
Ulster
University

Heat Pumps

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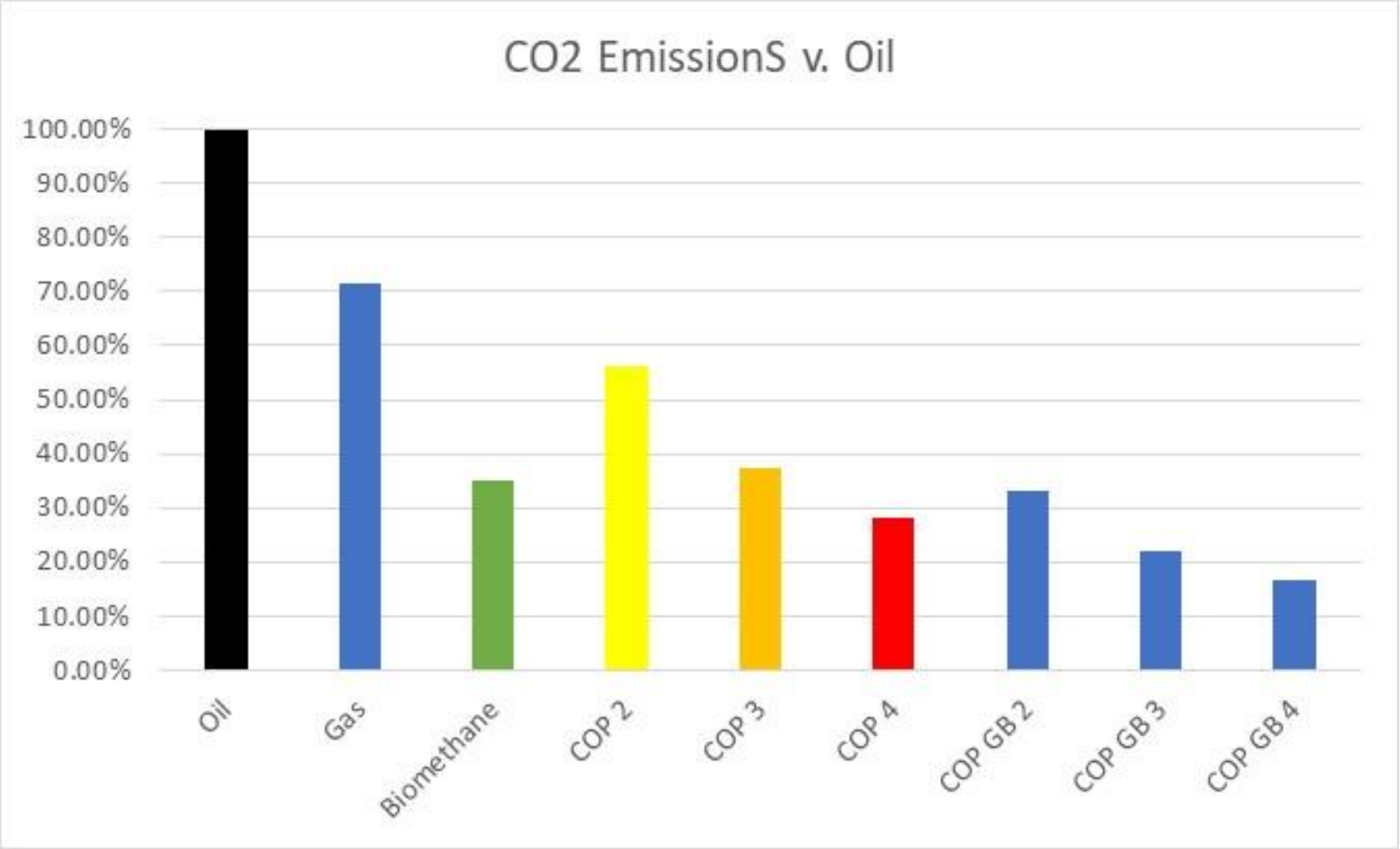
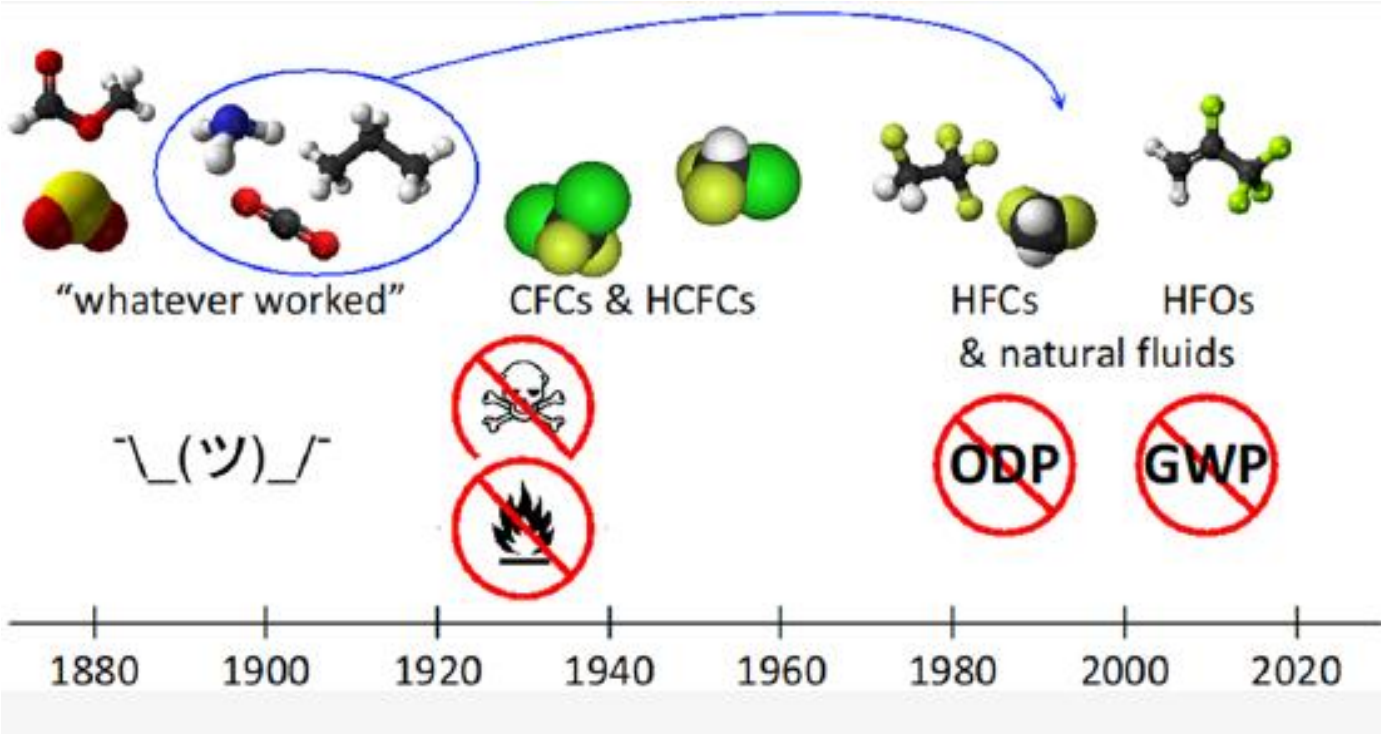
Why a heat pump?



Air Source Vapour Compression Heat Pumps

This will be my 4th Extinction?



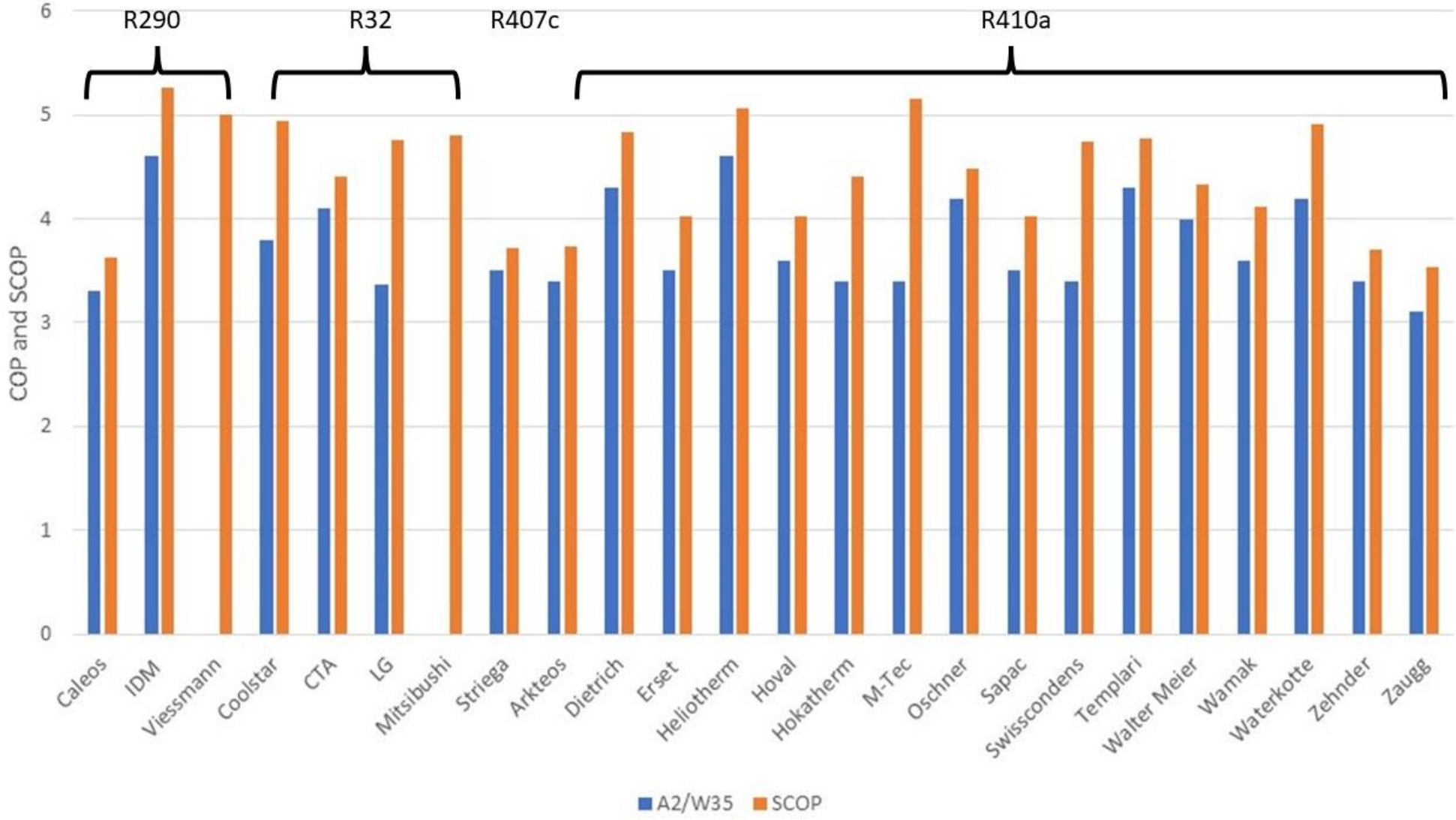
2024
EU – Proposed limiting use of polyfluoroalkyl substances (PFASs)

2023
EPA - GWP limit of 150 for refrigerants

2024
UK REACH
Case for limiting PFAS

McLinden & Huber, J. Chem. Eng. Data 2020, 65, 4176−4193

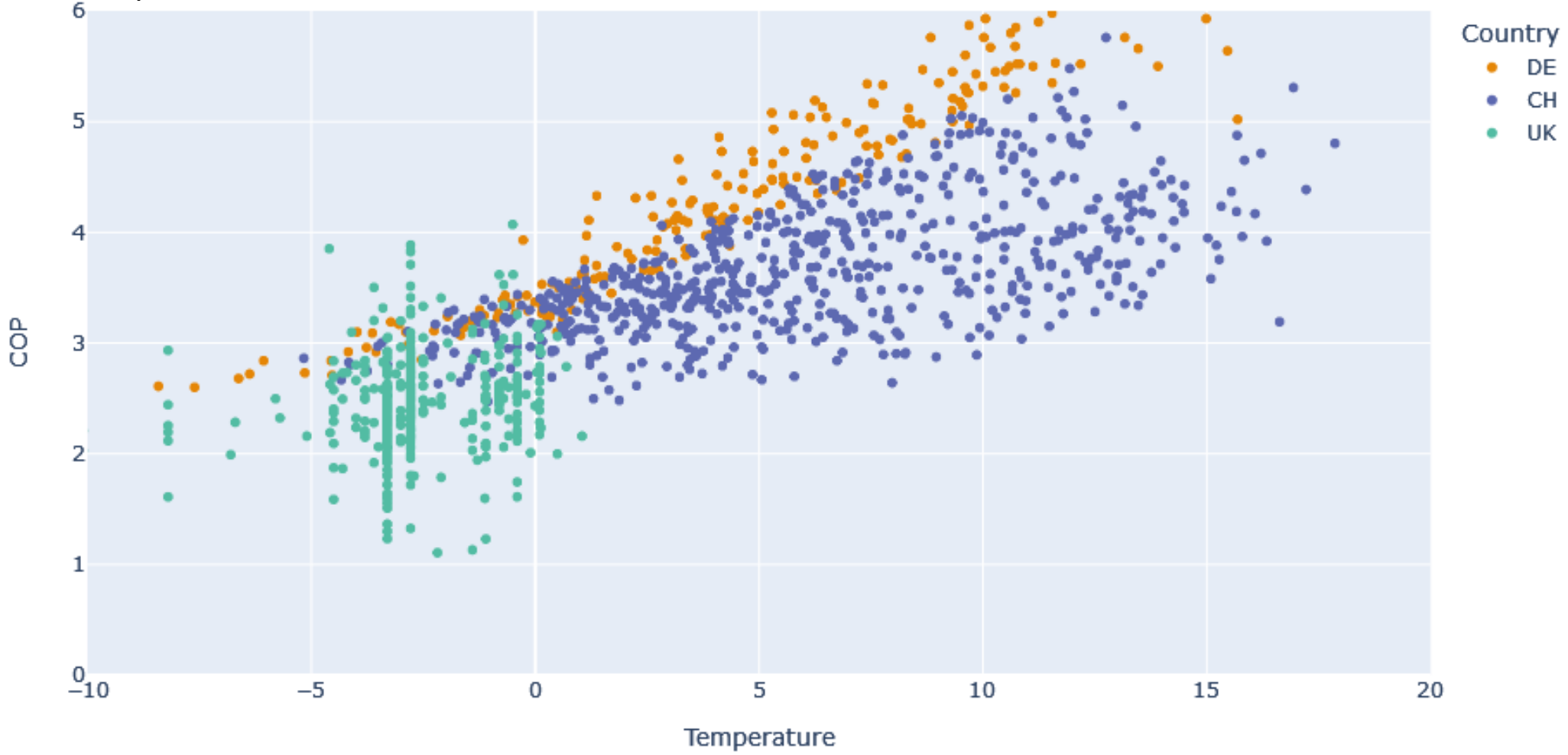
There are solutions



Adapted from WPZ Data at EN14511 and EN14825

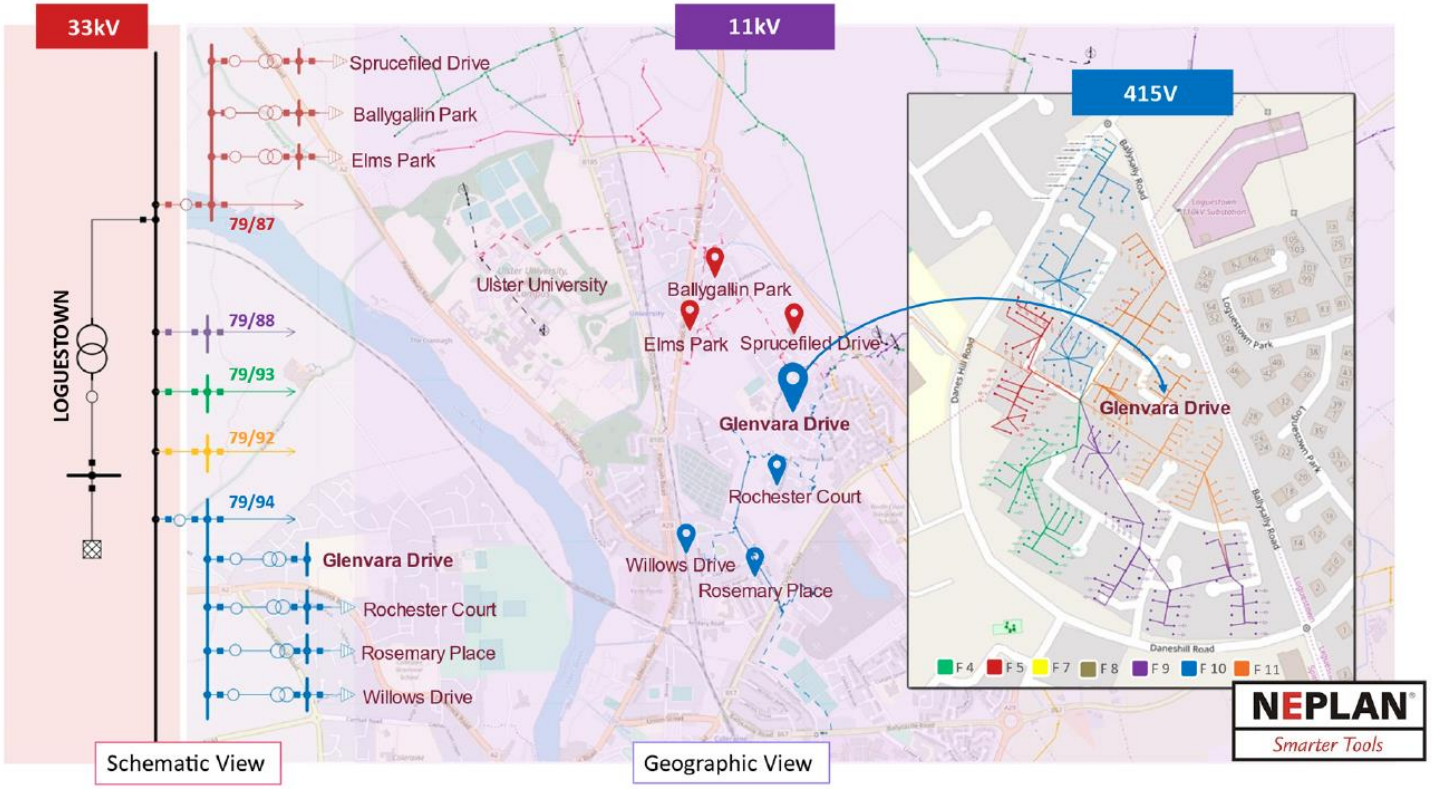
Air-source heat pump performance data from Germany, Switzerland, the United Kingdom

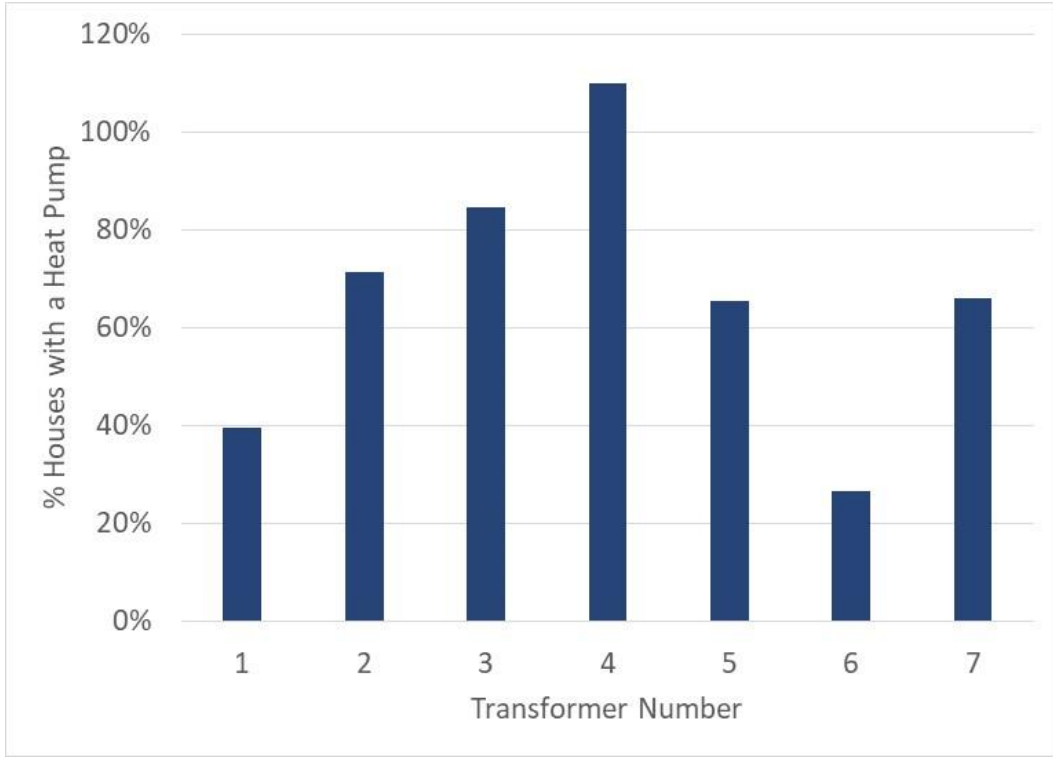
Coming in from the cold: Heat pump efficiency at low temperatures, Joule, Vol. 7, Issue 9, September 11, 2023, Duncan Gibb, Jan Rosenow, Richard Lowes, Neil J. Hewitt



Experiences with managing the Demand (Dark) Side

Air Source HP Deployment (modelled)

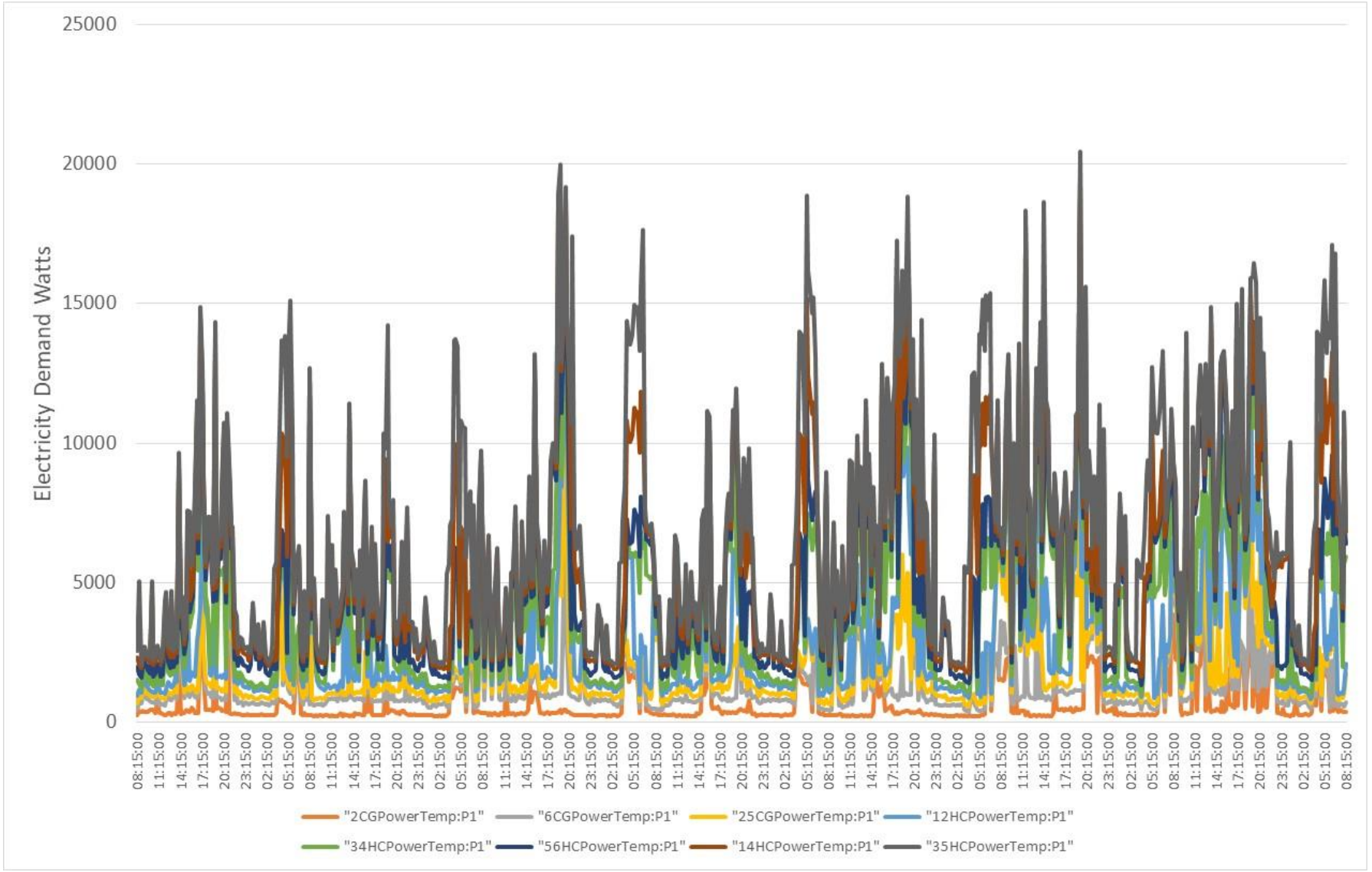




Osaru Agbonaye, Patrick Keatley, Ye Huang, Oluwasola O. Ademulegun, Neil Hewitt (2021) Mapping demand flexibility: A spatio-temporal assessment of flexibility needs, opportunities and response potential, Applied Energy, Volume 295

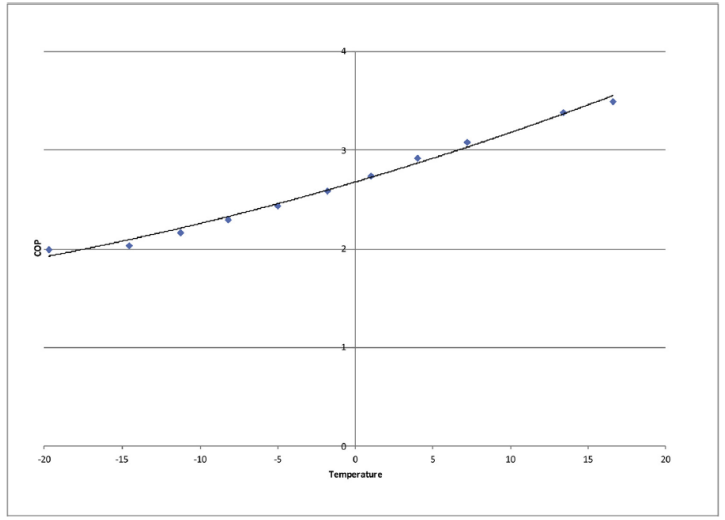
And Deployment (reality)

And Diversity with Rulet

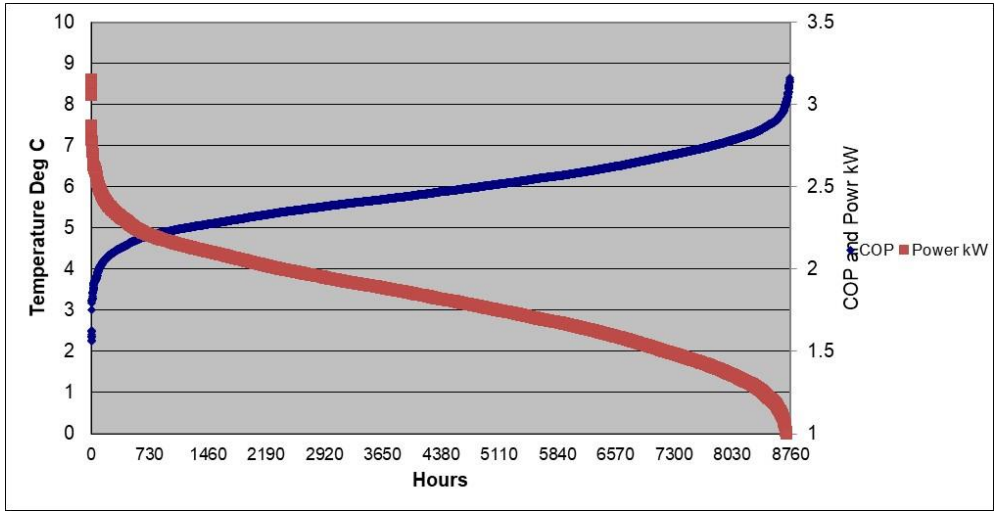


And Other Impacts on Diversity

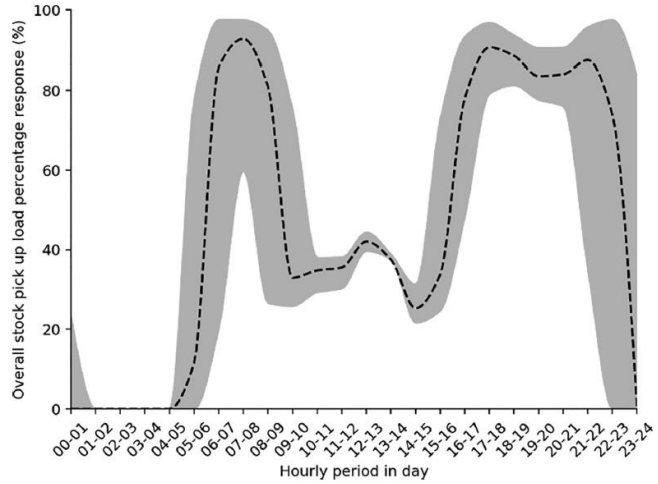
Numerous authors consider After Diversity Maximum Demand (community types, social etc.)
A range of UK values is typically from 1.3 kW to 1.93 kW per household per heat pump.
Kelly et al note a COP of 3.



1. COP can be a lot lower

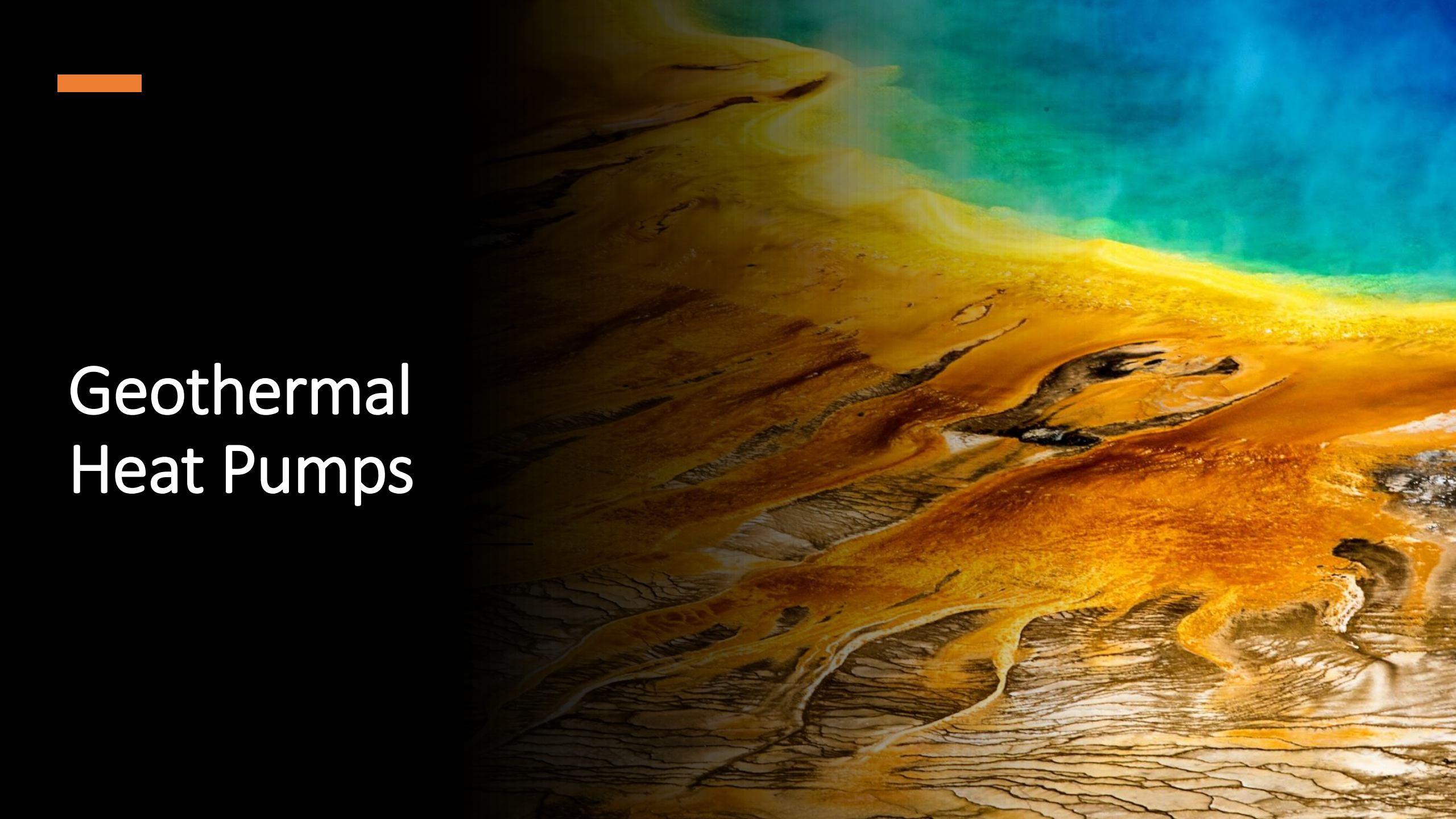


2. ASHP COP is affected by Air Temperature

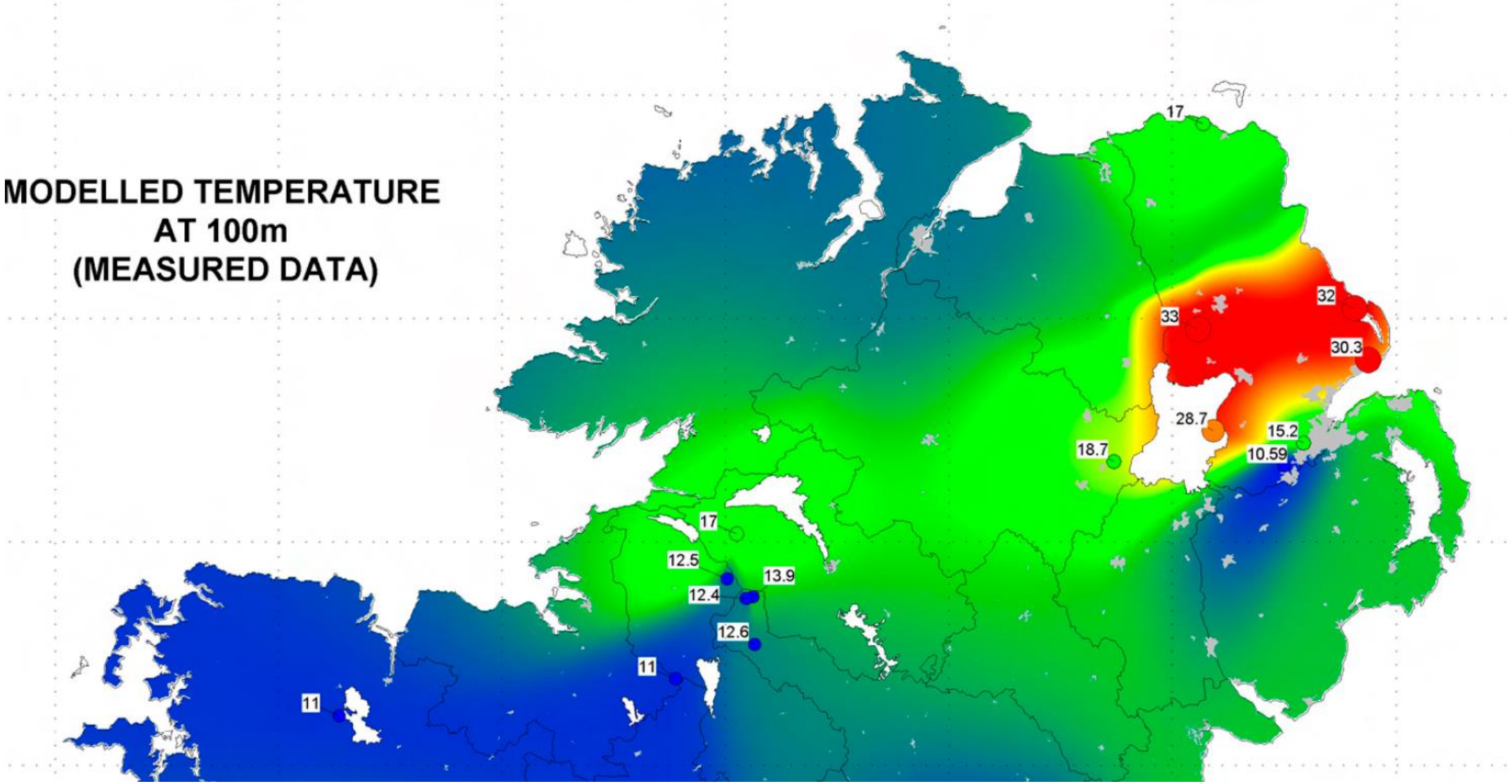


3. Time of Day is important

Geothermal Heat Pumps



What might this mean?



R1233zd(E)

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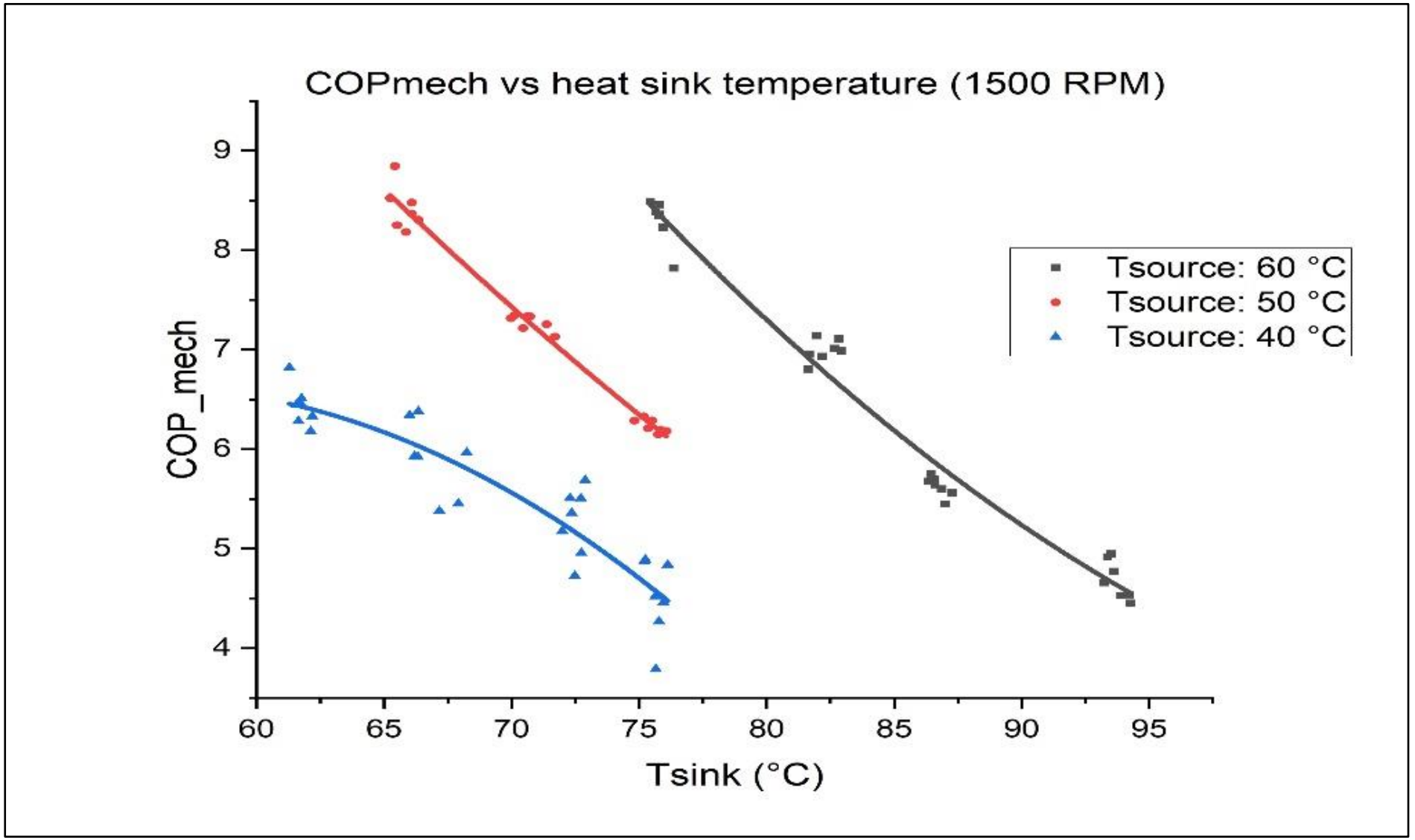
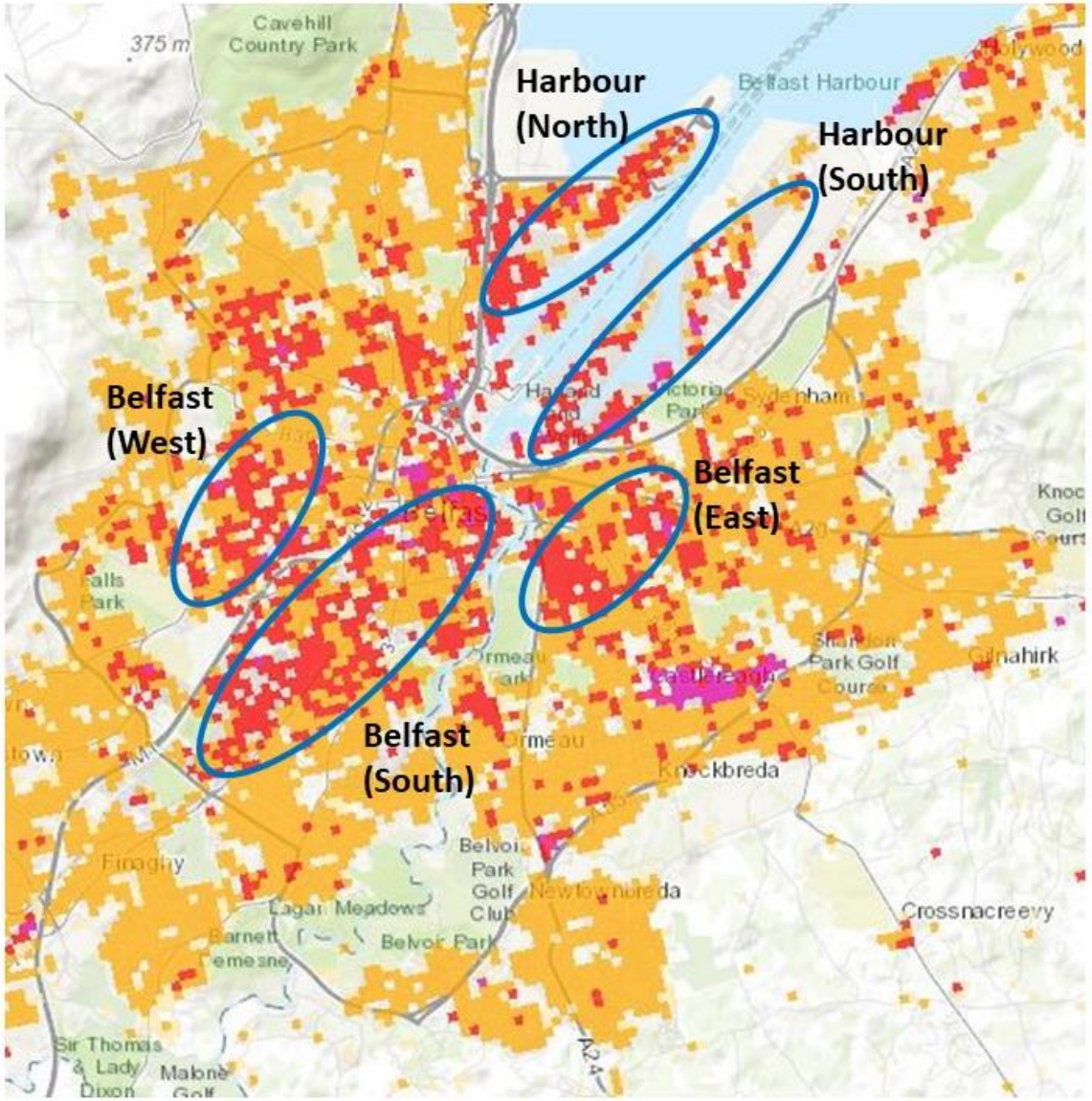

COPmech vs heat sink temperature (1500 RPM)
COP_mech
Tsink (°C)
Tsource: 60 °C
Tsource: 50 °C
Tsource: 40 °C
9
8
7
6
5
4
60
65
70
75
80
85
90
95

And delivering heat



Adapted from Heat Roadmap Europe

And how can we get hotter?

Current State of the Art?

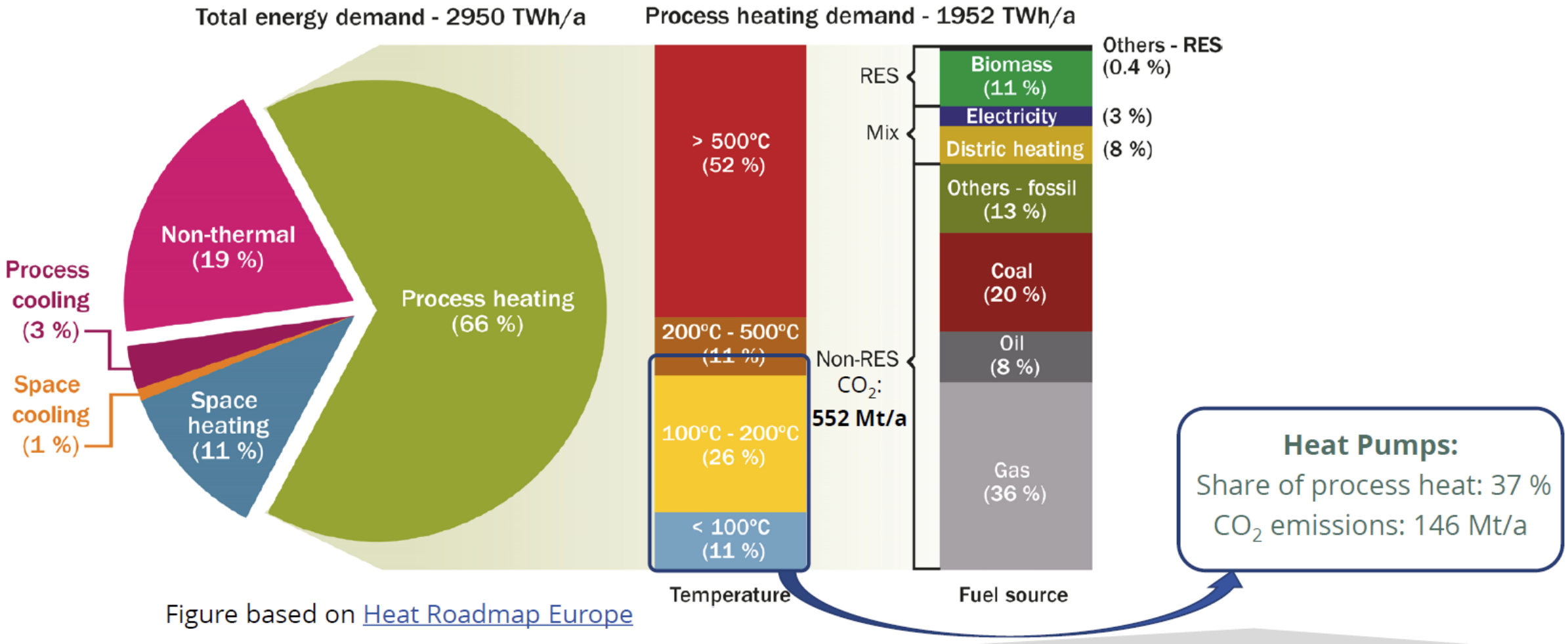


Figure based on Heat Roadmap Europe

Current State of the Art?

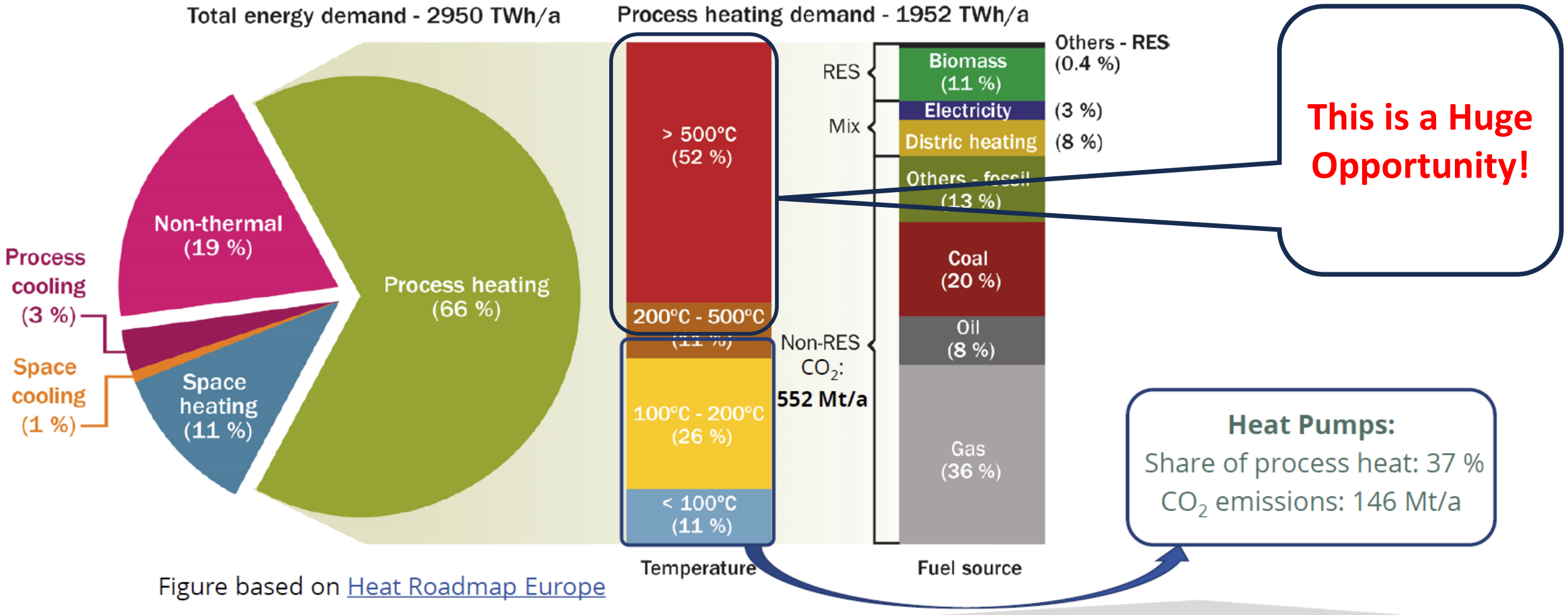
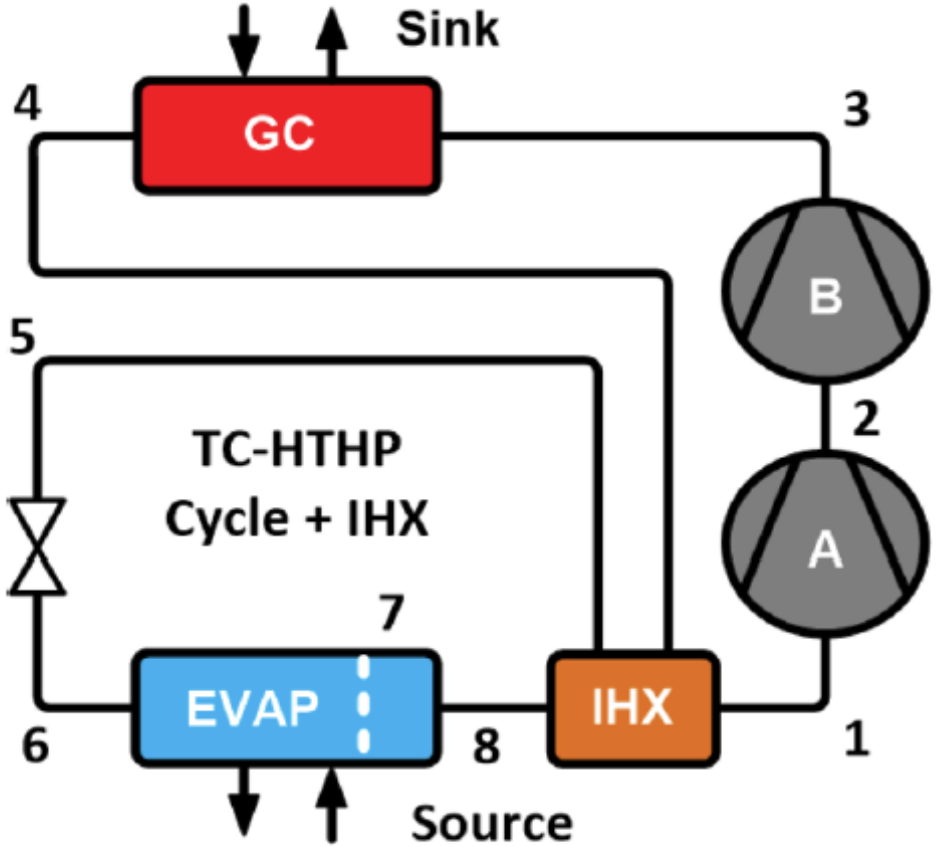
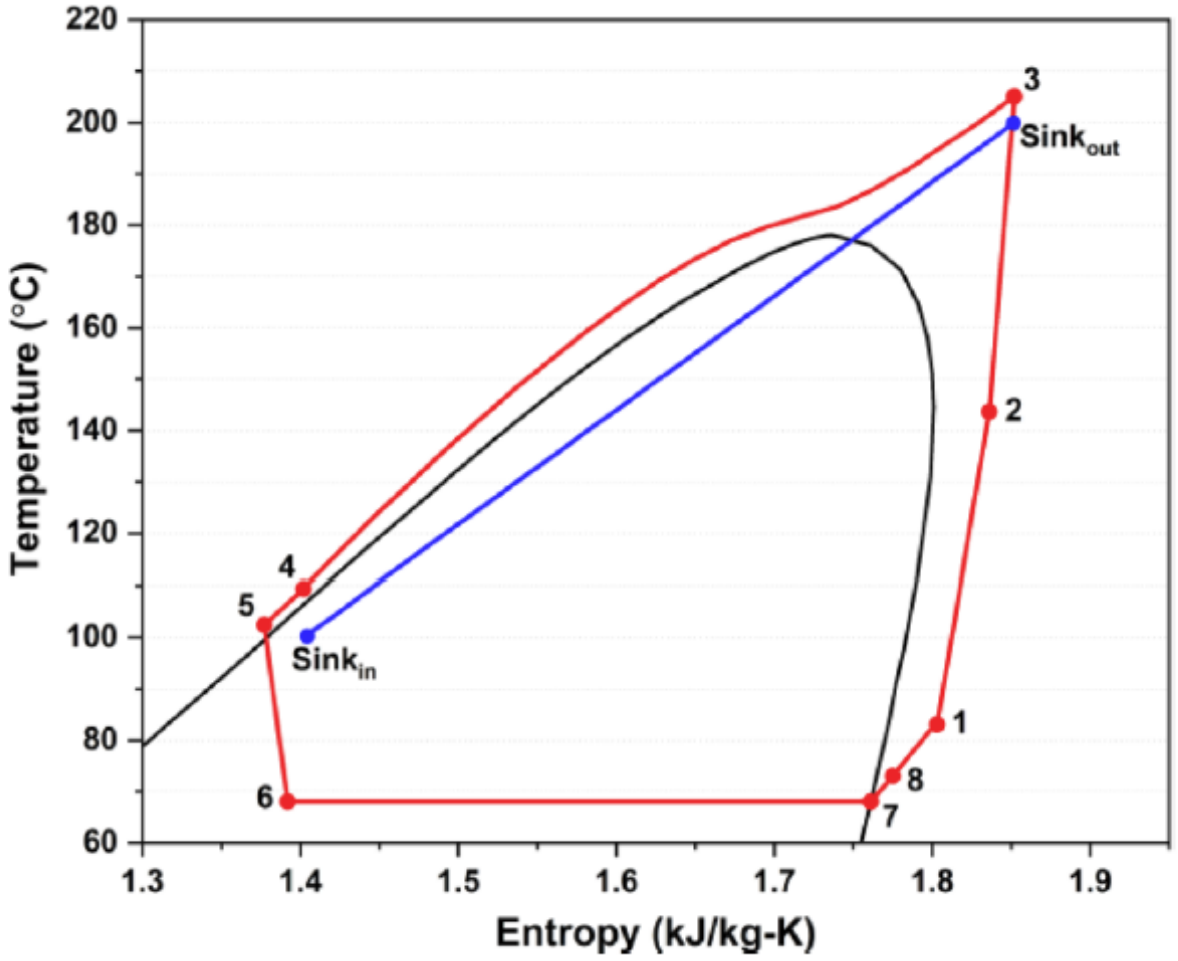


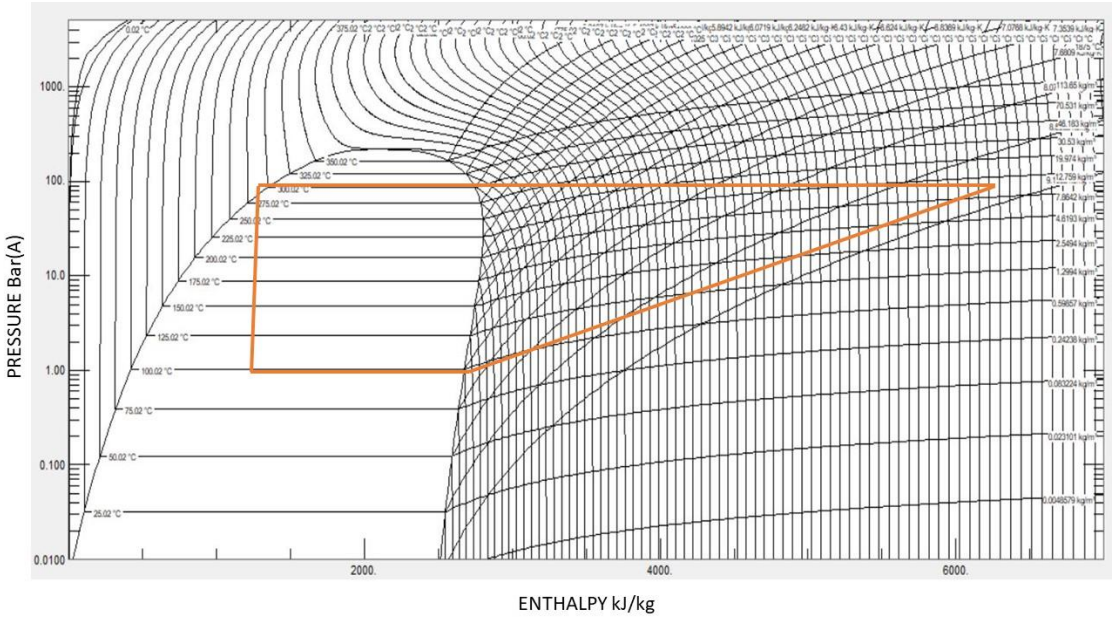
Figure based on Heat Roadmap Europe

Transcritical Cycles

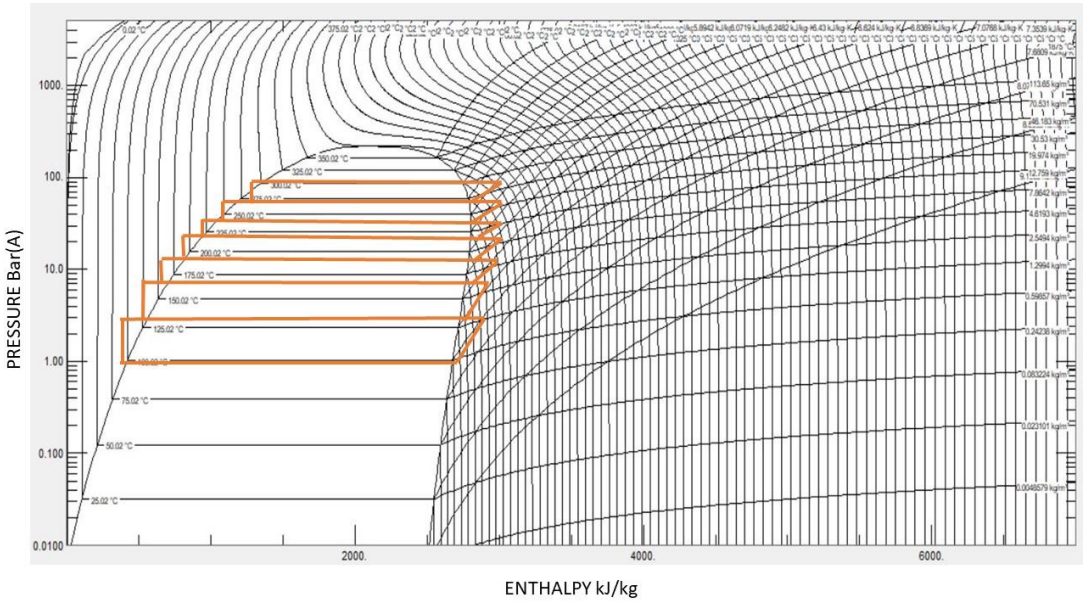




Water as a Refrigerant

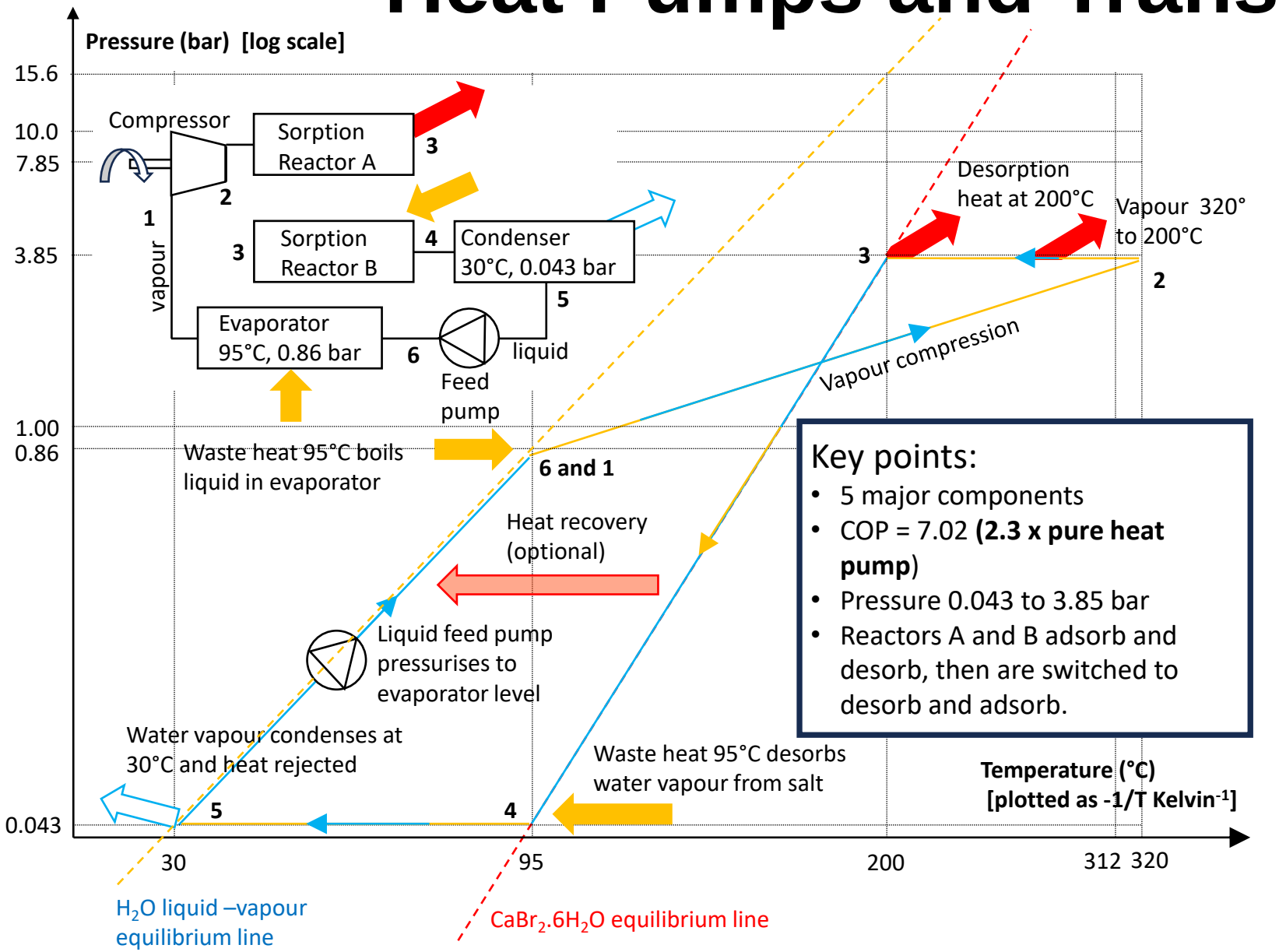


210K Temperature Lift to 300°C
Discharge Temperature 1630°C
COP 1.37



210K Temperature Lift to 300°C
Discharge Temperature 379°C
COP >5

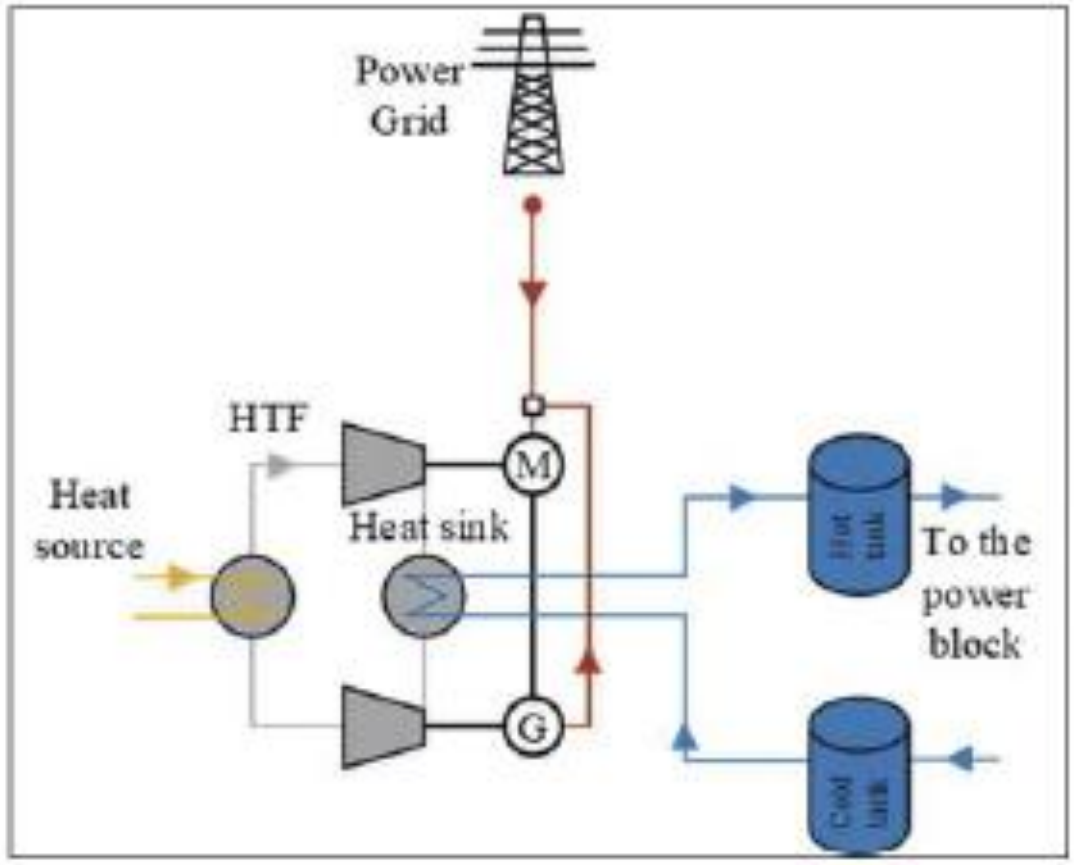
Heat Pumps and Transformers



Key points:

- 5 major components
- COP = 7.02 **(2.3 x pure heat pump)**
- Pressure 0.043 to 3.85 bar
- Reactors A and B adsorb and desorb, then are switched to desorb and adsorb.

And Gas Cycle Heat Pumps



HTF	COP
N2	2.811
CO2	2.685
Ar	2.839
Air	2.809

And to Conclude

Air Source Heat Pumps can be deployed.

Ideally, we would increase radiator size, insulate etc. to improve COP.

Energy Storage can increase diversity.

Ground source can increase COP further (and reduce impact on electricity network).

Heat Networks will capture waste heat and geothermal heat.

We can challenge industry needs.