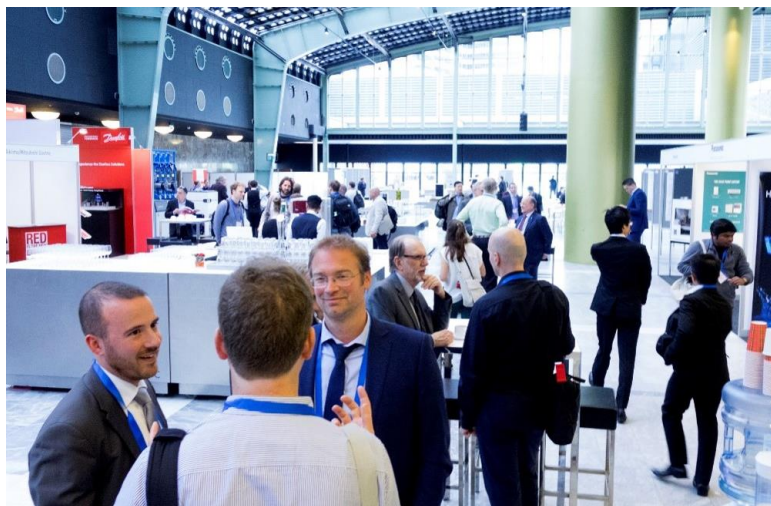


IEA Technology Collaboration Programme on Heat Pumping Technologies (HPT TCP)



Research, Development, Demonstration, and Deployment of Heat Pumping Technologies

The HPT TCP is part of a network of autonomous collaborative partnerships focused on a wide range of energy technologies known as Technology Collaboration Programmes or TCPs. The TCPs are organized under the auspices of the International Energy Agency (IEA), but the TCPs are functionally and legally autonomous. Views, findings, and publications of the HPT TCP do not necessarily represent the views or policies of the IEA Secretariat or its individual member countries.

Flexibility from large-scale heat pumps

IEA HPT TCP Annex 57 Task 4

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What do we mean by flexibility?



Thermal flexibility

- Adaption of heat uptake or heat output
- Adaption of delivered temperatures



Electric flexibility

Capability to adapt the consumed electricity at a defined node in the grid



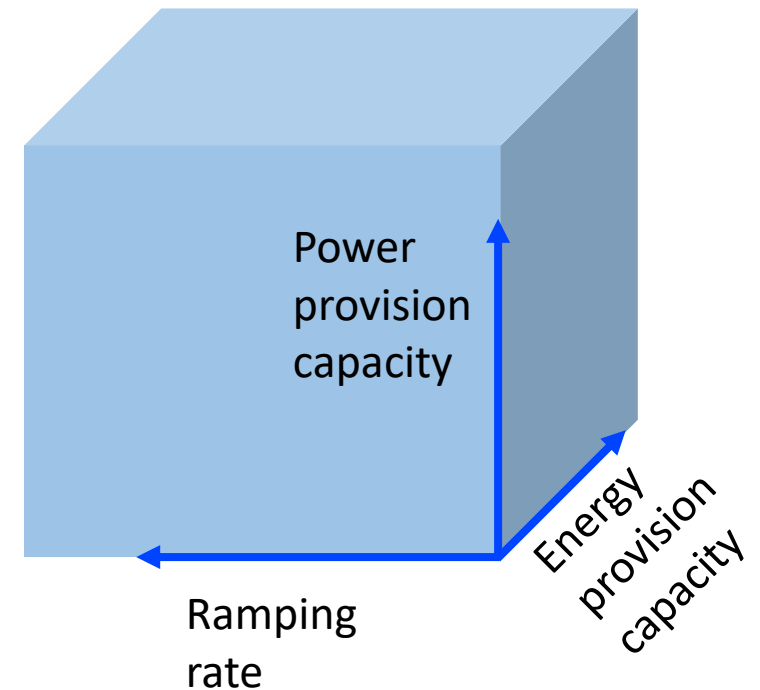
Short-term



Mid-term



Long-term



Adapted from: Ulbig A, Andersson G. Analyzing operational flexibility of electric power systems. Int J Electr Power Energy Syst 2015;72:155e64. <https://doi.org/10.1016/j.ijepes.2015.02.028>.

www.heatpumpingtechnologies.org



Flexibility services to the power grid

Implicit flexibility

Variable
electricity
price

Variable
grid tariffs

Explicit flexibility

Bilateral
agreements

TSO
ancillary
services

Local
flexibility
market

Conditional
agreements

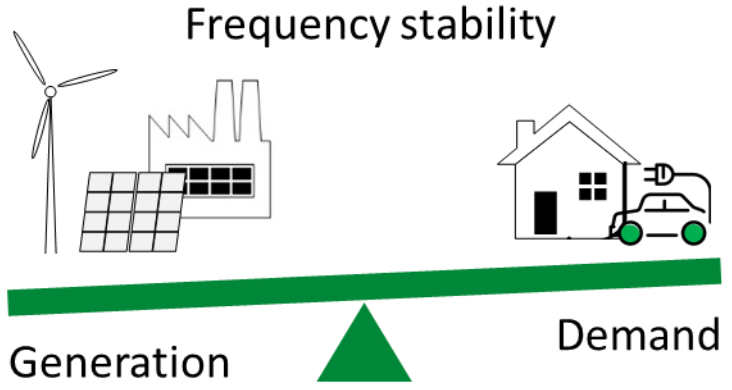
Directly procured
flexibility

Balance services,
bids are activated
upon calls

Flexibility market,
bids are activated
upon calls

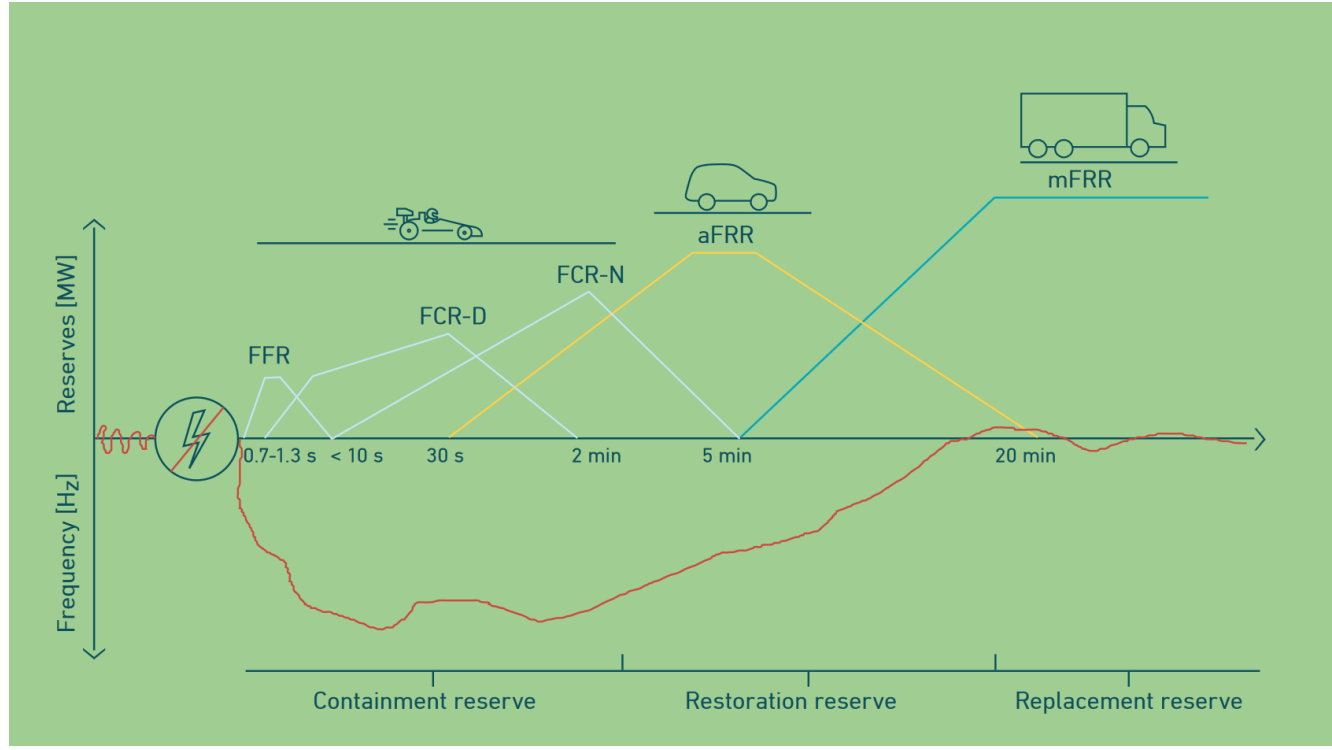
Agreement with
customer to
adjust the power
consumption
when necessary

Services to the transmission system operator (TSO)



Energy markets
Day-ahead market
Intra-day market
Balancing market

Ancillary services



Source: Energinet (2023). Outlook for ancillary services 2023-2040

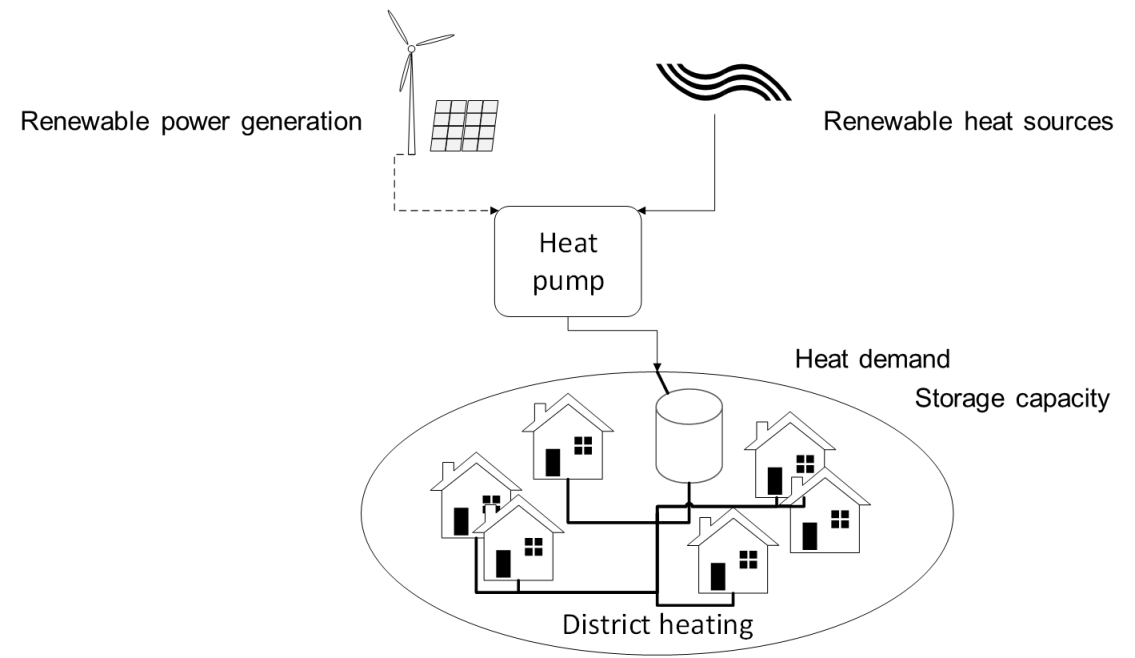


Sector coupling using large-scale heat pumps

Large-scale: Here, centralized heat pumps in thermal grids

Requirements

- Connection to storage
- Efficient part-load operation
- Higher number of starts- and stops
- Fast reaction time (dependent on the service)
- Measurement and direct control of the power uptake



Capacity control

- Flexibility requires adaption of heat pump load
- Typically heat output is controlled directly or indirectly via the source outlet temperature
- Quick adaption of load requires optimized control of the cycle and the secondary streams to avoid sudden fluctuations that may harm the plant.

Multiple parallel compressors
(On/Off, or (N-1)
On/Off + 1 VSD)

Piston compressors
(VSD + decoupling
of cylinders)

Screw compressors
(VSD + Slide valve)

Turbo compressors
(adaptation of
speed and guide
vanes)

Factors limiting ramp-up times

Other aspects related to flexible operation

Required stand-still times

- allow for the refrigerant to settle in the foreseen receivers/vessels in the system and to stabilize the conditions within the cycle. This ensures that no liquid is compressed in the compressor and that the valve is fed with liquid to ensure a safe and stable start-up.
- prevent overheating and/or increased wear on the electric motor of the compressor. Typically, large scale motors have a limited amount of consecutive starts as well as maximum starts per year.

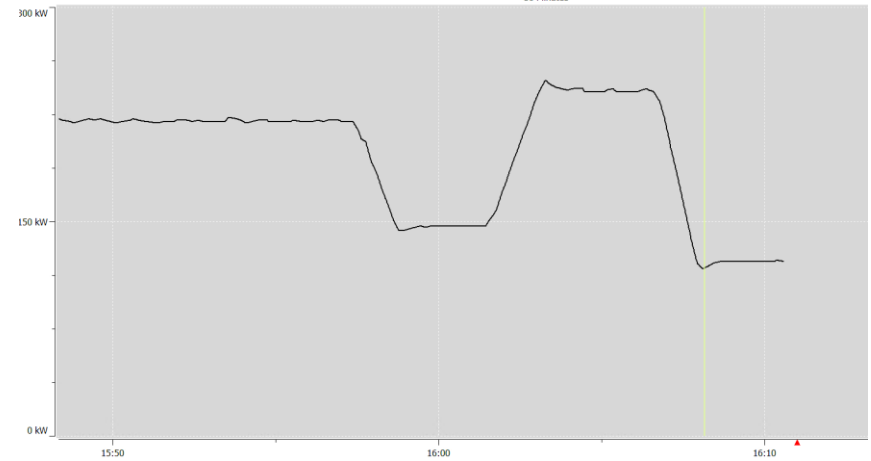
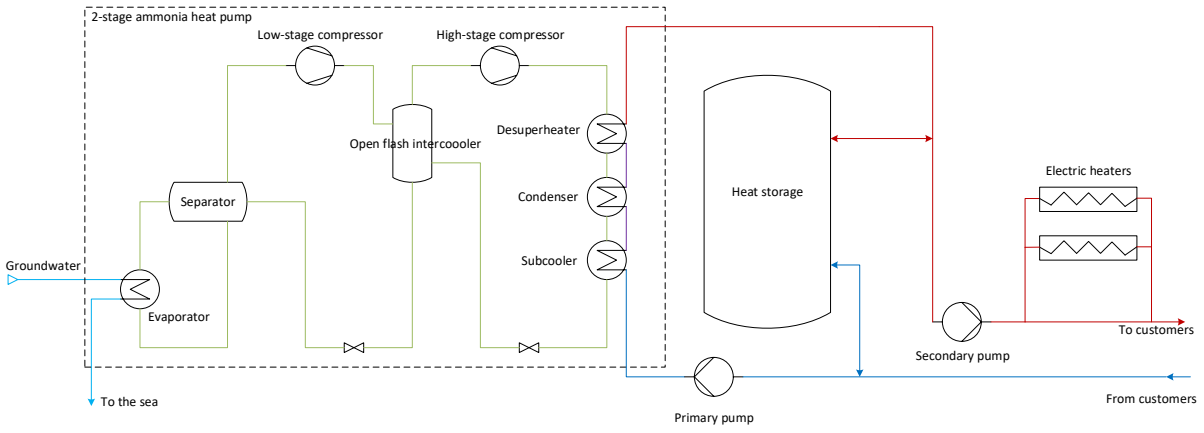
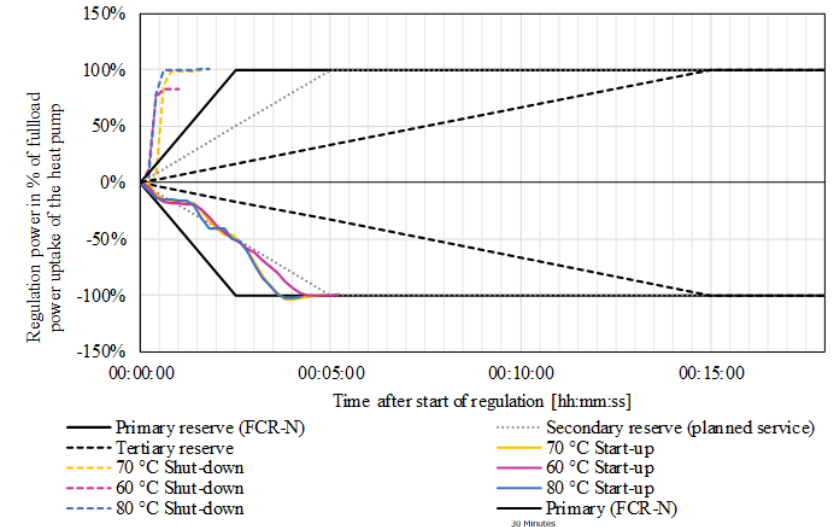
Temperature flexibility is given by

- Compressor envelop
- Material restrictions
- Max. and min. oil temperature
- Thermophysical properties of refrigerant and secondary medium

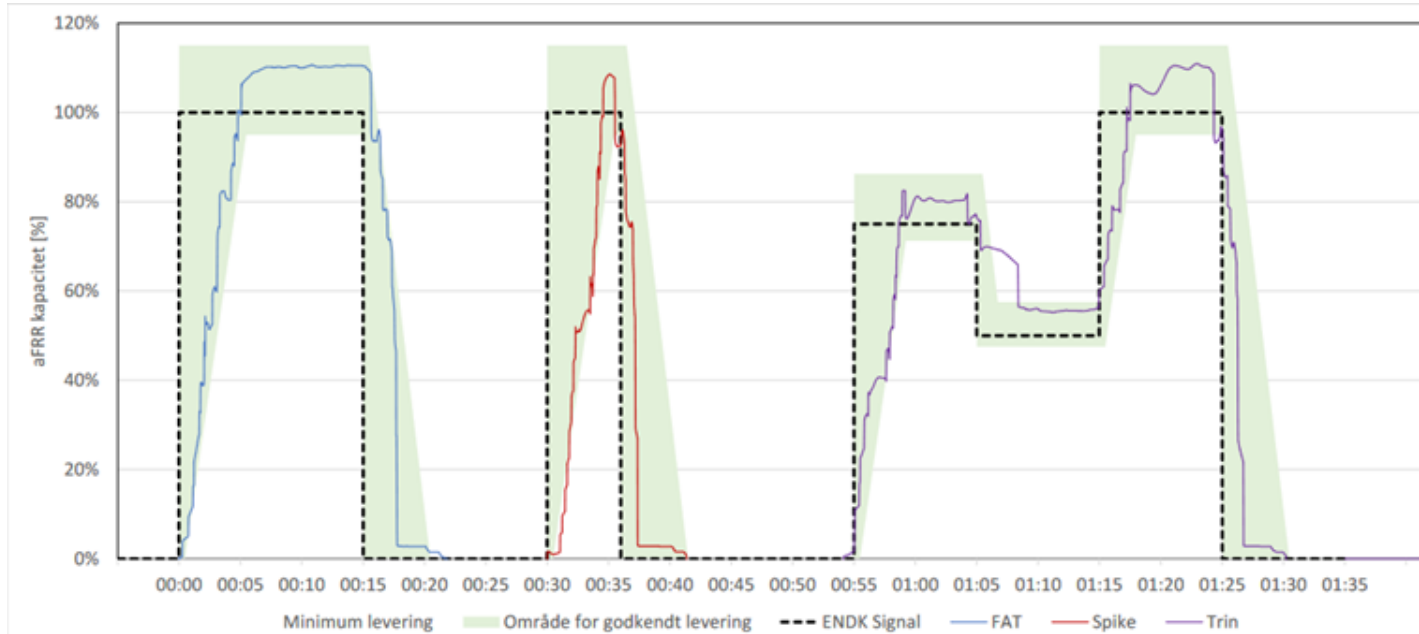
Example 1: FlexHeat, Copenhagen, DK



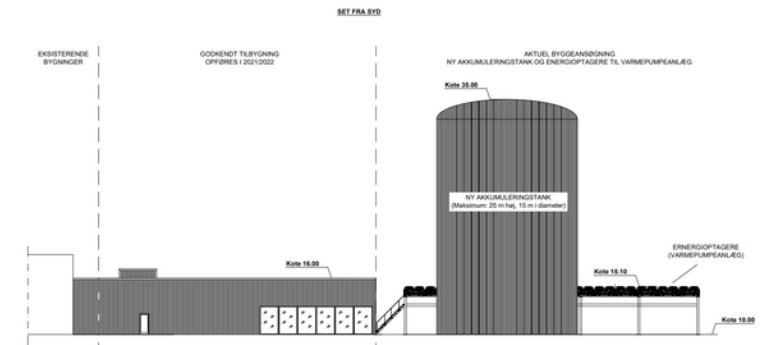
- 2-stage ammonia heat pump
- 800 kW thermal
- DH supply: 60-84 °C
- Part-load: 20-100 %



Example 2: CO₂ heat pump in Søndre Felding, DK



- CO₂ Heat pump
- Multiple parallel compressors
- 3.3 MW thermal
- Source: Ambient air



THANK YOU FOR YOUR ATTENTION!

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