

Energy sector coupling: electric-thermal interaction through heat pumps

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ELECTRICITY-MARKET PARTICIPATION OF HEAT PUMPS IN SINGLE FAMILY HOUSES AND DISTRICT HEATING NETWORKS

Workshop

"Energy sector coupling: electric-thermal interaction through heat pumps"

23 October 2018, Bozen/Bolzano

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1.300
employees

bmvit

8 Centers

Austria's largest
RTO

Infrastructure Systems

System
Competence

Applied Research

Next Generation
Solutions

2 Subsidiary
Enterprises

Federation of
Austrian Industries

146

€ m EUR total revenue

Tomorrow Today



TOPICS

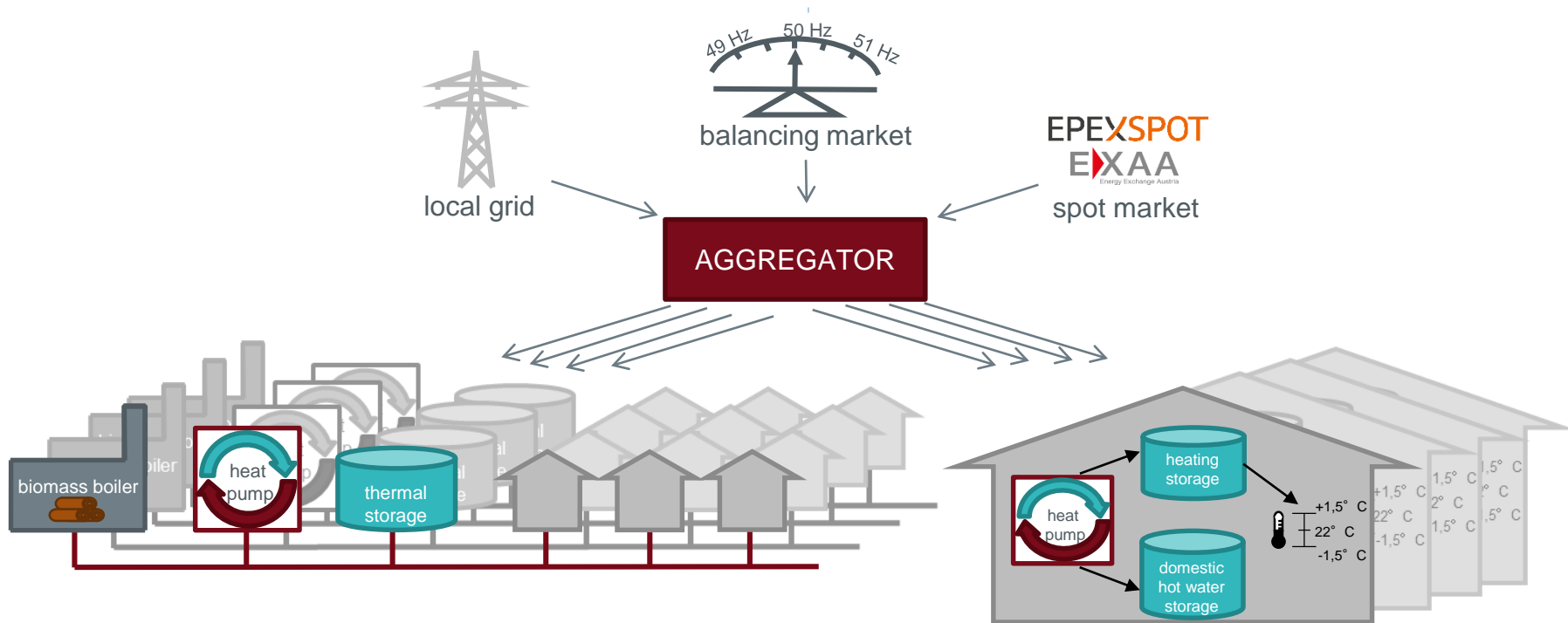
- Overview: Heat pump pooling for electricity markets
- Heat pumps in district heating networks
 - Balancing markets + Day-ahead spot market (project fit4power2heat)
- Heat pumps in single family houses
 - Balancing market (project DeCAS)
 - Day-ahead spot market (project iWPP-Flex/Annex 42)

OVERVIEW:

HEAT PUMP POOLING FOR ELECTRICITY MARKETS



HEAT PUMP POOLING



- Joint operation of a large number of heat pumps (HPs) instead of local optimization
- Better performance than in separate operation, by using resulting flexibility of HPs with thermal storage systems for market and grid purpose
- Heat pumps can be either in district heating networks or single family homes

TYPICAL APPLICATIONS FOR FLEXIBILITY

Market

- Cost minimization through **Day-ahead and Intraday market**
- Additional revenues through **Balancing Energy** / Frequency Restoration Reserve
- Minimization of the **imbalance settlement costs** of the balancing group

Customer

- Minimization of the **grid connection costs** through curtailment
- Maximization of **own consumption** (e.g. with additional PV)
- Connection at a lower grid level through **reducing connection power**

Electricity distribution grid

- Increase of **security of supply** through local grid support in case of outages
- Reduction of **grid reinforcement costs** for the distribution grid operator / delay of grid reinforcements

PARTICIPATION OF HEAT PUMPS IN THE DAY-AHEAD SPOT MARKET

- Prices are available day-ahead
- Heat pumps can reduce their electricity costs, either via a local control or with an aggregator
- In Austria/Germany:



Advantage of the day-ahead market for heat pumps

- + **Low technical requirements** for the market participation
- + **No bidirectional communication** necessary for the market participation
→ easy to implement

Disadvantage of the day-ahead market for heat pumps

- **Higher prices** expected for the future → lower profitability for heat pumps
- **Lower revenues** than in other markets due to smaller price difference between high and low price

PARTICIPATION OF HEAT PUMPS IN THE INTRADAY SPOT MARKET

- Continuous trading until 15 min before delivery
- Heat pumps can reduce their electricity costs with an aggregator
- In Austria/Germany:

EPEXSPOT

Advantage of the intraday market for heat pumps

- + **Higher price spread** than for the day-ahead market
- + Closer to real-time → **Better forecast** of the heat load, weather etc. available

Disadvantage of the intraday market for heat pumps

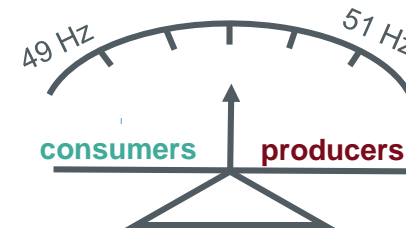
- **Higher technical requirements**; participation only possible via an aggregator
- **Bidirectional communication** is very likely needed

OVERVIEW BALANCING ENERGY

Balancing energy is used by the electricity transmission grid operator in case of imbalances between electricity production and consumption

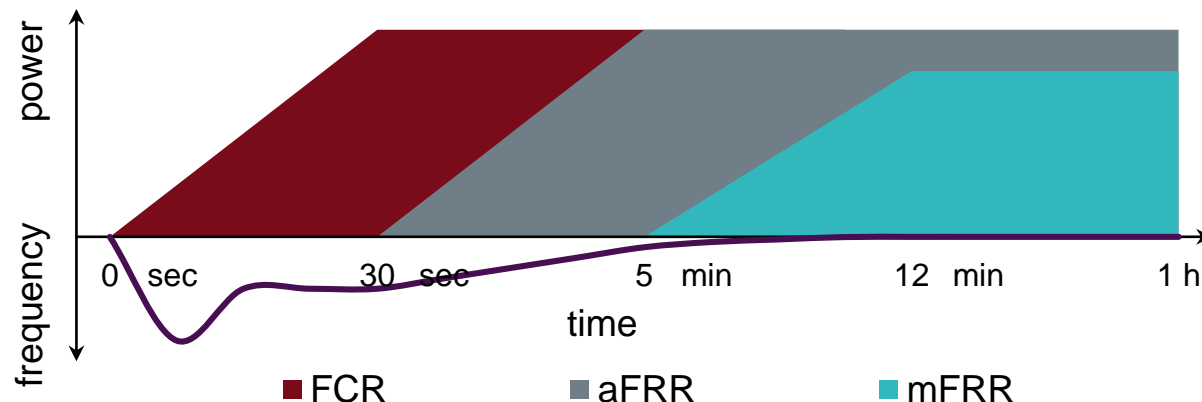
Balancing products in Austria/Germany:

- Frequency Containment Reserve (FCR)
- automatic Frequency Restoration Reserve (aFRR)
- manual Frequency Restoration Reserve (mFRR)



Two types of balancing energy:

- Positive balancing energy = increase in electricity production / decrease in electricity consumption
- Negative balancing energy = decrease in electricity production / increase in electricity consumption



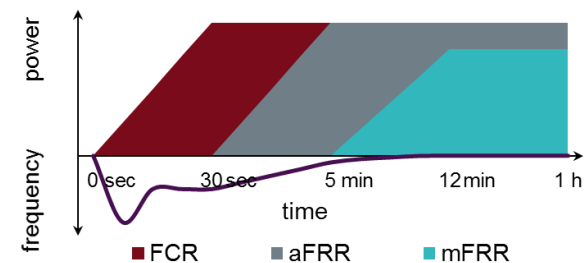
PARTICIPATION OF HEAT PUMPS IN THE BALANCING MARKETS

Advantage of the balancing markets for heat pumps

- + Heat pumps can earn revenues by providing balancing energy
- + Both the availability and the delivery are remunerated (power & energy price)
- + Additionally HPs can save some grid fees during the times where they provide balancing energy

Disadvantage of the balancing markets for heat pumps

- Prequalification process necessary
- Strict technical requirements for the market participation
 - Bidirectional communication necessary
 - Fast reaction times: a few seconds / a few minutes
 - Product size: 4 h (secondary, tertiary) / 1 week (primary)
 - Minimum pool size: 1 MW / 5 MW
- Frequent switchings → modulating heat pump / large pool necessary



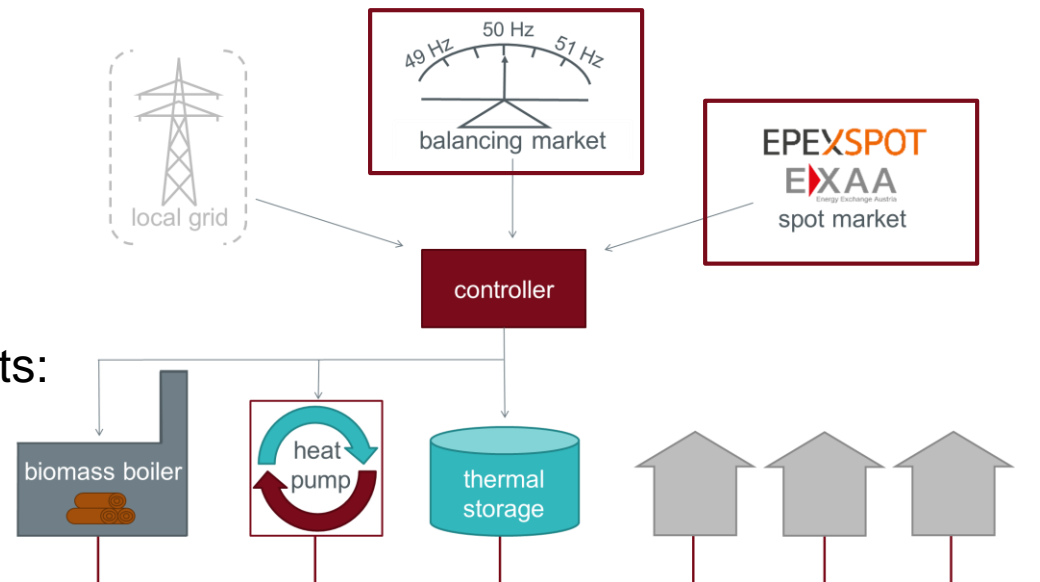
HEAT PUMPS IN DISTRICT HEATING NETWORKS

Balancing markets + Day-ahead spot market (project fit4power2heat)

PROJECT: FIT4POWER2HEAT

Business models for heat pump pooling concepts in small heating networks

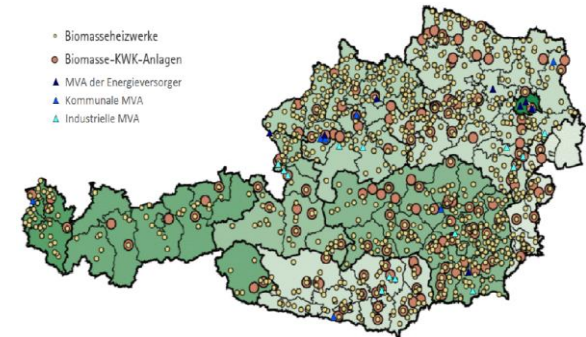
- Heat pump integration in existing old and inefficient district heating networks
- Use the flexibility provided by:
 - Thermal storage
 - Back-up biomass boiler
- Participate in electricity markets:
 - Day-ahead spot market
 - Balancing markets
- Aim: Investigate potential business models



This work was funded by the Austrian Research Funding Association (FFG) under the scope of the City of tomorrow program.

BACKGROUND

- Austrian district heating (DH) network settings:
 - 900 biomass heat plants above 1 MW with a total of 2.600 MW_{th}
 - old heat plants operating with low efficiency
 - highly replicable business case
- Power to heat solutions:
 - Heat pumps support both electricity and DH networks.
- Project partner:



HEAT PUMPS IN SINGLE FAMILY HOUSES

Balancing market (project DeCAS)



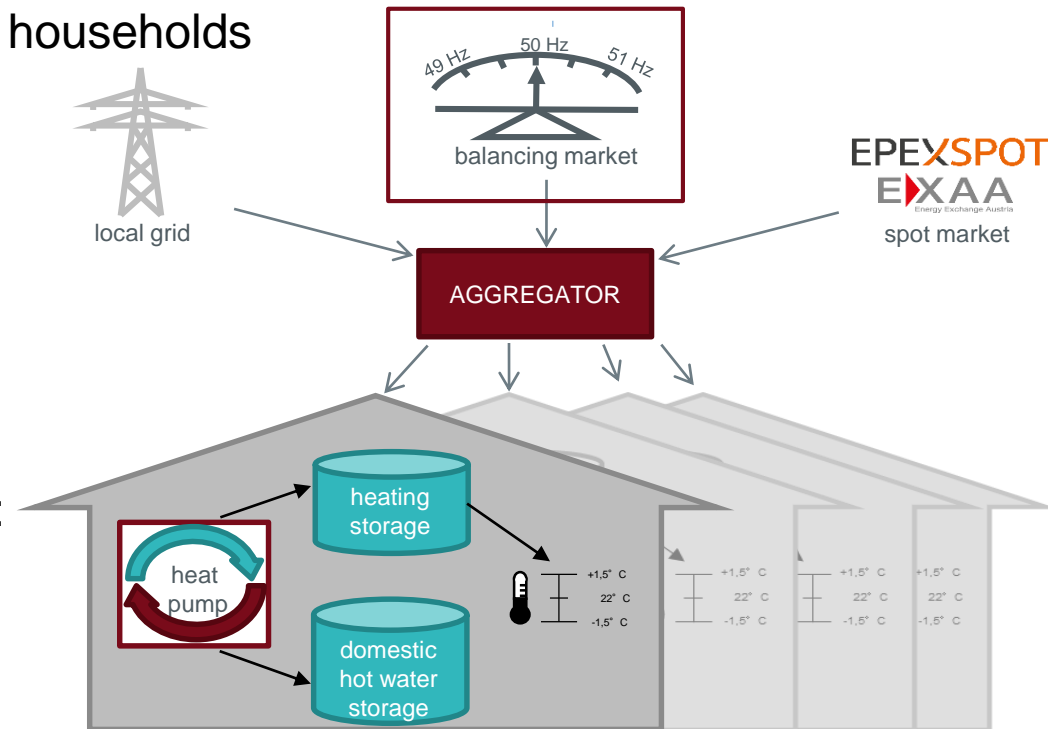
PROJECT: DECAS

Pooling concept on the example of the Austrian balancing market

- Facilitate market participation of households

- Use the flexibility provided by:
 - Heating storage
 - Domestic hot water storage
 - Building

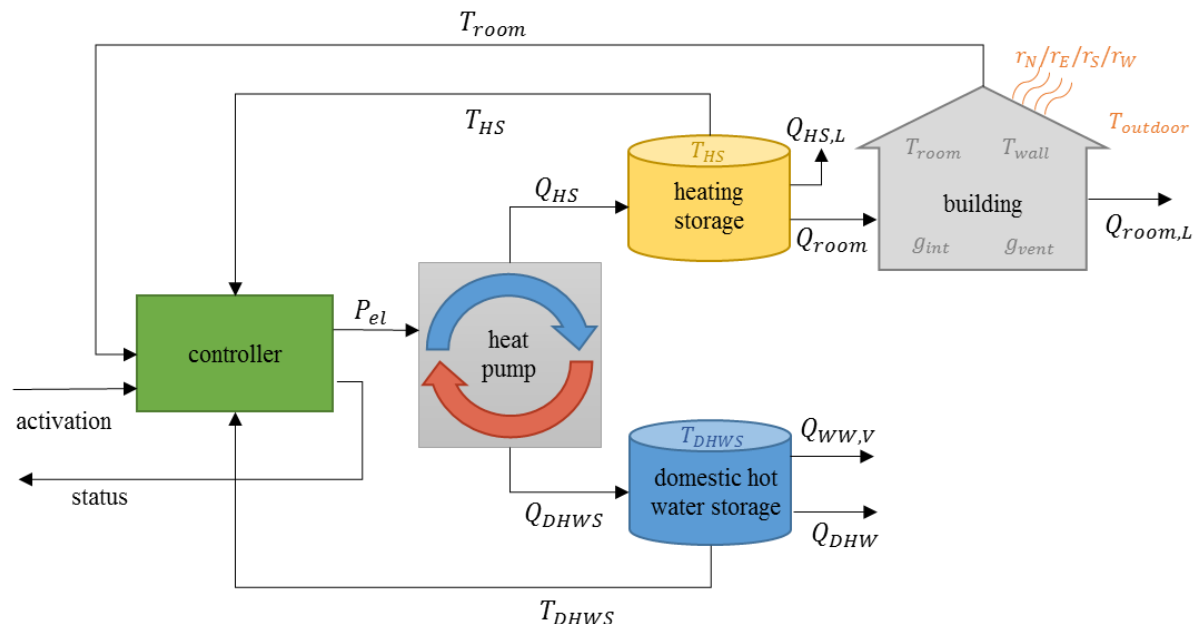
- Participate in electricity markets:
 - Balancing market (mFRR)



- Aim: Calculate saved heating costs for households

METHODOLOGY

- Pool of 400 single-family houses
- Linear bottom-up optimization model
- Start: detailed thermal models in Dymola
- Four types of buildings: passive house, low-energy building, old building, renovated building
- Linearization and simplification of the building, storage and heat pump models

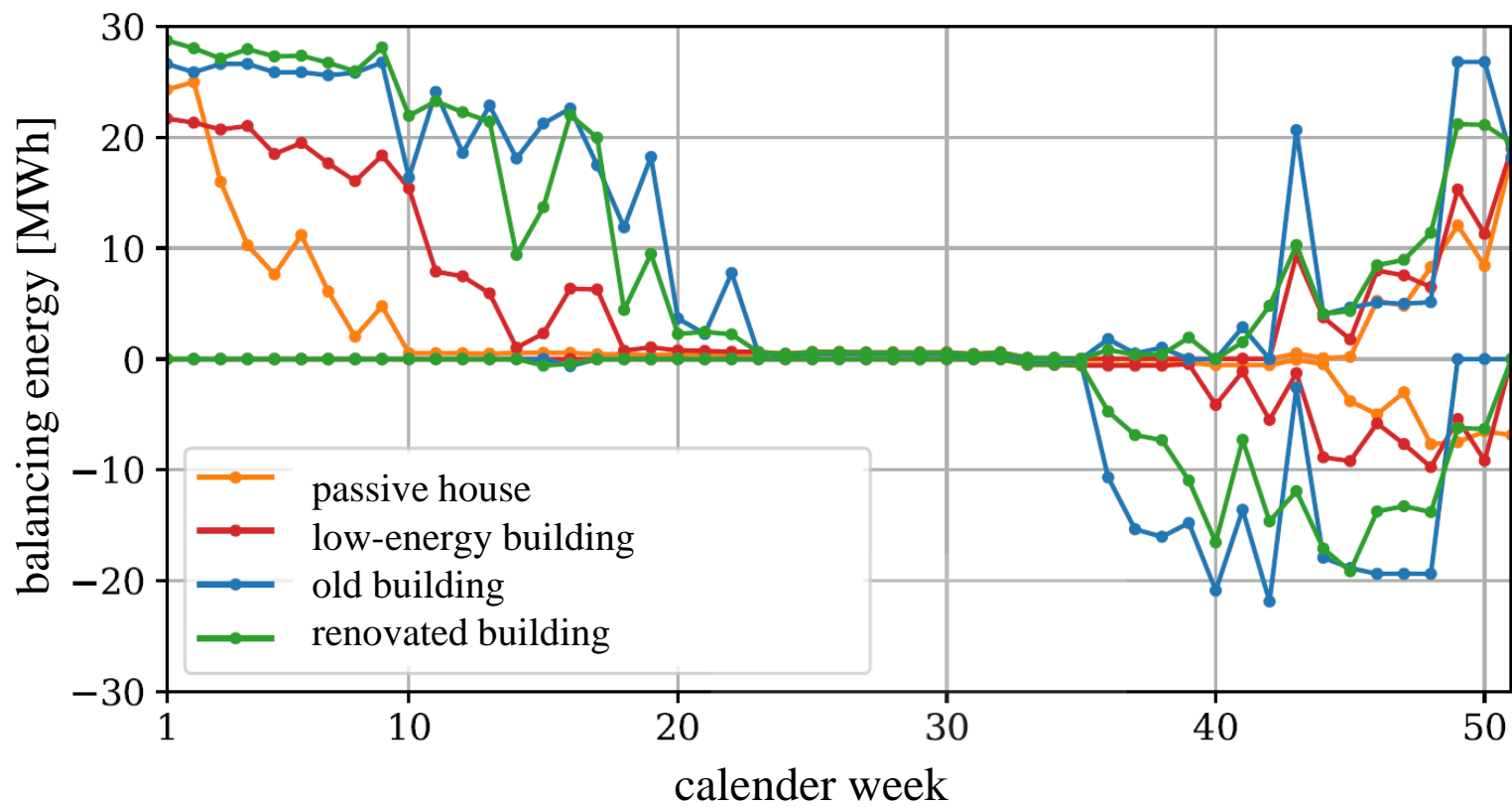


TYPICAL THERMAL SYSTEM CONFIGURATIONS FOR AUSTRIA

	passive house	low-energy building	low-energy building	old building	renovated building
Space Heating	15 kWh/(m ² *a) [~30 ° C]	45 kWh/(m ² *a) [~35 ° C]	45 kWh/(m ² *a) [~35 ° C]	100 kWh/(m ² *a) [~55 ° C]	70 kWh/(m ² *a) [~45 ° C]
Heated area	140 m ²	140 m ²	140 m ²	120 m ²	120 m ²
DHW	3000 kWh/a [~55 ° C]	3000 kWh/a [~55 ° C]	3000 kWh/a [~55 ° C]	3000 kWh/a [~55 ° C]	3000 kWh/a [~55 ° C]
Therm./ el. capacity	3 kW / 1 kW	5 kW / 1.5 kW	5 kW / 1.2 kW	12 kW / 4 kW	7 kW / 2.7 kW
Capacity control	variabel	on/off	on/off	on/off	variabel
Heat Source	Air	Air	Ground	Ground	Air
Heat Sink	Water	Water	Water	Water	Water
Heat Distribution	Floor Heating	Floor Heating	Floor Heating	Radiators	Radiators
Storage SH	no	300 l	no	500 l	500 l
Storage DHW	300 l	300 l	300 l	300 l	300 l

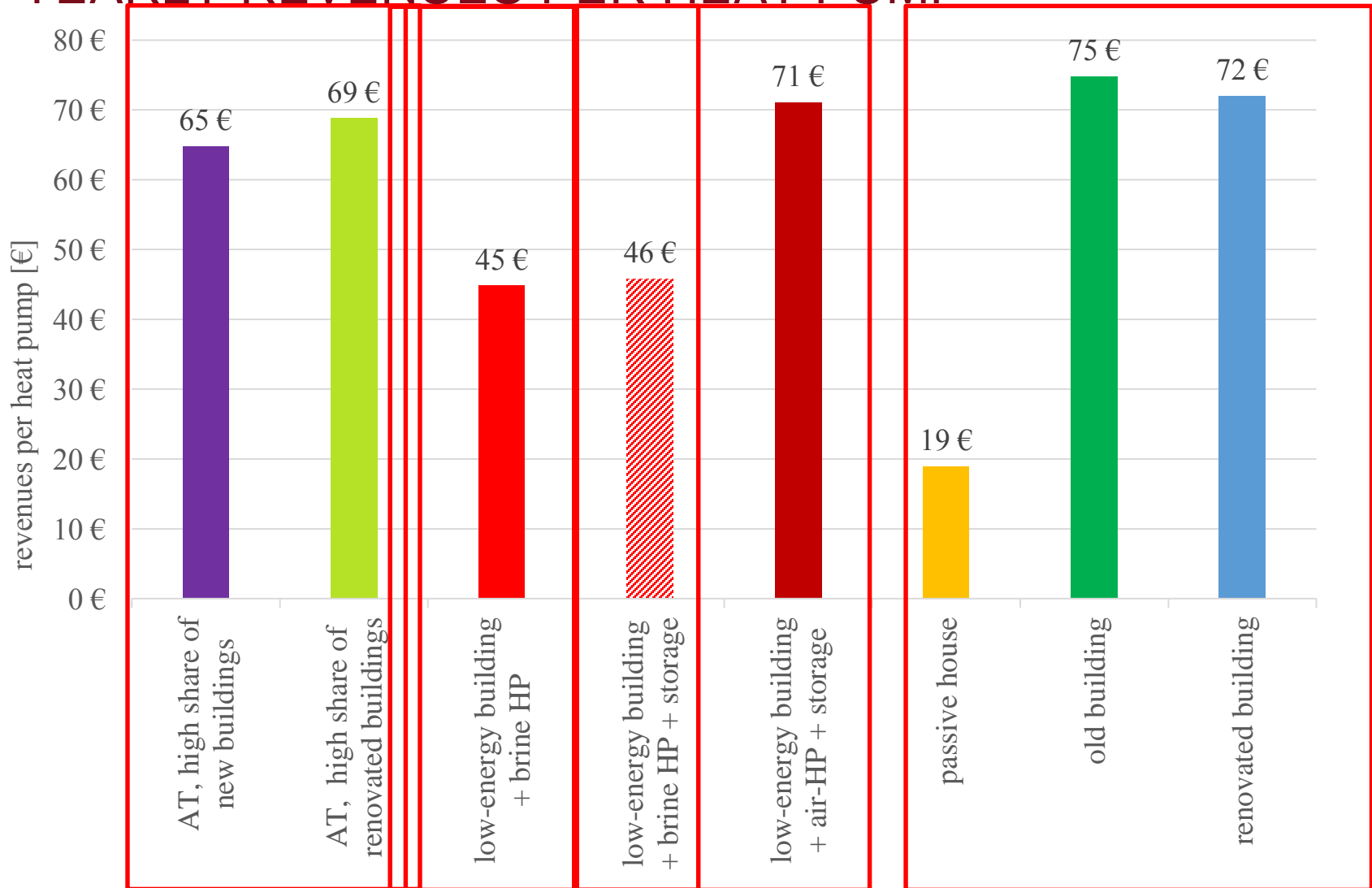
RESULTS: COMPARISON OF BUILDING TYPES

balancing energy provided by the whole pool



RESULTS:

YEARLY REVENUES PER HEAT PUMP



CONCLUSIONS

- Heat pumps in single-family houses can provide balancing energy for 4-8 hours
 - mFRR possible in Austria
 - aFRR possible in Austria since 07/2018
- At average yearly revenues of 65-69€ for Austria
- Old buildings with a high heat load, as well as new buildings with air-to-water heat pumps have the highest potential
- Low-priced IT infrastructure for communication and control is necessary for a positive business case
- Open questions:
 - Impact of catch-up effects
 - Impact on the efficiency and the life cycle of the heat pumps

HEAT PUMPS IN SINGLE FAMILY HOUSES

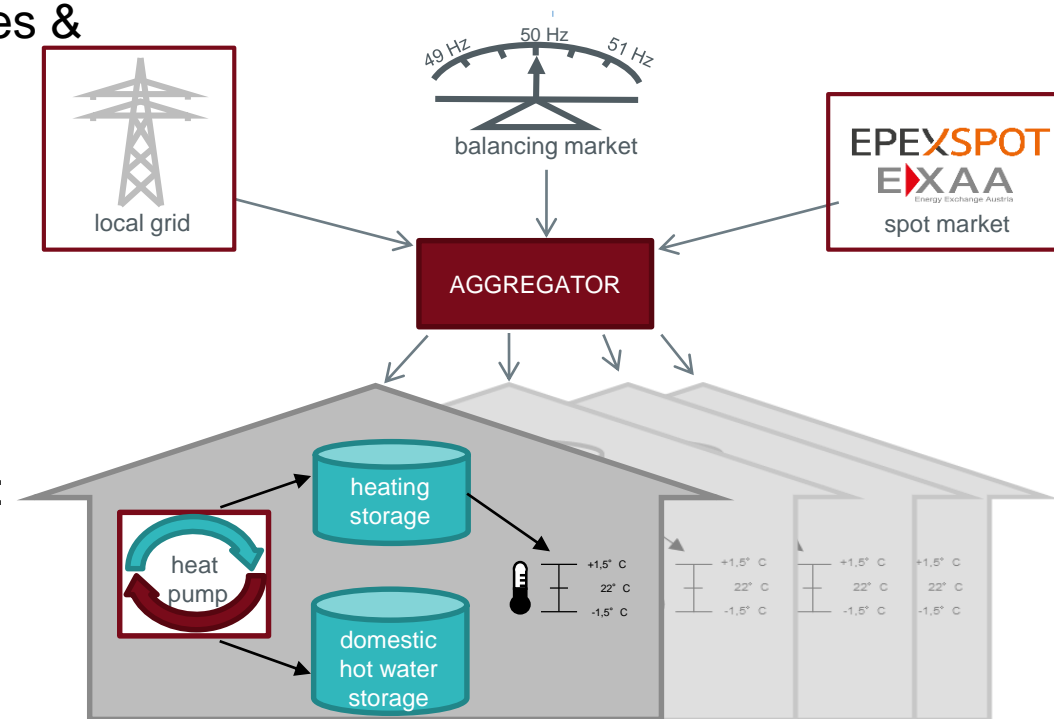
Day-ahead spot market (project iWPP-Flex/Annex 42)



PROJECT: IWPP-FLEX / ANNEX 42

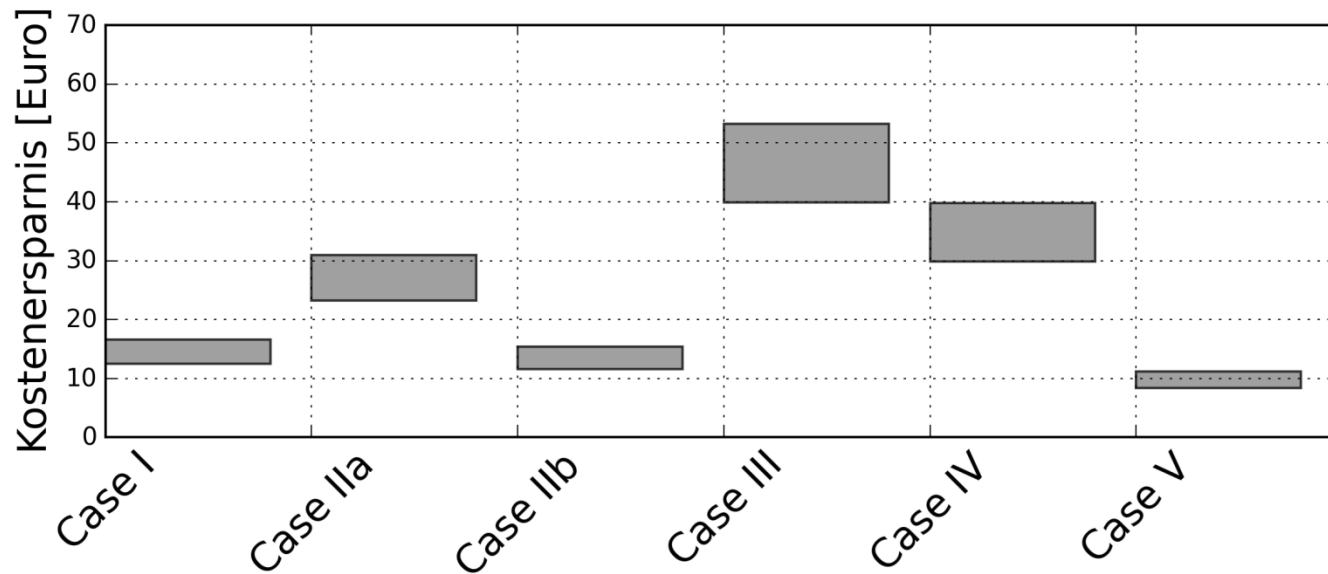
Heat pump participation in the Day-ahead spot market

- Profit from cheap electricity prices & avoid price peaks
- Use the flexibility provided by:
 - Heating storage
 - Domestic hot water storage
 - Building
- Participate in electricity markets:
 - Day-ahead spot market
- Aims:
 - Calculate saved heating costs for households
 - Evaluate influence on the distribution grid



RESULTS DAY-AHEAD SPOT PRICE (2015)

Simulation of supplier view: Optimization of heat pump pool on historic hourly day-ahead spot market prices



CASE I
Passiv
house

CASE IIa
New building
(heating storage)

CASE IIb
New building

CASE III
Existing
buildings

CASE IV
Existing buildings
ren.

CASE V
Hot water

CONCLUSIONS

- **Economic potential** on the day-ahead spot market:
10 – 50 € costs savings per heating heat pump and per year (23 – 35% of energy costs (only energy, not taxes or grid tariffs))
- **Influence on results:**
 - Thermal storage of heat pump system and building
 - Flex-availability differs depending on season of the year
 - Heating heat pump higher potential than hot water heat pump
- Possibly **negative influence** on the local **distribution grid**:
 - Higher simultaneity through coordinated activation
 - Grid problems possible in weak grid parts
 - In the simulated grids, only high shares of heat pumps would lead to problems

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