

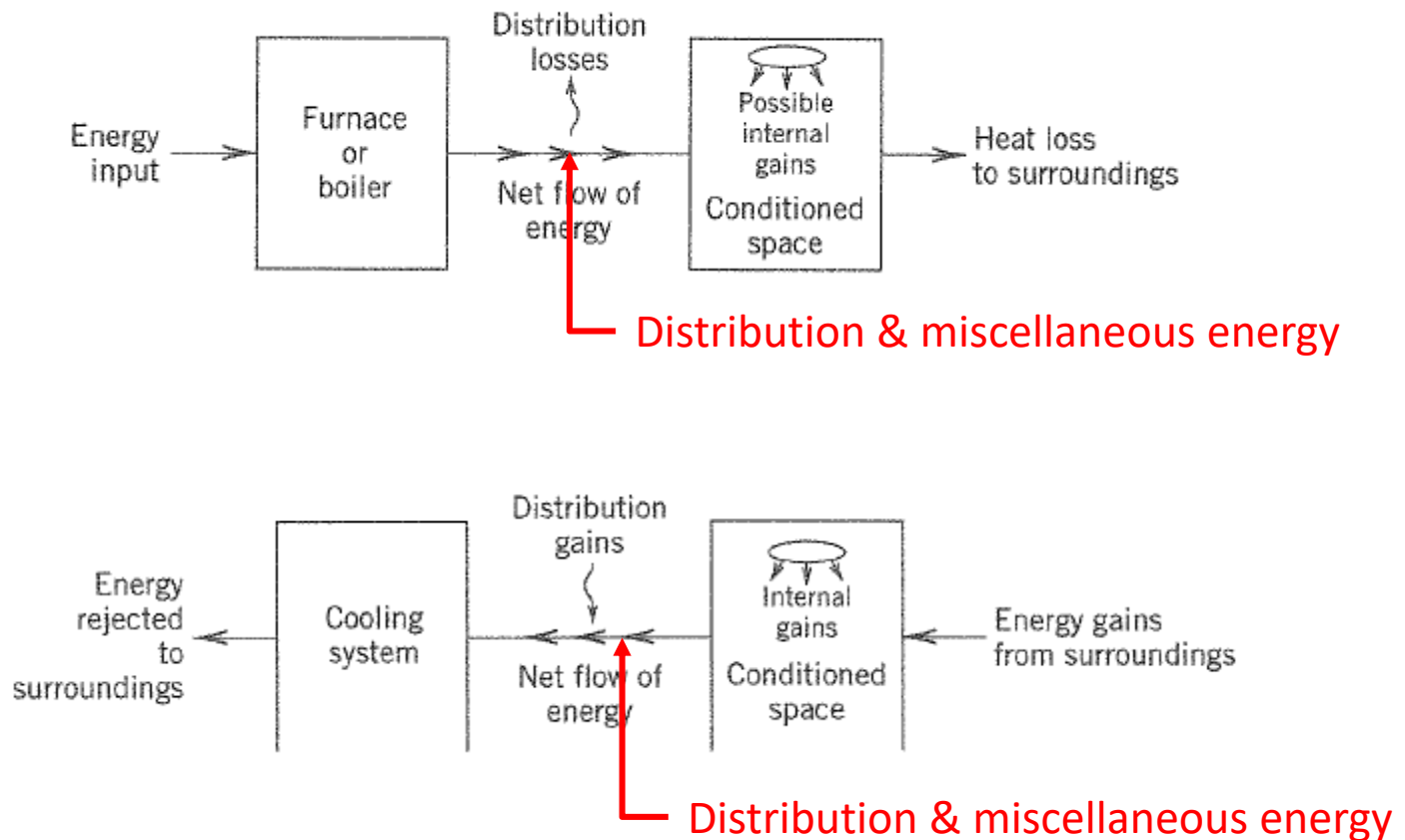
GSHP systems: More than just the ground loop and heat pump



Jeffrey D. Spitler



An inconvenient truth



Distribution energy: Pumps and fans required to move “hot and cold”

Miscellaneous energy: Controls, control boards (consume energy even when off)

SEPEMO 2012

- System integration effects
- “Heat pump system performance largely depends on the climate and quality of installation and not only on the product itself...”

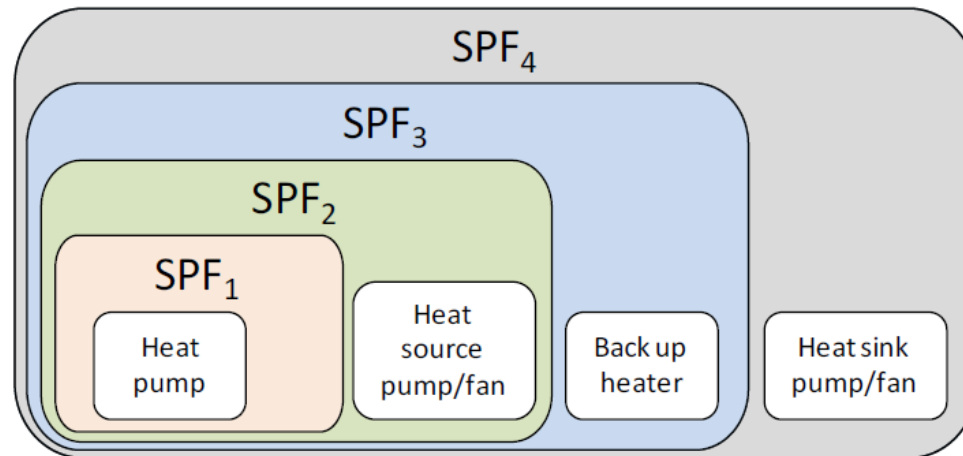


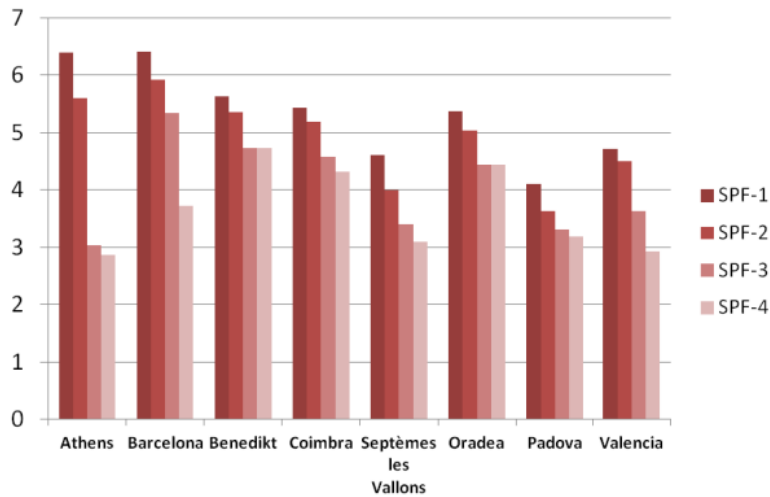
Figure Source: Nordman, R., et al. 2012. Seasonal performance factor and monitoring for heat pump systems in the building sector. SEPEMO-Build Final Report.

System Integration Challenge

- Most common failure – excess electricity consumption due to poor hydraulic design.
 - Non-optimal, overly high flow rates
 - U-tubes of too small a diameter
 - Unnecessary control valves
 - Blind reliance on variable-speed drives
 - No mechanism for shutting off central pumps.
- Other issues discussed below.

Ground-Med Project

Heating



Cooling

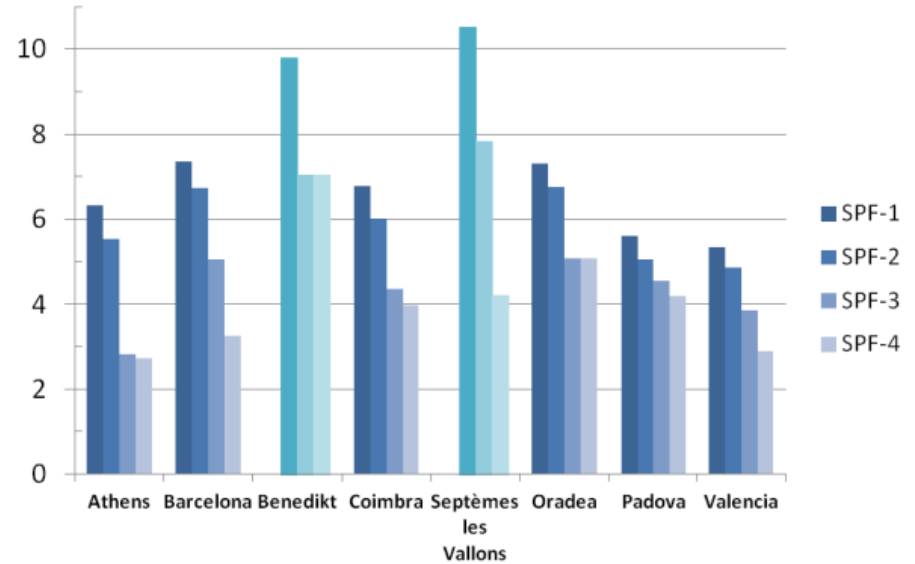
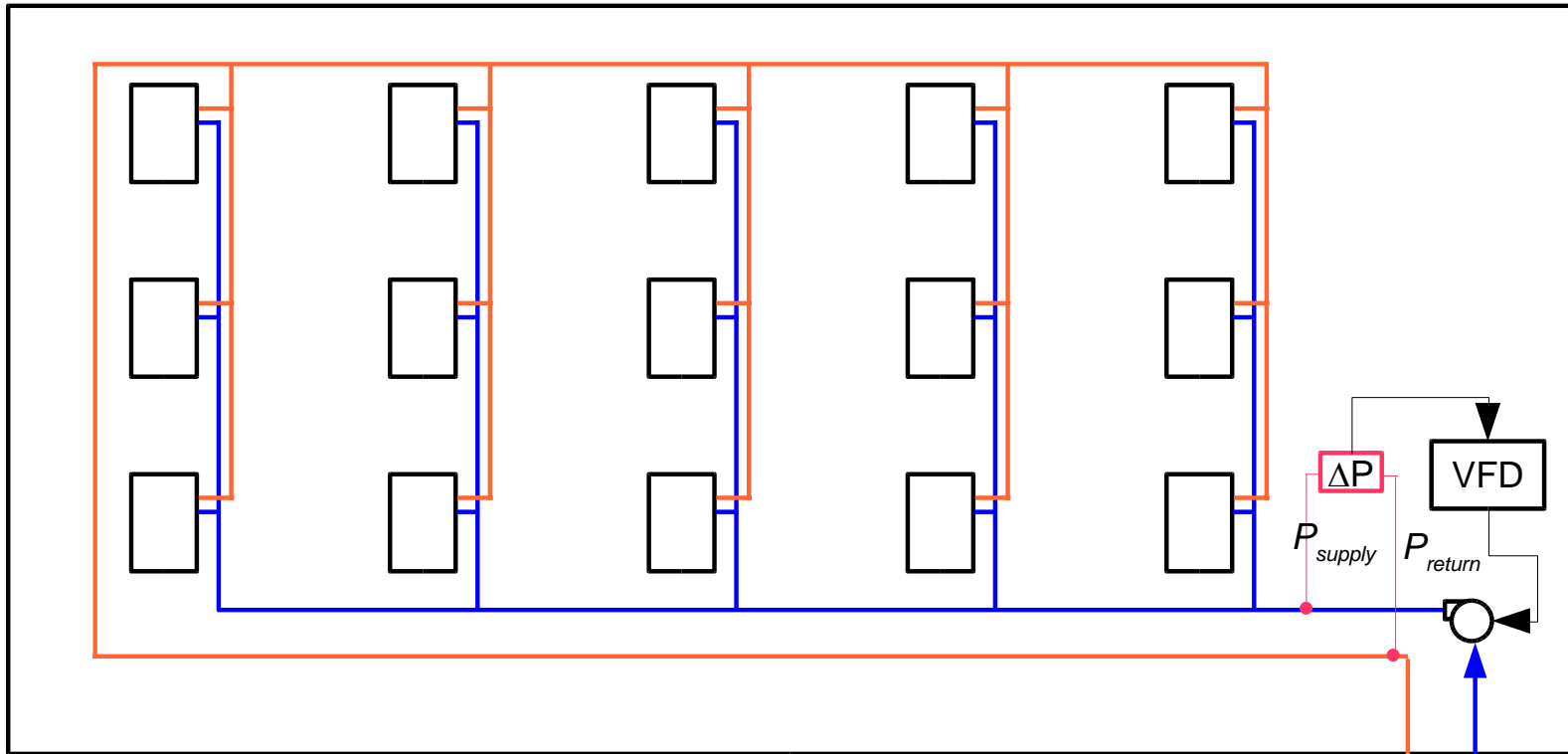


Figure source: Mendrinou, D. and C. Karytsas. 2016. *Monitoring results after 12 months of provision of heating and cooling at the 8 demonstration buildings of the European project "Ground-Med"*. Proceedings of the European Geothermal Congress 2016. Strasbourg, France 19-24 September.

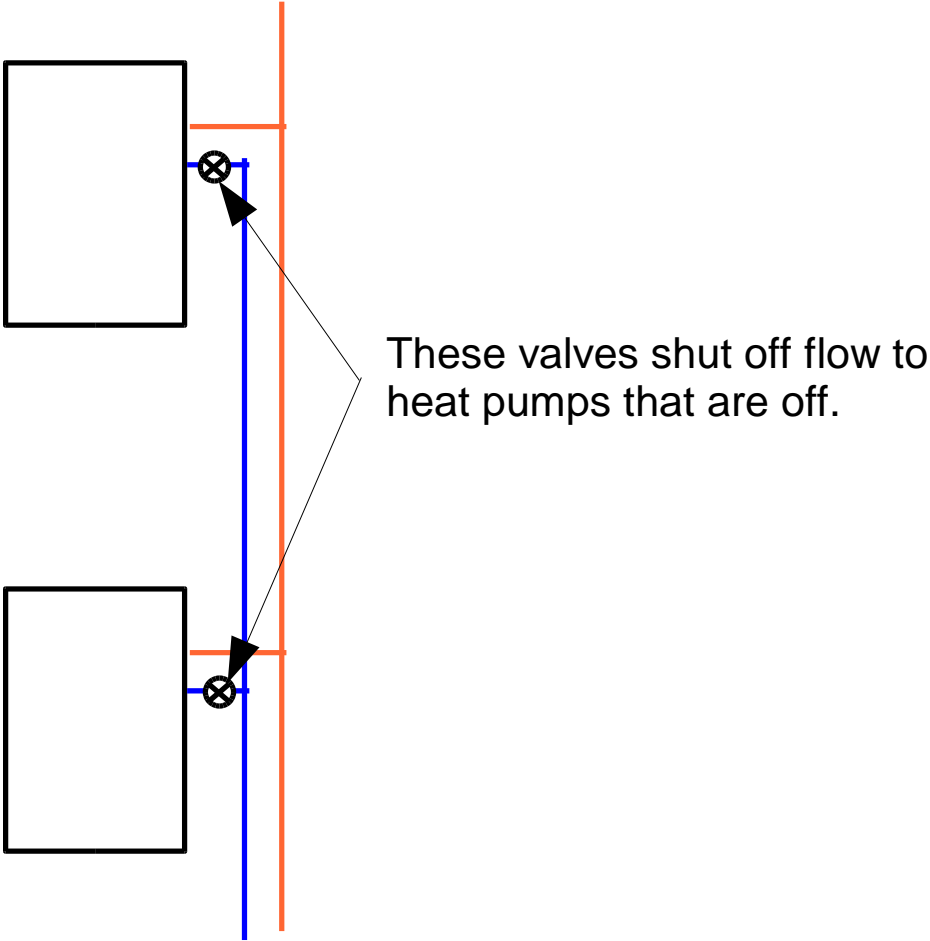
USA – Distributed heat pumps



Central pumping with variable speed pump

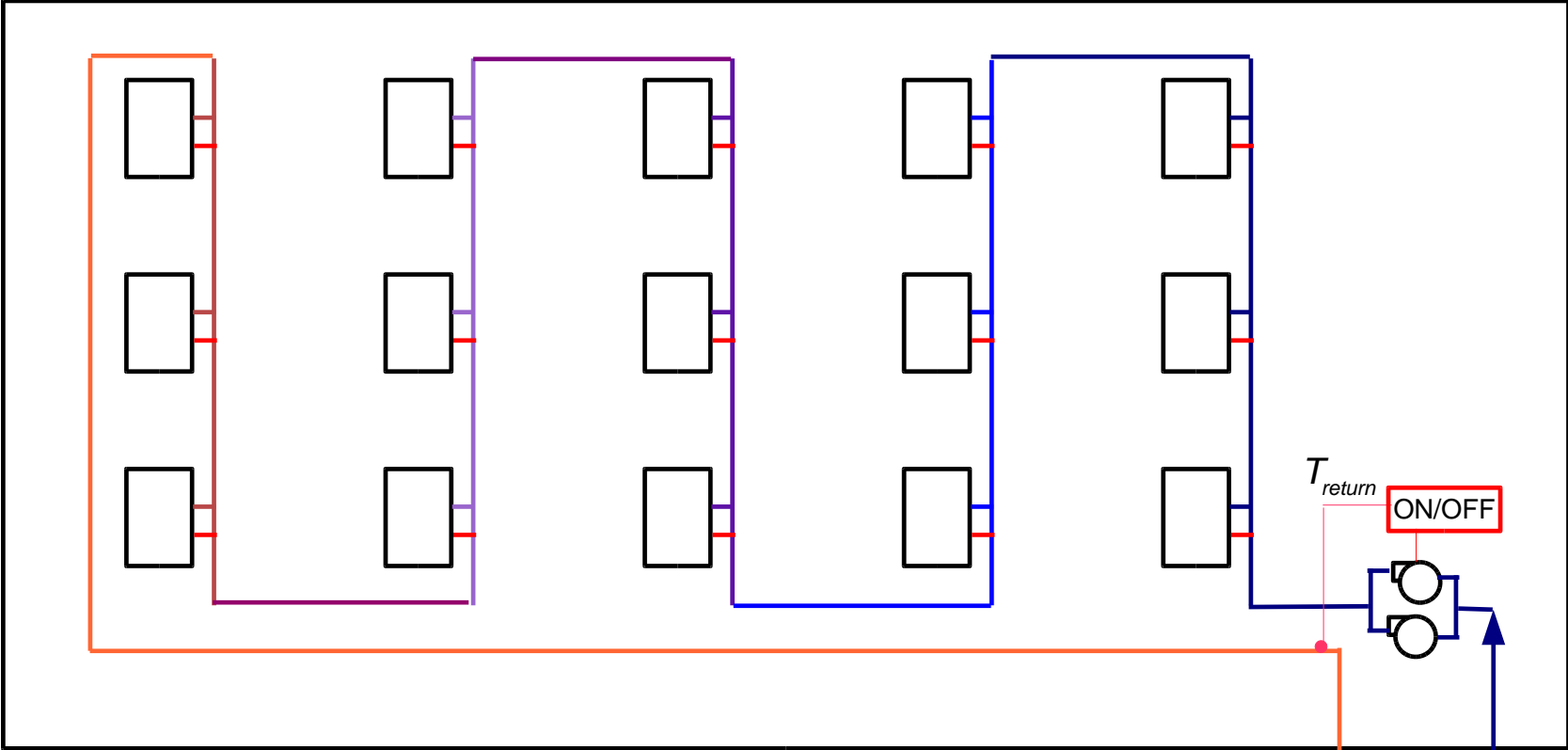
To/from borefield

USA – Distributed heat pumps



Central pumping with variable speed pump

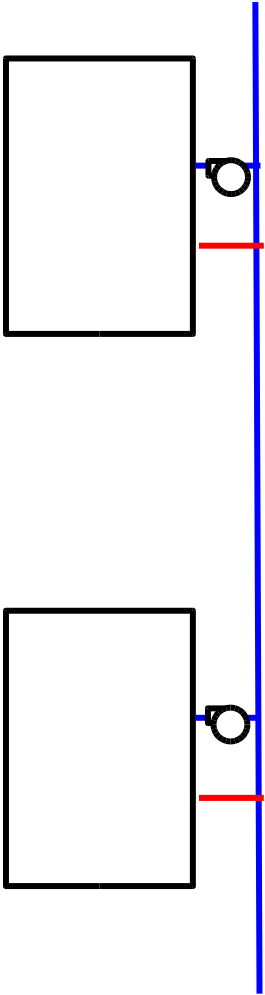
USA – Distributed heat pumps



“One-pipe” pumping system

To/from borefield

USA – Distributed heat pumps



Every heat pump has its own low-head circulating pump



Photo: J.D. Spittler

ASHRAE HQ GSHP SYSTEM

A living laboratory

- 2-story office building, built in 1965
- Renovated and enlarged in 2007-2008
 - Air-source heat pump (VRF) system - 1st floor
 - Ground source heat pump system -2nd floor
- Extensive measurement system
- EnergyStar building (75 or better)
- Extremely knowledgeable owner and maintenance staff

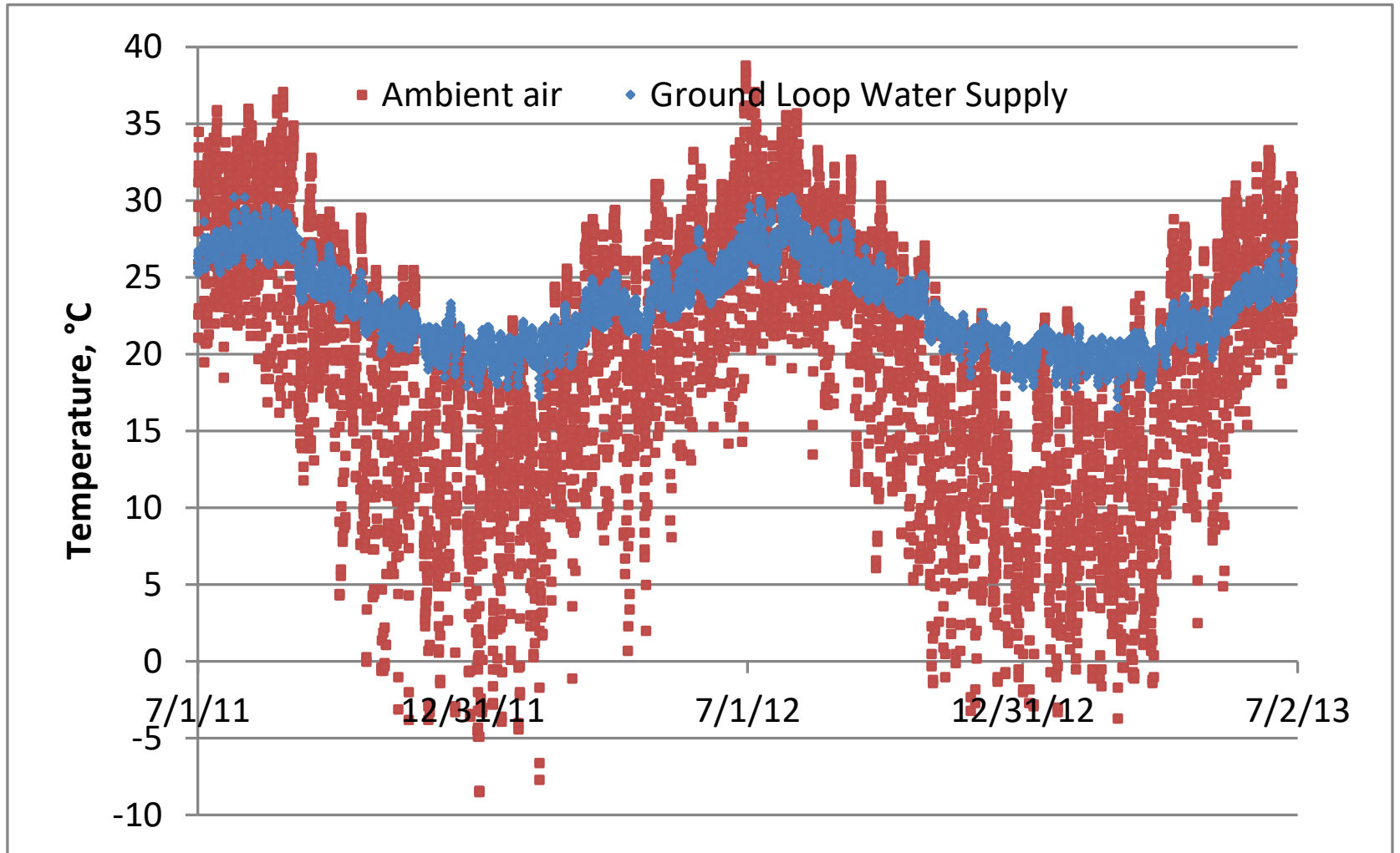
GSHP System

- 12 boreholes, 122 m deep, **grouted**
- 14 water-to-air heat pumps, 111 kW nominal capacity (**Distributed system, not central.**)

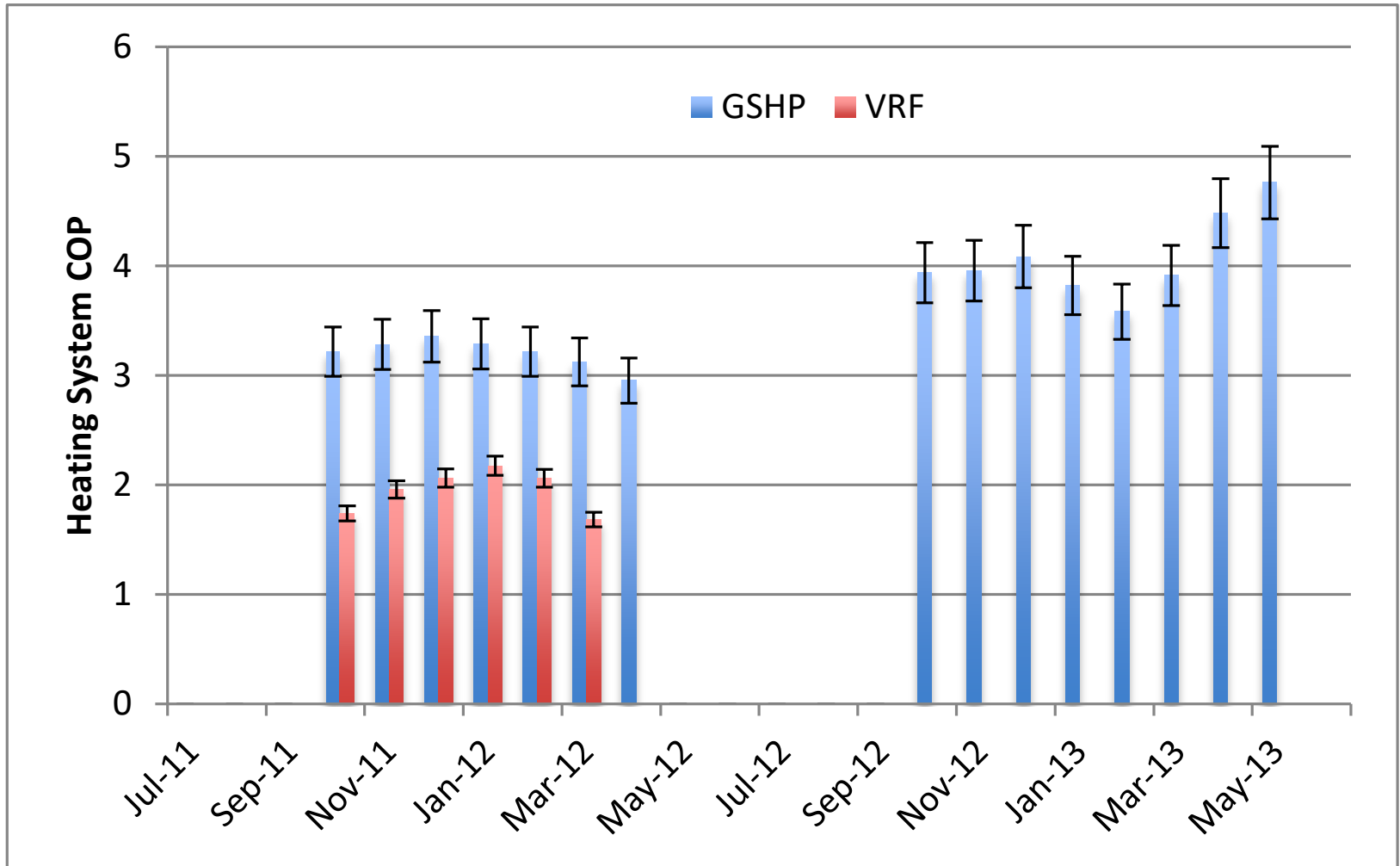


Photos: J.D. Spitler

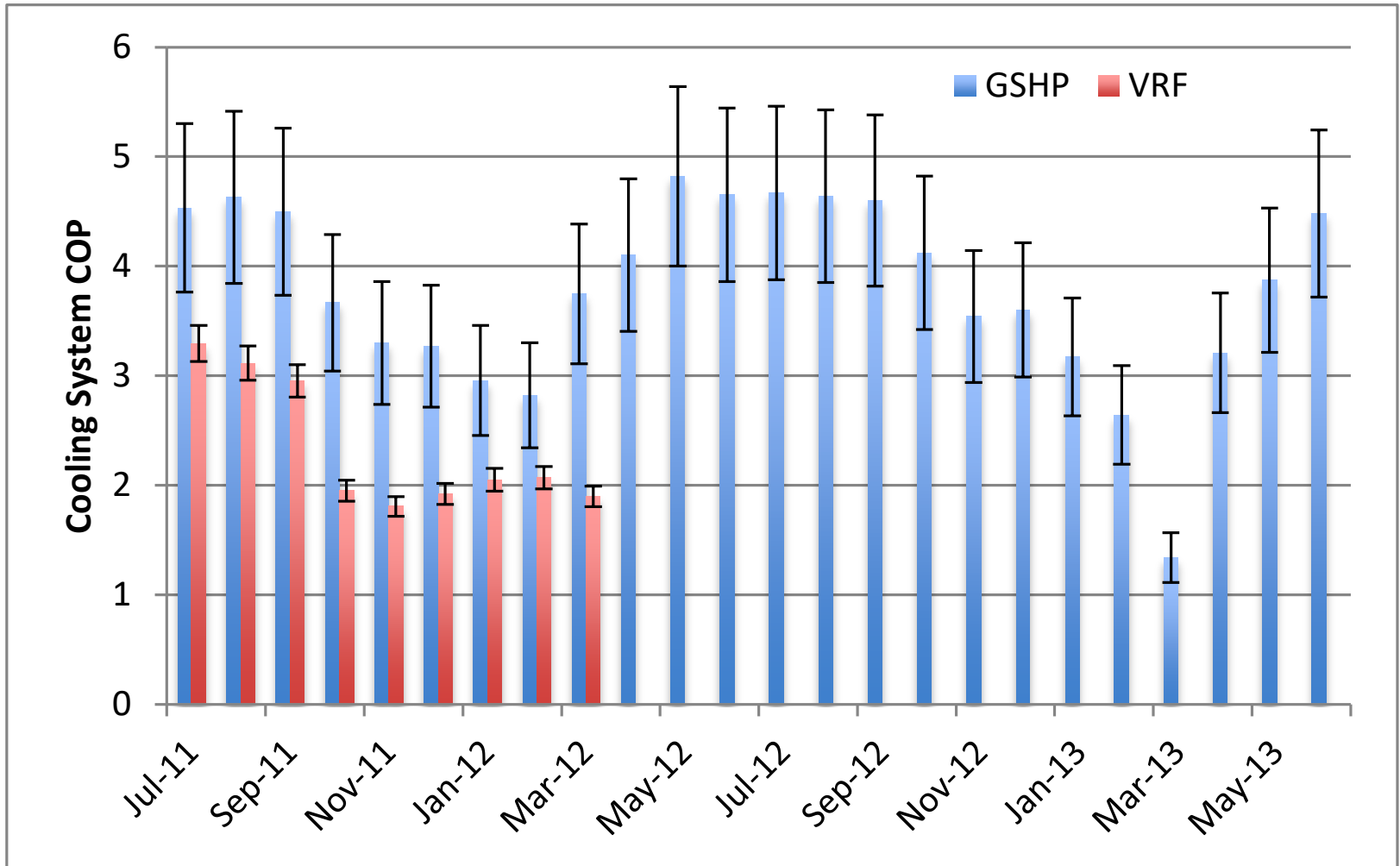
Source Temperatures



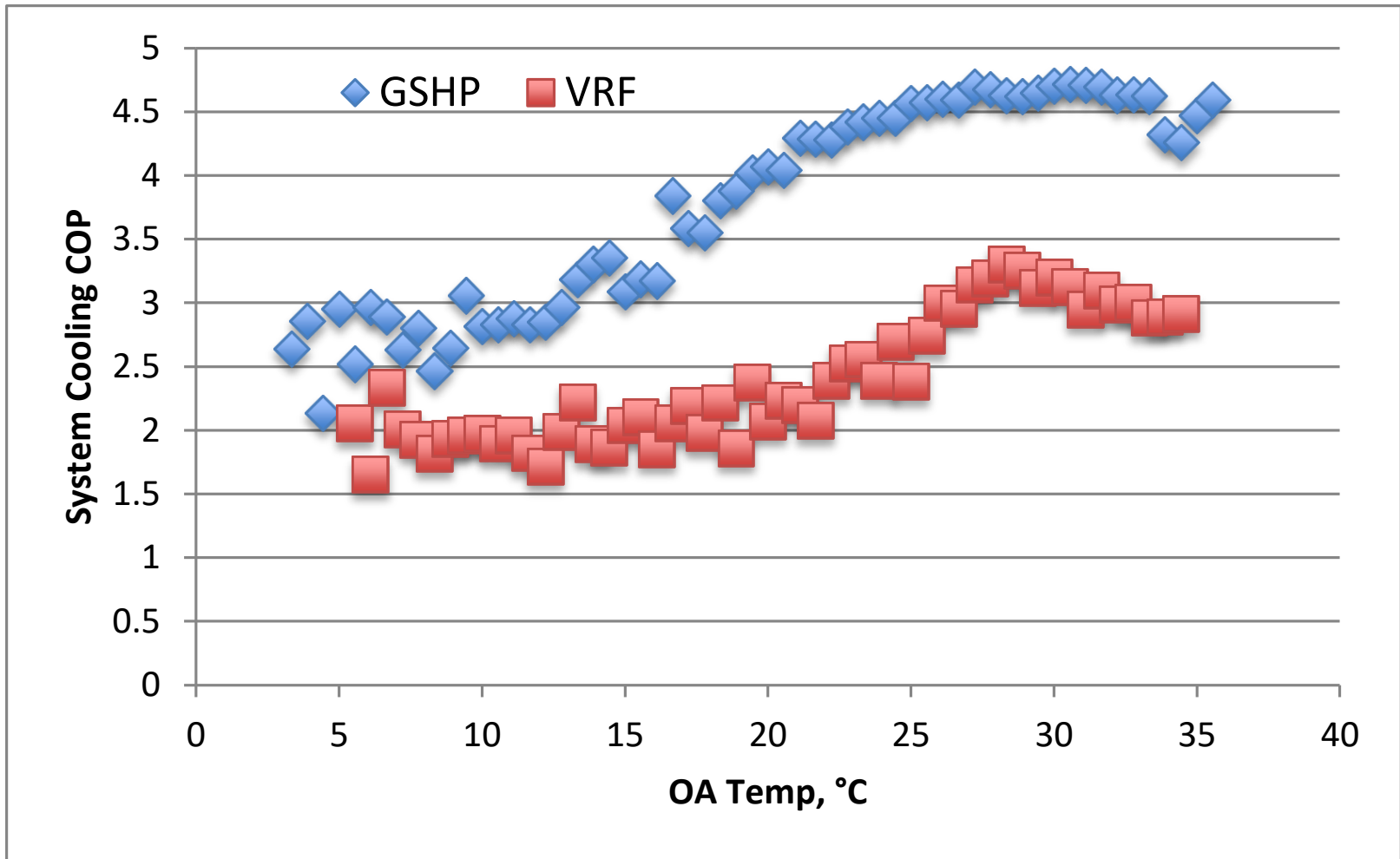
Monthly System Heating COP



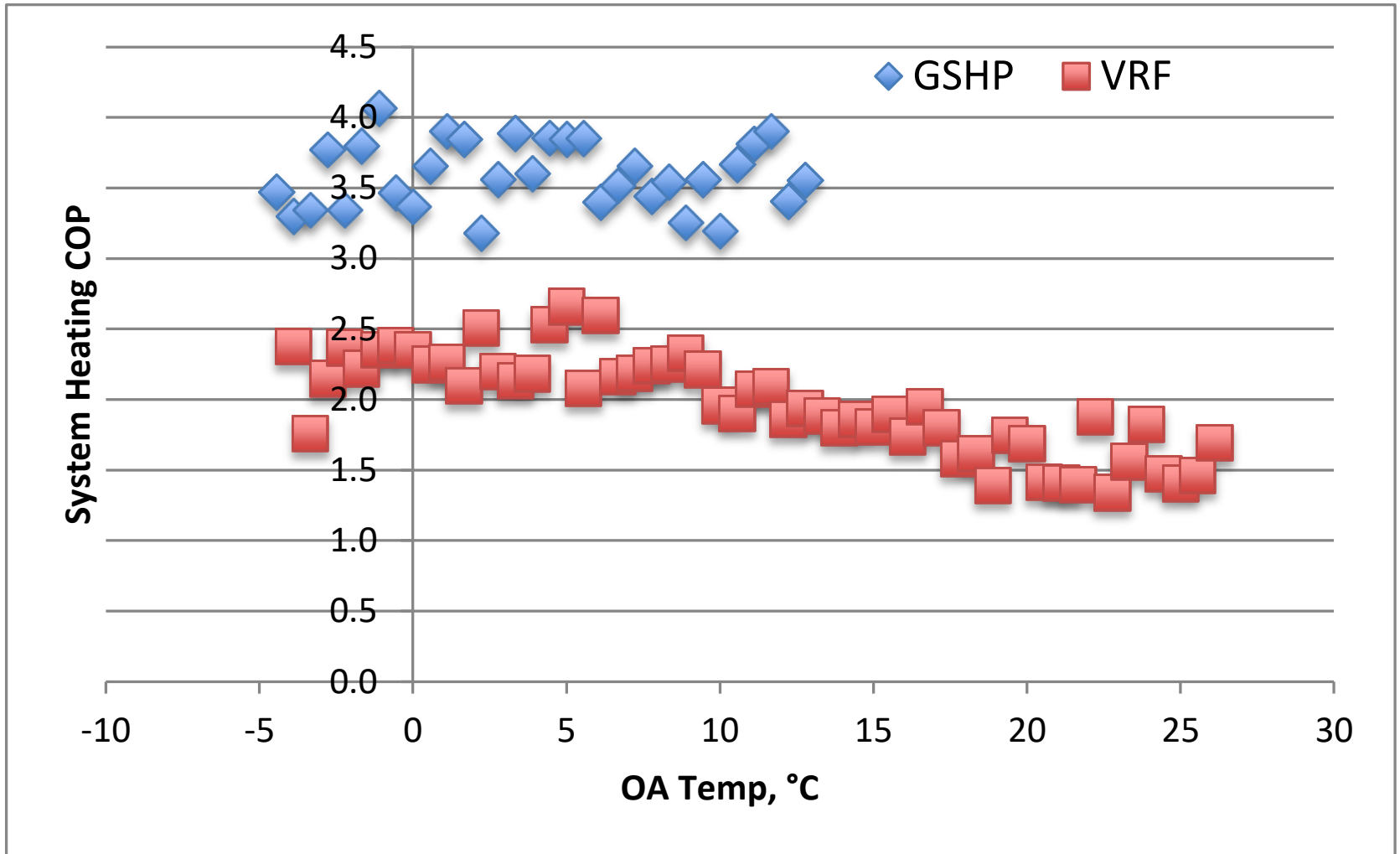
Monthly System Cooling COP



Cooling performance



Heating Performance

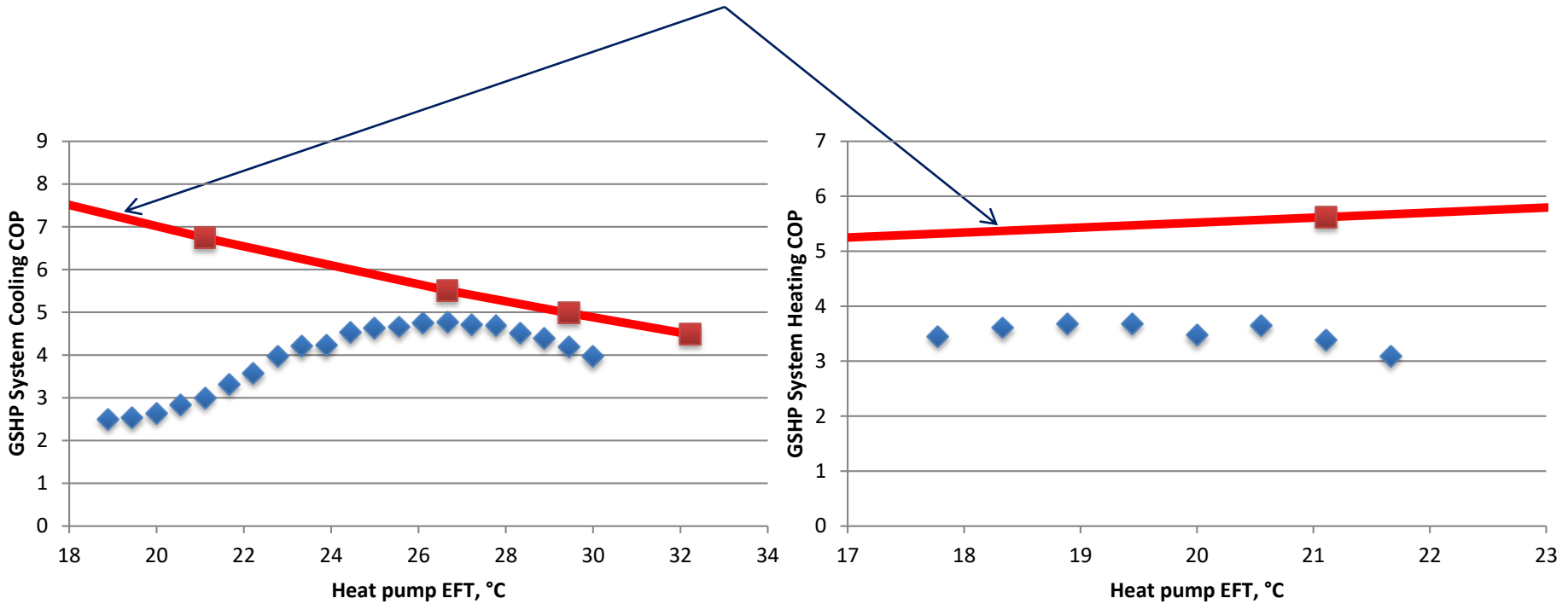


Comparison

- GSHP system has significantly higher COP than air-source VRF system for both heating and cooling.
- But, could the GSHP system be better?
- What else can we learn from the ASHRAE HQ building?

System COP vs. Rated HP COP

Catalog data for one of the heat pumps, medium flow conditions



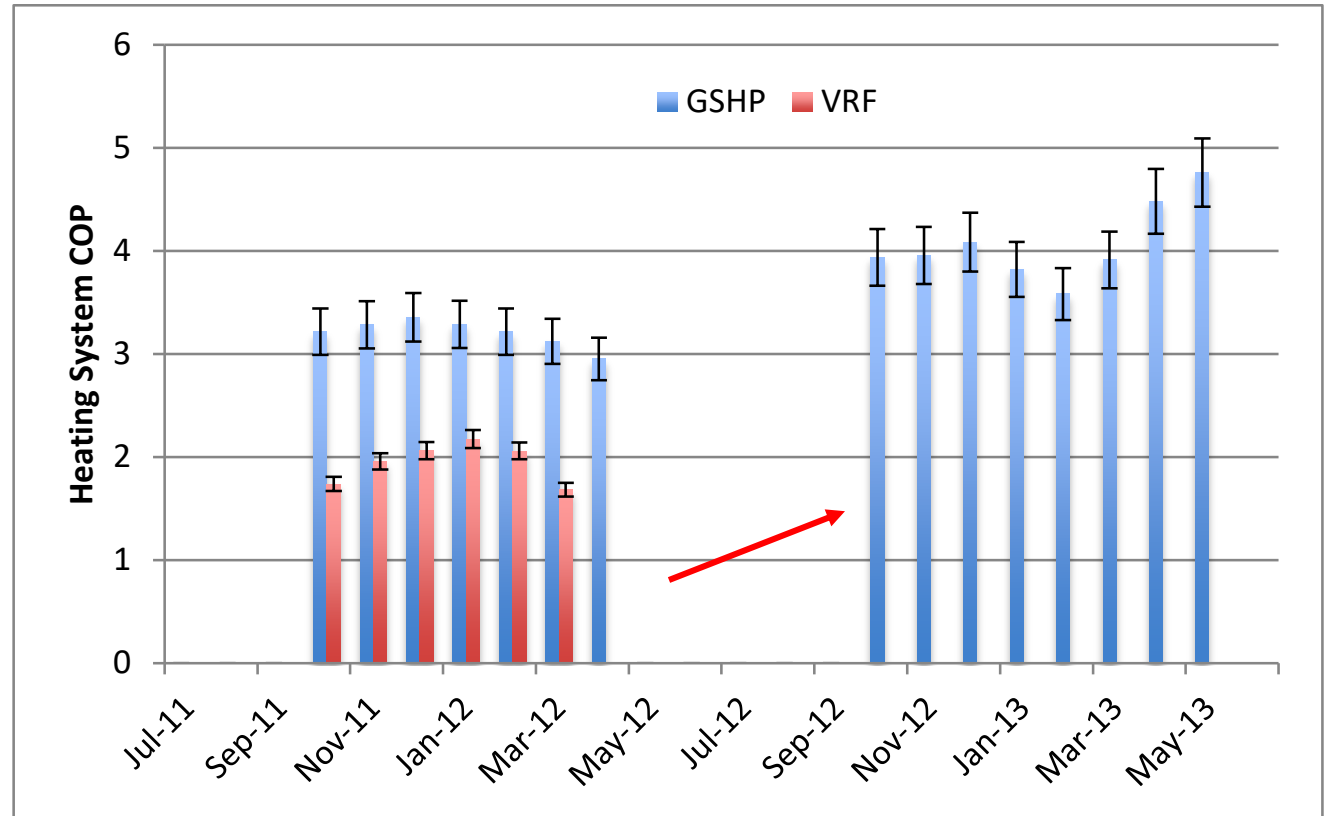
System COP drops as EFT is more favorable

- Particularly for cooling
- What accounts for this?
 - Pumping energy
 - Heat pump cycling losses
 - Energy uses occurring while compressors are off:
 - Heat pump fans running for ventilation.
 - Control boards run all the time.
 - One failed heat pump also affects the results

Sensitivity to pumping energy

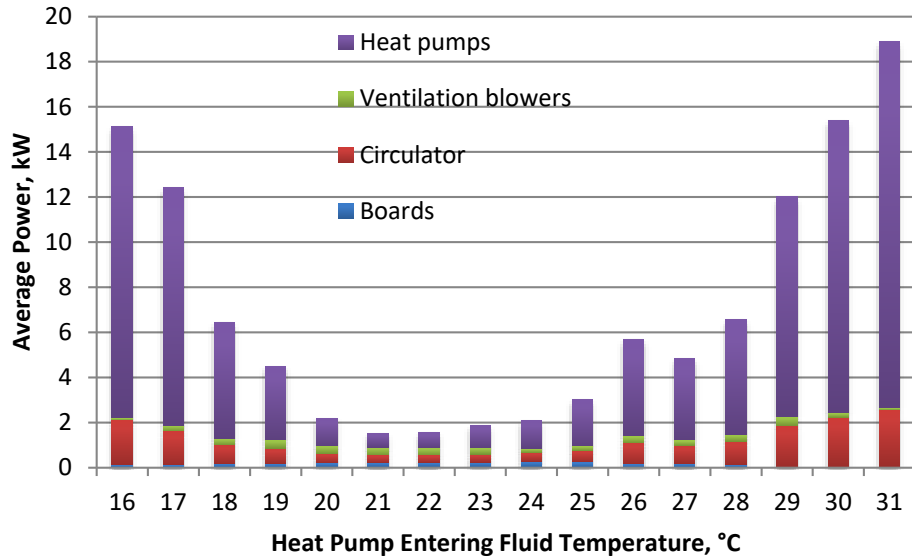
Lowering setpoint of differential pressure controller at ASHRAE HQ, from 138 kPa to 55 kPa.

(Weather effects?)

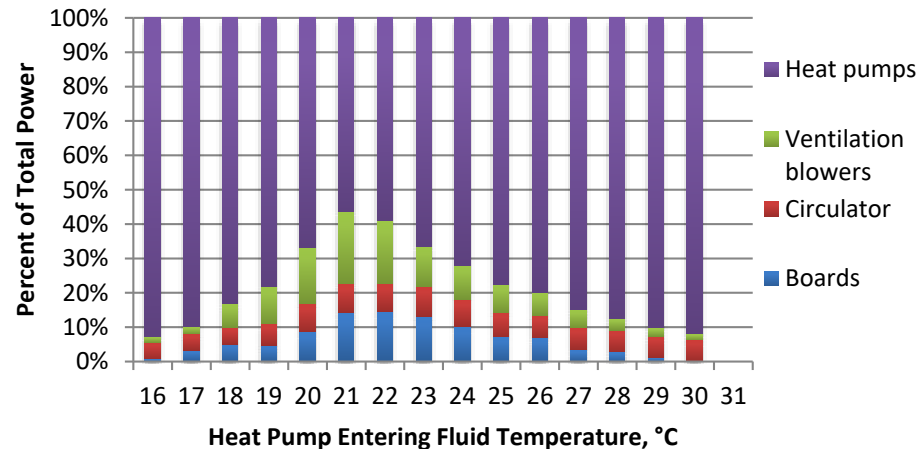
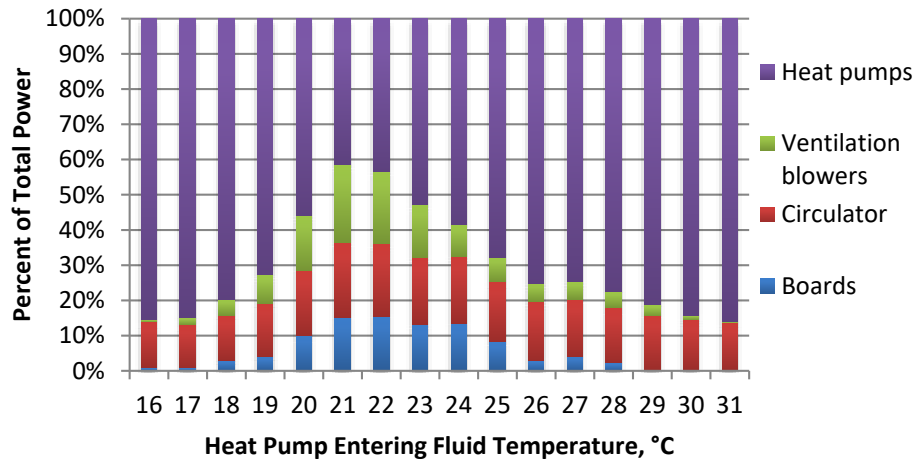
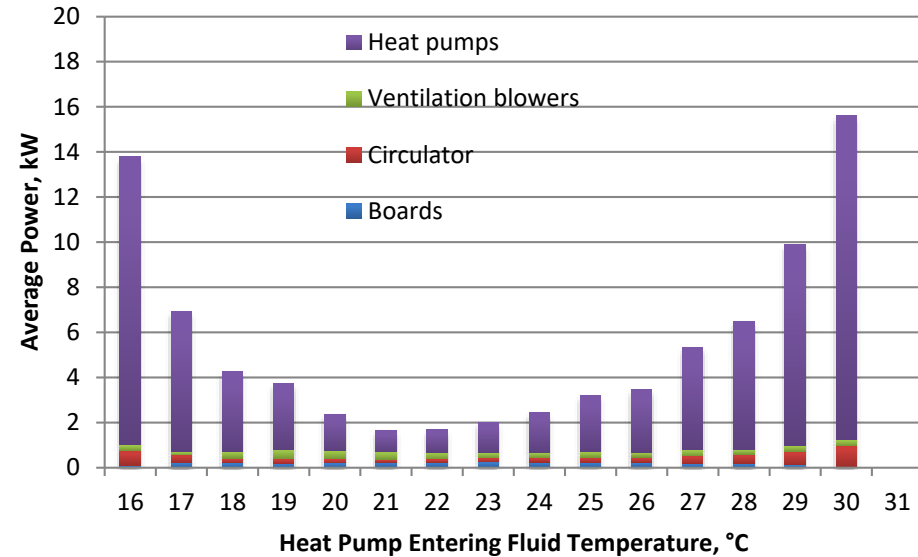


Heating and Cooling Power

138 kPa.

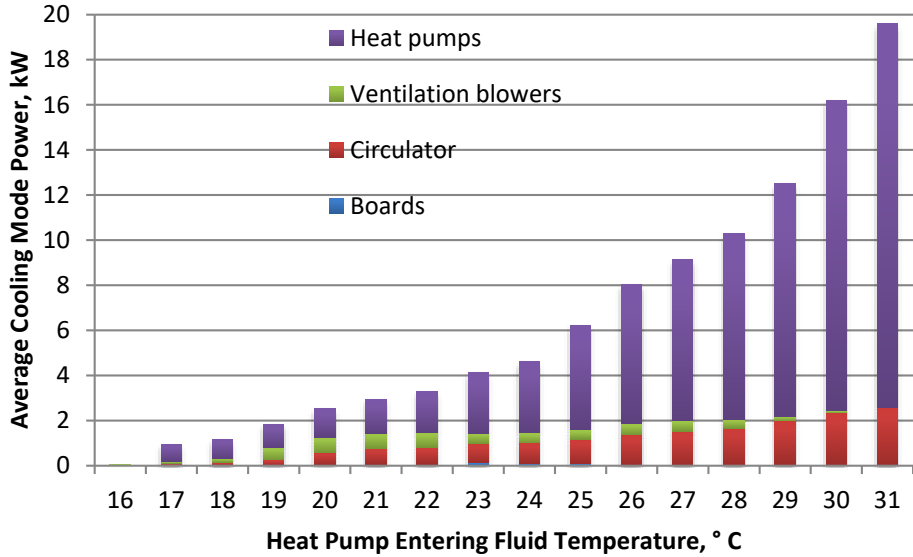


55 kPa.

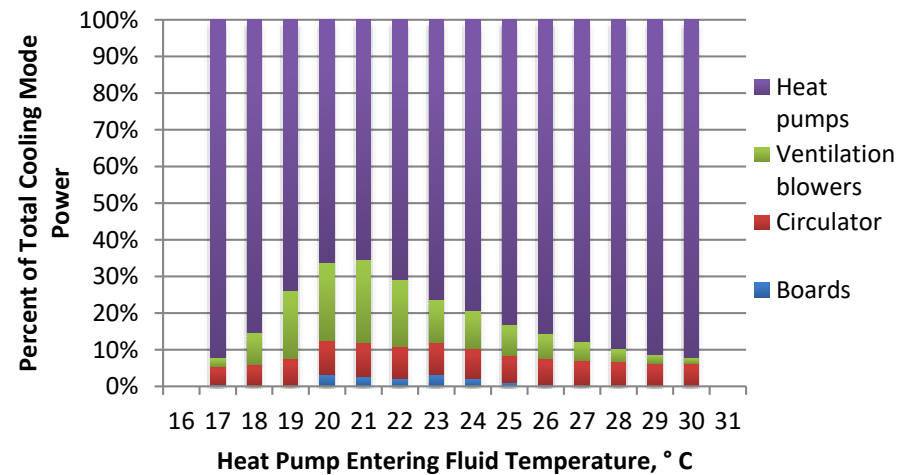
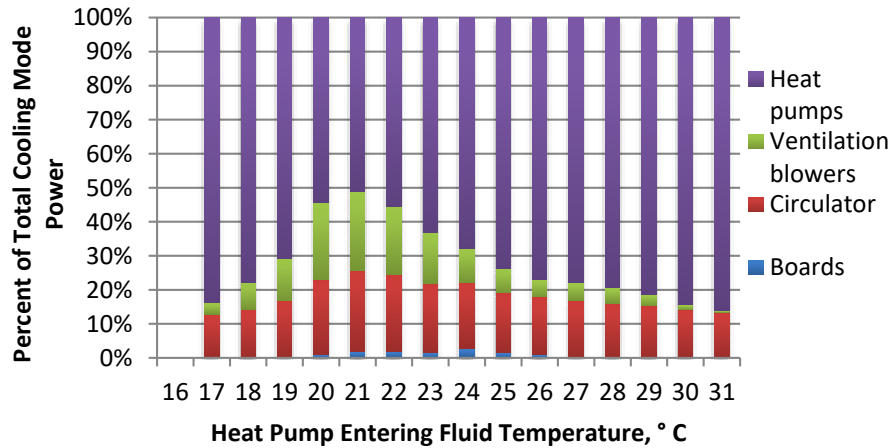
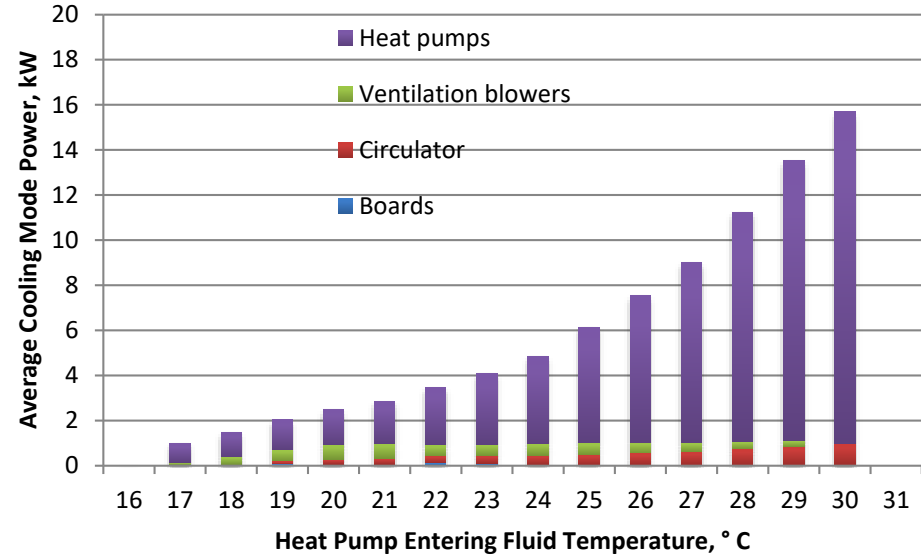


Cooling Power

138 kPa.

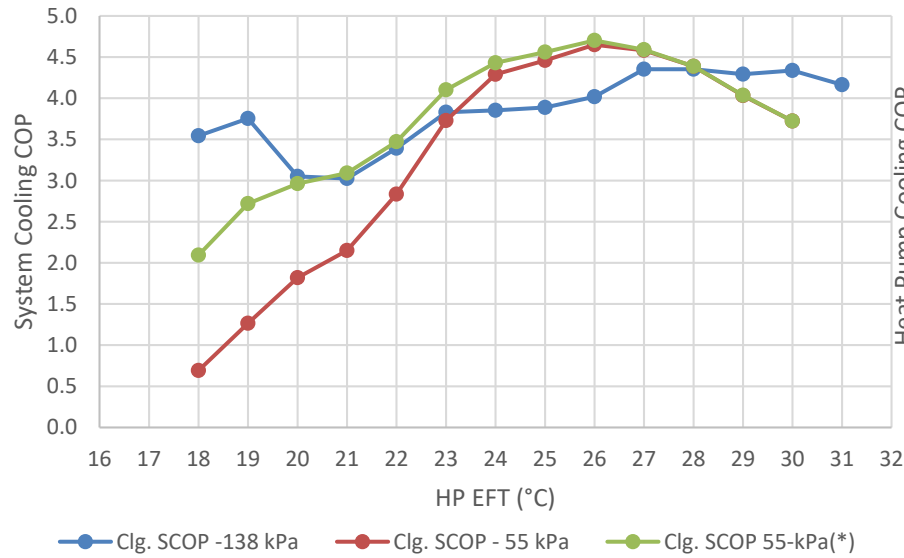


55 kPa.

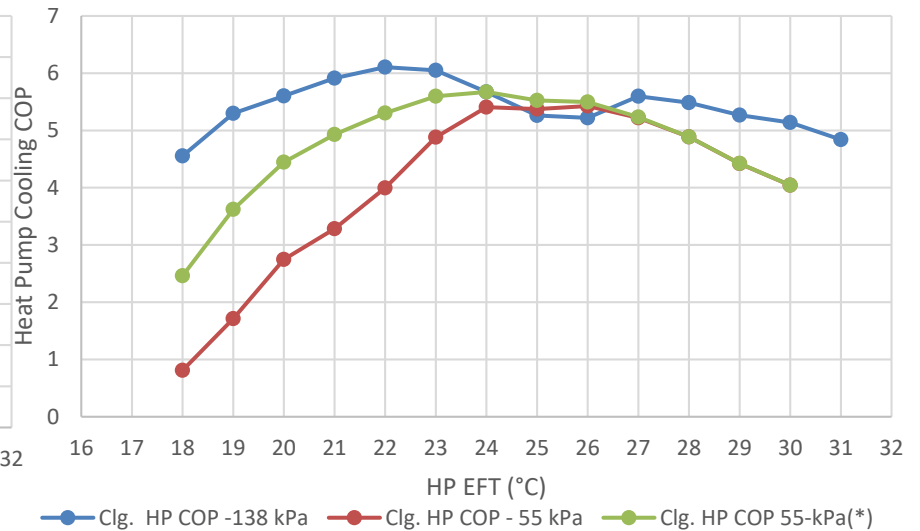


Cooling COP

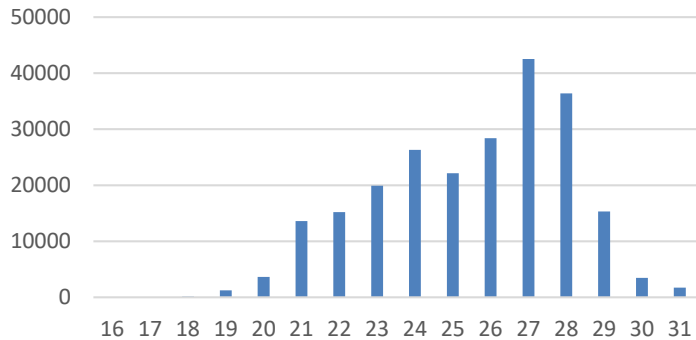
Cooling System COP



Heat Pump Cooling COP

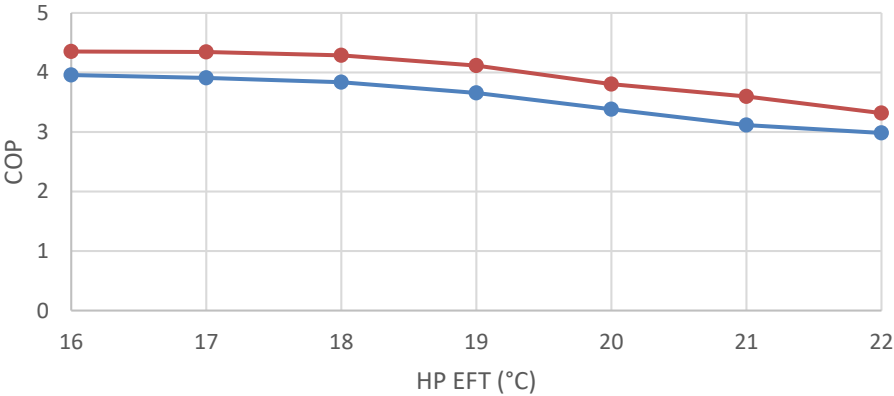


Cooling provided, kWh



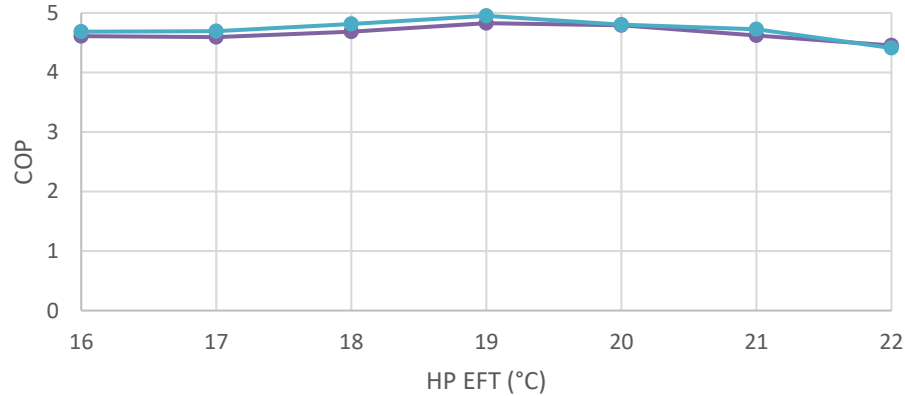
Heating COP

Heating System COP



● Htg. SCOP -138 kPa ● Htg. SCOP -55 kPa

Heat Pump Heating COP



● Htg. HP COP -138 kPa ● Htg. HP COP -55 kPa

Summary

- GSHP system much more efficient than ASHP system, but:
- Efficiency significantly affected by:
 - Pumping system design
 - Pumping system controls
 - Heat pump cycling losses (more significant in cooling?)
 - Miscellaneous losses
 - Undetected heat pump failure

Today

- Design system for low head loss.
- Don't rely on VSD alone for reducing pumping energy.
- Don't leave a central pump on all the time.
- Commissioning – by someone who understands how the system is supposed to work!
- Reduce cycling – larger buffer tanks?

Future

- Automated performance analysis.
- Automated fault detection.
- Reduce cycling losses with variable-speed heat pumps?
- Monitor and reduce parasitic losses.
- More system-monitoring research would be useful.

SPF/COP

