

# Flexibility potential of heat pump in Swedish thermal grids

-For district heating companies and end users

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SE**

Research  
Institutes  
of Sweden

The logo for Energimyndigheten, featuring a stylized red and black circular graphic.

**Energimyndigheten**



# Scope of the study



- **Scope:**
  - Evaluate potentials and constraints to use heat pumps for increasing the flexibility of energy systems.
- **Two types of heat pump systems included:**
  - Centrally placed heat pumps in thermal grids which are operated by district heating companies
  - Decentralized heat pumps which are installed on customer side and combined with district heating as a hybrid heating solution.
- **Focus on Swedish conditions**
  - In terms of: Climate, demand for space heating and hot water consumption, prices for heating and electricity, market conditions for frequency regulation services, projection of future scenarios, etc.



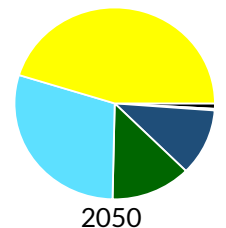
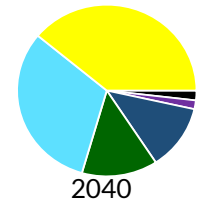
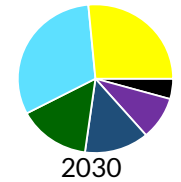
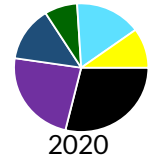
# Definition of Flexibility



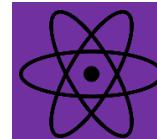
- Flexibility and demand response are broad terms without a clear definition
- Definition of flexibility within this paper:
  - The flexibility refers to the adjustment of heat pump operation for two purposes:
    - Respond to dynamic prices such as the variations in price for electricity, district heating or fuels.
    - Respond to dedicated markets for flexible resources such as local flexibility markets or TSO's market for ancillary services.
  - Focus on demand response of heat pumps that are owned either by district heating companies or by property owners with a hybrid heating solution.

- Changed power production
  - The installed capacity of electricity from intermittent renewable sources (wind and sun) is increasing rapidly
  - Increased variations in power production
- Ongoing electrification of the society
  - The need for flexibility will likely increase in the future
- Capacity shortage and bottlenecks in the grids

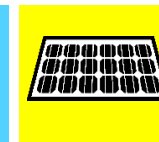
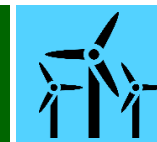
Forecast, 100% renewable elec. in EU 2050 (Child et.al, 2019)



Thermal  
(Coal, gas  
& oil)



Biofuel  
& waste





# Background

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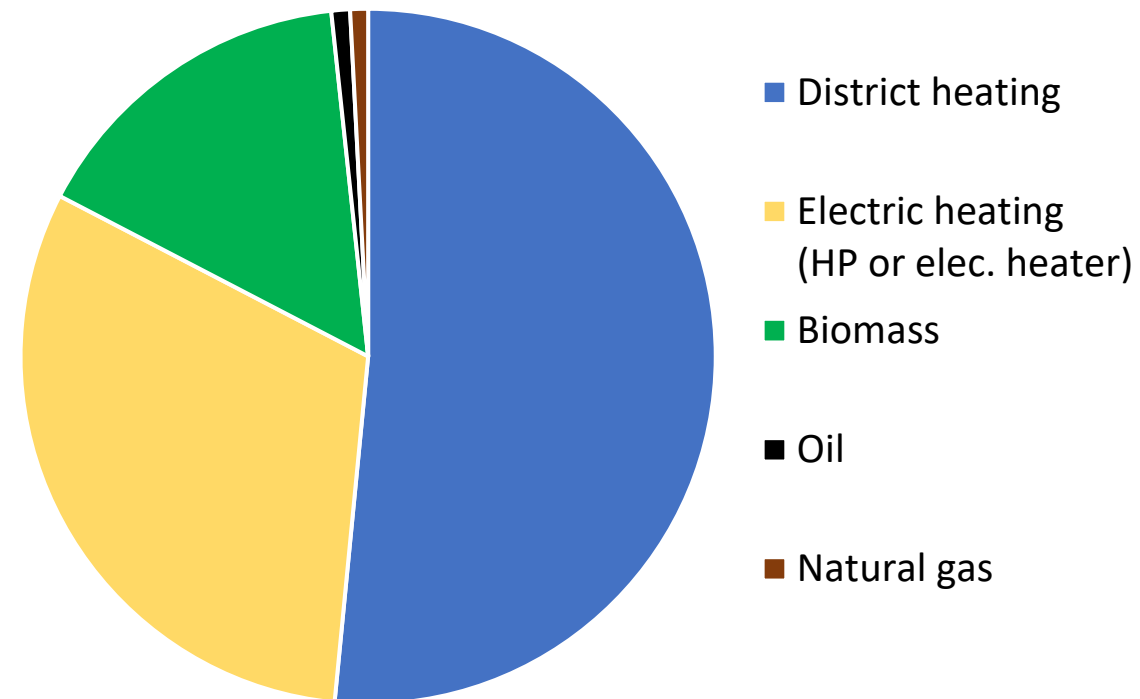


- By controlling the power consumption of the heat pump one can:
  - Help balancing the power systems variations in supply and demand.
  - By using the thermal inertia in grid, storage and buildings the heat pump can provide demand response
- The electric load from one single HP gives low flexibility
- A coalition of heat pumps needs to be controlled together to support the power grid with a useful size flexibility.
- An advantage of using a combination of heat pumping technology and thermal networks is the greater flexibility in heat production and storage options.



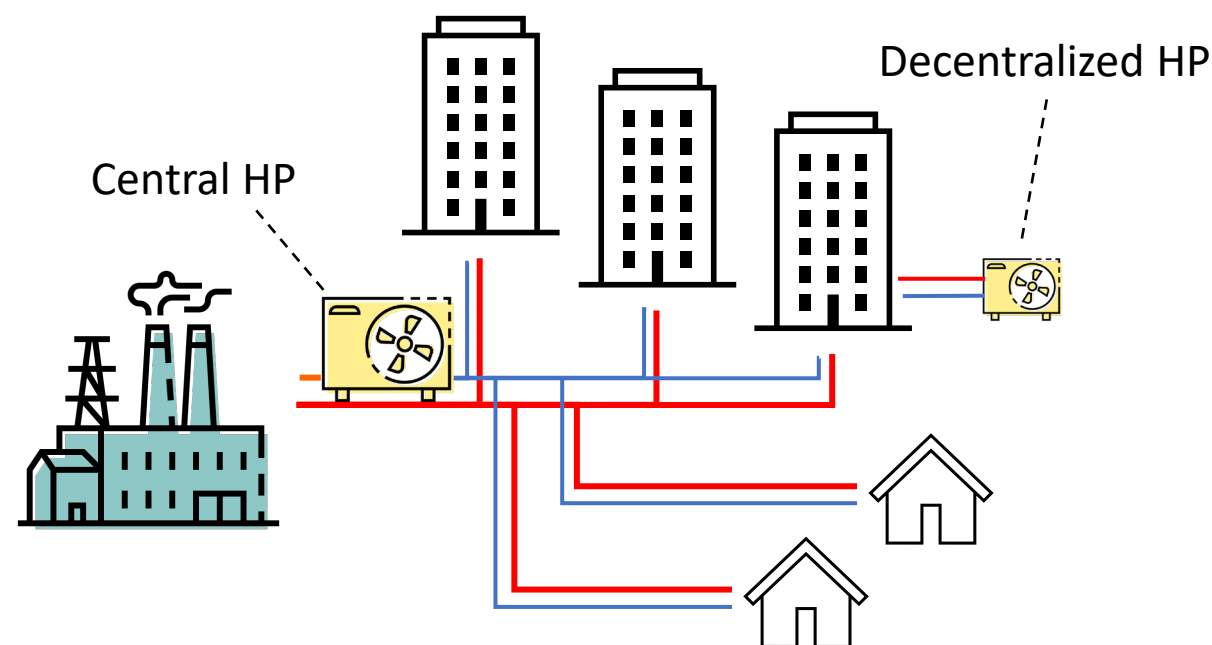
- Sweden has well-developed district heating systems in almost all cities
- Many heat pumps are installed
- Most Swedish buildings are heated with:
  - District heating
  - Electricity (HP or electric heaters)
  - Biofuel-boilers
- Single family homes: Mainly HP/electric heaters
- Apartment buildings: District heating dominates
- *Natural gas is rarely used to heat buildings*

Energy use for heating and hot water in Swedish dwellings



Data source: Swedish Energy Agency

- District heating (DH) provides heat to buildings
  - Central heat production
  - Distribution through a network of pipes carrying hot water or steam
- DH can be produced by various sources of energy:
  - Biomass
  - Waste incineration
  - Heat Pumps
  - Waste heat from industry
  - Natural gas
  - etc.



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Typical district heating piping in street in Sweden

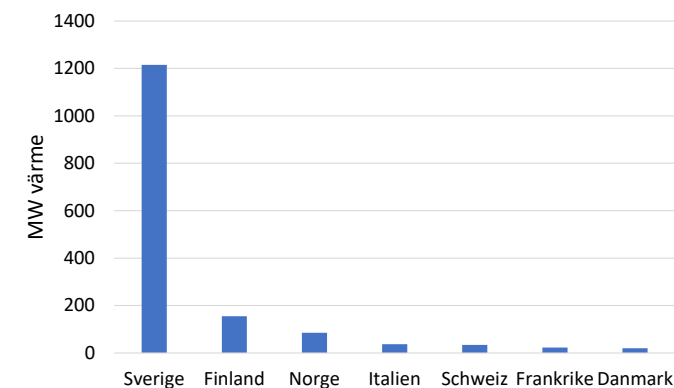


District heating central in Karlstad Sweden

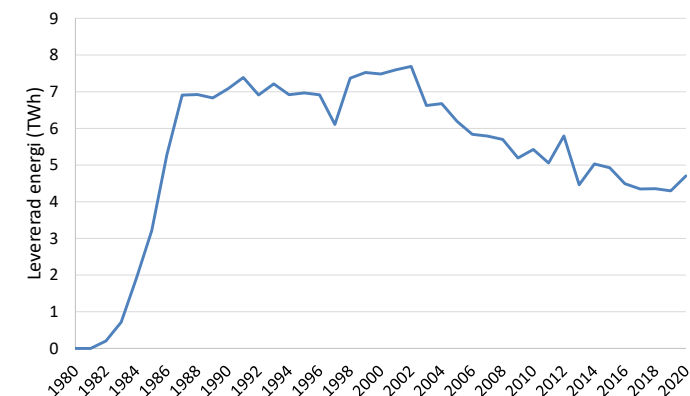
# Heat Pumps in Swedish DH-grids

- Sweden has high installed capacity of large HP in district heating grids
  - 70 heat pumps in 20 different grids
  - 1,2 GW installed heating power
- Strong growth during the 1980's
  - Due to a lot of cheap electricity from new nuclear plants
- Since year 2000 the share of heat from heat pumps has slowly decreased in district heating grids

Installed heating power, central HP in DH-grids



Delivered heat from HP in DH-grids in Sweden

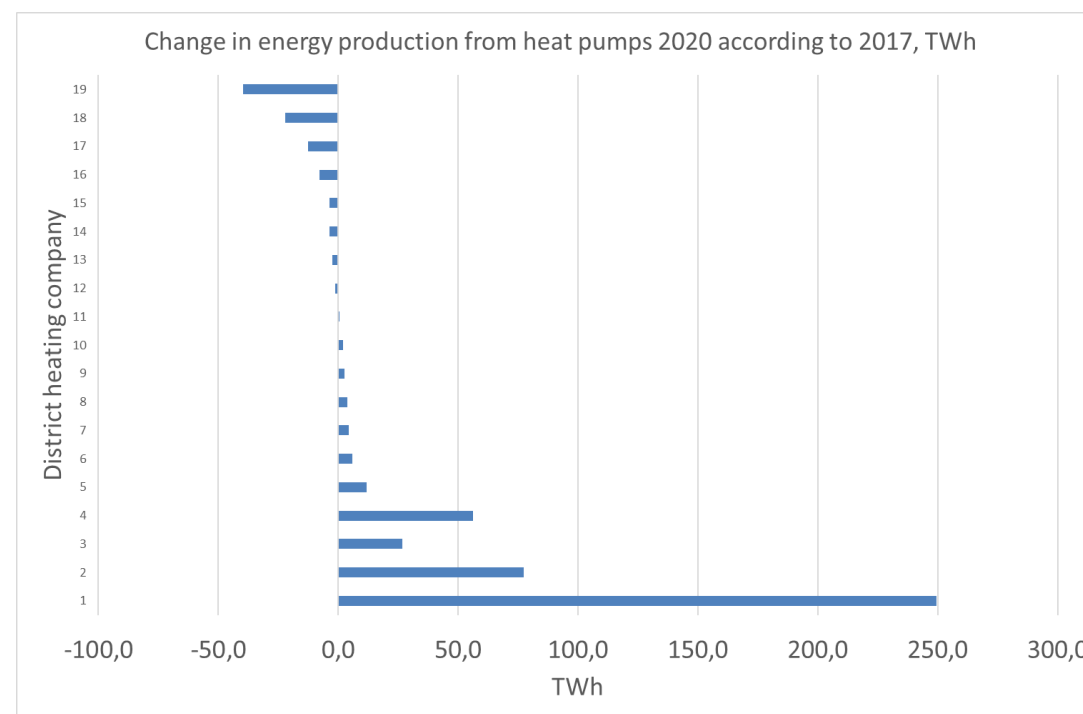


# Interview study with 8 district heating companies

## Installed heat pumps in the study:

- Heat pumps from 1980's need repairing or replacement
- District cooling has increased
- "Island installations" with low temperature grids
- Available heat source for the cold side

## Changes in energy production from heat pumps between 2017 and 2020





# Flexibility with heatpumps in district heating grids – result from the interview study



## Drivers for flexibility

- + Price is used to choose the production mix
- + Thermal storage in grid and accumulators
- + Shorter time for start/stop with heat pumps than other production
  - + A furnace takes days to start a heat pump is started in hours

## Barriers for flexibility with heat pumps

- Agreements of waste combustion
- Power tariffs in the electricity networks limit the use of heat pumps
  - minimum operating time necessary for good enough economy
- Lack of capacity on cold side
- Need of skilled personnel to run heat pumps
- Investment cost for heat pump



# District heating company's opinions about heat pumps at end consumers



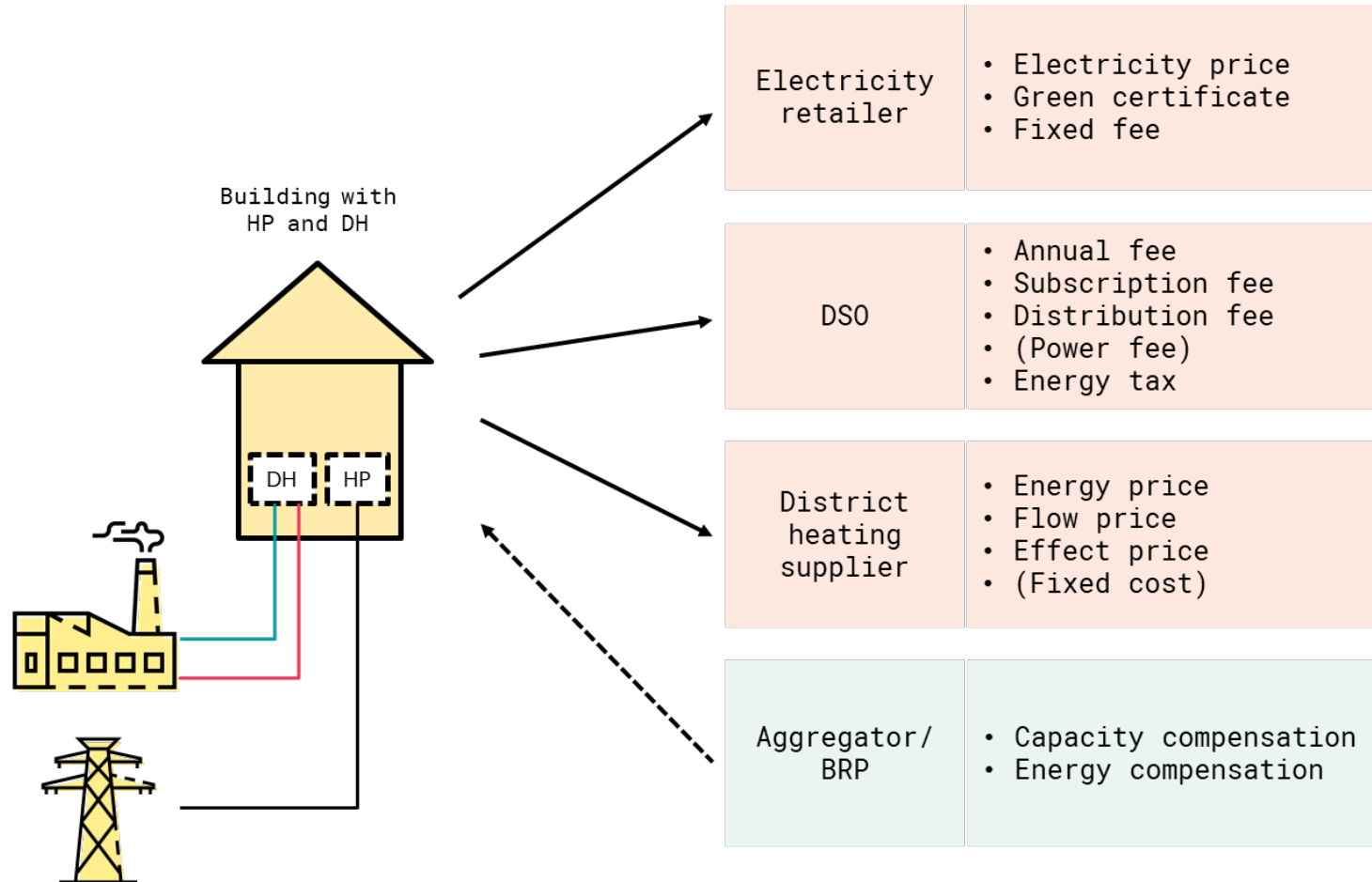
*"... But really, we think they're free riding on us. They remove the base load when we have the best heat production and then they want to buy peak load production from us that is expensive, difficult to provide and has poor environmental performance."*

12

*"We price against customers having heat pumps in order to outcompete them."* 18

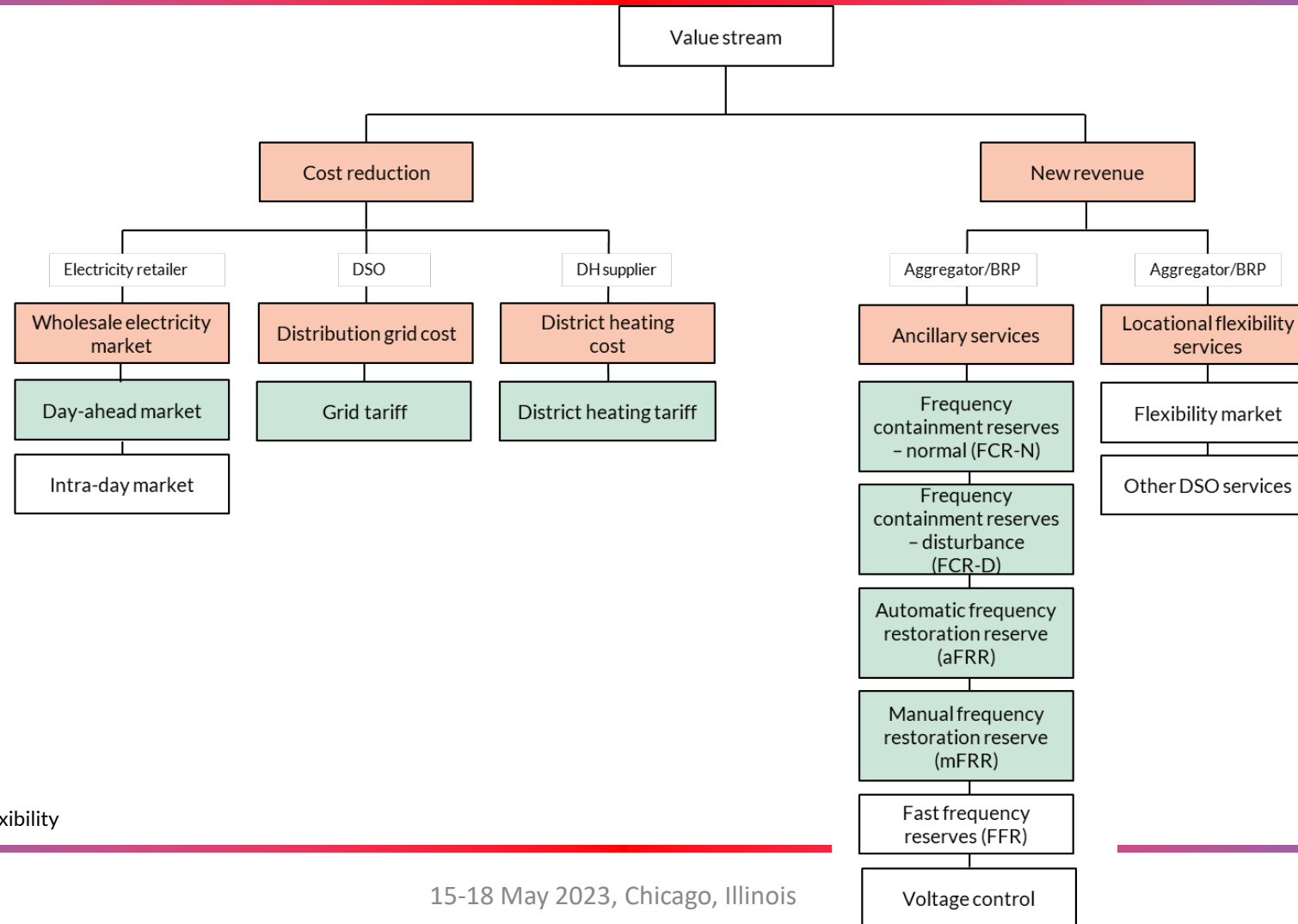


# Cost and revenue for property owner with HP and DH





# Value stream of flexibility

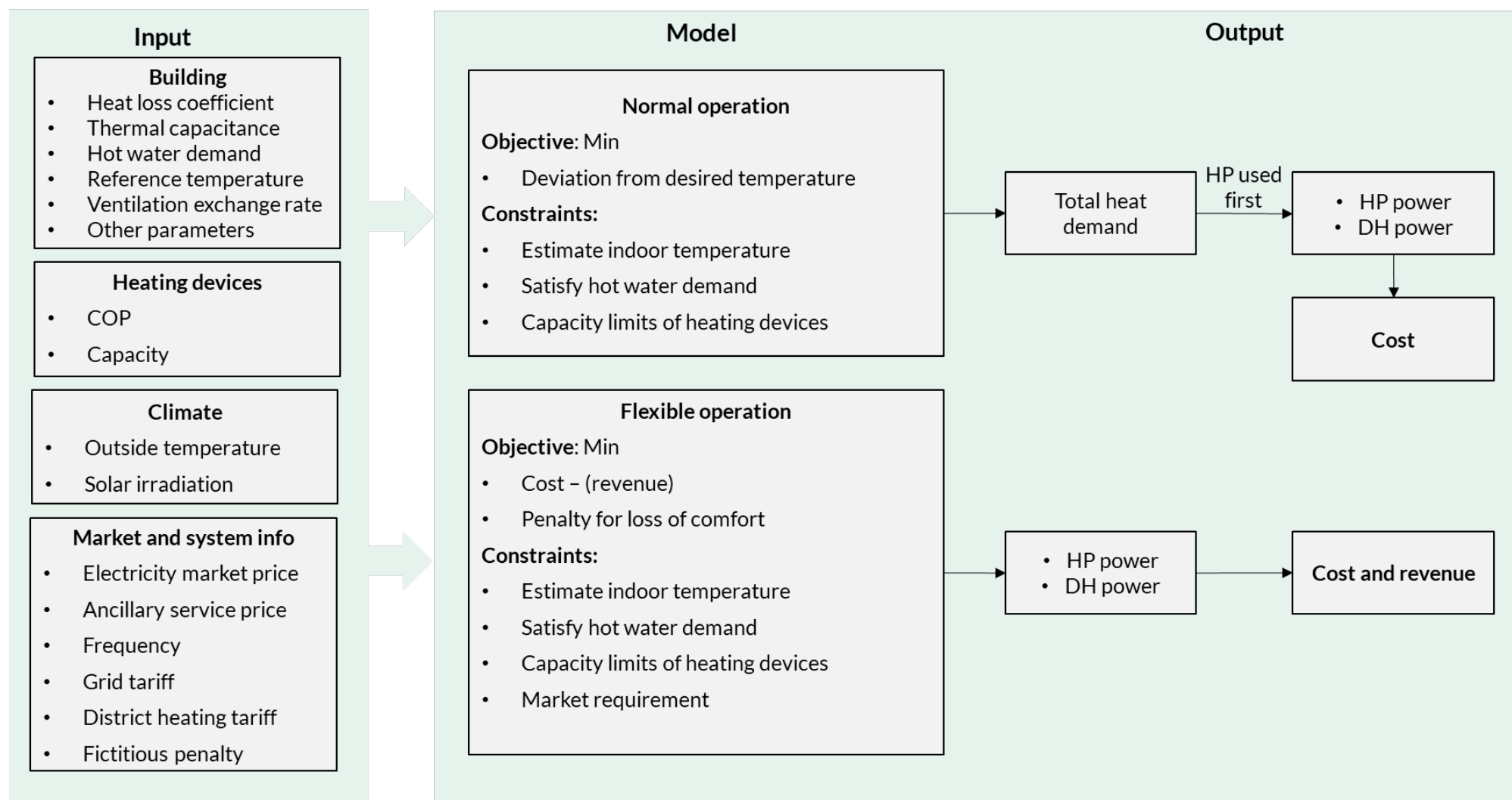


In the study scope

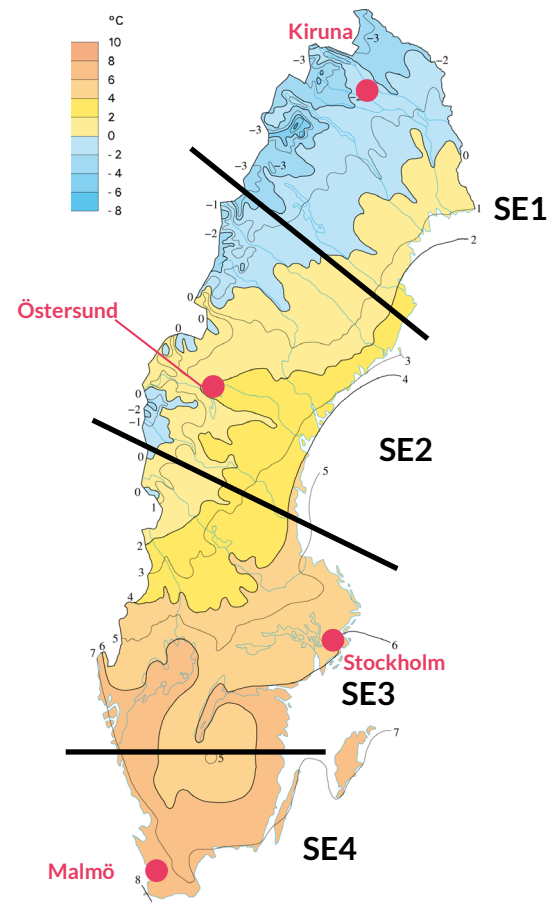
Source: Based on Delta EE, Fundamentals of flexibility



# Simulation model: Heating system in a building, 24 hours planning horizon



ELECTRICITY PRICE AREA	CLIMATE ZONE
SE1	Kiruna
SE2	Östersund
SE3	Stockholm
SE4	Malmö



Source:  
<https://www.smhi.se/kunskapsbanken/klimat/sveriges-klimat>

Price minimization  
Heat pump - District  
heating

FCR-N – Frequency  
Containment  
Reserve-Normal

FCR-D up/down –  
Frequency Containment  
Reserve-Disturbance

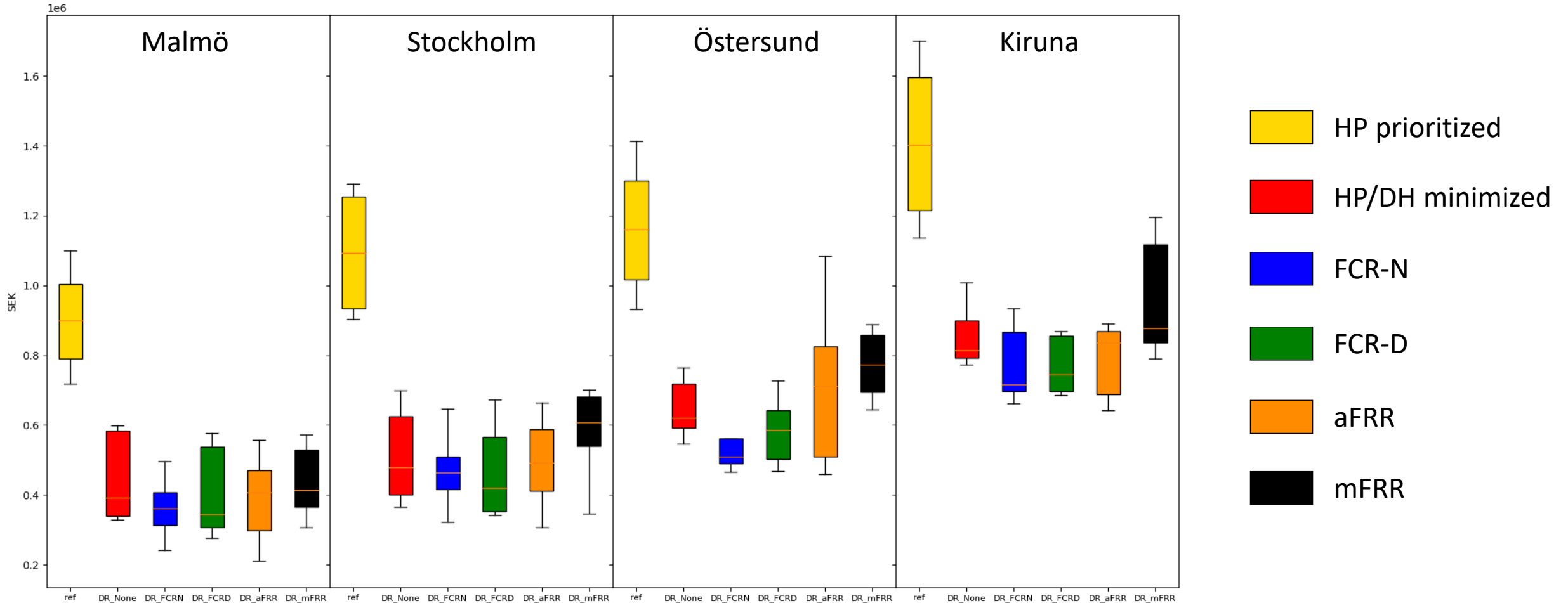
aFFR – automatic  
Frequency Restoration  
Reserve

Cost minimization with each  
of these ancillary services

Reference – Heat  
pump prioritized

FFR – Fast  
Frequency  
Reserve  
*Not used, too fast!*

mFFR – manual  
Frequency Restoration  
Reserve



- An interview study with district heating companies has been carried out:
  - It is an advantage to use HP for flexibility when electricity prices variates.
  - To invest in a new heat pump to get additional flexibility is described as hard to motivate and to get profitable.
  - Technically it is possible to start or stop heat pumps almost immediately
    - In practice the minimum running time for the heat pump is from 3-4 hours to 12 hours in most grids.
- The economic potential for end users by utilizing the flexibility of heat pumps combined with district heating has been analyzed based on simulations
  - The energy cost for end users could be effectively reduced by using flexibility of a hybrid heating system
  - The cost saving potential vary among locations, price scenarios and the type of system services provided by the heat pump.



# Thank you!

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