CELSIUS Talk:

Integration of heat, power and intermittent renewables

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The future of large-scale electric heat pumps in district heating systems

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What is the role of heat pumps?

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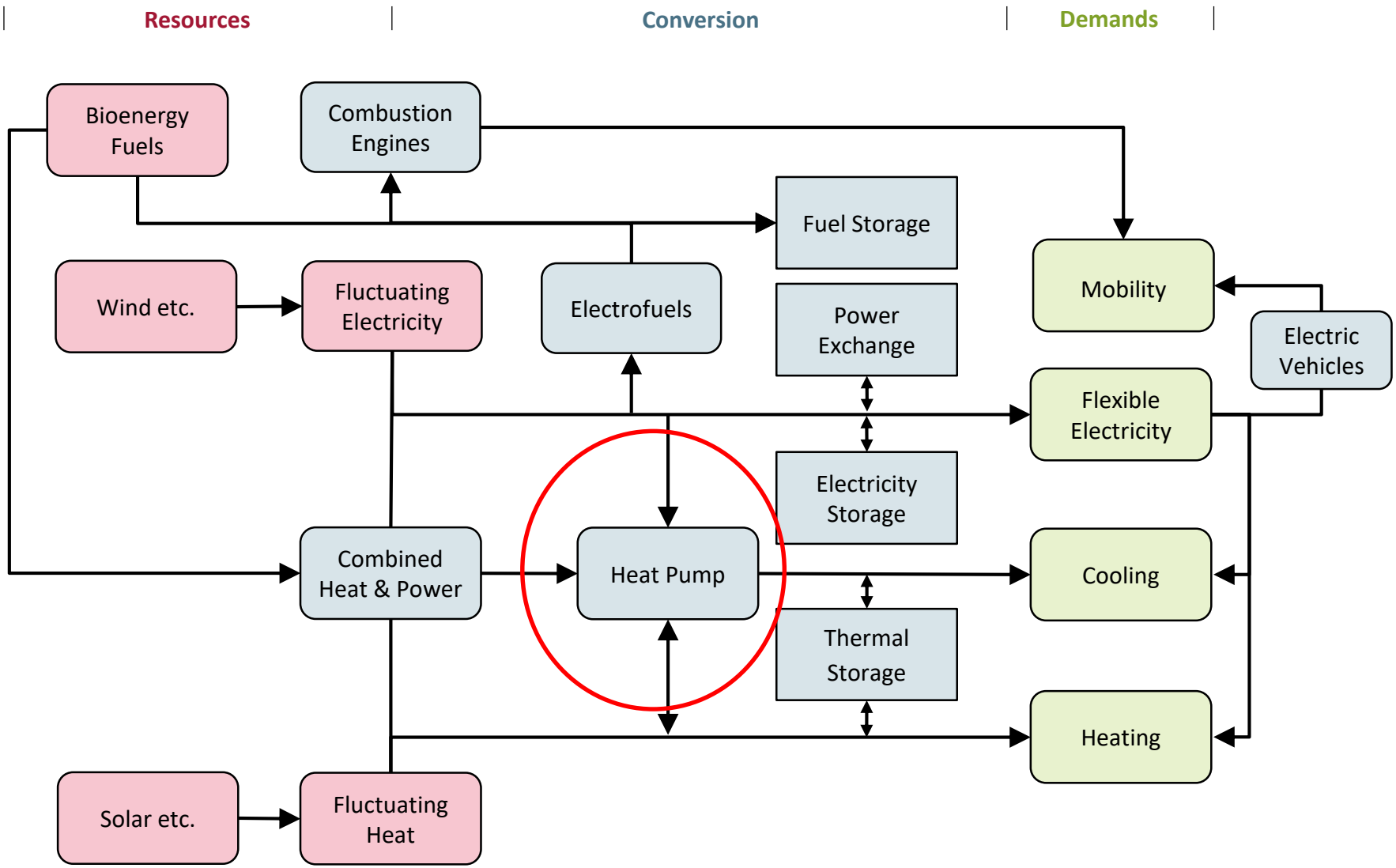

High RES integration, high heat pump use

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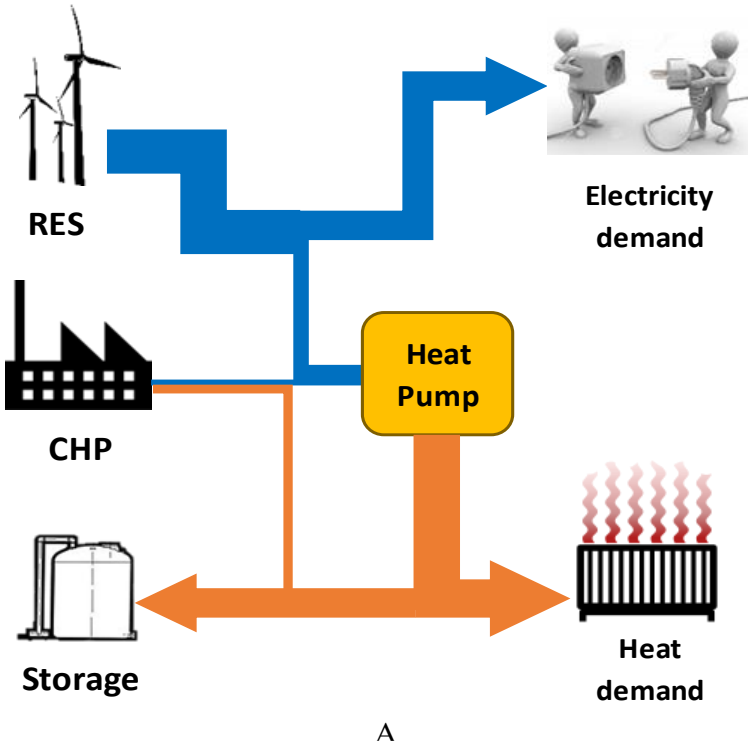

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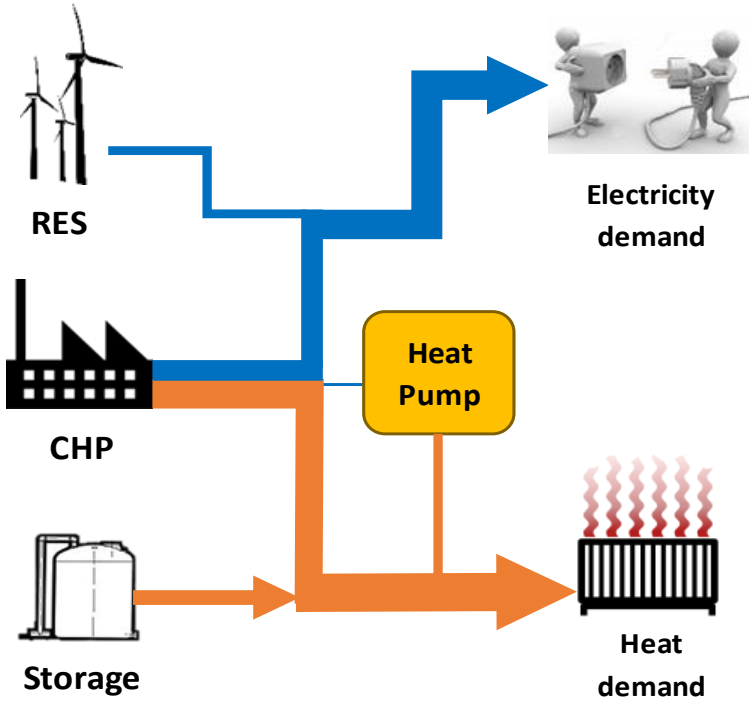

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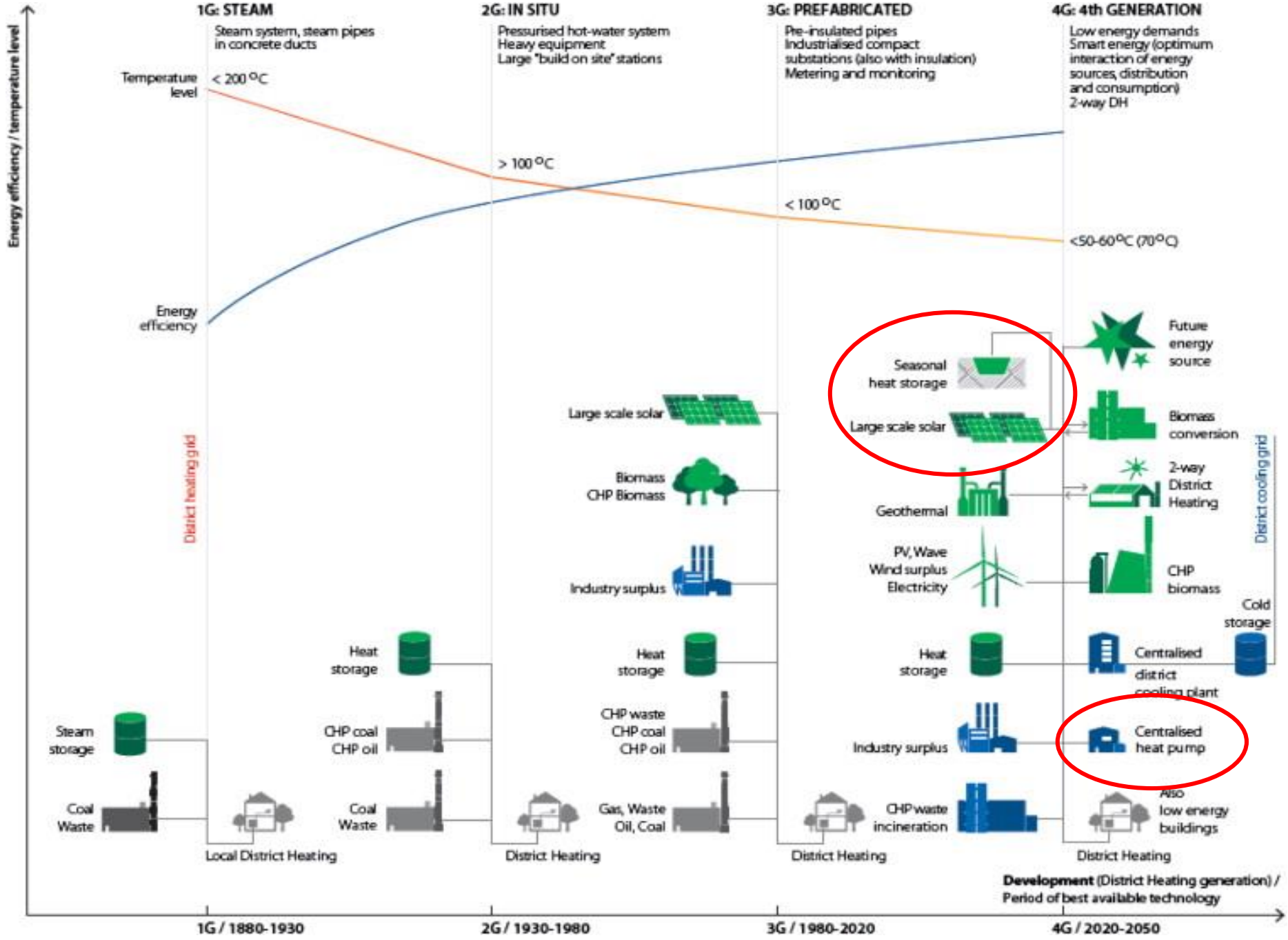
1G: STEAM
Steam system, steam pipes in concrete ducts
2G: IN SITU
Pressurised hot-water system
Heavy equipment
Large "build on site" stations
3G: PREFABRICATED
Pre-insulated pipes
Industrialised compact substations (also with insulation)
Metering and monitoring
4G: 4th GENERATION
Low energy demands
Smart energy (optimum interaction of energy sources, distribution and consumption)
2-way DH
Energy efficiency / temperature level
Temperature level
< 200 °C
> 100 °C
< 100 °C
<50-60 °C (70 °C)
Energy efficiency
District heating grid
Seasonal heat storage
Large scale solar
Future energy source
Biomass conversion
2-way District Heating
Geothermal
PV, Wave Wind surplus Electricity
CHP biomass
District cooling grid
Cold storage
Centralised district cooling plant
Centralised heat pump
Also low energy buildings
Large scale solar
Biomass CHP Biomass
Industry surplus
Heat storage
CHP waste CHP coal CHP oil
Gas, Waste Oil, Coal
CHP waste incineration
Steam storage
Coal Waste
Heat storage
CHP coal CHP oil
Coal Waste
Heat storage
CHP waste CHP coal CHP oil
Gas, Waste Oil, Coal
Heat storage
Industry surplus
CHP waste incineration
Local District Heating
District Heating
District Heating
District Heating
Development (District Heating generation) / Period of best available technology
1G / 1880-1930
2G / 1930-1980
3G / 1980-2020
4G / 2020-2050

Capacity development

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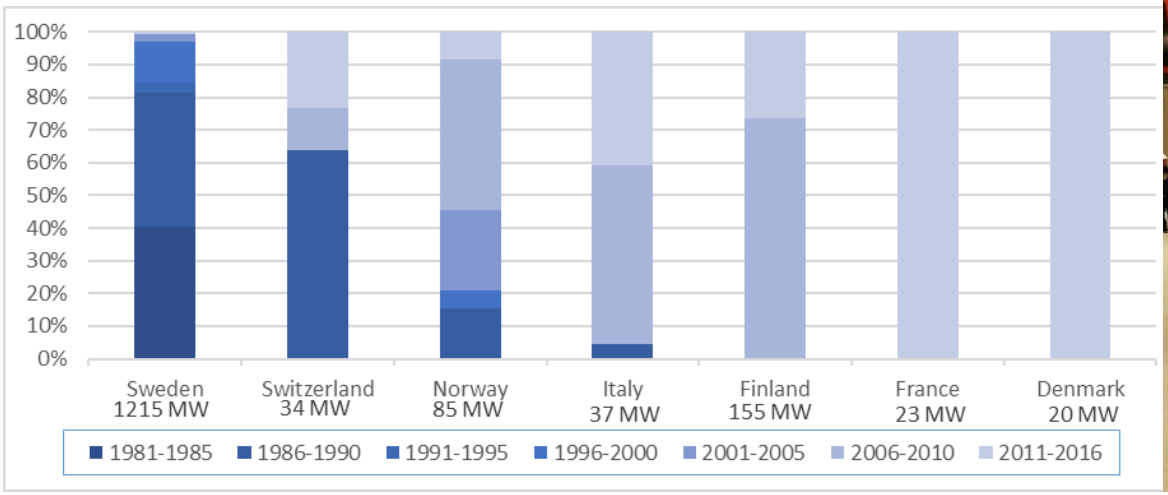
- Technology in use since 1980s in Sweden
- Over 300 MW units decommissioned in Sweden
- Today 1580 MW installed in Europe
- New heat pumps built, but smaller than before

Year	Capacity (MW)	Number of Units	Average Capacity (MW)
1981–1985	490	37	13
1986–1990	533	28	19
1991–1995	35	3	12
1996–2000	157	10	16
2001–2005	59	8	7
2006–2010	173	20	9
2010–2016	121	37	3
Total	1568	143	11



Largest Heat Pump at Rya Heat Pump Plant, Gothenburg (own photo)

Heat sources

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- Sewage water – largest capacities and best future potential
- Sea water – successful examples in Stockholm
- Industrial waste heat – high volumes available, but important capacity decommissioned

Type of Heat Source	Capacity (MW)	Number of Units	Average Capacity Per Unit (MW)	Temperature Range (°C)
Sewage water	891	54	17	10–20
Ambient water	390	34	11	2–15
Industrial waste heat	129	28	5	12–46
Geothermal heat	97	19	5	9–55
Flue gas	40	7	6	34–60
District cooling	30	4	7	0–9
Solar heat storage	4	3	1	10–35
Total	1580	149		0–60

Sewage water connection at Rya Heat Pump Plant, Gothenburg (own photo)

Refrigerants, output temperatures and COPs

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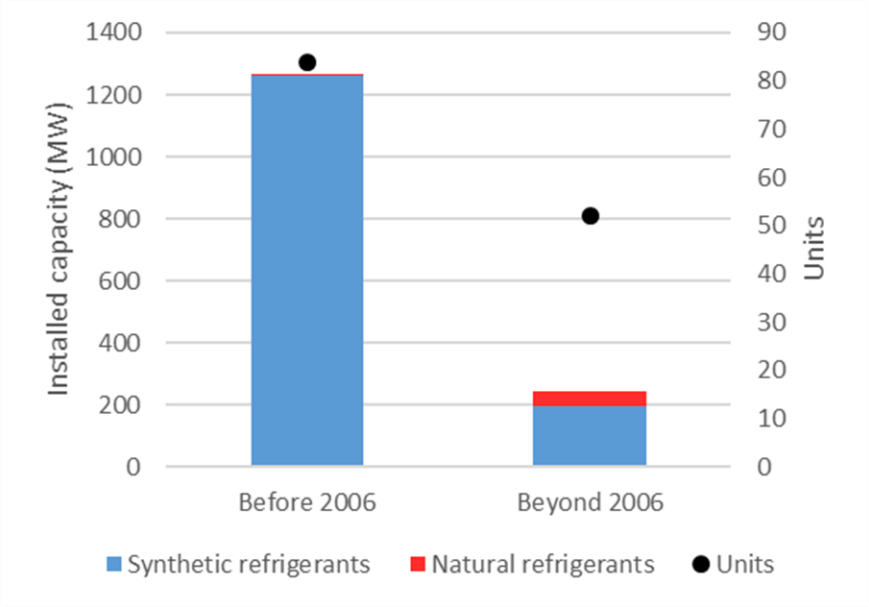
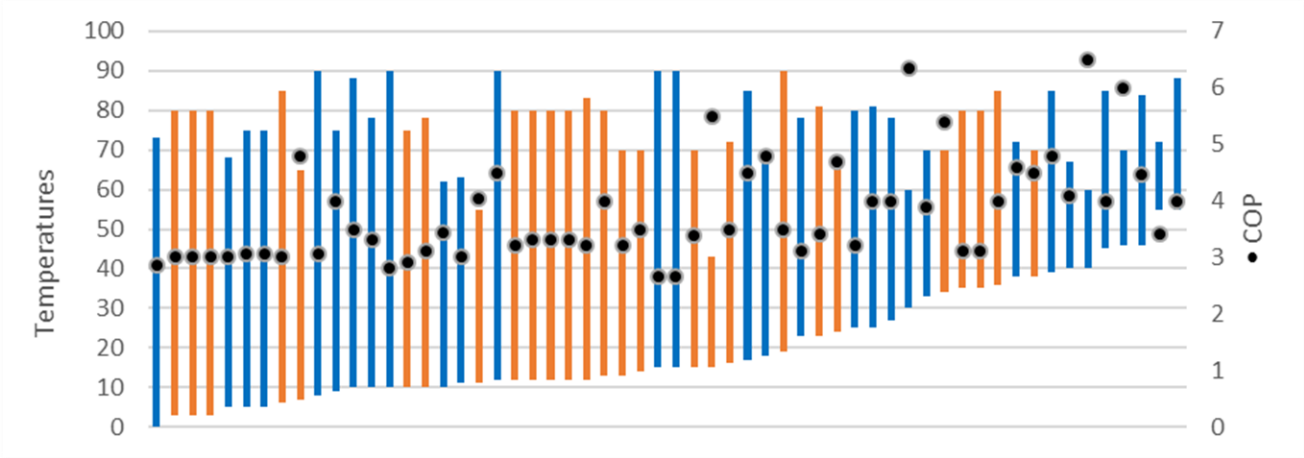


- 23 heat pump use natural refrigerants (mainly ammonia)
- HFOs could represent another solution (?)
- DH output temperatures can be achieved with COP over 3



Heat pump operation

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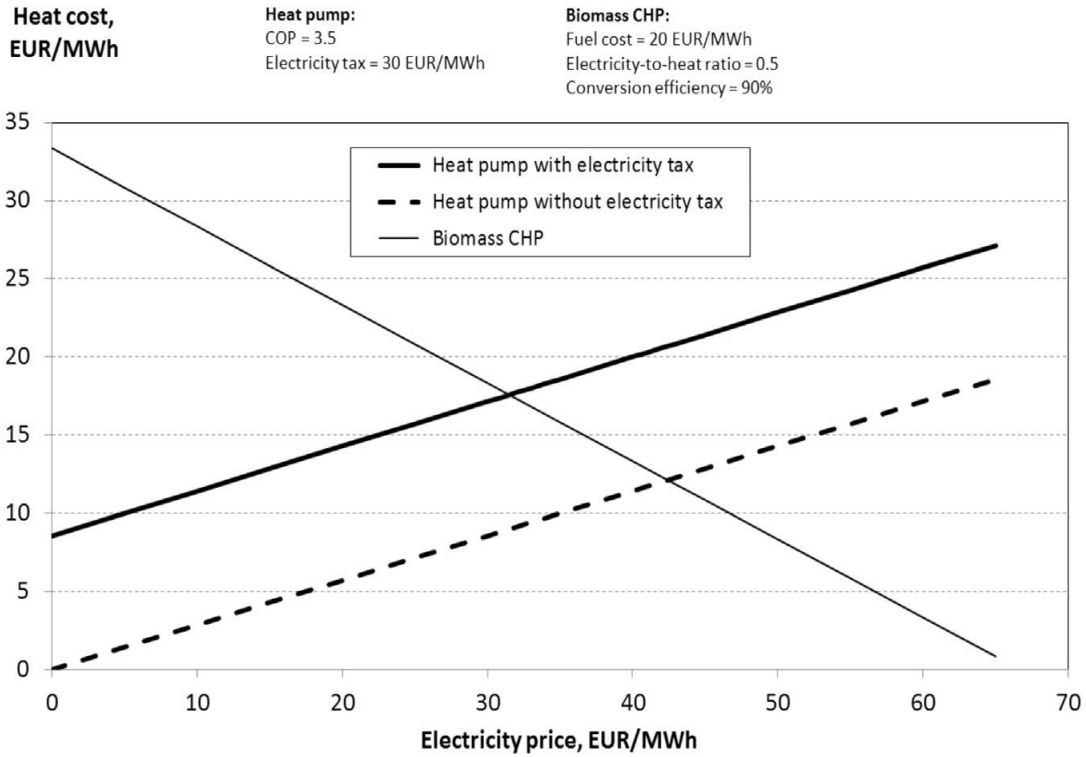
- Differences in how the heat pumps are operated
- Knowledge on component wear is still limited
- Dependent on electricity and biomass prices
- Displace production from expensive units
- Type of grid connection influences COP



Source: Averfalk, Helge, et al. "Large heat pumps in Swedish district heating systems." Renewable and Sustainable Energy Reviews 79 (2017): 1275-1284

Barriers for implementing more large-scale heat pumps

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- Energy market with no carbon penalty
- Subsidies for biomass and fossil fuels
- Willingness of some policy makers to stay technology neutral
- High(er) investment cost (than direct competing technology)
- Lack of knowledge on the technology maturity

Thank you!

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