Aalto University
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NANJING TECH UNIVERSITY

Decentralized and centralized demand response control of district heating system in education building

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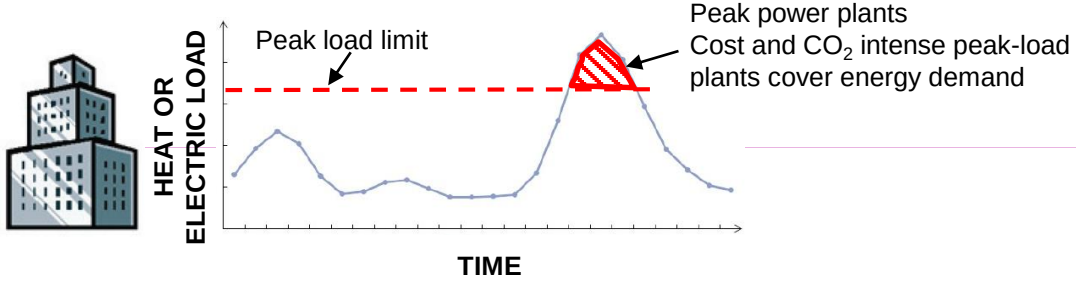
Research objectives

- **To find out:**
  - cost saving potential by dynamic price tariff and Demand Response of district heating and ventilation in an educational building
  - to compare Decentralized and Centralized Demand Response
  - the effect of Demand Response on perceived thermal comfort

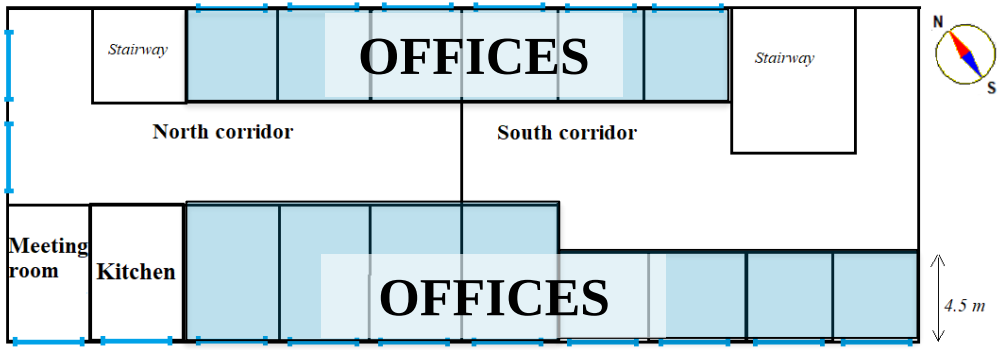
Motivation of demand response

- Demand response on the building level aids stabilization of the consumption profile in the district heating and electricity grid.
- A stable consumption reduces peak demand and need for high cost peak power plants:
  → Less CO_2 emissions
  → Financial savings for energy producer and consumer



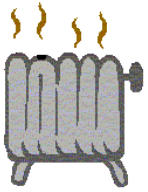
Analysis of demand response of district heating and ventilation in office

- **Dynamic energy and indoor climate simulations of the 4th floor of Otakaari 4:**

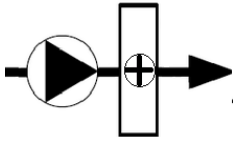


- **Cost saving potential by hourly price-based demand response control of**:

A.Space heating



B. Supply air temperature

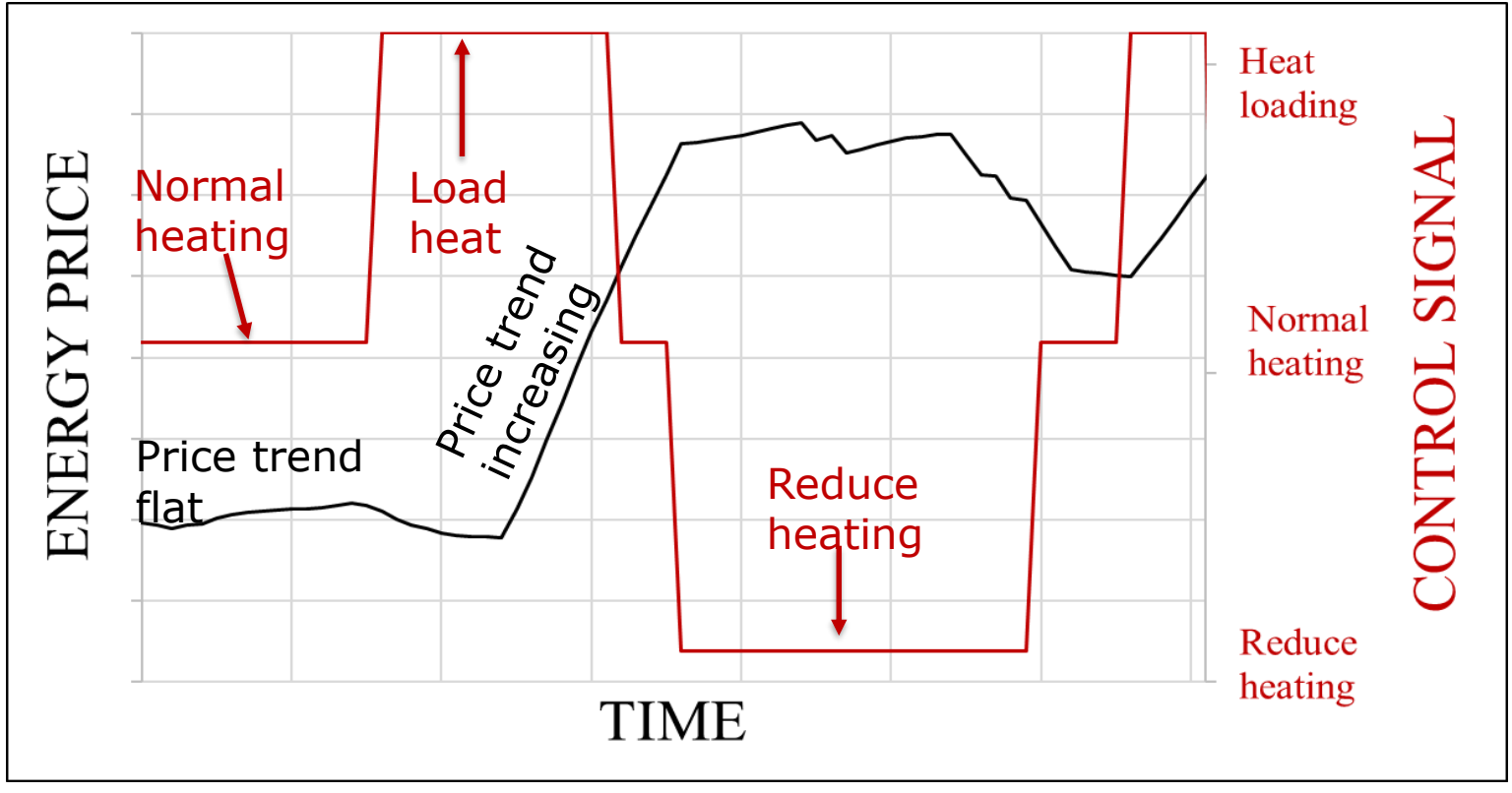


C. Supply airflow rate

<u>Both individual and combined control</u>

Control strategy

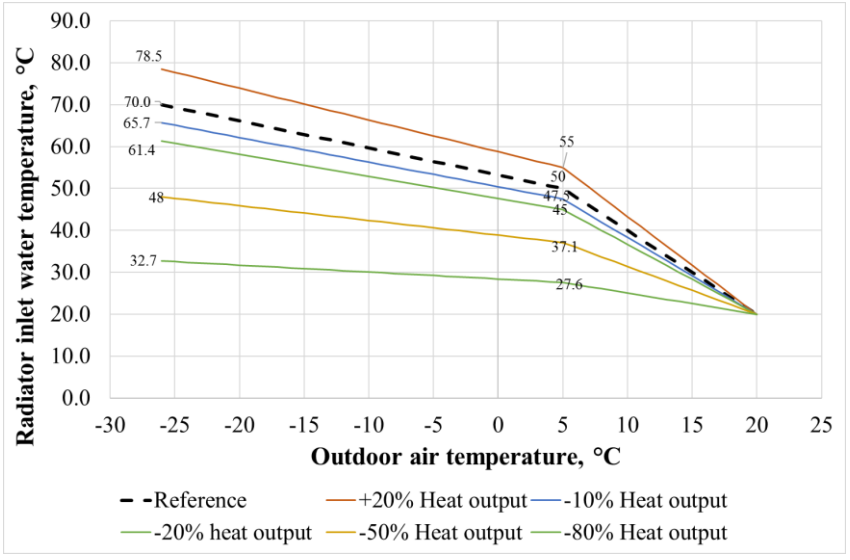
- Dynamic energy price and control signal:



Methods for space heating control

A. Centralized control

→ Adjustment of radiator inlet water temperature



Manual thermostatic radiator valves (TRV):

B. Decentralized control

→ Room air temperature set-point adjustment (20-24.5°C)

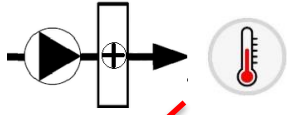
Electronic TRV:s

Cost saving potential of heating

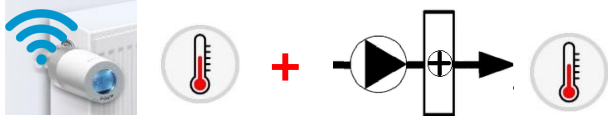
- Decentralized control of space heating:

→**5.2%** annual heat cost saving

- Supply air temperature control:



→**0.4%** annual heat cost saving

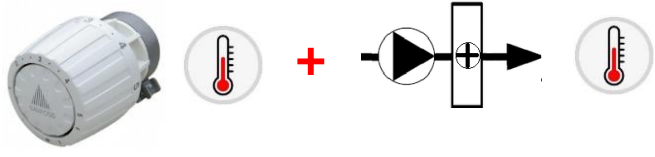


5.7% total annual cost saving

- Centralized control of space heating:

→**1.6%** annual heat cost saving

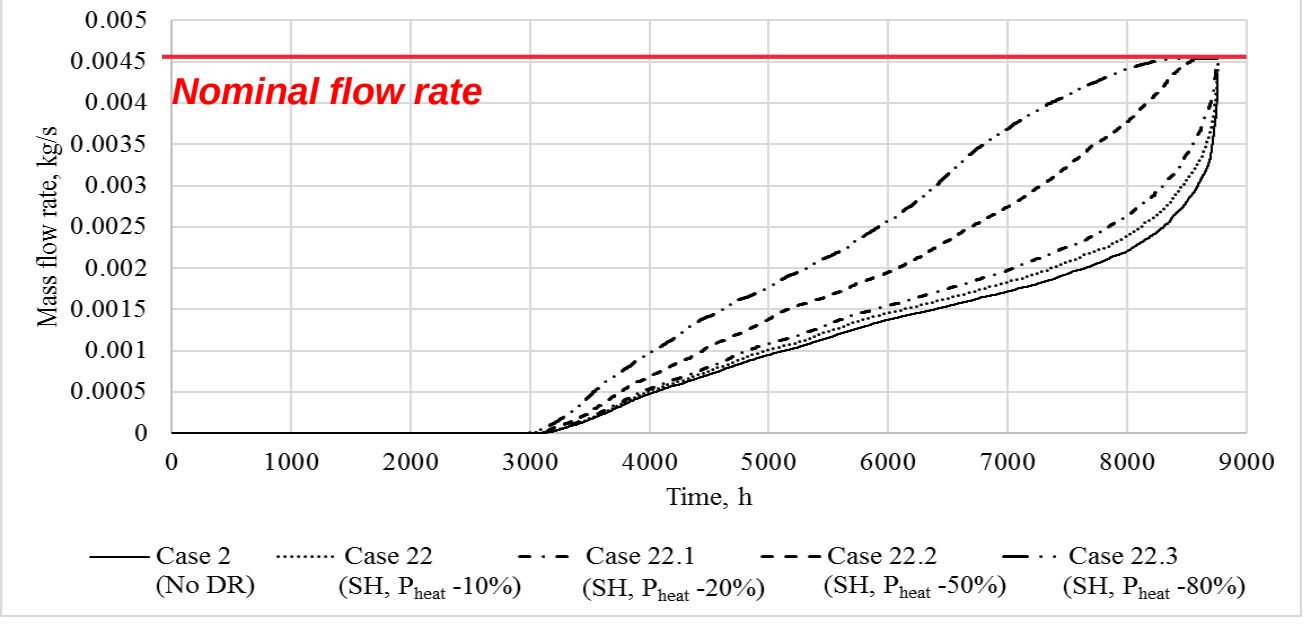
- Centralized control of space heating+ supply air temperature control:



→**1.6%** annual heat cost saving

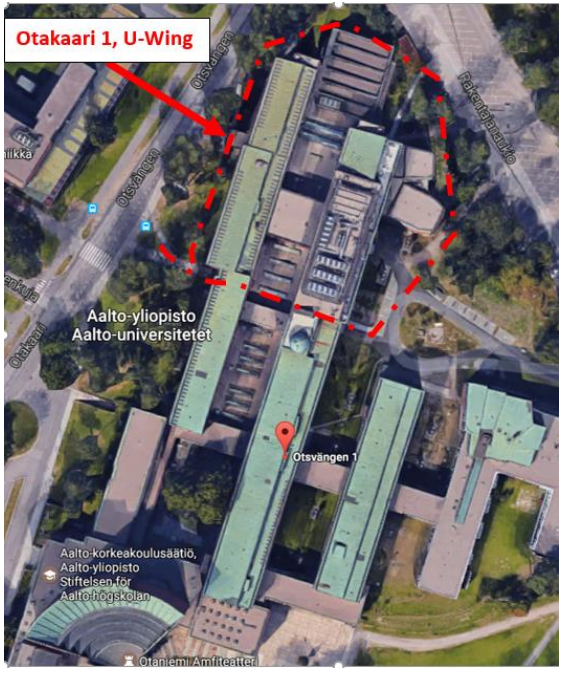
Why the saving potential is very low with the centralized demand response control?

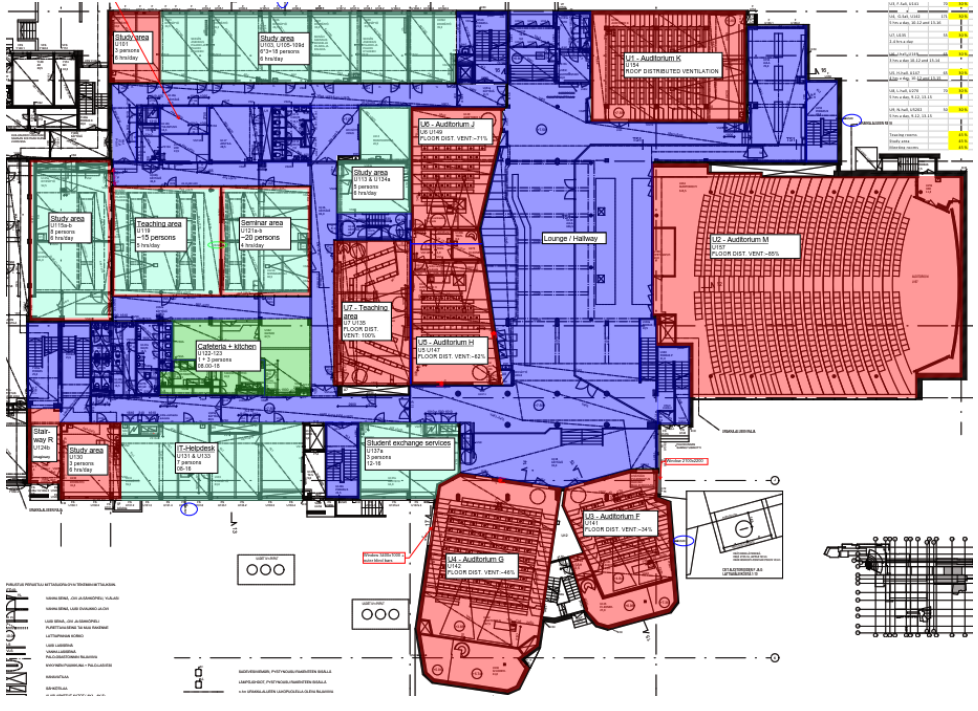
- The higher the deviation of the room temperatures, the lower the saving potential
- The thermostats compensate the inlet water temperature decrease by increasing the mass flow rate:



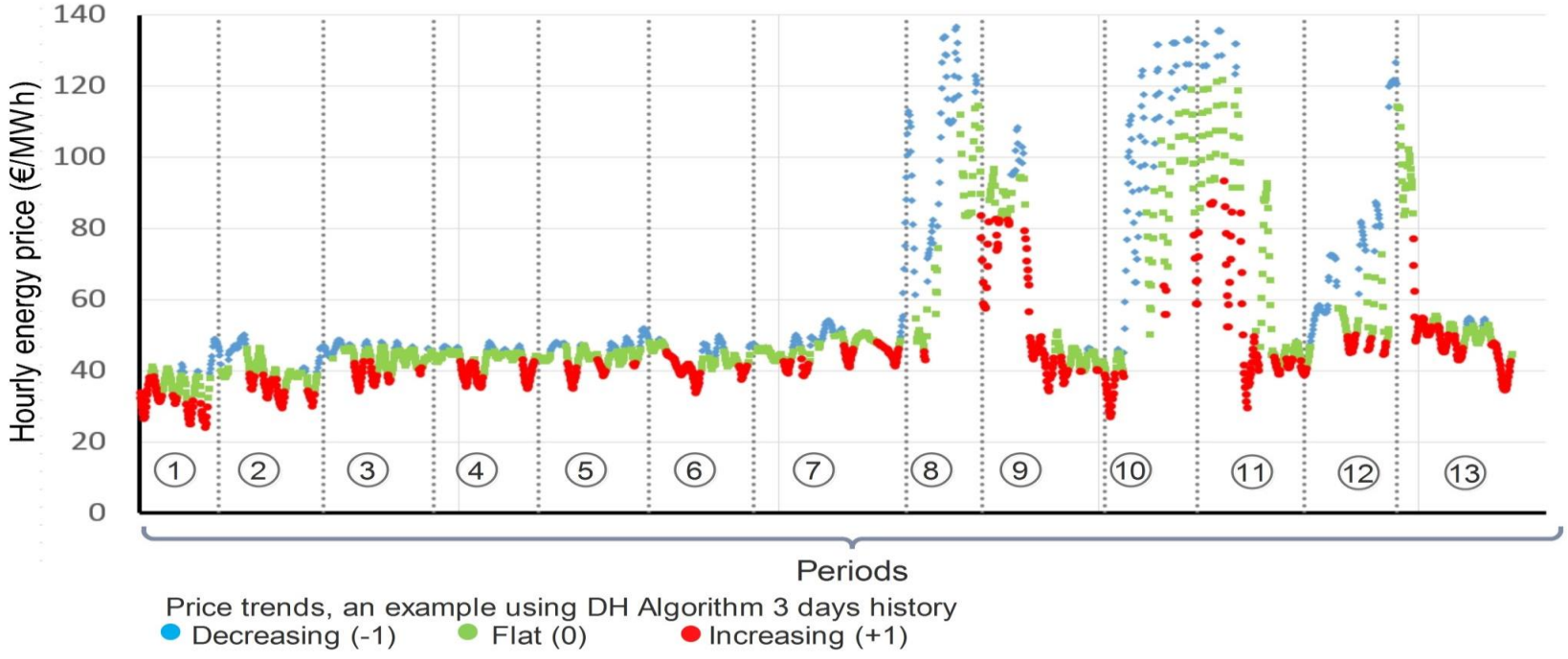
Centralized DR Field Study – Otakaari 1

1960’s building that is renovated in 2014 (windows, HVAC-systems)

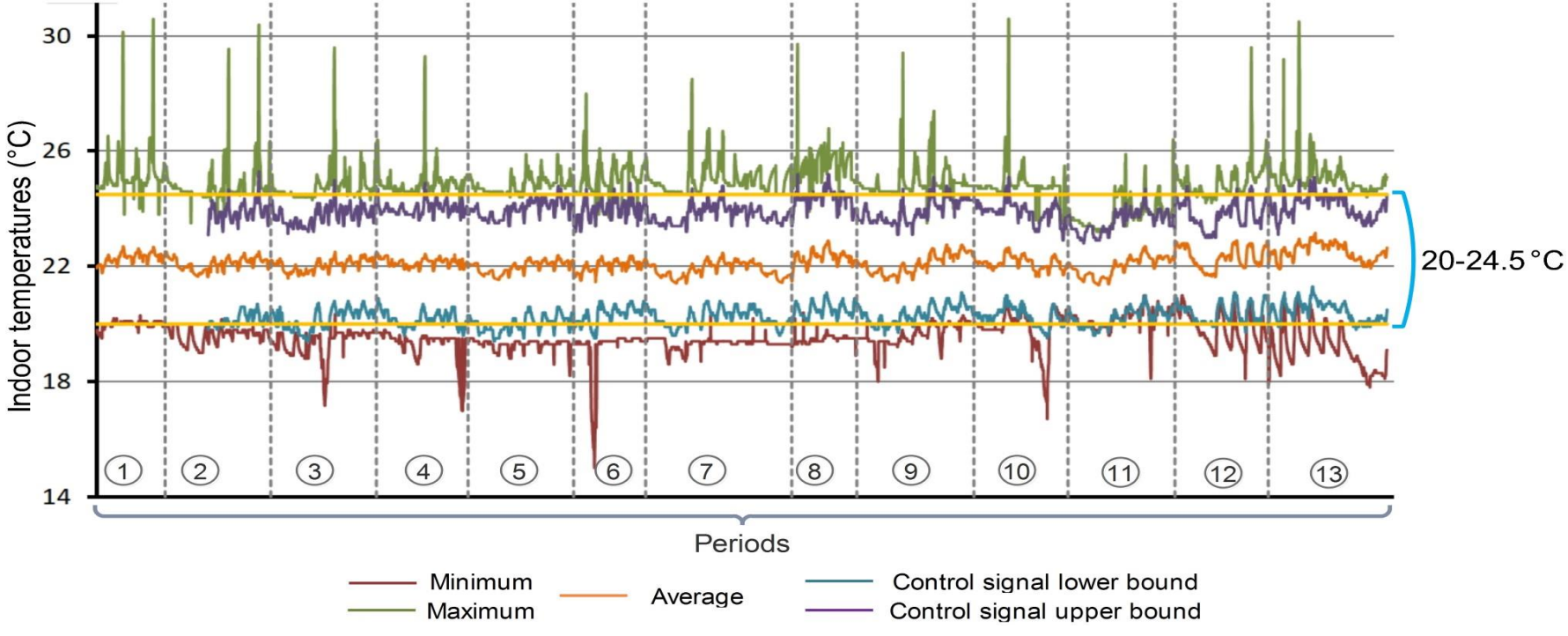




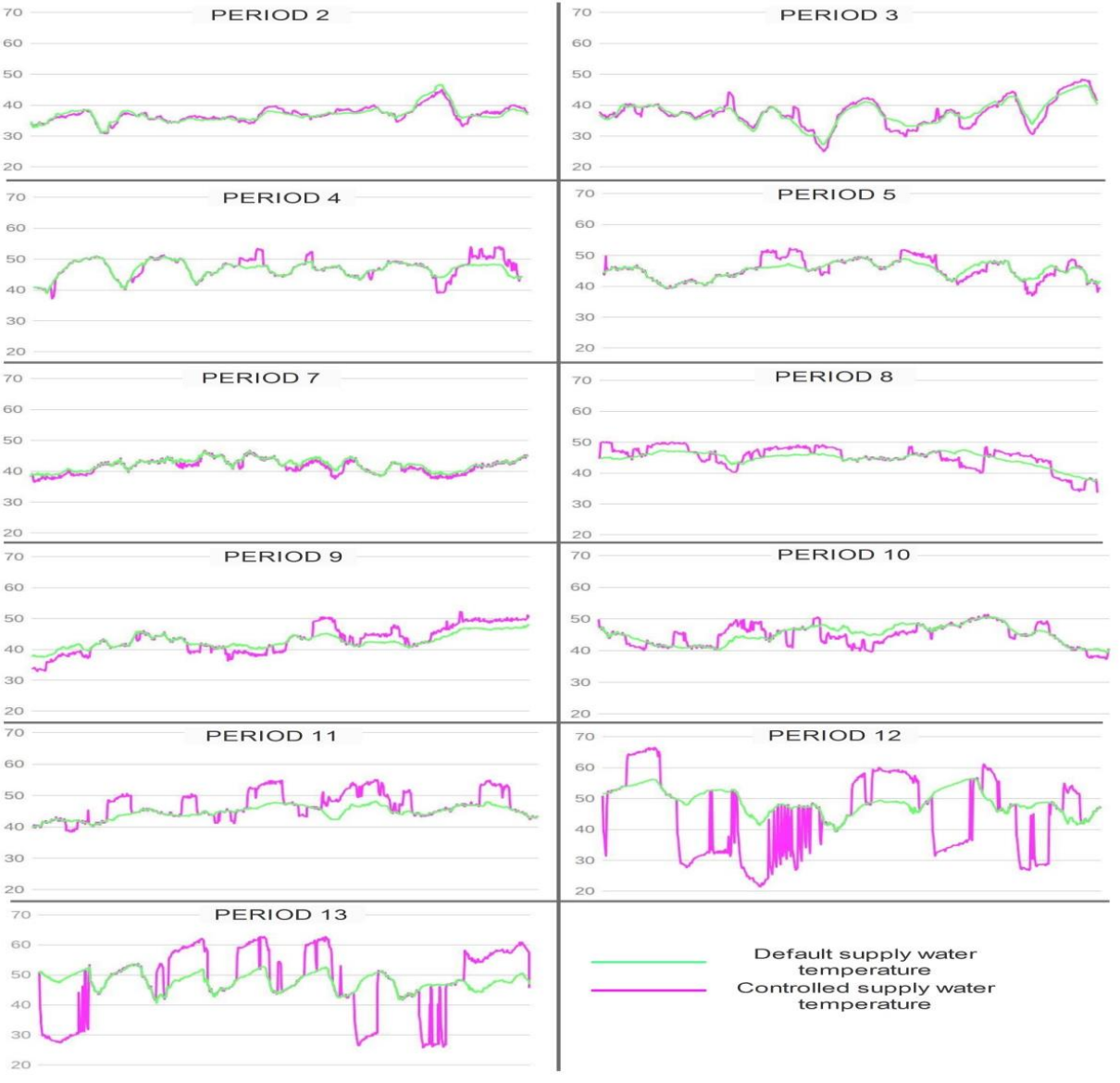
Hourly energy price variations during 13 control periods in the case-study building



Measured Room Air Temperatures



Standard and actual temperature of heating inlet water during each period when DR algorithms were introduced

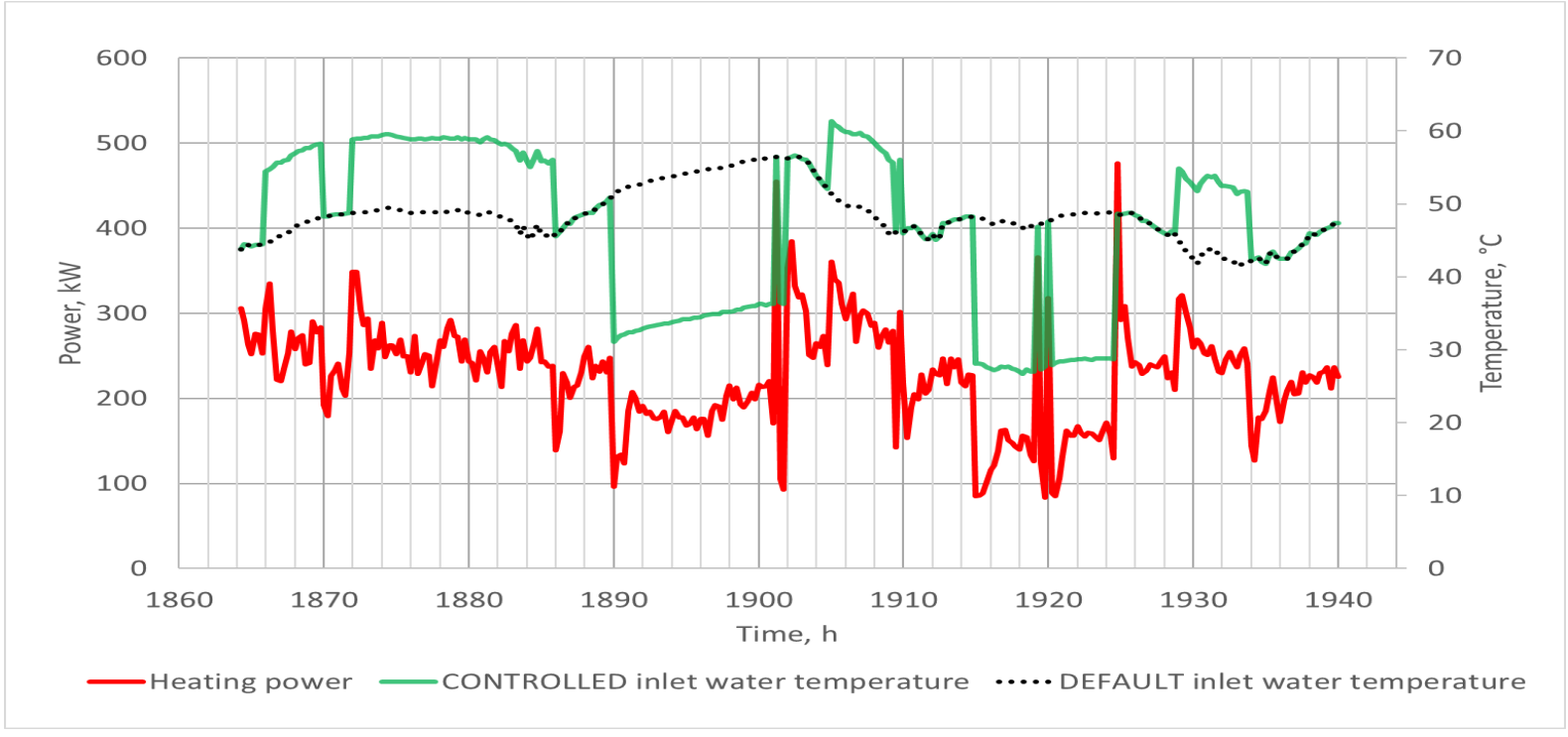


Occupants satisfaction during the different control periods

Period	P1 (no DR)	P2	P3	P4	P5	P6 (no DR)	P7	P8	P9	P10	P11	P12	P13
Negative ☹	8	11	1	1	3	2	55	35	54	61	46	13	5
Positive ☺	9	3	1	0	1	0	66	39	107	127	51	36	12
Negative ☹ (%)	47	79	50	100	75	100	45	47	34	32	47	27	29
Positive ☺ (%)	53	21	50	0	25	0	55	53	66	68	53	73	71

→ Share of the positive feedback was highest during the periods (P12 and P13) with the highest inlet water temperature variations (+10/-20 C)

The effect of centralized demand response control on inlet water temperature and heating power of space heating



Conclusions

- Simulations indicate energy saving potential of 6 % with decentralized systems and only 1-2 % with centralized system
- In the field test, perceived comfort was good even the inlet water temperature of radiators was changed of ~20 ℃


Thank you!