Aalto University
School of Engineering

Rakennuksen älykäs energiajärjestelmä:
IoT:n ja kysyntäjouston hyödyntäminen lämmityksen ohjauksessa

Global District Energy Days
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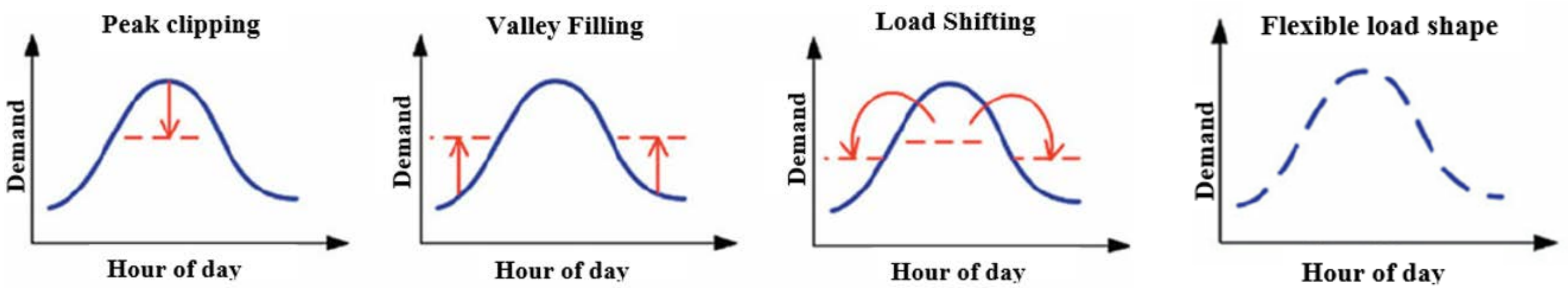
Research objectives

- **To find out:**
  - The effect of centralized demand response on indoor air temperatures, perceived thermal comfort and the operation of heating system in existing building
  - Cost saving potential of demand response of district heating and ventilation in an educational building by dynamic price tariff
  - The operation of decentralized and centralized demand response control

Motivation of demand response

- Types of demand response:

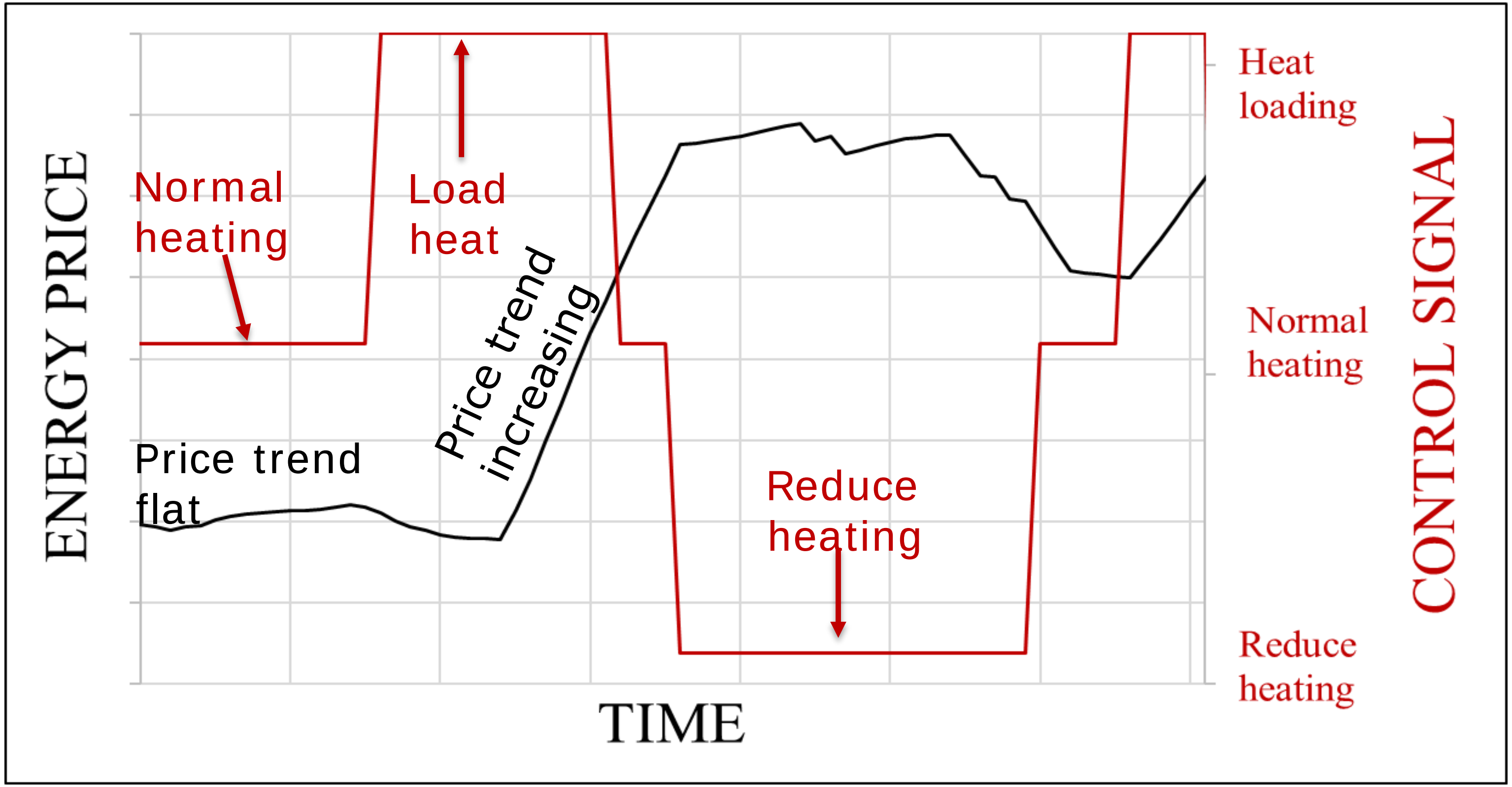


(Source:Wang & Yan, 2014)

- 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*

Example of price based demand response control

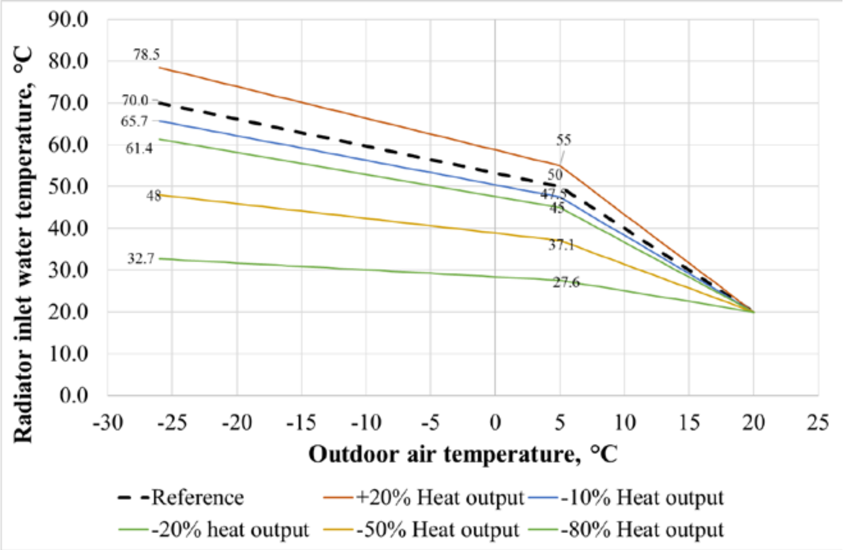
- Dynamic energy price and resultant operation:



Demand response control of space heating

A. <u>Centralized control</u>

→ Adjustment of radiator inlet water temperature



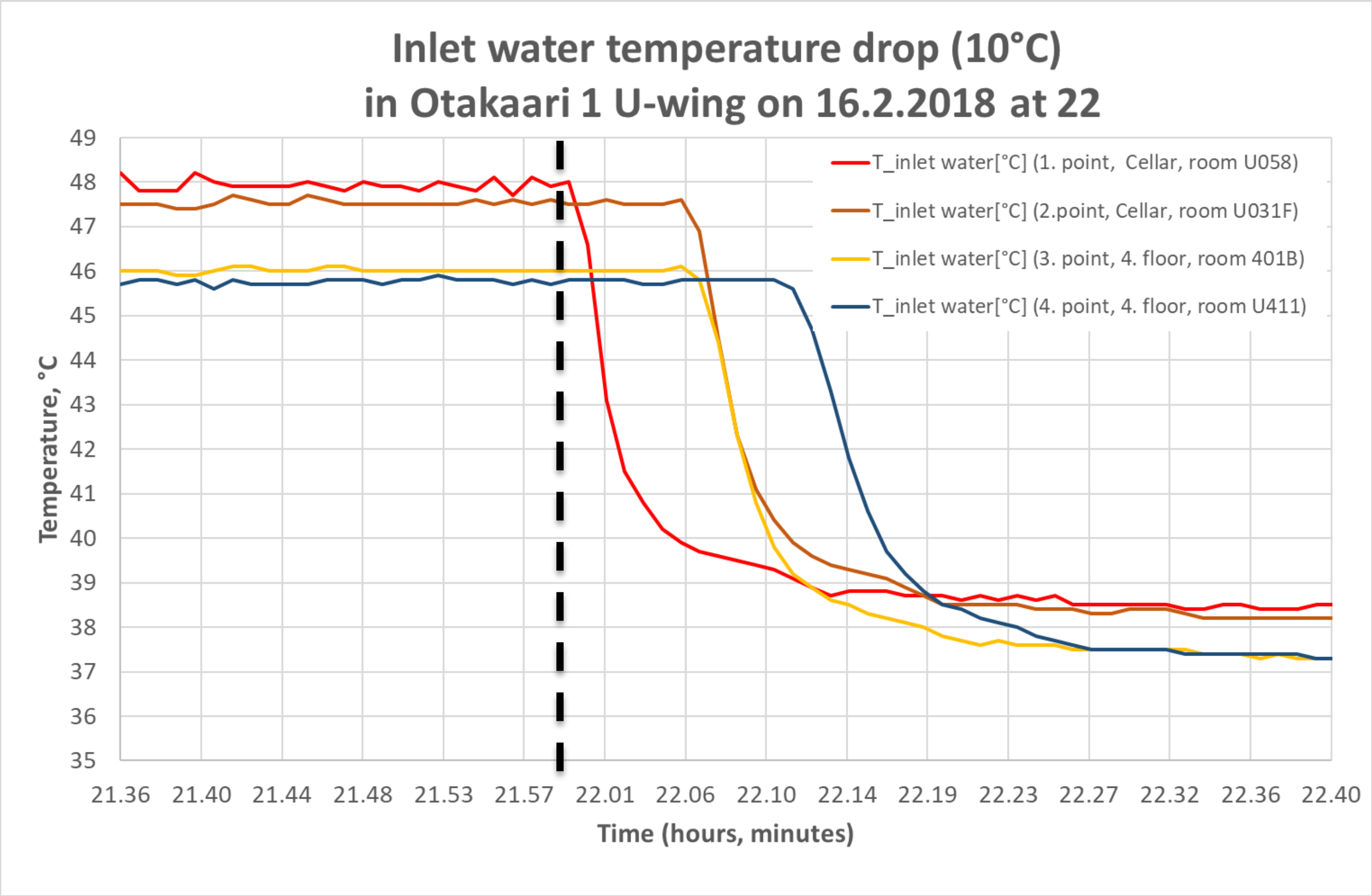
Manual thermostatic radiator valves (TRV):

B. <u>Decentralized control</u>

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

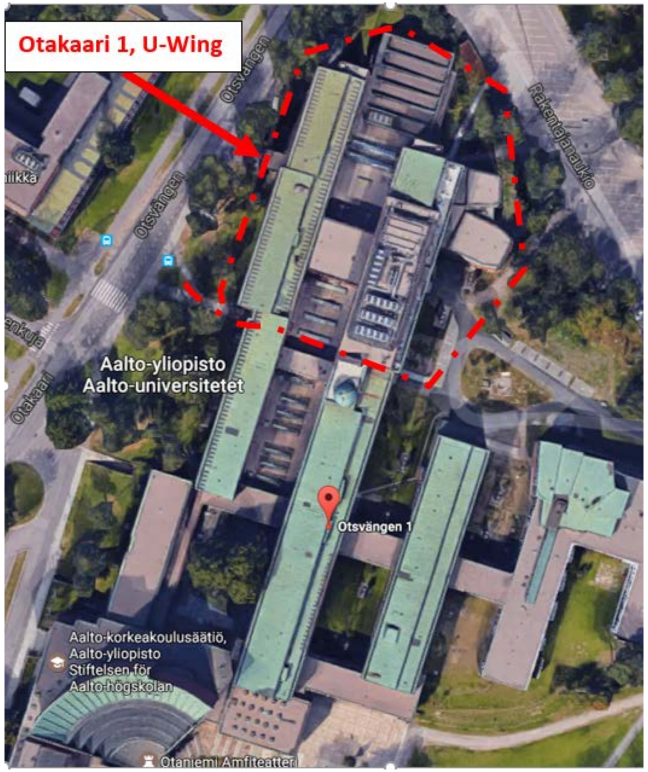
Electronic TRV:s

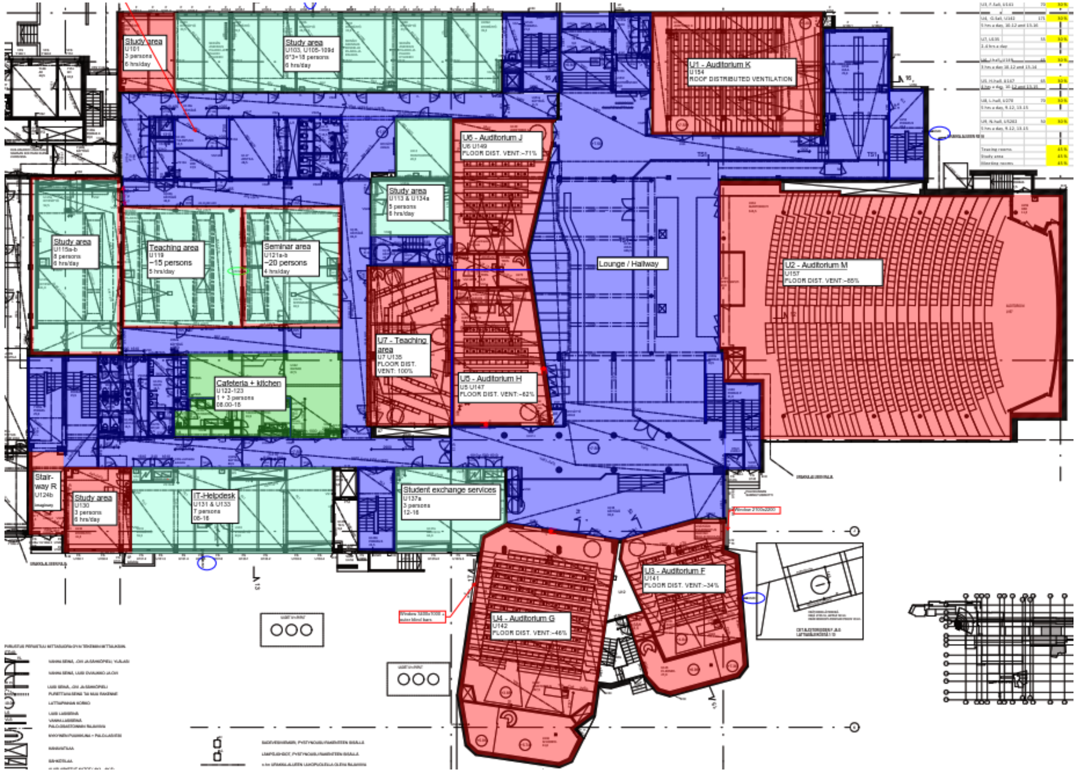
Does the slowness of the heat distribution system set a barrier for the utilization of centralized demand response?



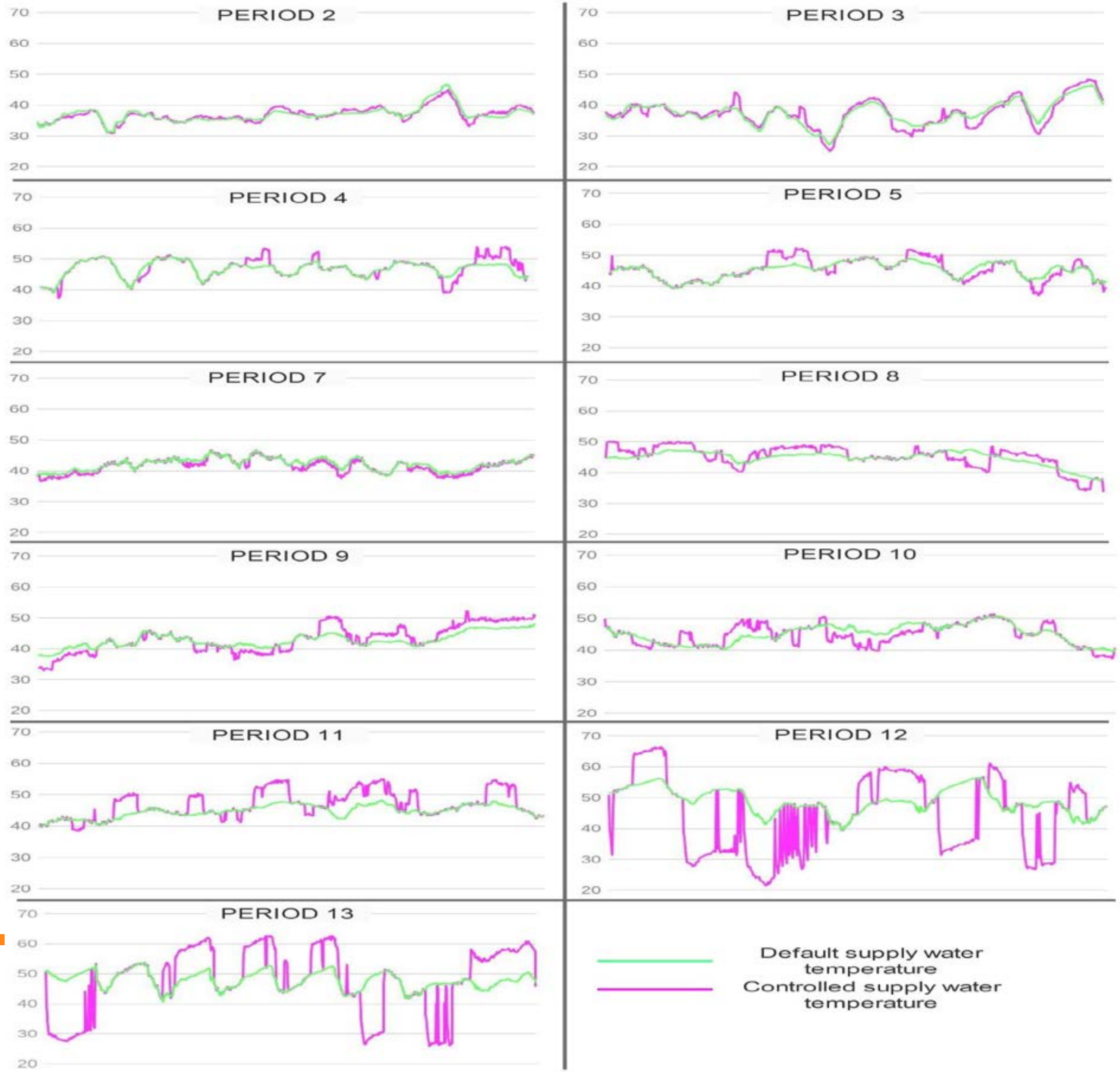
Centralized demand response field study: U-wing of Otakaari 1

- Heated net floor area of the U-wing: 13 800 m^2





Standard and actual temperature of heating inlet water during the test periods with different demand response control algorithms



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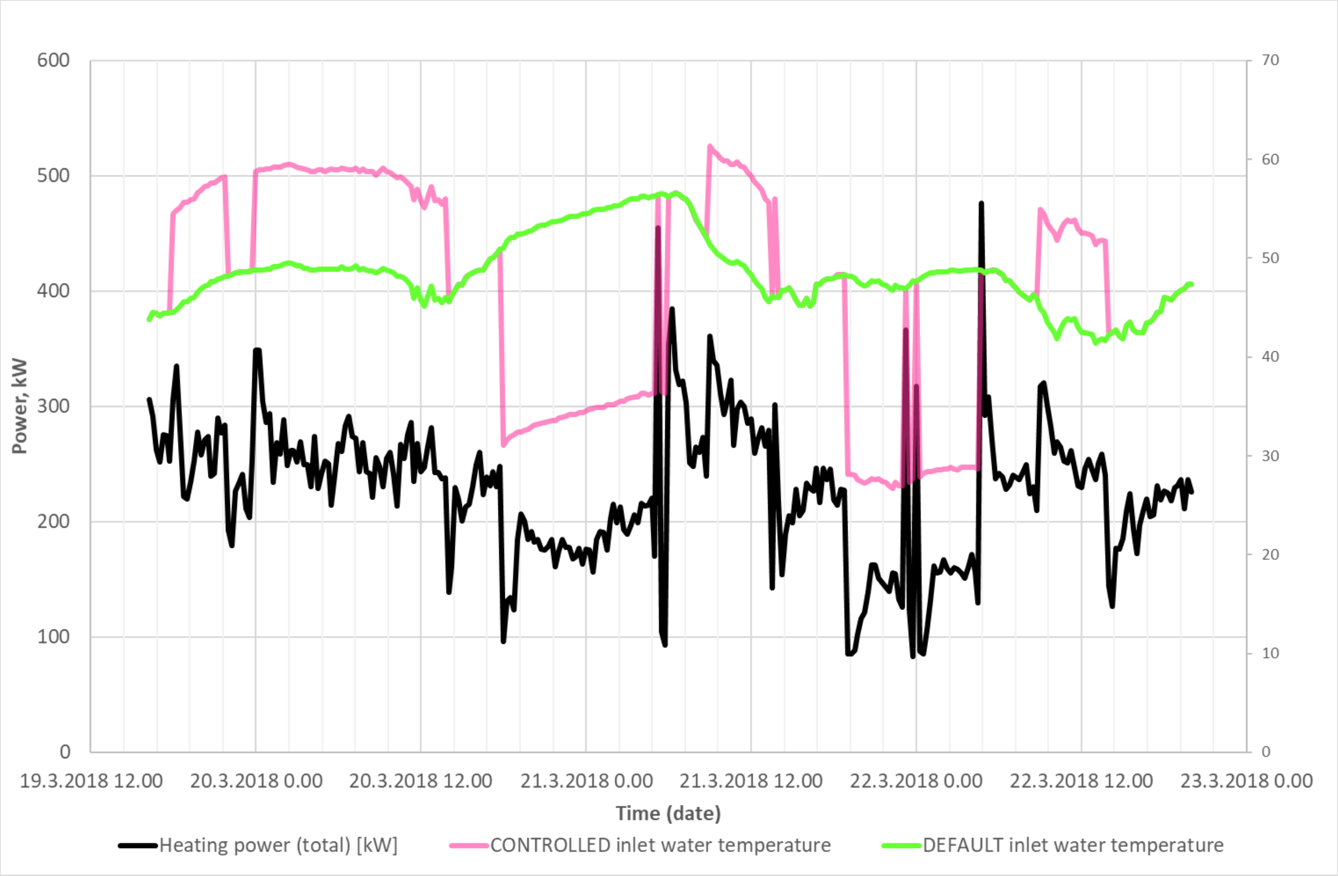
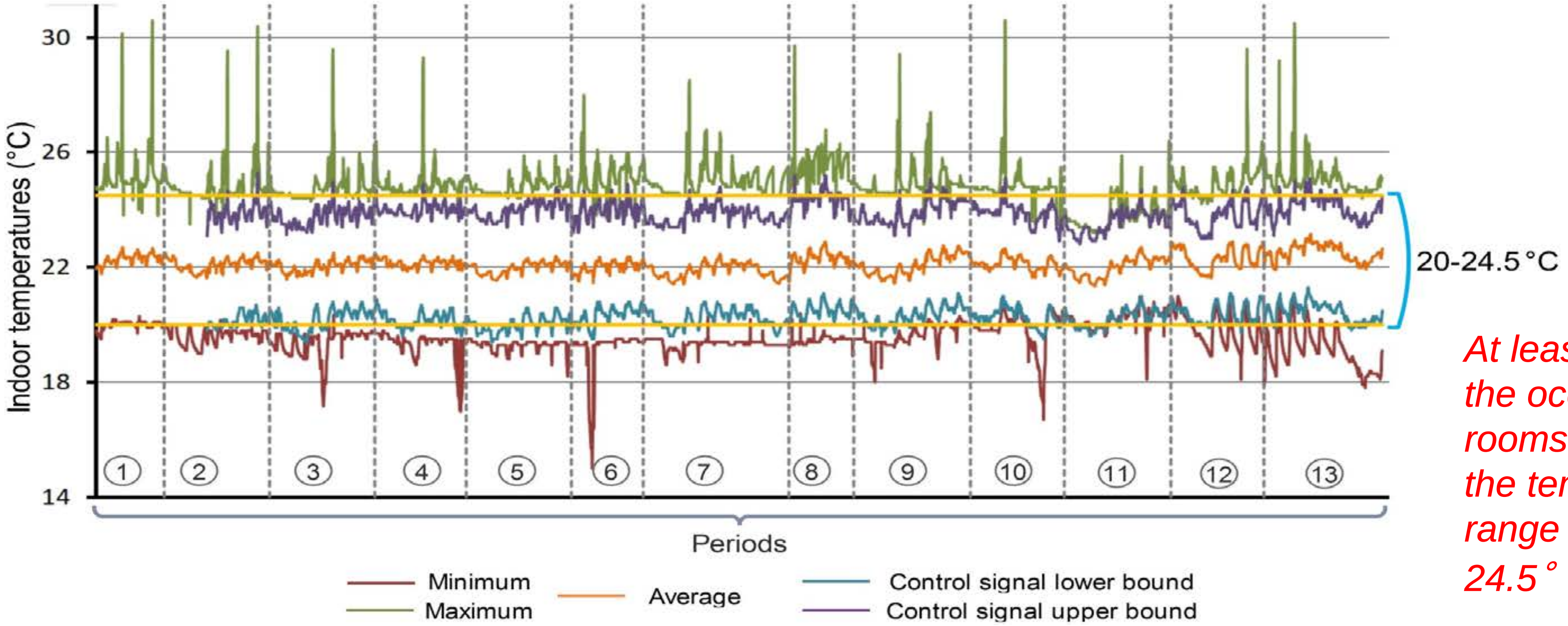
Inlet water temperature and heating power of space heating during one example period (P12)



Measured indoor air temperatures



At least 90% of the occupied rooms are within the temperature range 20-24.5° C

Feedback on the indoor temperature conditions by Granlund Pulse system

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Share your opinion about the indoor temperature!

We are collecting feedback on indoor temperature of Otakaari 1 U-wing at Aalto University's research project. With your feedback, we are developing intelligent heating control. The aim of the developed solutions is to reduce the CO_2 emissions of energy production and to optimize the energy use of the building.

More information about REINO-project:
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Feedback on the indoor temperature conditions

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

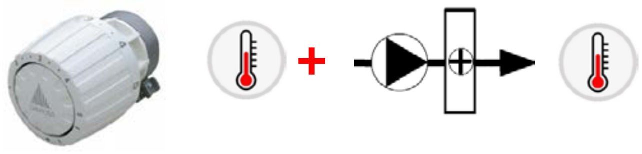
→ Share of the positive feedback was highest during the periods (P12 and P13) with the highest inlet water temperature variations (+10/-20° C)

Simulated cost saving potential of demand response

- Centralized control of space heating:

→**1.6%** annual heat cost saving

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

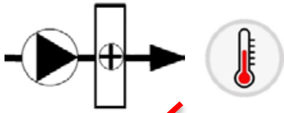


→**1.6%** annual heat cost saving

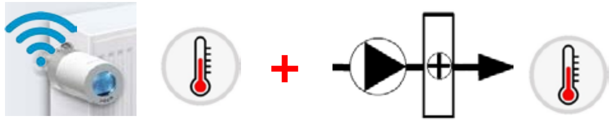
- Decentralized control of space heating:

→**5.2%** annual heat cost saving

- Supply air temperature control:



→**0.4%** annual heat cost saving



5.7% total annual cost saving

Conclusions

- The slowness of the heat distribution network does not cause any obstacles to demand response control.
- The field study indicates that even centralized demand response control can be implemented without affecting major alterations in the indoor thermal conditions and without increasing occupant discomfort.
- Simulations indicate heat energy cost saving potential of 1-2 % with centralized system and 6 % with decentralized systems.
- Decentralized demand response control is more promising approach.


Thank you!