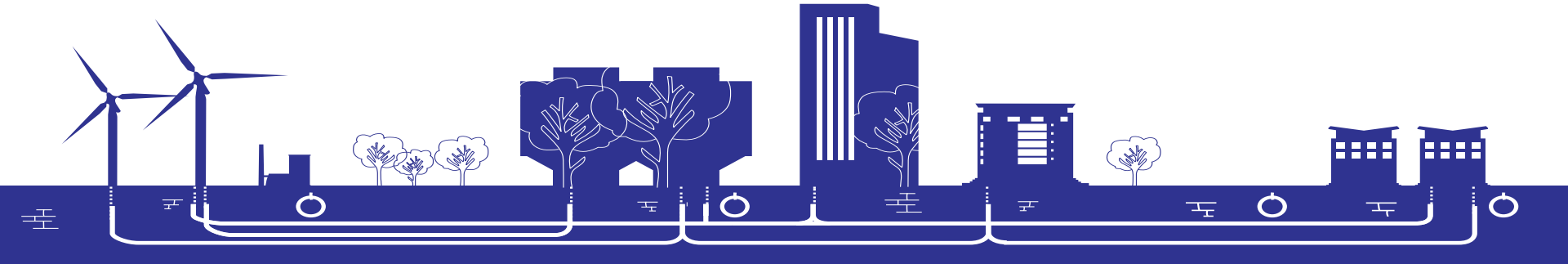
# Dynamic operation of a large-scale heat pump and implications for the provision of ancillary services - Case study from EnergyLab Nordhavn

Wiebke Meesenburg, DTU Mechanical Engineering, wmeese@mek.dtu.dk
Tore Gad Kjeld, HOFOR, tgkj@hofor.dk



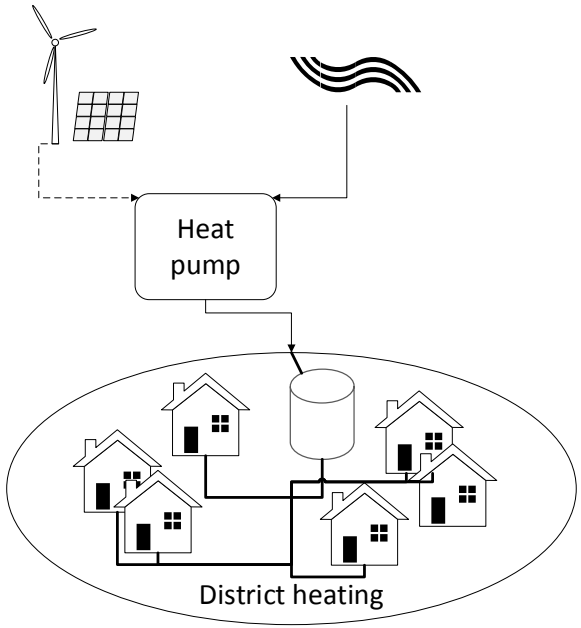
# Can large-scale heat pumps deliver ancillary services?

## Advantages compared to individual heat pumps

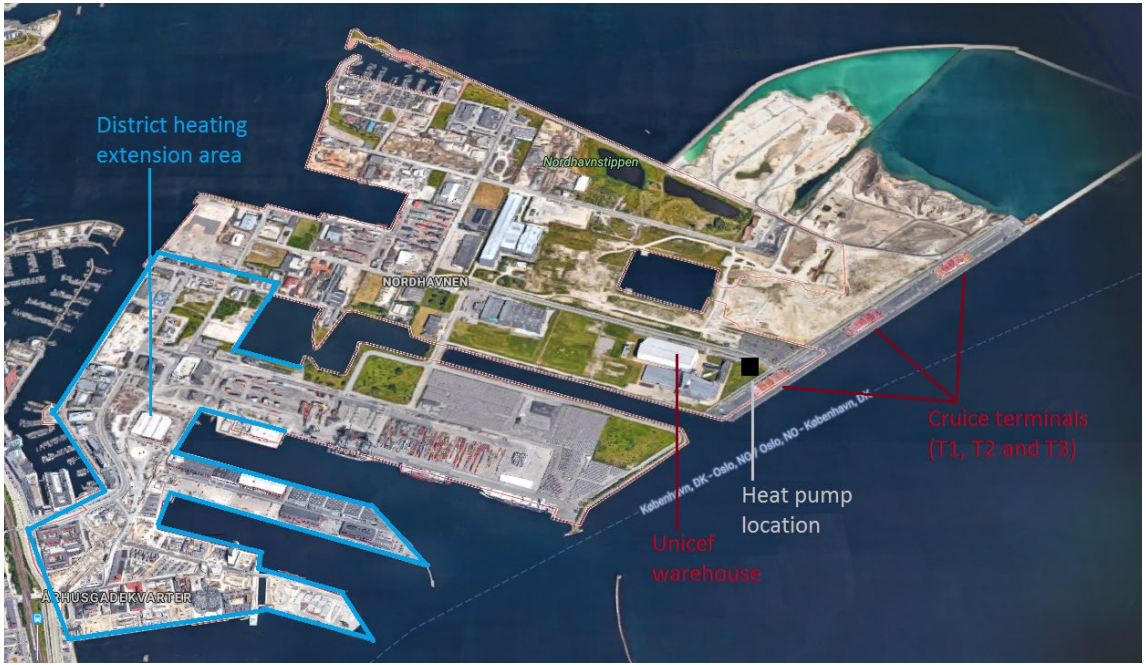
- Larger amount of regulation power
- District heating systems offer high flexibility (storages, network, buildings)
- Professionally managed units
- Specific cost for control and communicaction is lower

## Disadvantages compared to individual heat pumps

- Slower start-up and ramping
- Designed for base load



# The FlexHeat heat pump system




Source: Hofor

Source: C.Saltini & A. Sanchez Garcia

# The FlexHeat heat pump system

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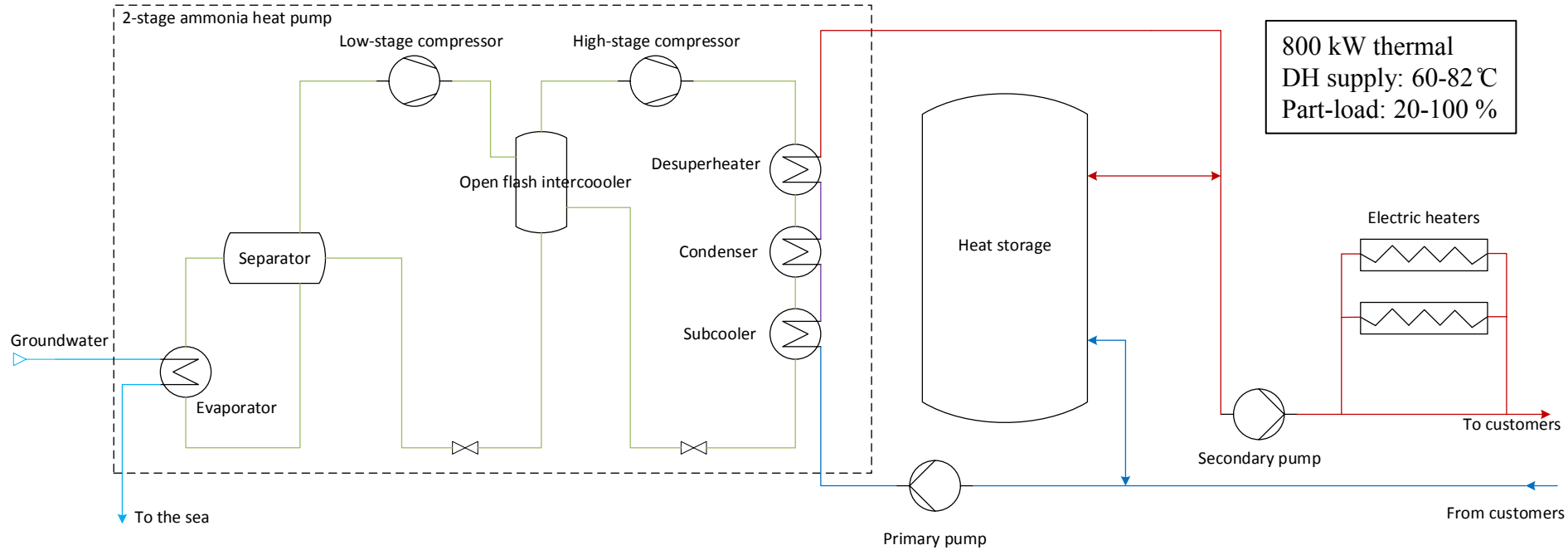
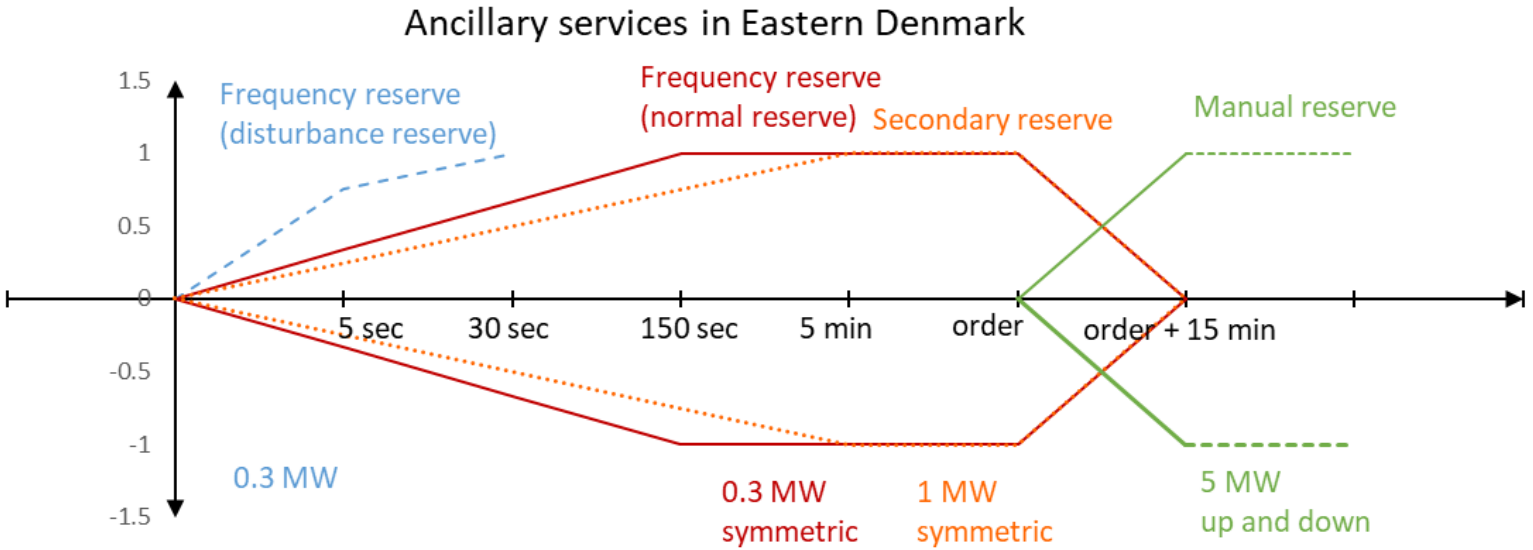
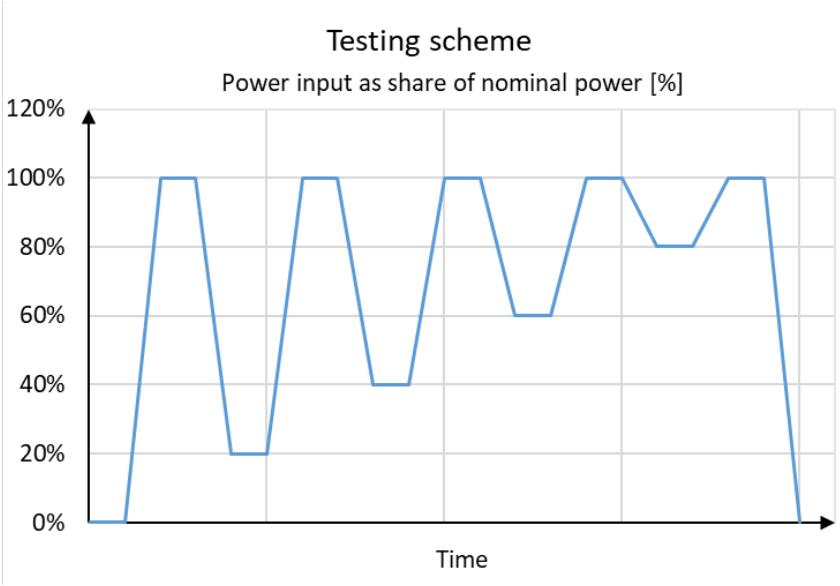
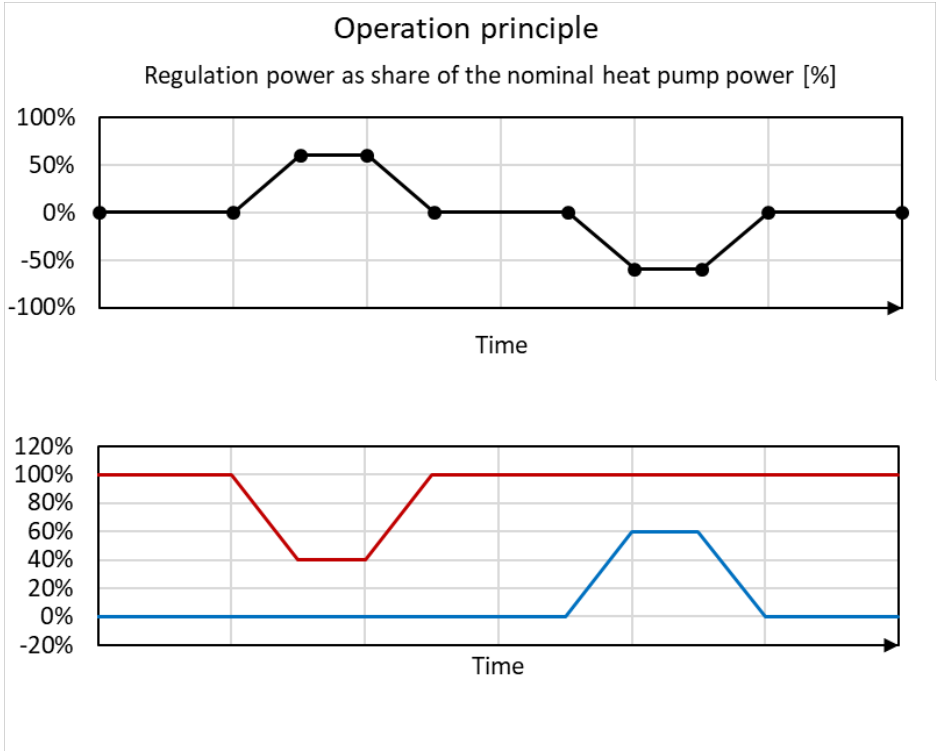


# Regulation services in Denmark

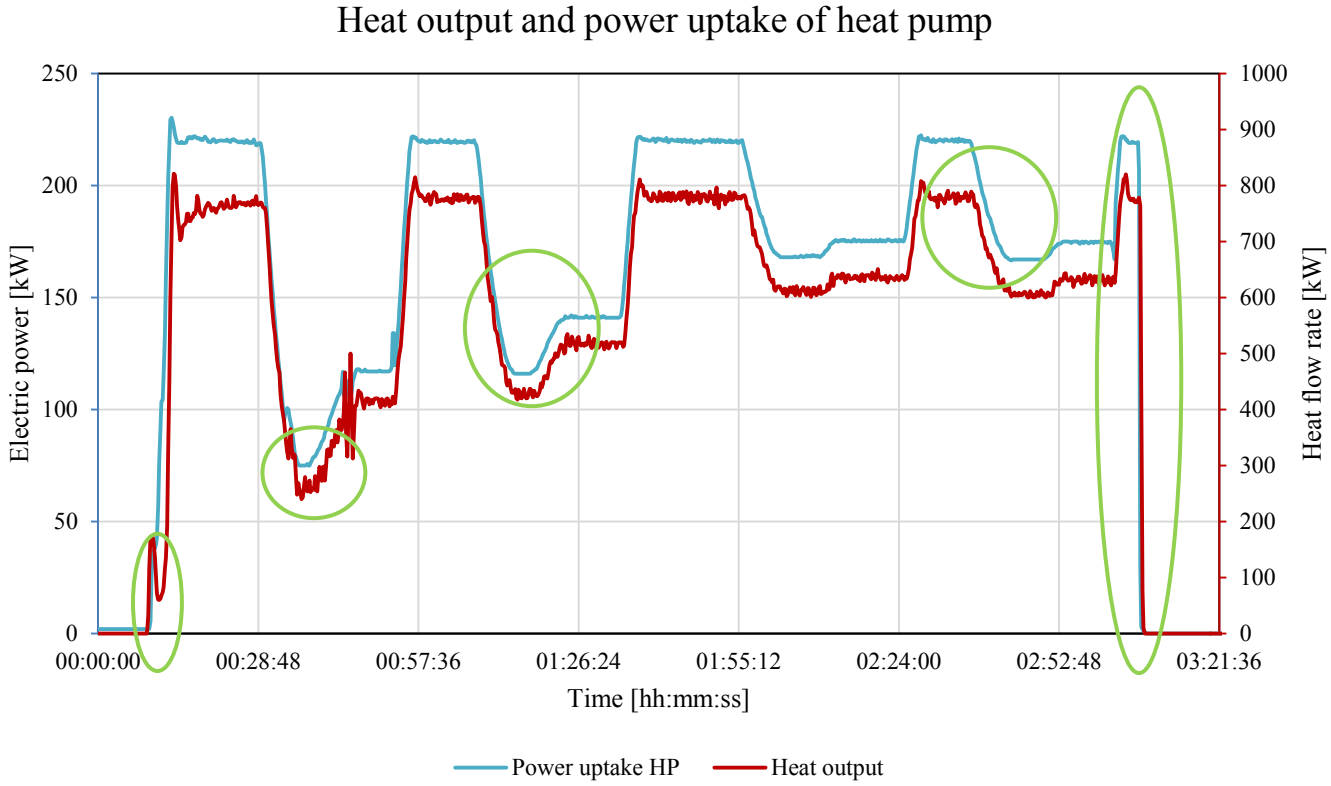


# Testing scheme & Operation principle

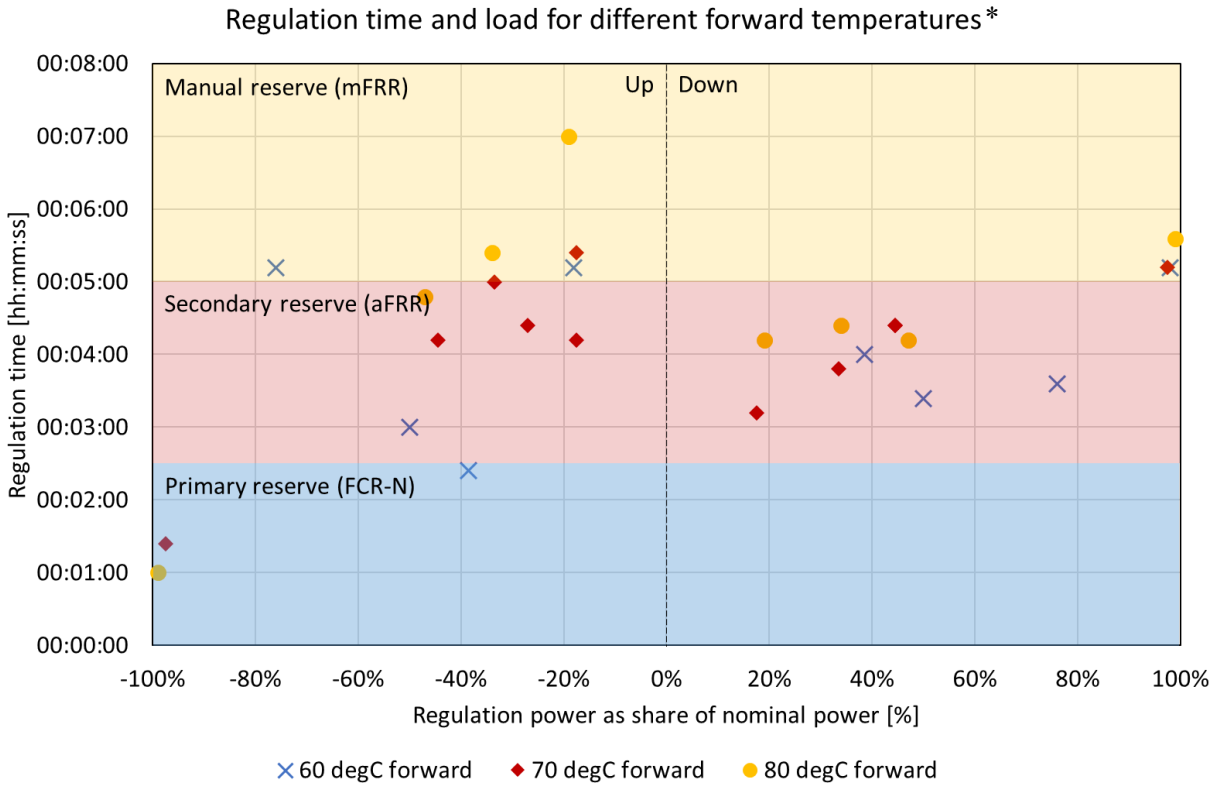


# Results: Dynamic test of heat pump



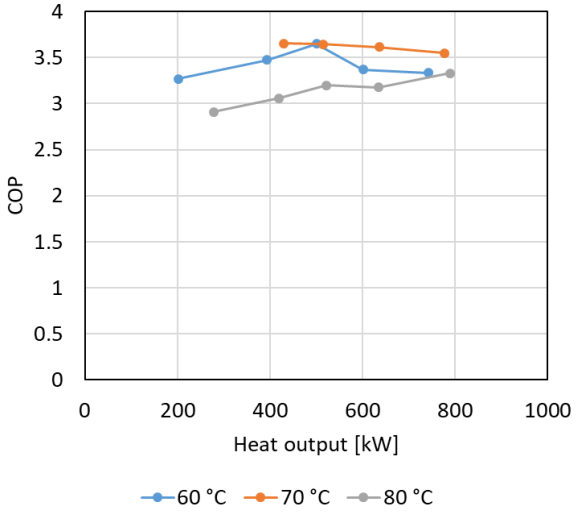
# Results: Regulation time



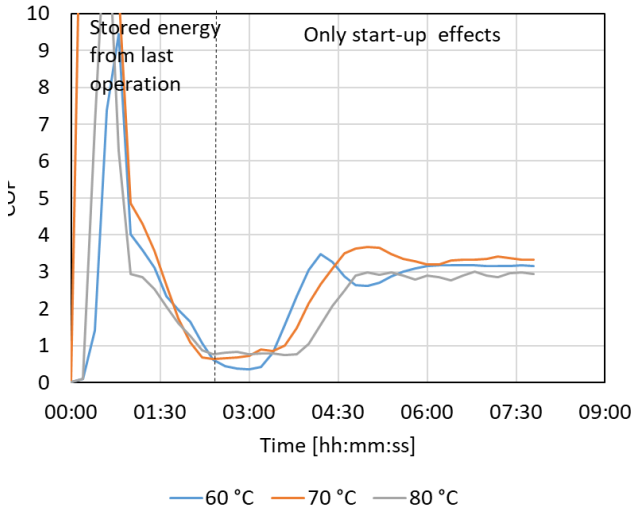

* If overshooting during down-regulation can be balanced out

# Results: Coefficient of performance

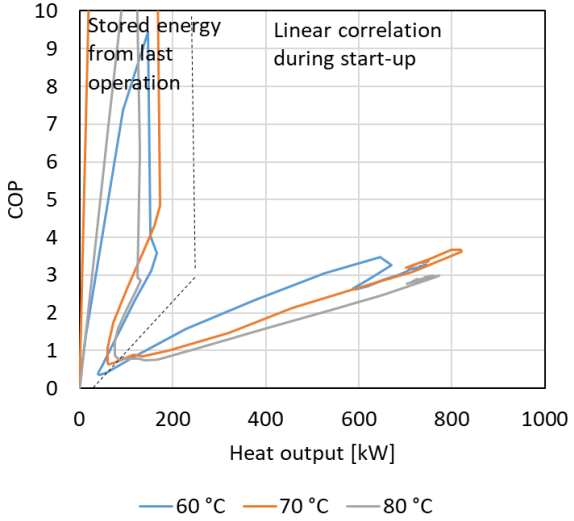
Measured COPs under steady-state conditions



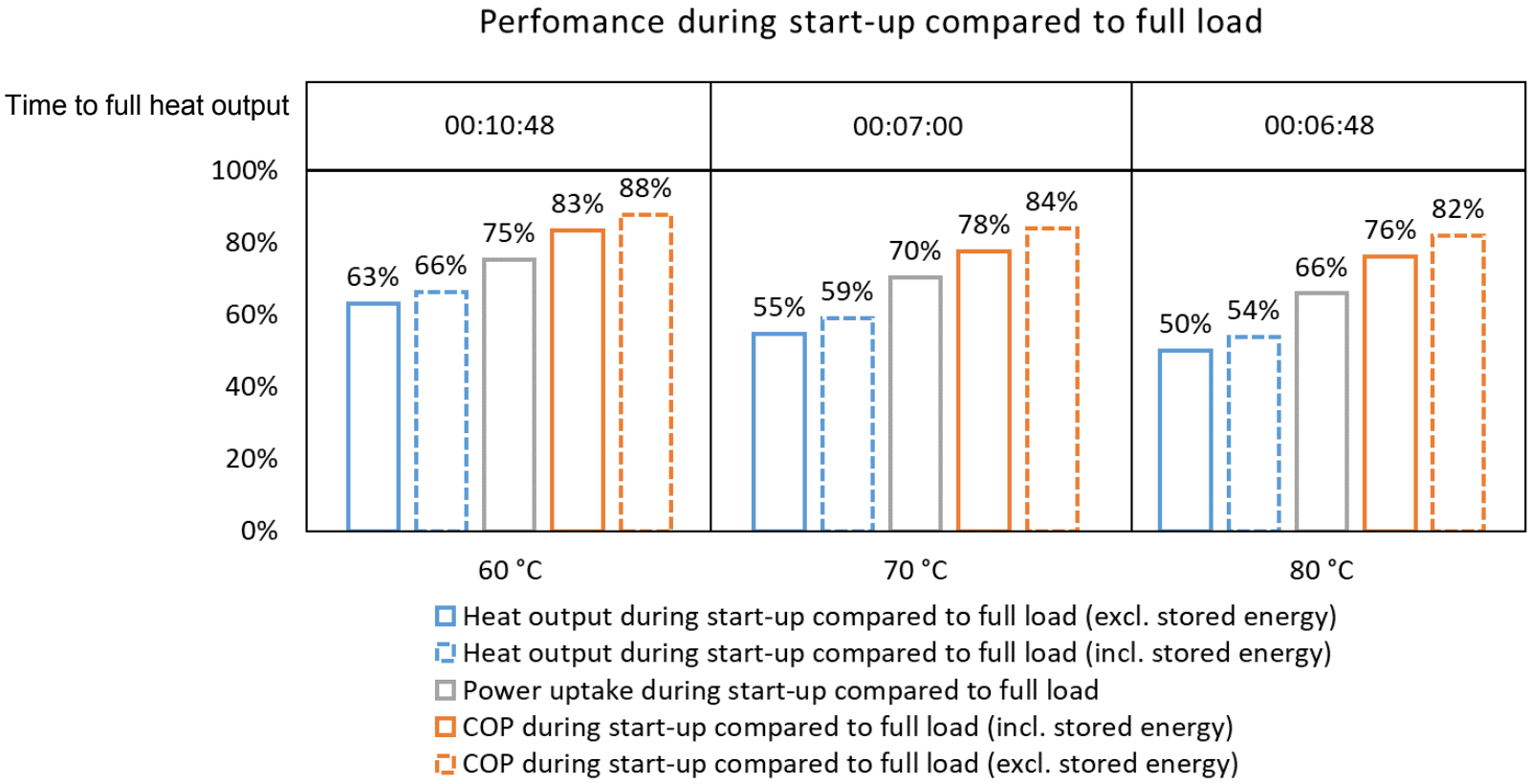

COP during start-up for three different forward temperatures




COP during start-up over heat output for three different forward temperatures



# Results: Perfomance during start-up

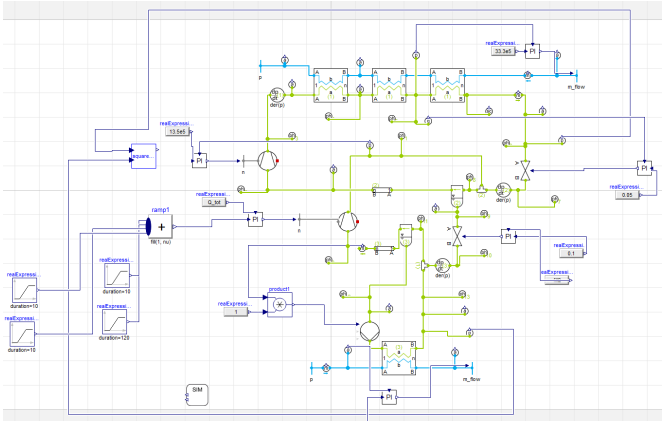


# Learnings from experiments

For very fast regulation (<150 sec)…

- Heat pump design and control strategy have to be designed for flexible operation
  - to avoid damages due to sudden condensation in the suction line
  - to enable the necessary ramping rates
  - to use the combination of heat pump and electric boiler power uptake optimally
- Heat exchangers cool down very slowly during stand still -> cold start-up seems not to be a problem
- Fast start-up benefits high perfomance, i.e. low operation cost of flexibly operated heat pump

# Simulation & on-going work



Dynamic model of the heat pump to

- Test improved design
- Test of control strategies
- Derive design recommendations for flexible heat pumps

Example:

Prediction of the necessary preheating of the suction line, to prevent spontanous condensing in the suction line during rapid ramp-down.

# Conclusion & Outlook

Implications for the provision of ancillary services

- Tertiary reserve
  - Is possible without changing the system
  - Could also be provided by shutting down completely and start-up from zero
- Secondary reserve
  - is possible by going into part-load
  - improved control is recommended for down-ramping
- Primary reserve
  - might be possible with special design of the heat pump -> future research

Thank you for your attention ☺

**Wiebke Meesenburg**
PhD student

Technical University of Denmark
Mechanical Engineering, Section of thermal energy
Nils Koppels Allé 403, DK-2800 Kgs.Lyngby
wmeese@mek.dtu.dk
www.dtu.dk