political targets

Political treaties and strategies:

- Energy-Strategy (adopted in 2011)
  - By 2050:
    - Independent of fossil fuels
- Energy-Agreement (adopted in 2018)
  - By 2030:
    - 40 % Reduction in GHG emissions
    - 55 % Renewables
    - 33 % Increase in energy efficiency
    - < 10 % fossil fuels in district heating
- Plans for Copenhagen:
  - Carbon neutral by 2025
  - 300 MW heat supply to DH by HPs

Energy system:

- High share of renewables in electricity production:
  - 2017: 65 %
  - Increased share of biomass during last years
- High share of district heating in heat supply:
  - Approximately 65 % of households

→ High potential impact for heat pumps

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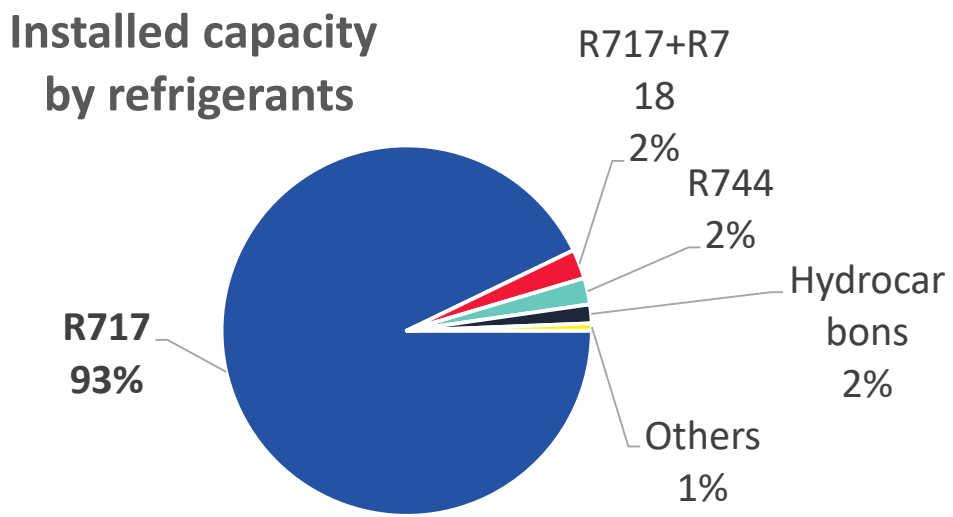
Overview of industrial HP installations

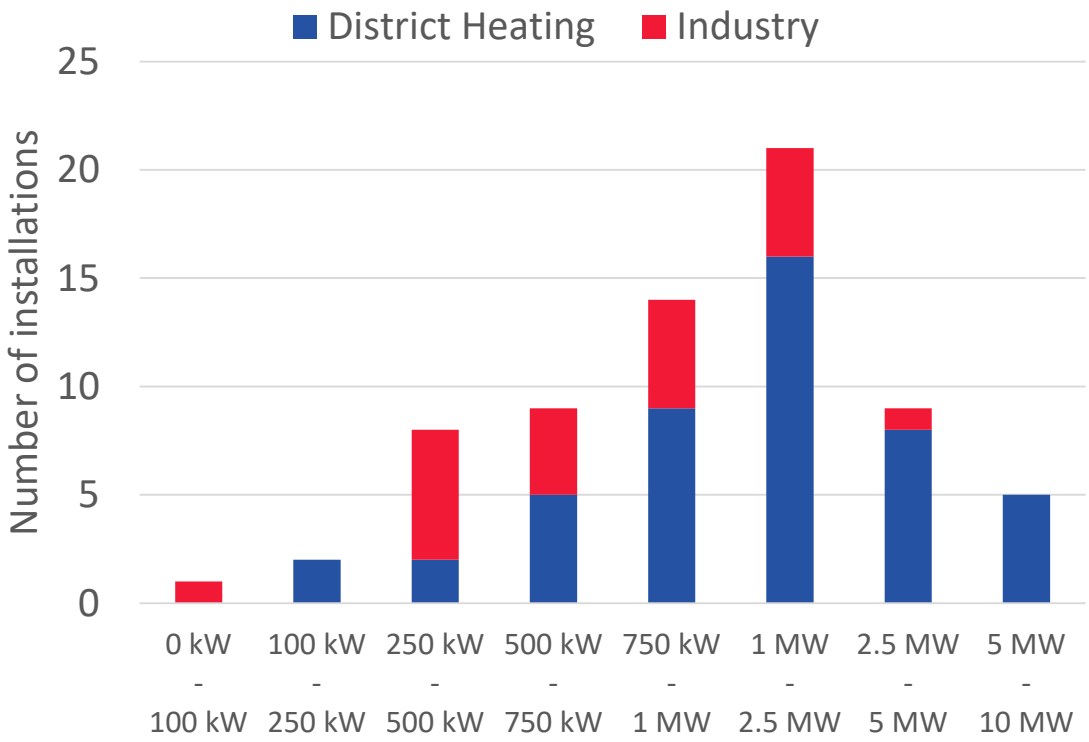
Survey for IEA HPT Annex 48:

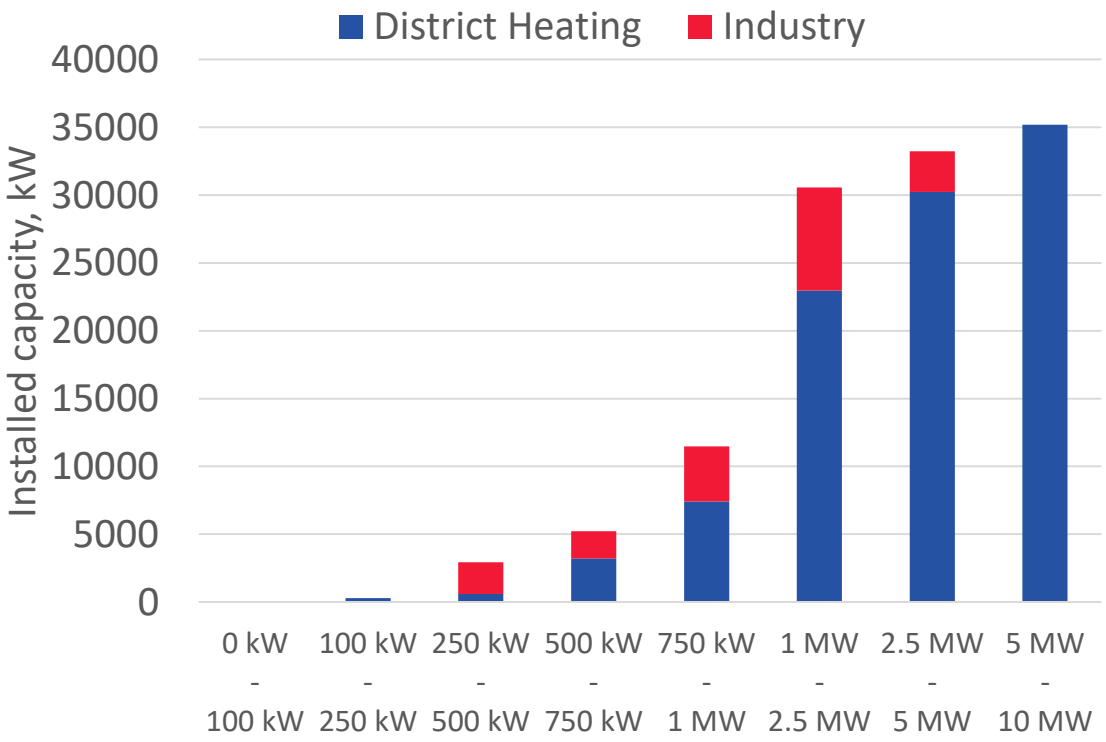
- Data on Total (2007 – 2018) 69 119 MW
- Industrial energy recovery 22 19 MW
- District Heating 47 100 MW



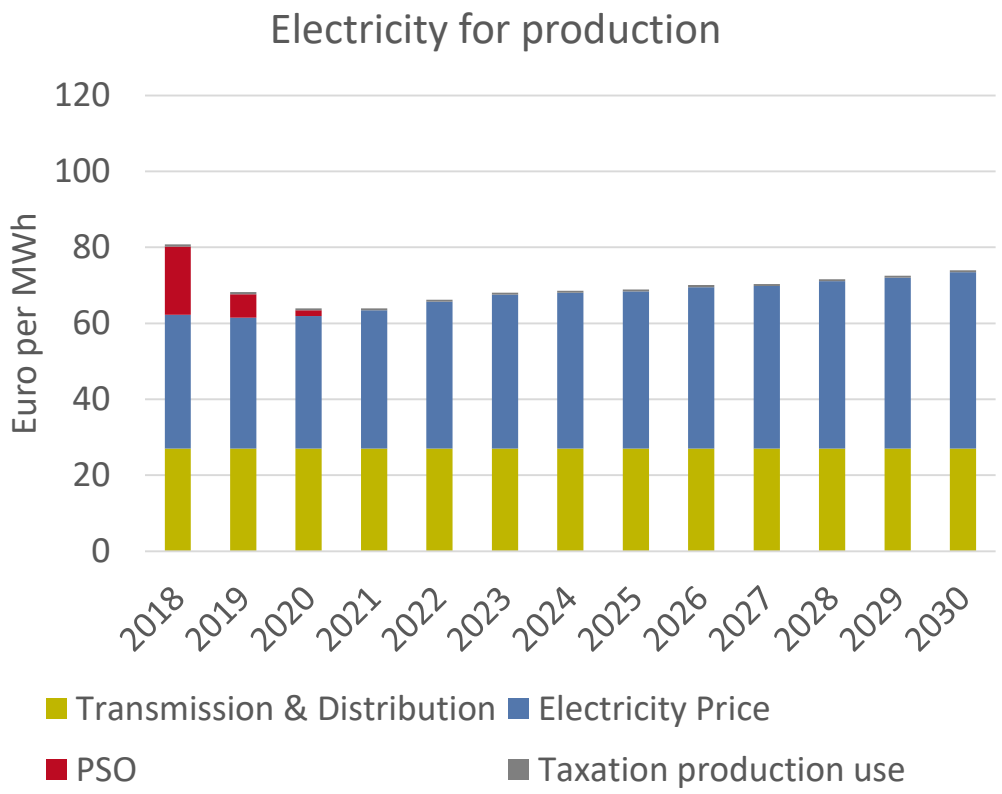

Heat pumps at Bjerringbro Energy central, Denmark

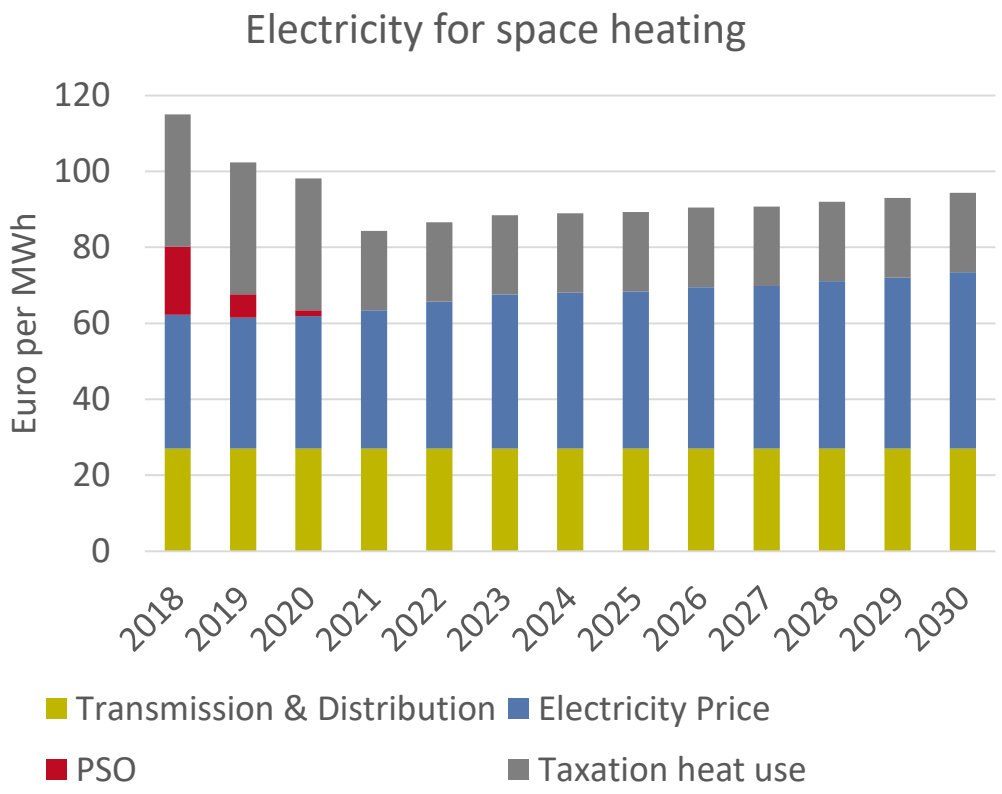
Overview of industrial HP installations





Economic boundary conditions





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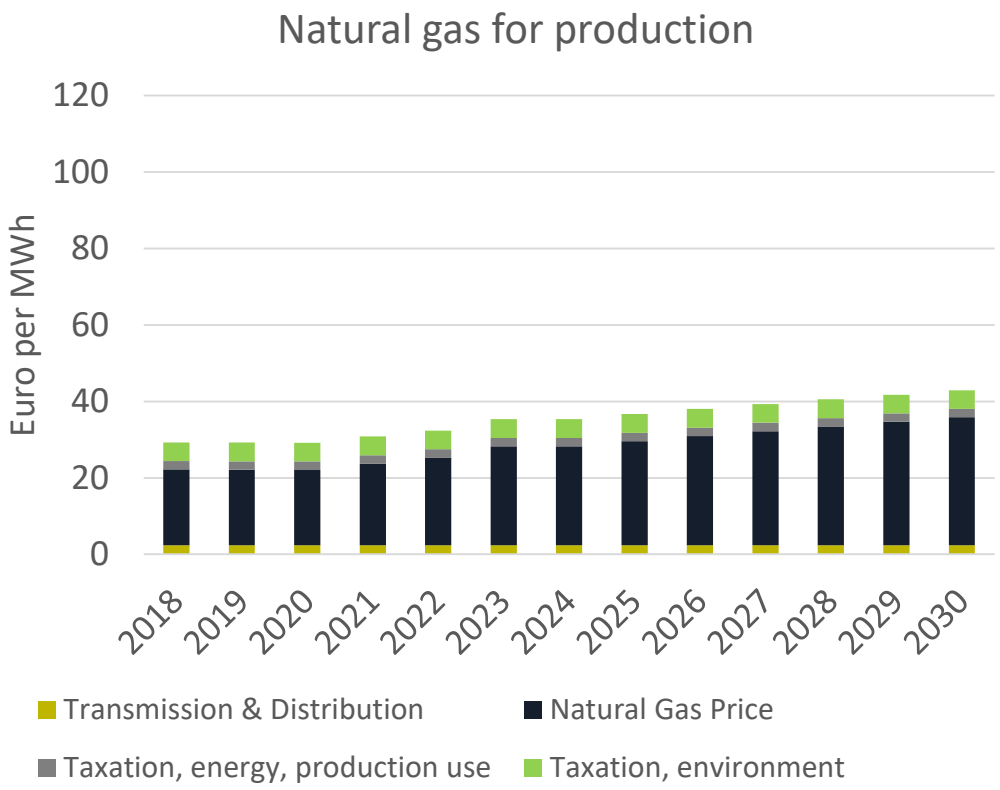

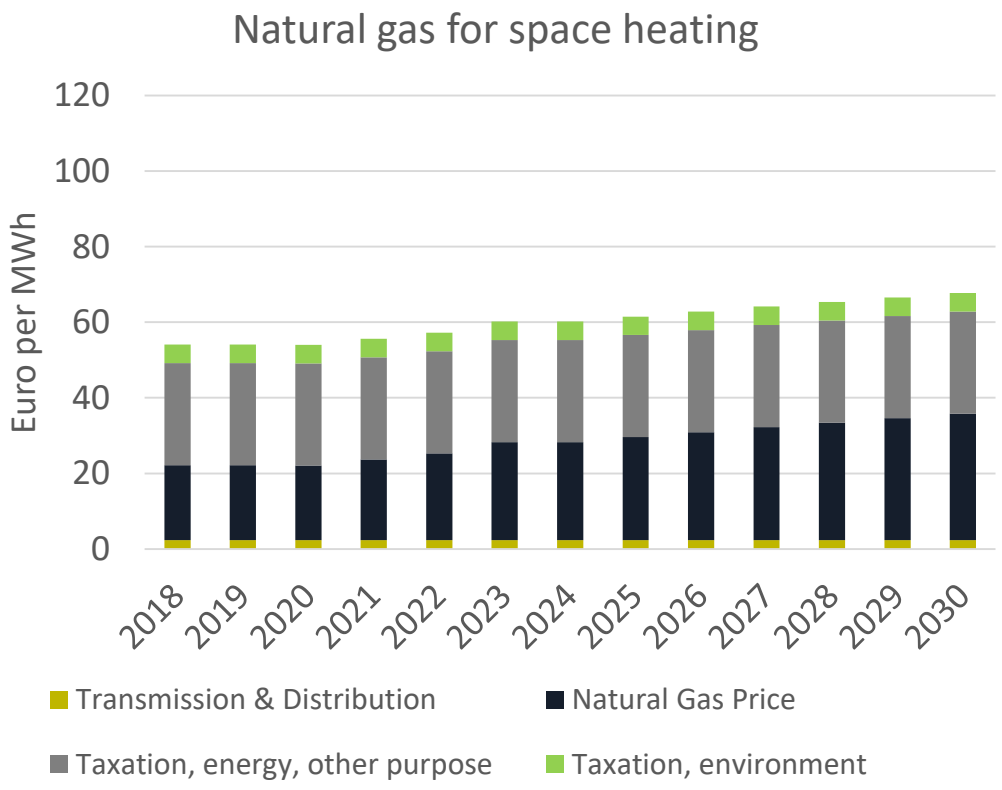

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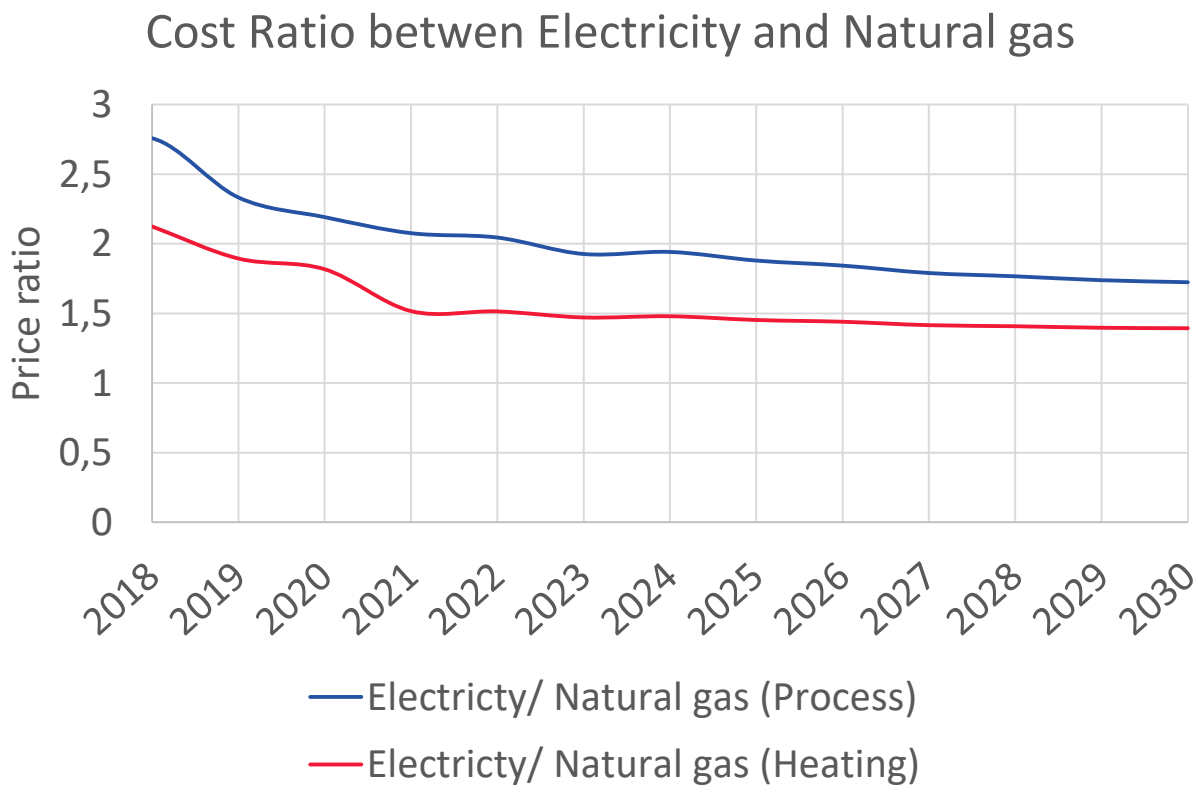

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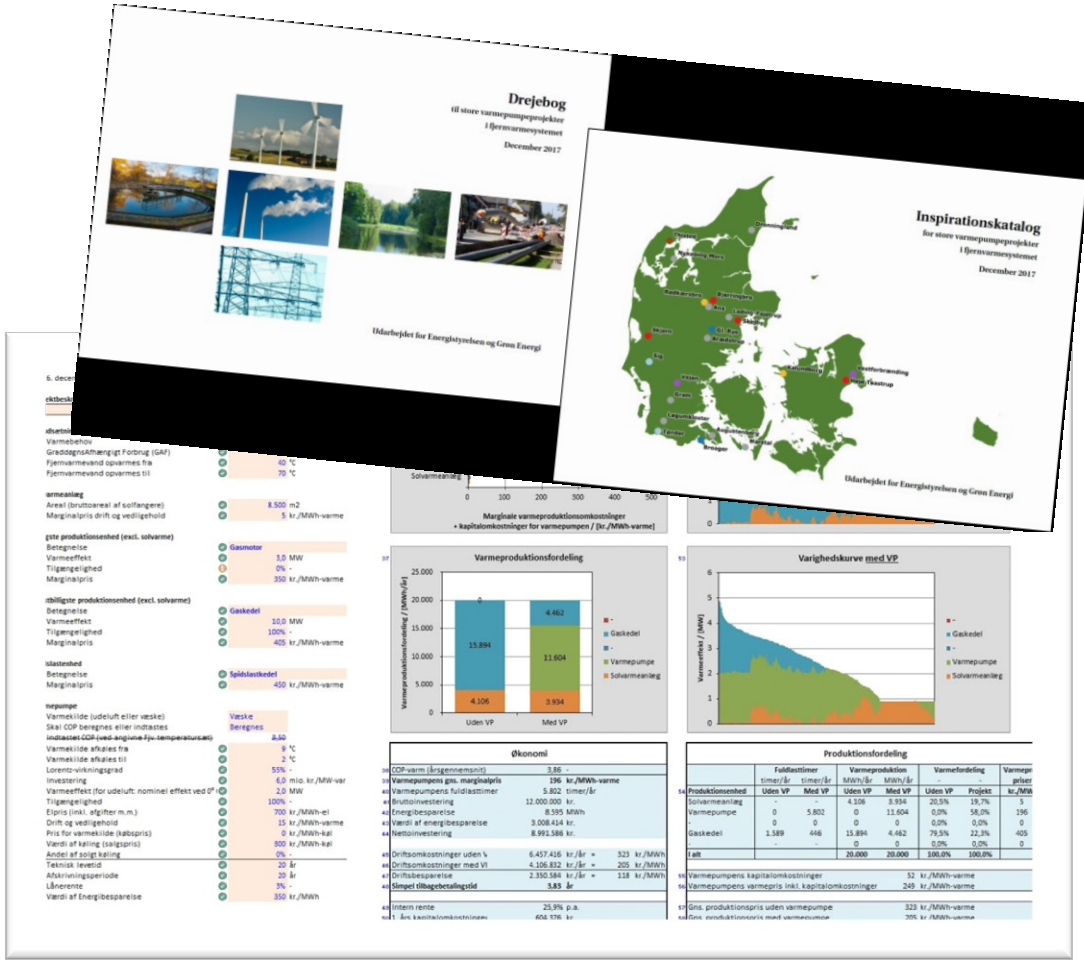
Heat pumps in district heating

- Situation is understood by all involved parties
- Solutions are becoming standardized
- Different tools for planning support available
  - Planning guidelines, incl. all required information
  - Structured overview with possible scenarios
  - Catalogue with inspiration and best case examples
  - Calculation tools
- Heat pumps are becoming preferred solution
- Focus of developments shifts to:

→ Operational issues

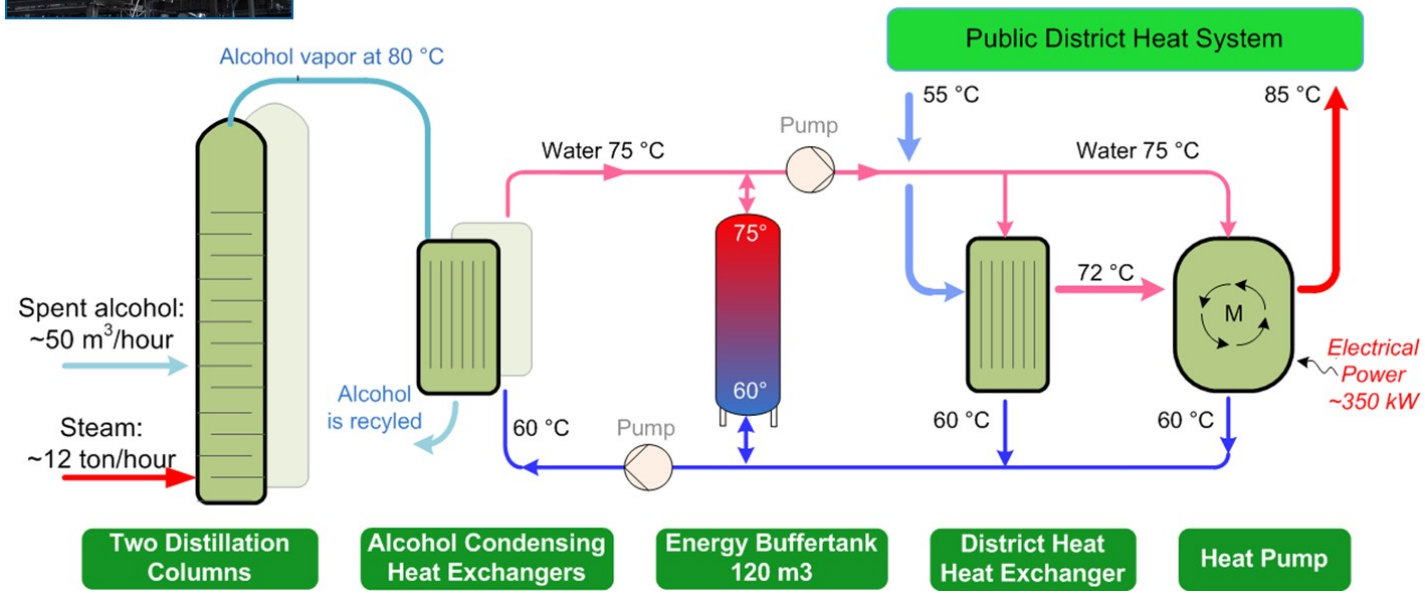
→ Integration into smart grids

→ Upscaling of technology



Industrial applications: CP Kelco

Power	Energy	System COP
4-7 MJ/s	140 TJ/year (38,700 MWh/year)	18.5



Key figures:

- High System COP (>> 18.5)
- Maximum DH supply 8.7 MW
- Average DH supply 6.9 MW
- Covering the heating demand in the Køge region approx. 5-6 month per year

General aspects:

- No “main-business” for customer
- Large variety of boundary conditions
- Extensive process integration
- Secondary benefits (e.g., reduced cooling load, no exhaust gases, …)

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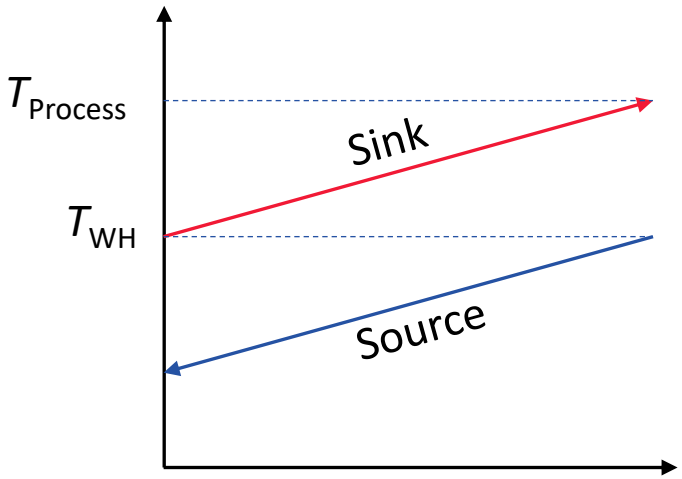
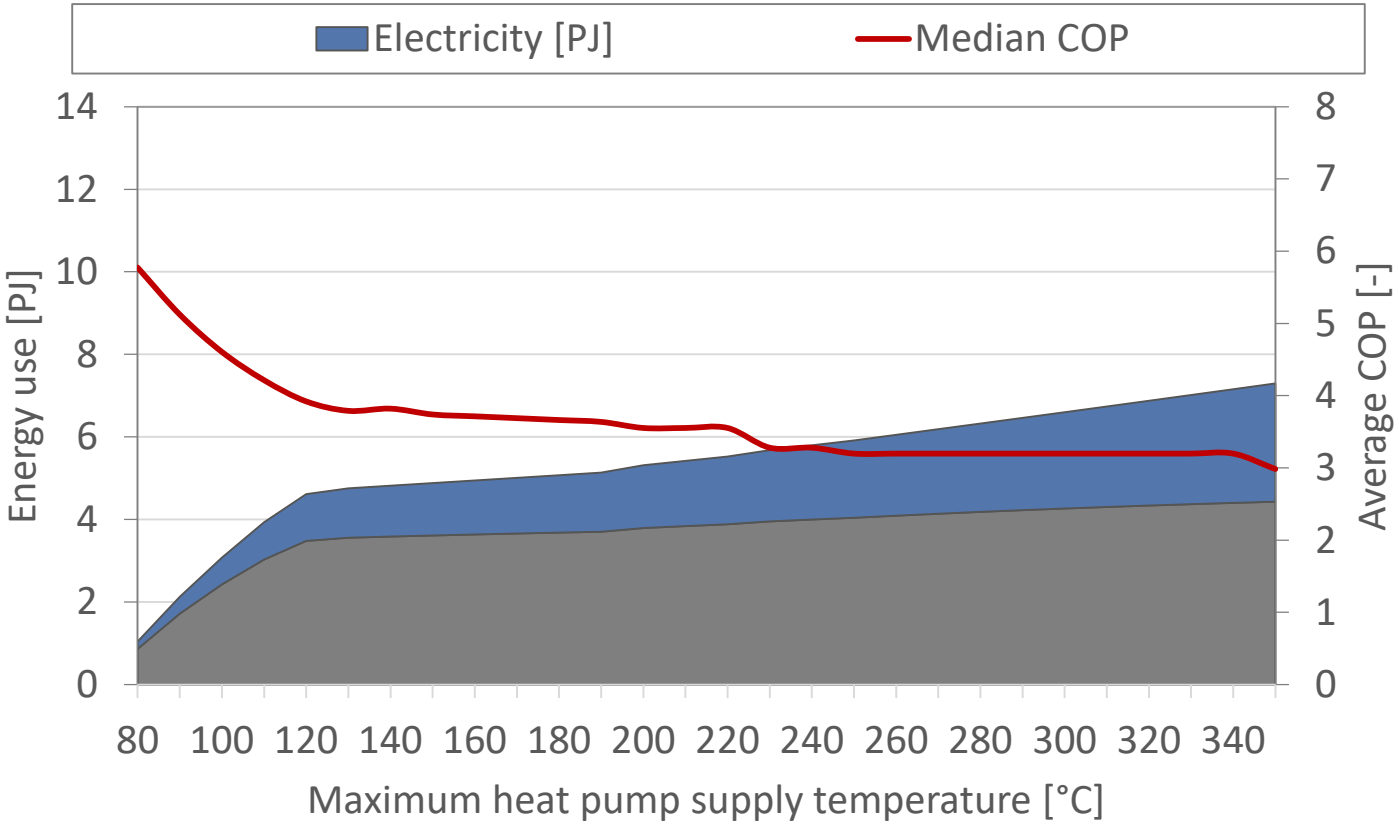
Potential of HPs in the Danish industry

- Mapping of excess heat and heat demand for various industrial processes
- Integration of HPs using Lorenz efficiency





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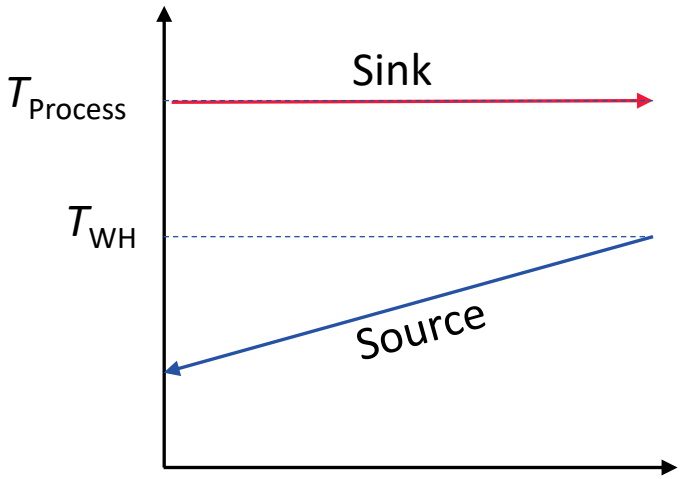

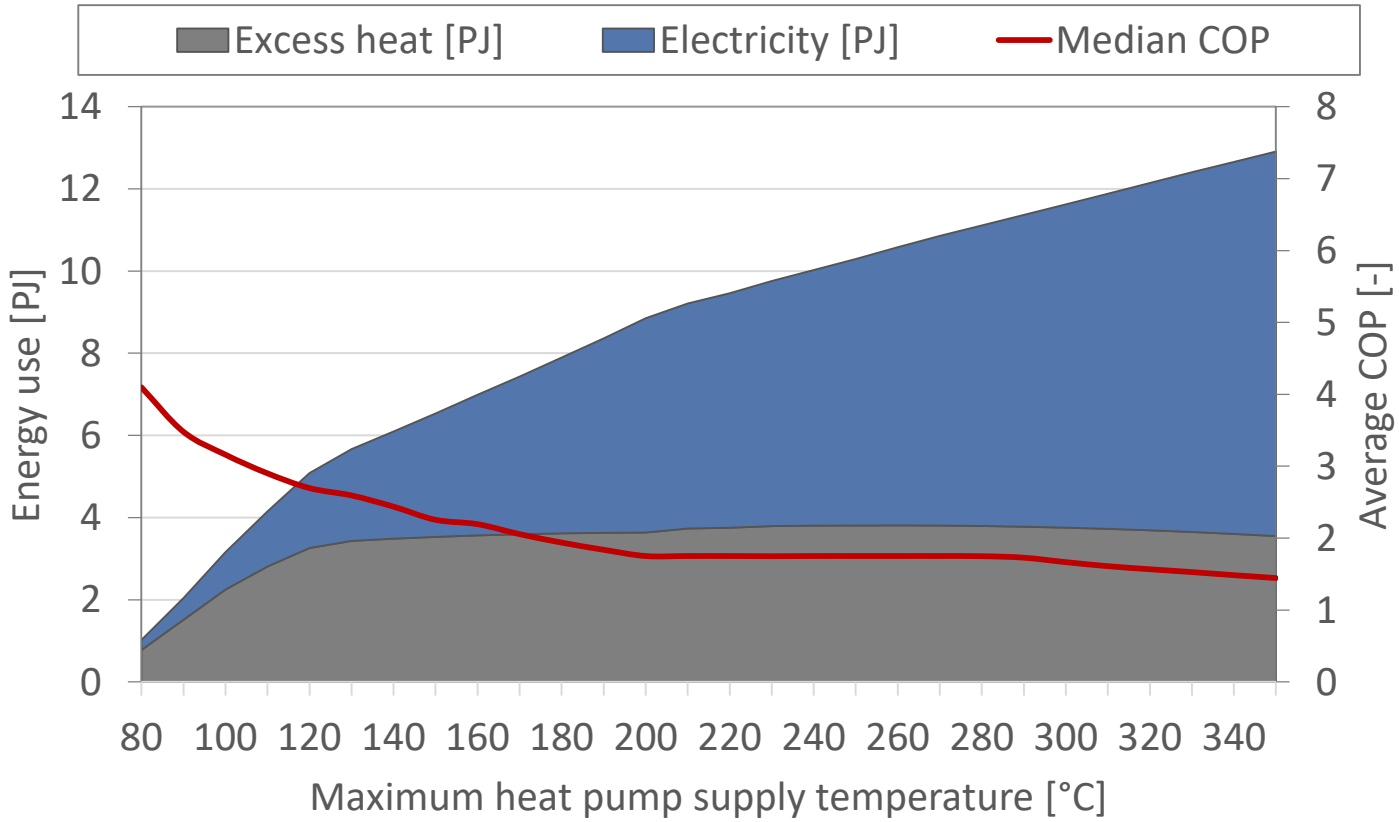

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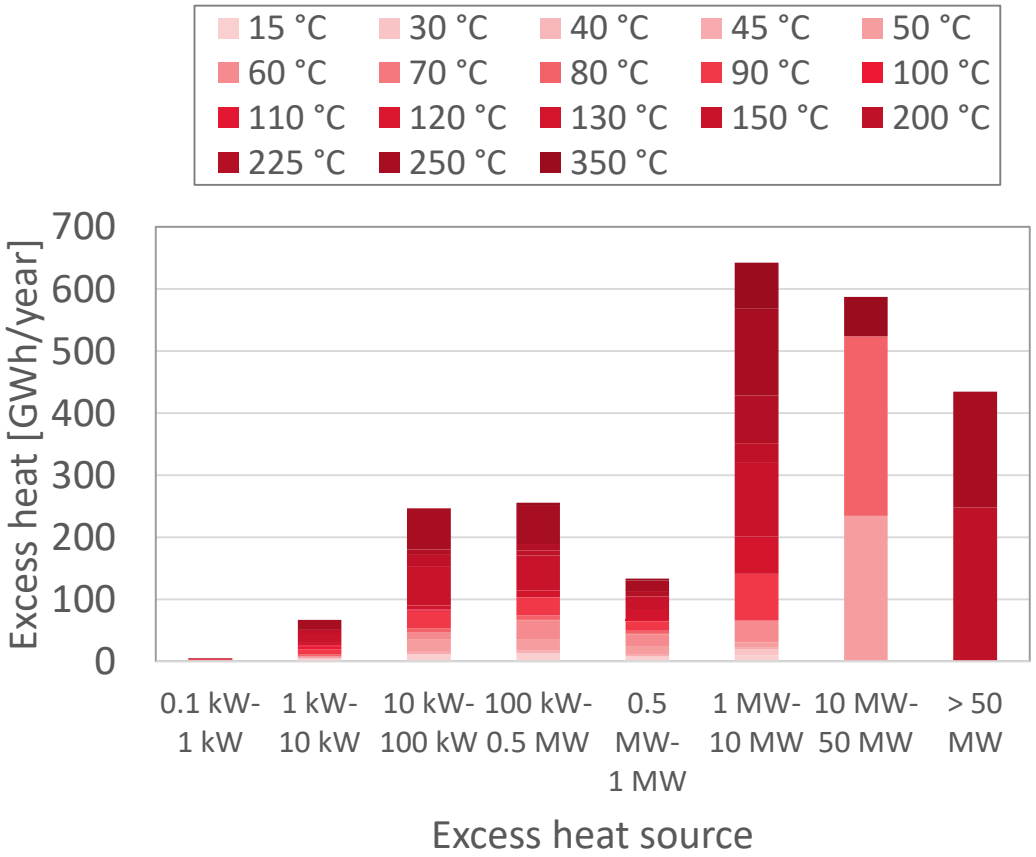

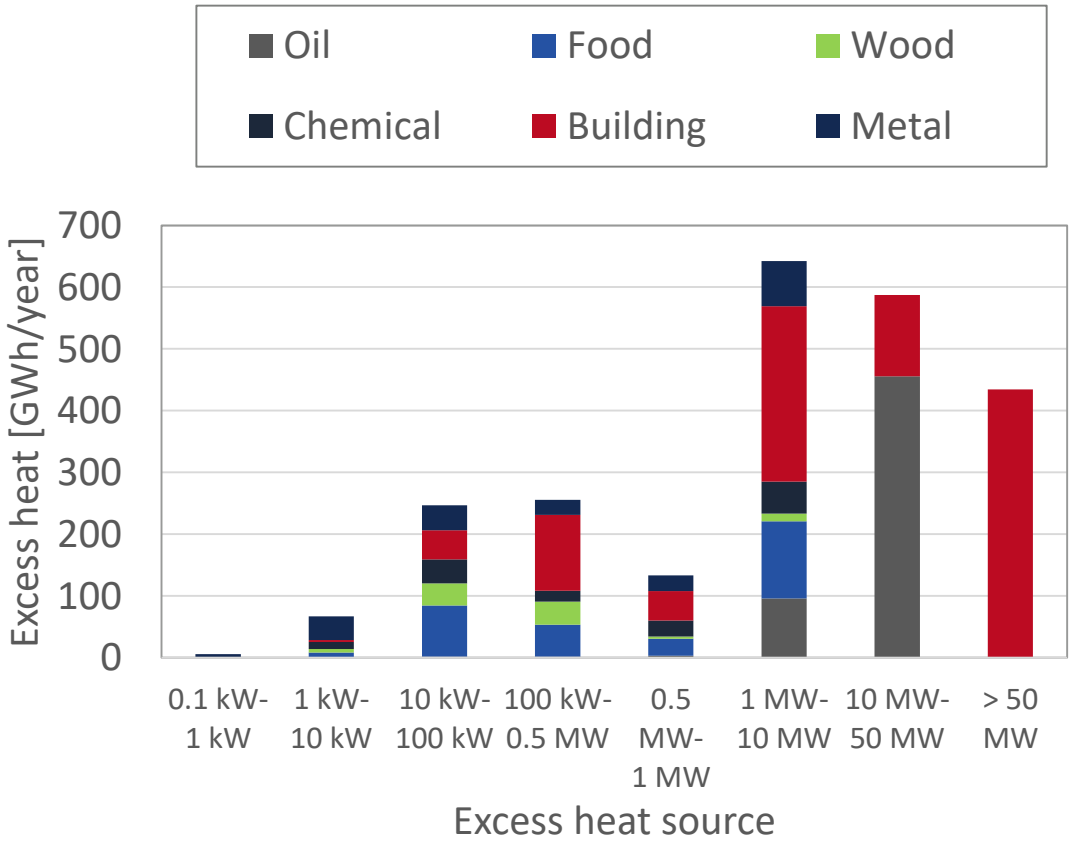

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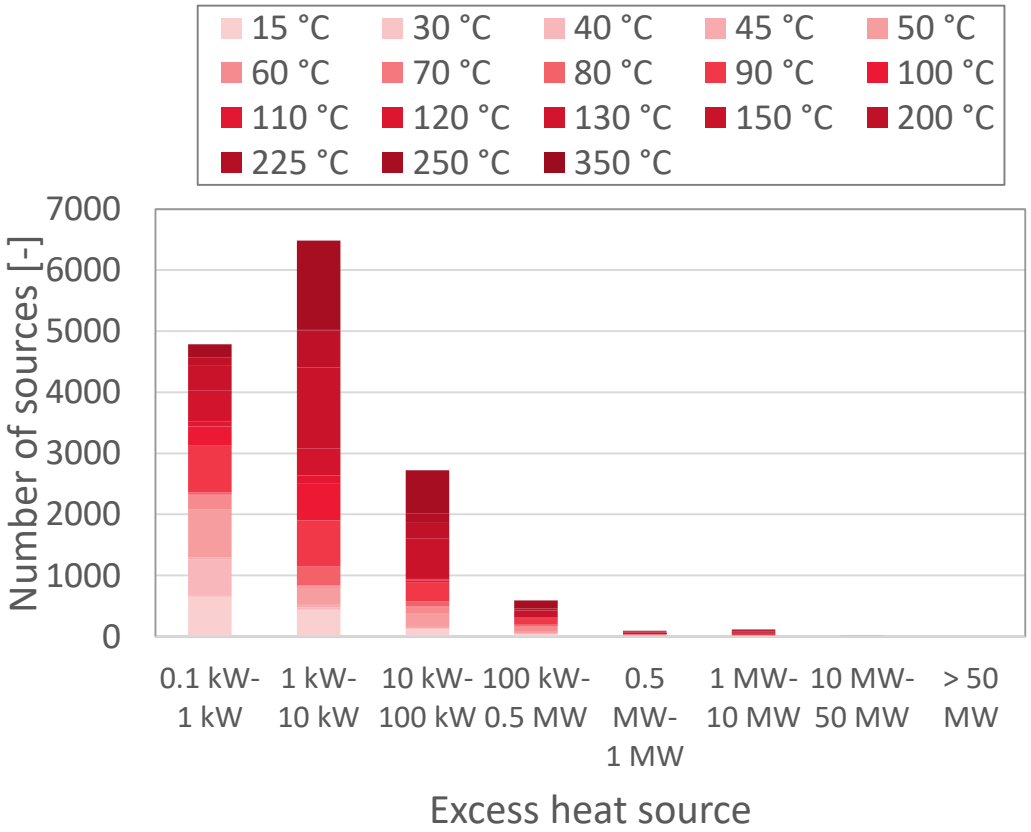

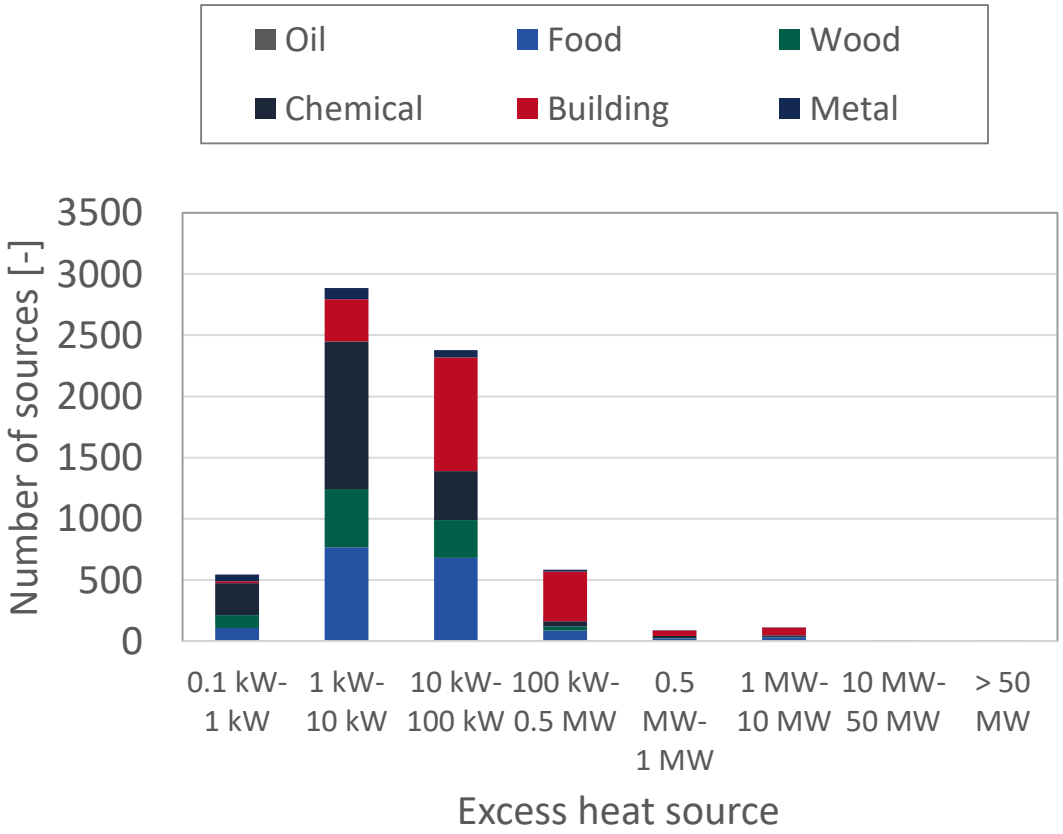

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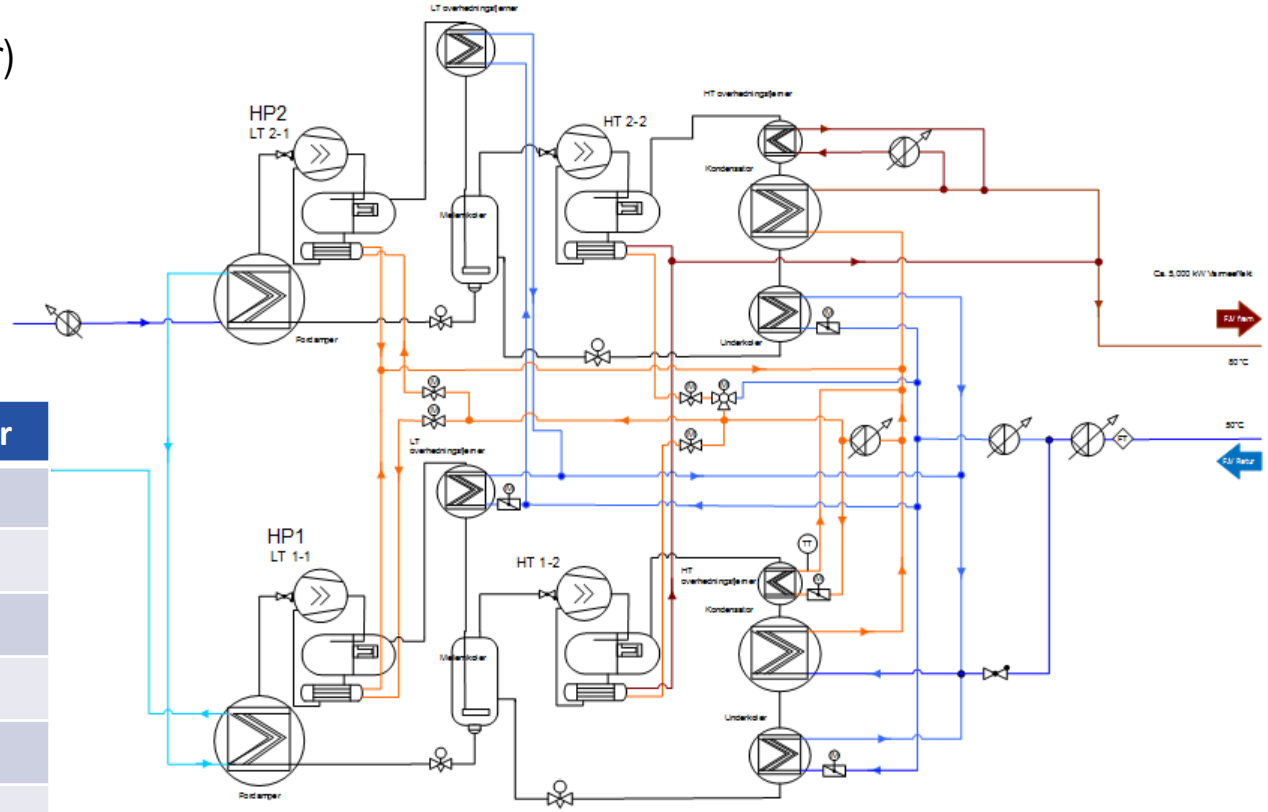
Improving the operation of large-scale HPs

- Demonstration plant for
  - Analysis of heat sources (Sewage water and seawater)
  - Testing new method of optimizing COP
  - Testing new method for monitoring operation
- Project investment:
  - Overall: 110 Mio. Dkk (≈ 15 Mio. €)
  - Funding: 23 Mio. Dkk (≈ 3 Mio. €)

		Seawater	Sewage water
Source	Temperatures	4 °C → 0.5 °C	10 °C → 4 °C
	Heatflow	3672 kW	3732 kW
Sink	Temperatures	50 °C → 80 °C	
	Heatflow	5194 kW	5177 kW
Power		1635 kW	1552 kW
COP_h		3.2	3.3



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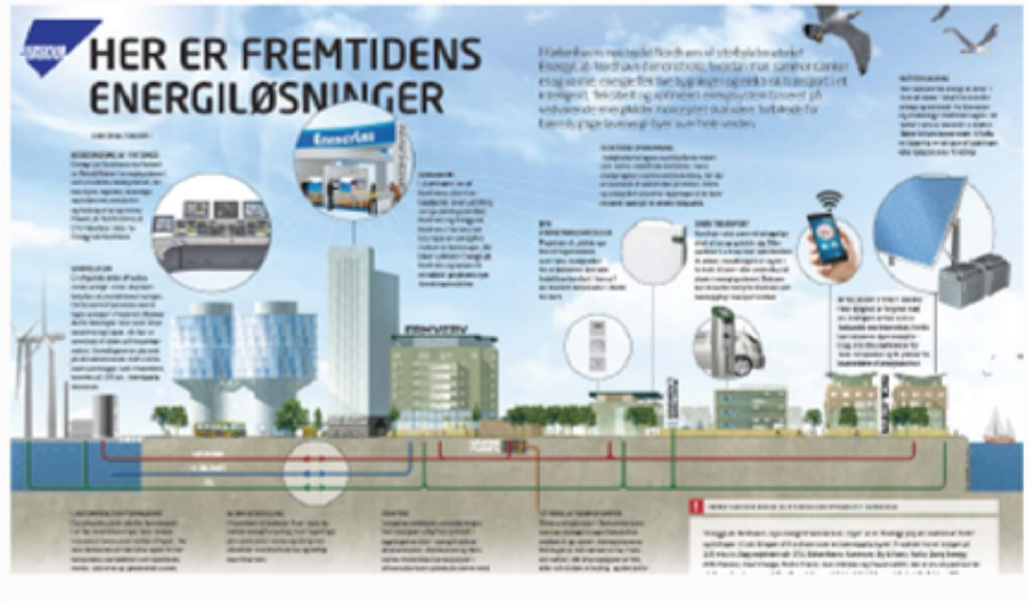
Flexible operation of heat pumps

Energylab Nordhavn: Smart City Lab

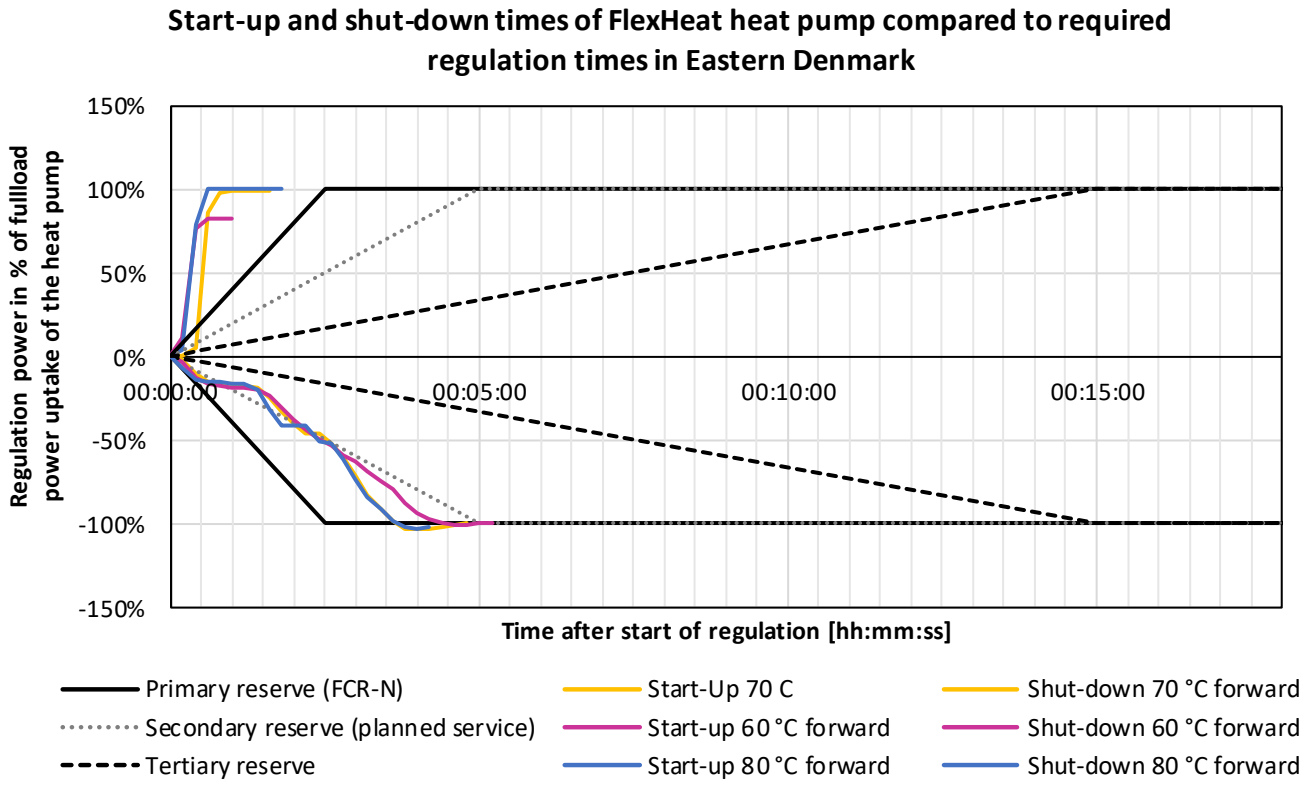
http://www.energylabnordhavn.com/



Flexible operation of heat pumps

- …

- W. Meesenburg et al. 2019 'Design considerations for dynamically operated large-scale ammonia heat pumps' (Presentation in 'Dynamics and Control' at 13.30-15:10)



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Conclusions

- Ongoing transition of the Danish Energy system → HPs are playing a key role
- High share of renewables in electricity production → high potential for electrification of heat supply
- District heating:
  - HPs are (becoming) an established solution and the preferred choice
  - Good knowledge base for HPs in DH available
  - Increasing number of installations noticeable
- Industrial applications:
  - Higher diversity in boundary conditions and large effort for integration
  - More challenging economic conditions
- R&D Focus shifts to operating issues, upscaling & integration benefits

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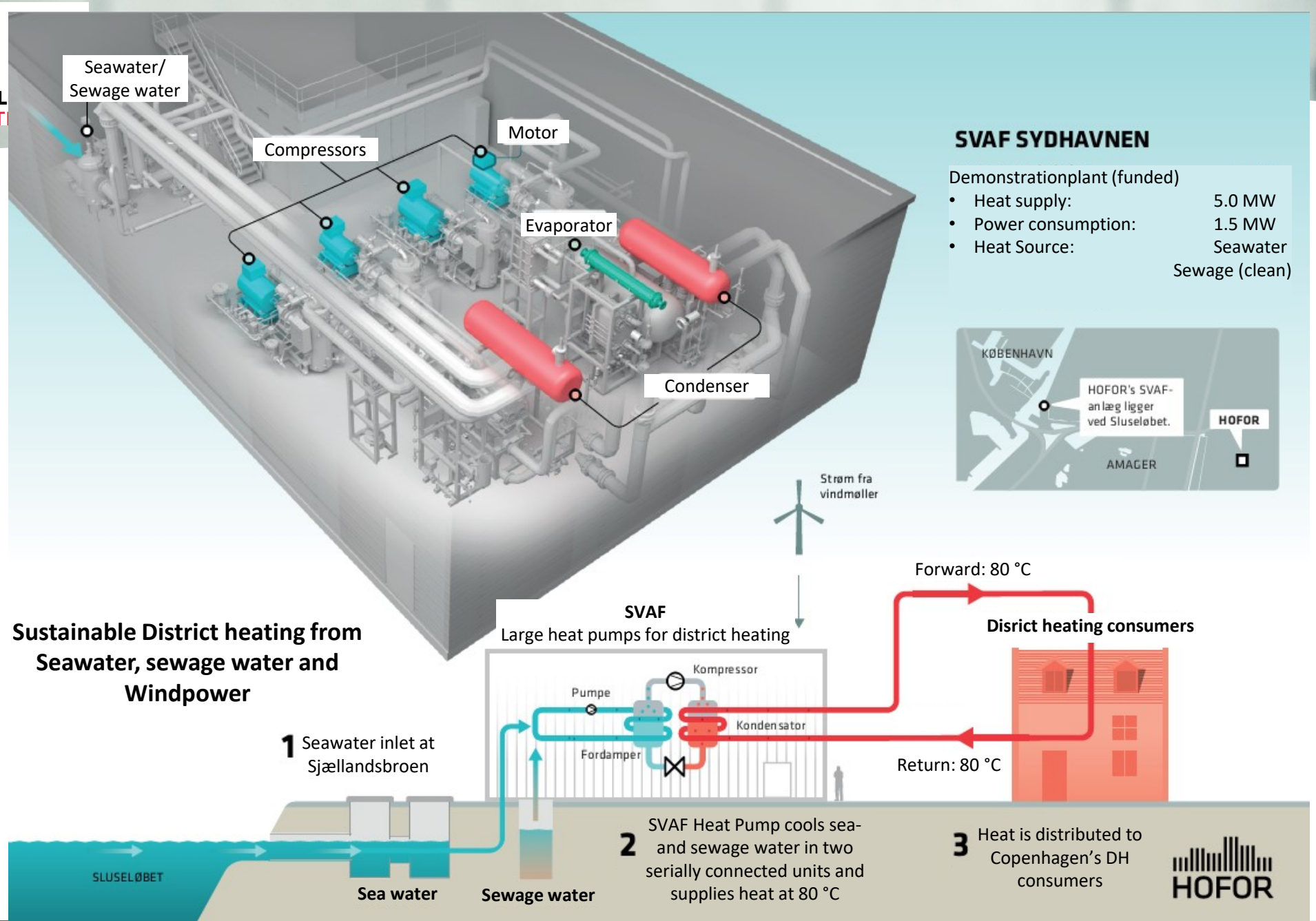

Sustainable District heating from Seawater, sewage water and Windpower

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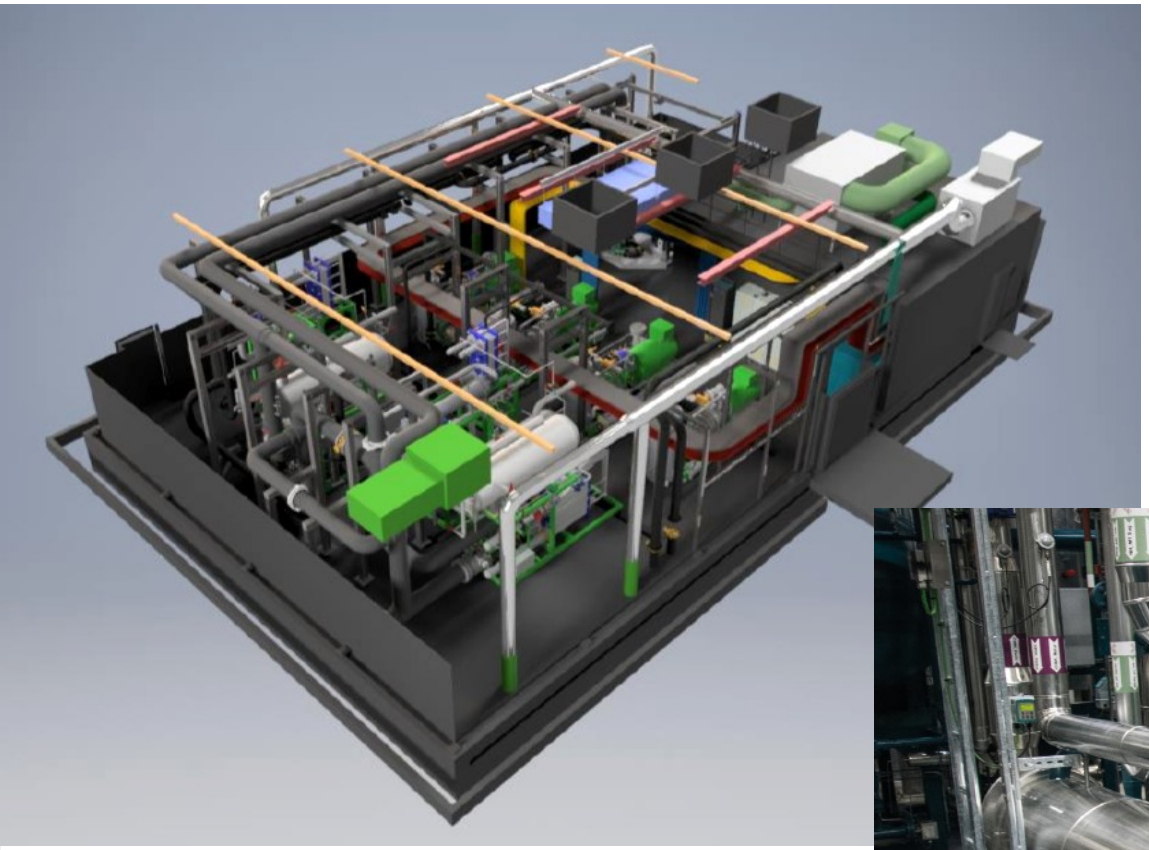
Best Case I: SVAF Heat Pump



Best Case II: CP Kelco

Background:

- CP Kelco produces ingredients for the food sector → High cooling loads
- 2014: Energy symbiosis of VEKS (Utility company), CP Kelco, Sun Chemical, Fef Chemicals and Junckers
- Expansion of DH network to Køge region

Key factors for project realization:

- Expansion of DH network
- Availability of excess heat
- Strong interest from CP Kelco and VEKS
- Energy saving subsidy
- Government support
- Availability of similar business cases

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viegand maagøe
energy people

Best Case II: CP Kelco

Technology

System level
- Energy symbiosis Køge
- Cooling towers
- Heat recovery system
- Buffer systems
- System efficiency

Production level
- Integration with existing system
- HX redesign
- Piping
- Securing redundancy

District heating
- Expansion of network
- Demand (temperature and loads)
- Ownership
- Agreement between VEKS and CP Kelco

Technology
- **Heat pump**
- Heat storage
- HX equipment

Partners

Authorities
- Municipality
- Applications for dispensation and construction
- Danish Working Environment Authority

Client (CP Kelco)
- In house engineering
- Maintenance
- Production
- Procurement
- Management
- EHS

District heating
- Management
- In house engineering
- Subcontractors

Suppliers
- Mechanical
- Electrical
- Building
- Civil
- **HEAT PUMP**

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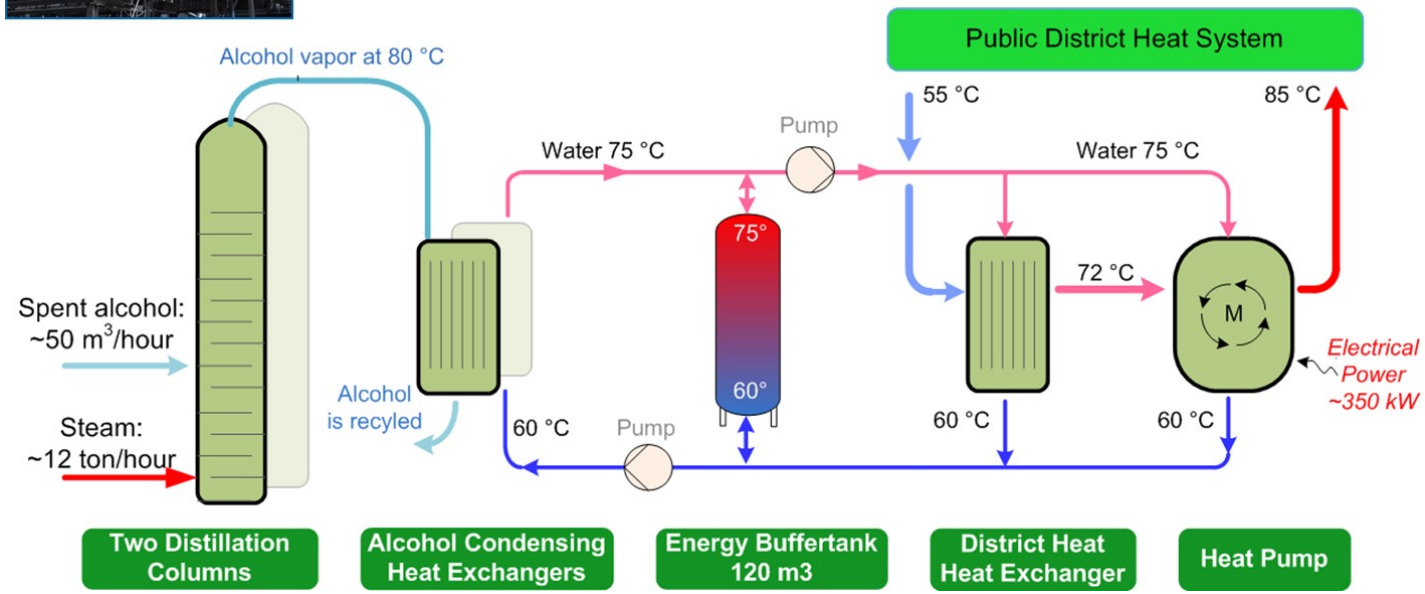
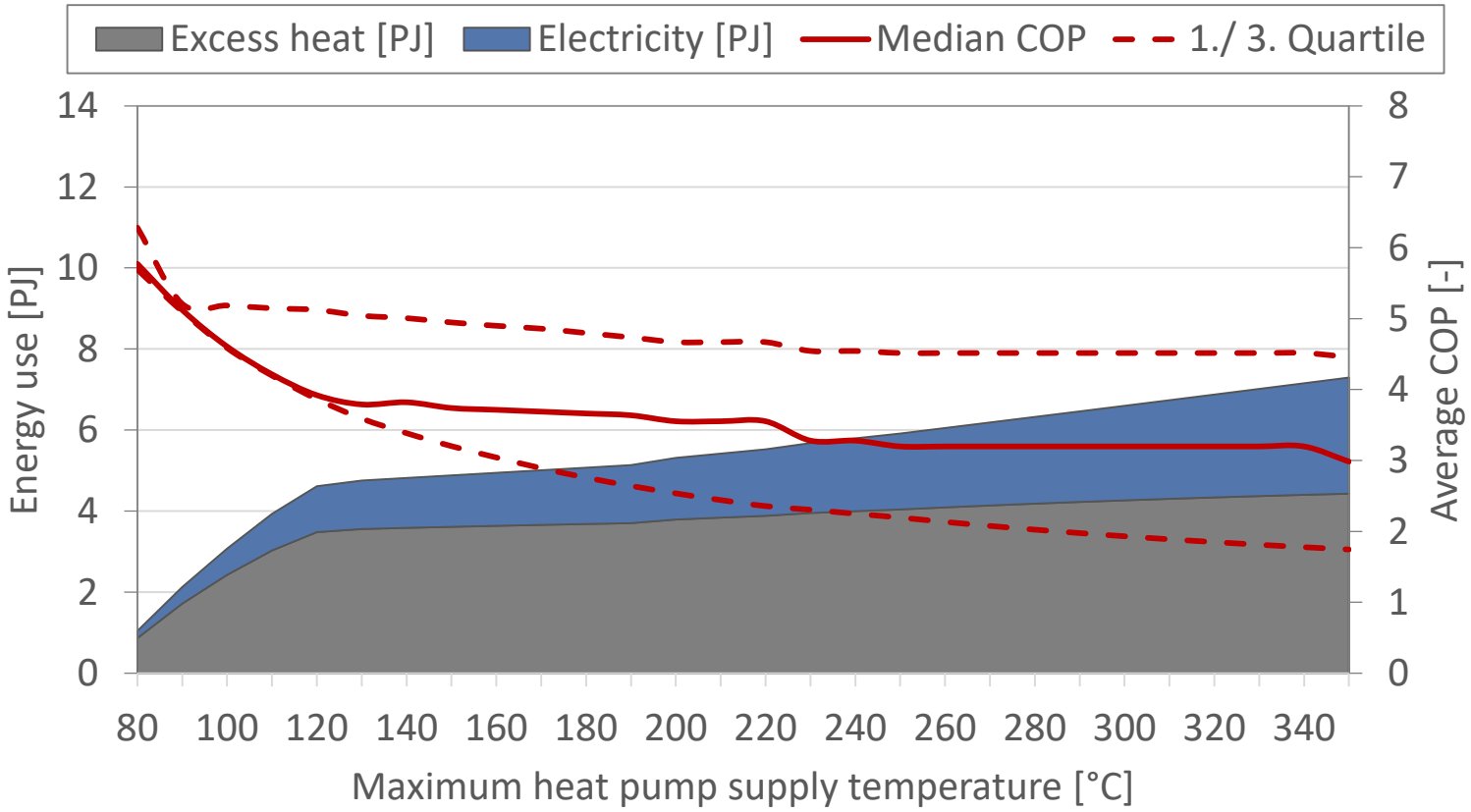
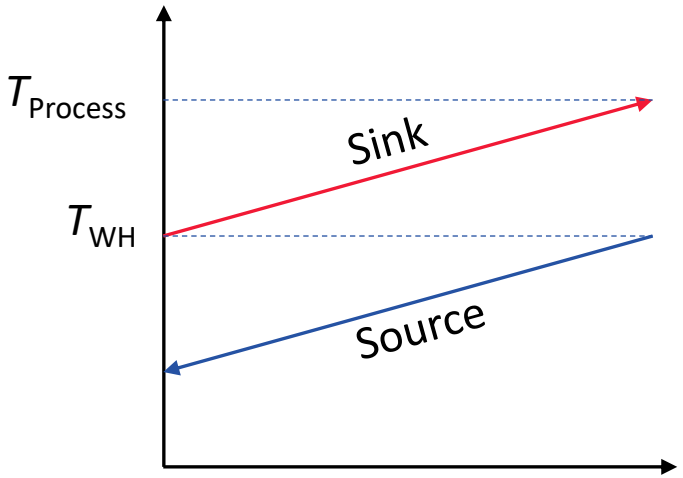


Key figures:

- System COP > 80
- After system design
- maximum district heating effect 8.7 MW (Business case 5 MW)
- Averages district heating effect 6.9 MW
- Expected district heating production of 55 GWh (Business case 40 GWh)
- Covering the heating demand in the Køge region approx. 5-6 month per year

Potential of HPs in the Danish industry





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