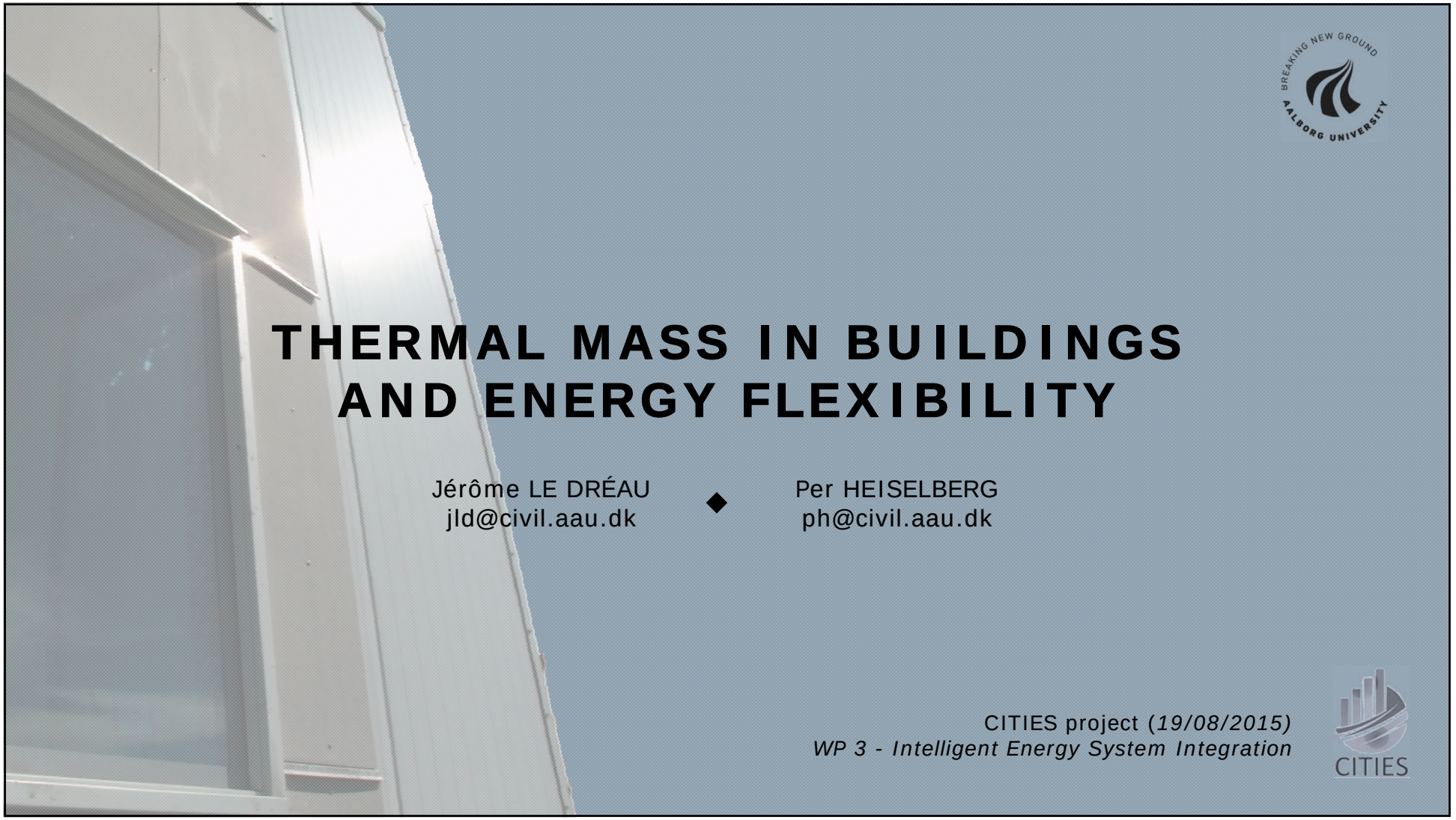

THERMAL MASS IN BUILDINGS AND ENERGY FLEXIBILITY

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CITIES project (*19/08/2015*)
WP 3 - Intelligent Energy System Integration

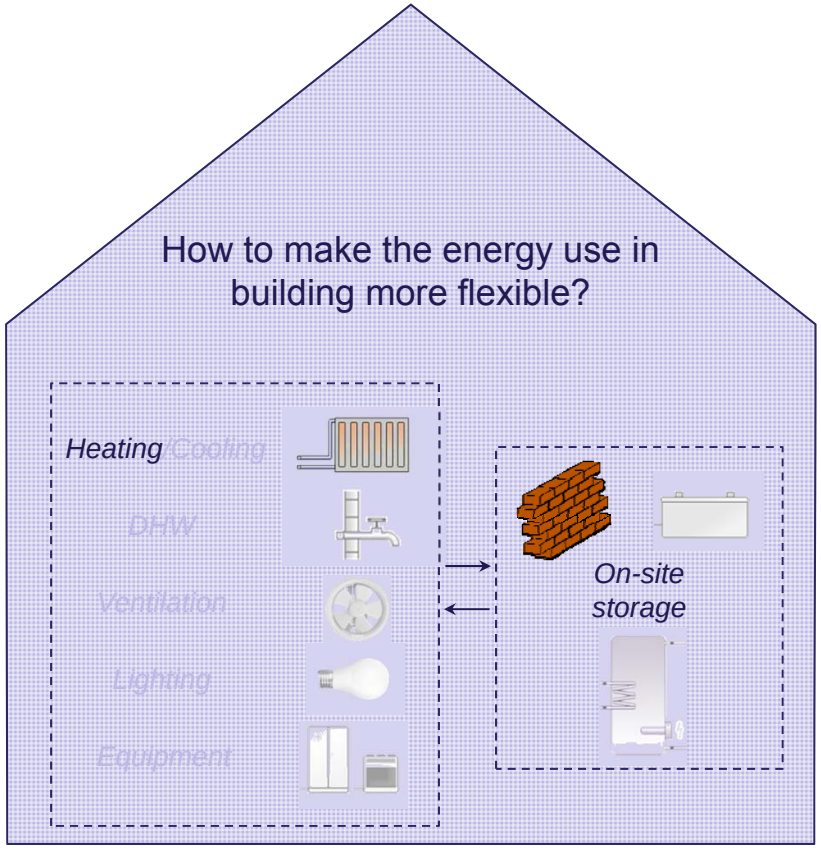
Scope and Objectives

Scope: space heating for residential applications with storage in the thermal mass of the building

Objectives: quantify the flexibility of different terminals for heating

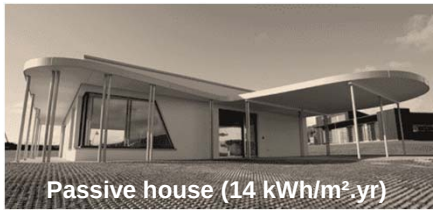
- Storage
- Heat release

Building stock

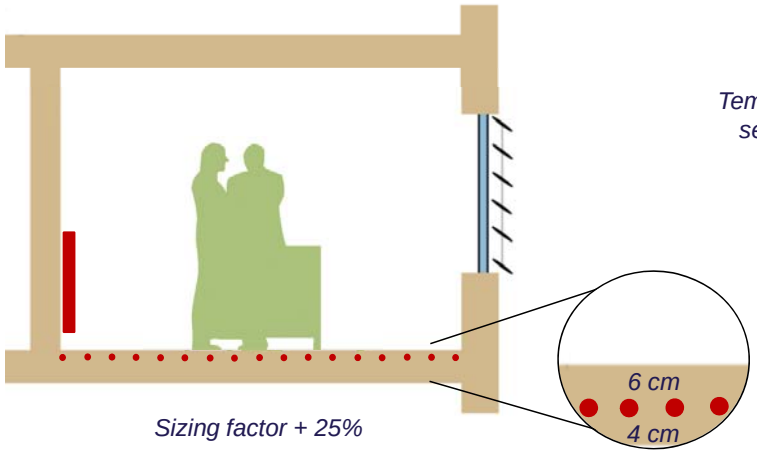


Parameter variation

Type of buildings

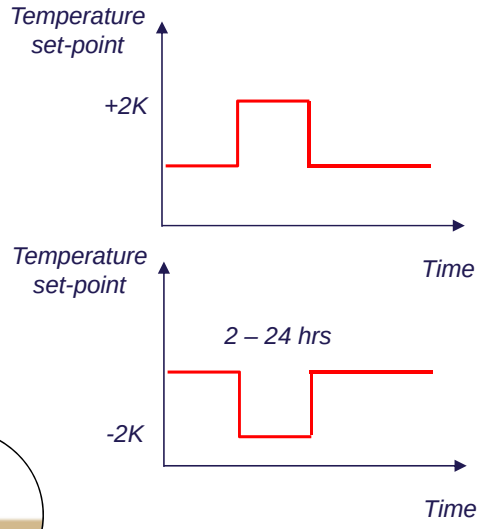


Type of emitters



Sizing factor + 25%

Type of activation
(duration, starting time, increase vs. decrease)



Simulations

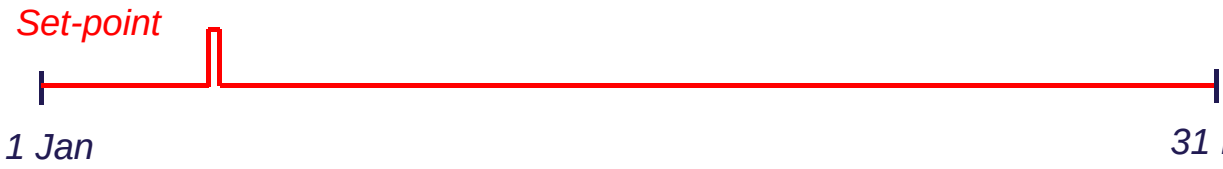
Coupled with BCVTB

Main characteristics:

- Danish weather file (DRY.v2)
- Equipment load from hourly pattern (*Marszal et al., 2015*)
- 8 thermal zones
- Solver: time-step 2 minutes, conduction modelled using FDM

Simulation procedure:

- Single activation at different time of the year
- No interaction between activations (i.e. full discharge)



× 365 activations

U_{walls} = 0.32 W/m².K
Natural ventilation 0.4 ACH
Infiltration 0.2 ACH

Thermal mass: light (44 Wh/K.m²)
τ = 27 hrs

Heating set-point: 20°C
Design power: 70 W/m²
Primary water tmp: 70°C radiator, 43°C UH

U_{walls} = 0.09 W/m².K
Mechanical ventilation 0.4 ACH (η = 0.8)
Infiltration 0.07 ACH

Thermal mass: medium (53 Wh/K.m²)
τ = 105 hrs

Heating set-point: 21°C
Design power: 25 W/m²
Primary water tmp: 45°C radiator, 30°C UH

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SINGLE FAMILY HOUSE FROM THE 80'S

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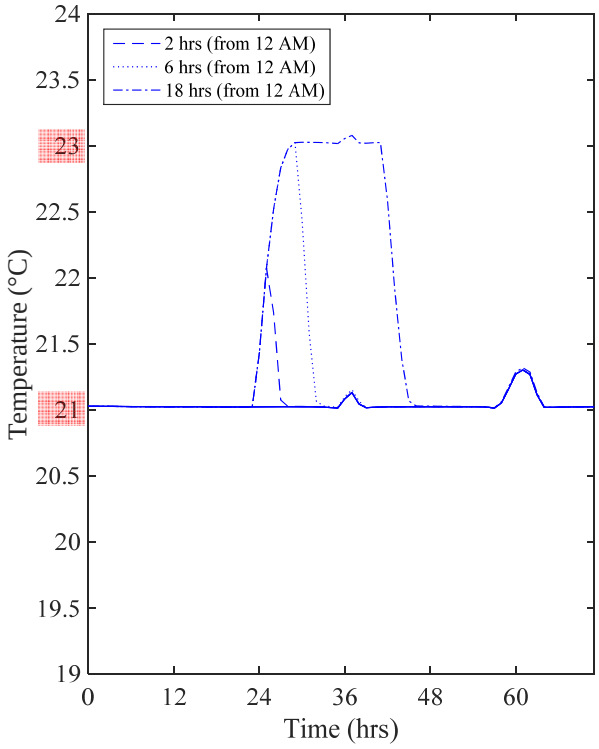
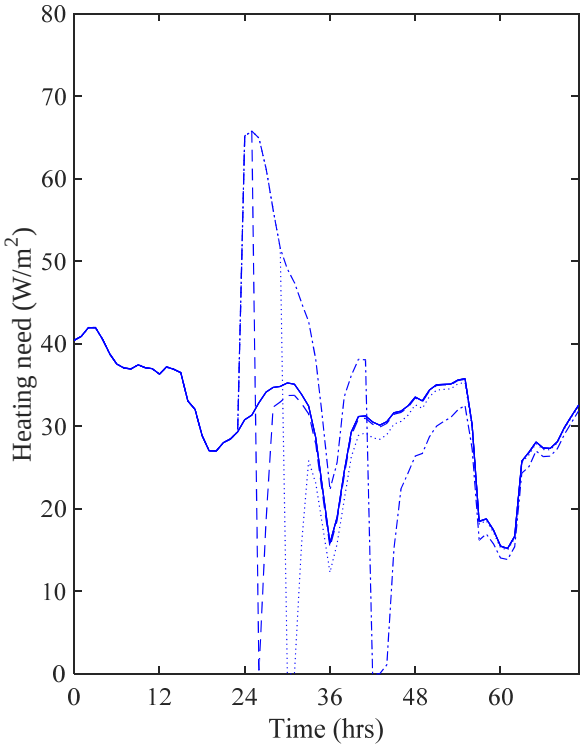
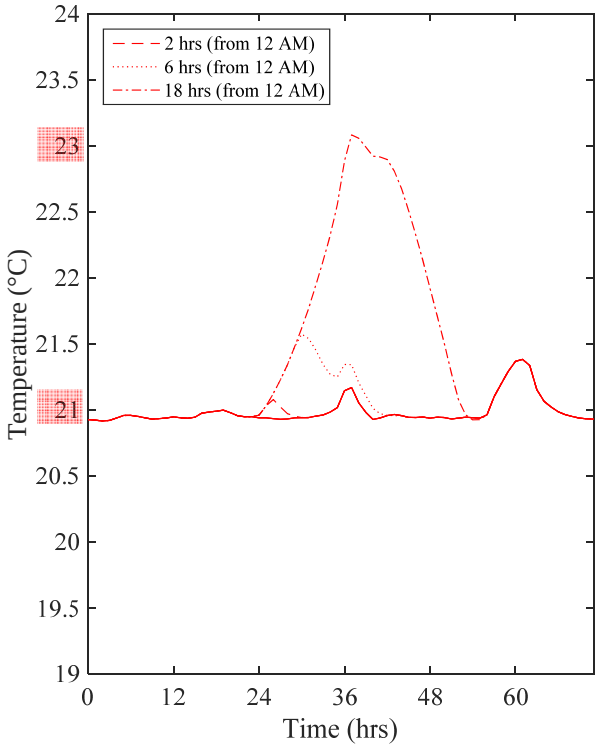
Radiator *[15th of January]*

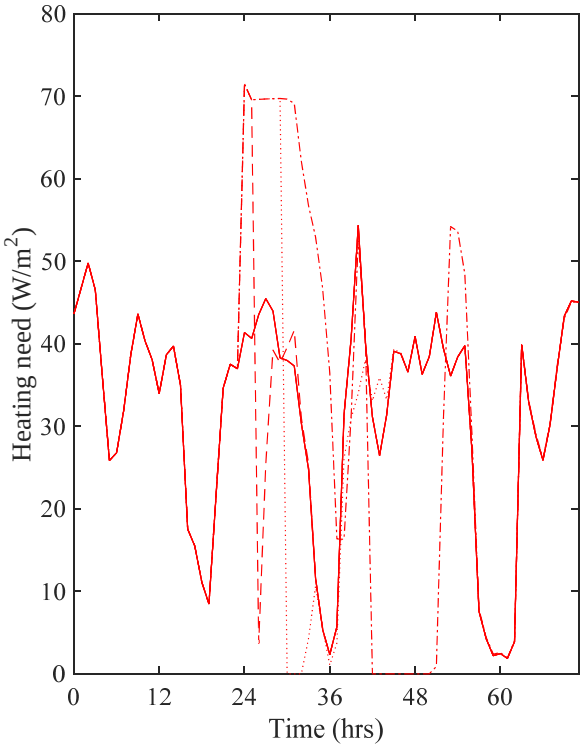




- Large influence on the indoor temperature
- Small potential for full disconnection

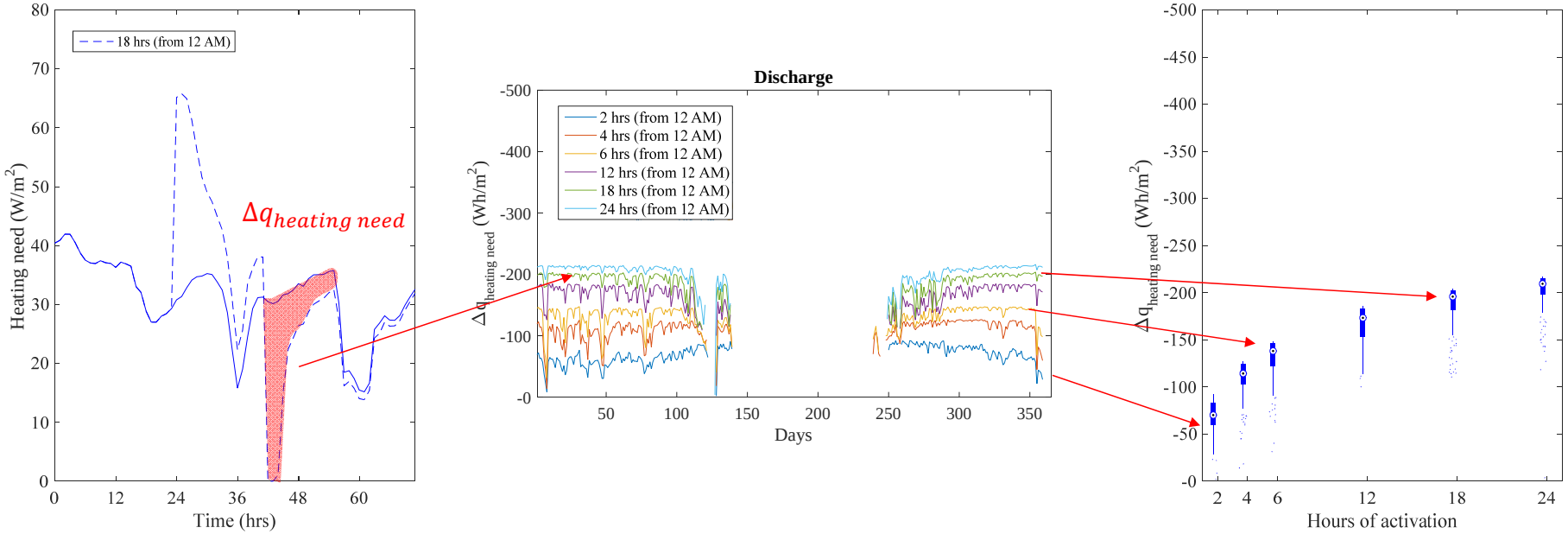
Underfloor heating (UH) *[15th of January]*



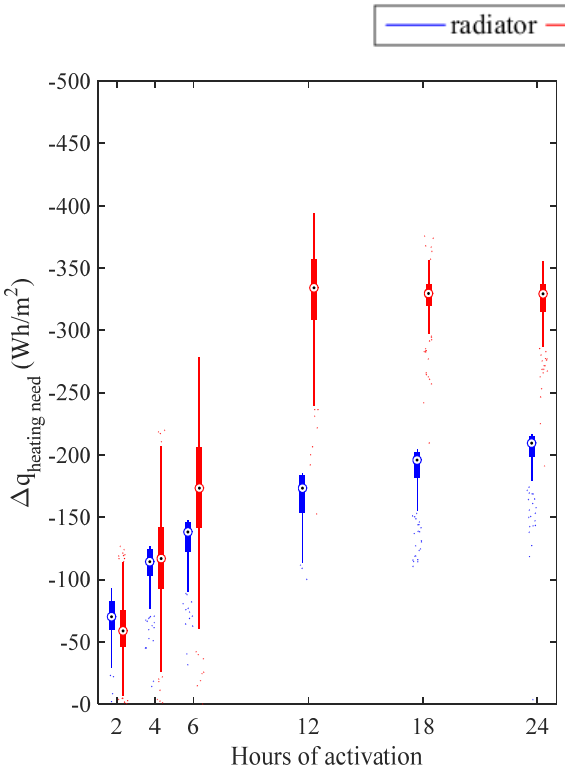


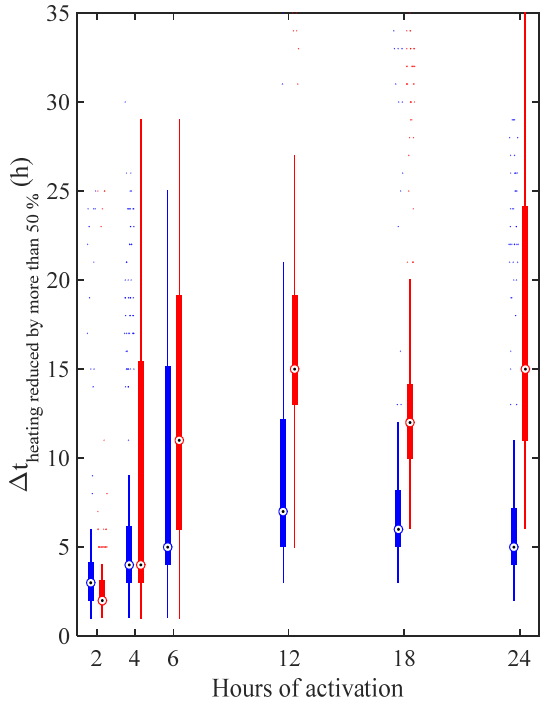
- Lower influence on the indoor temperature for short charges

Analyse of the results



Radiator vs. Underfloor heating *[All days of heating season]*

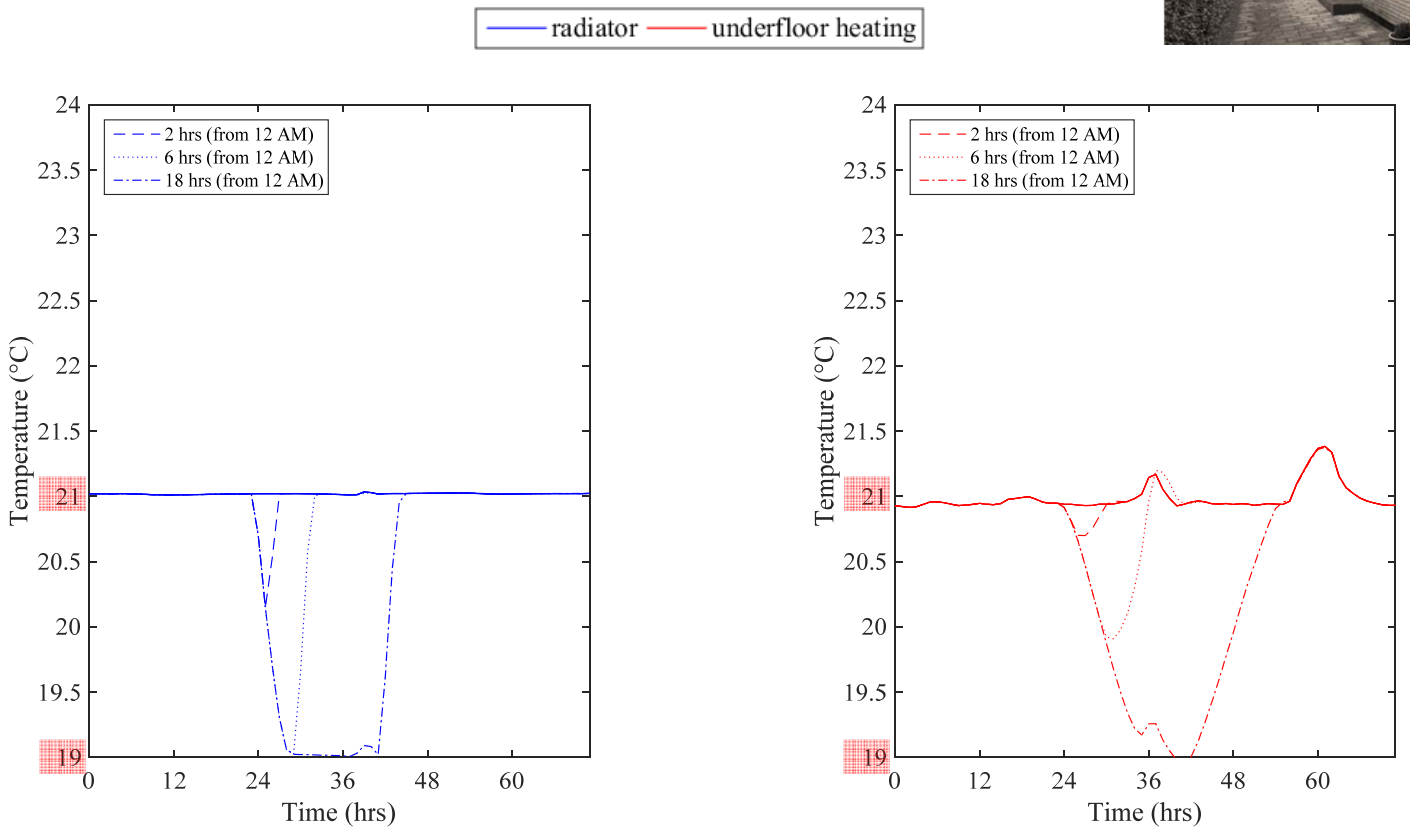




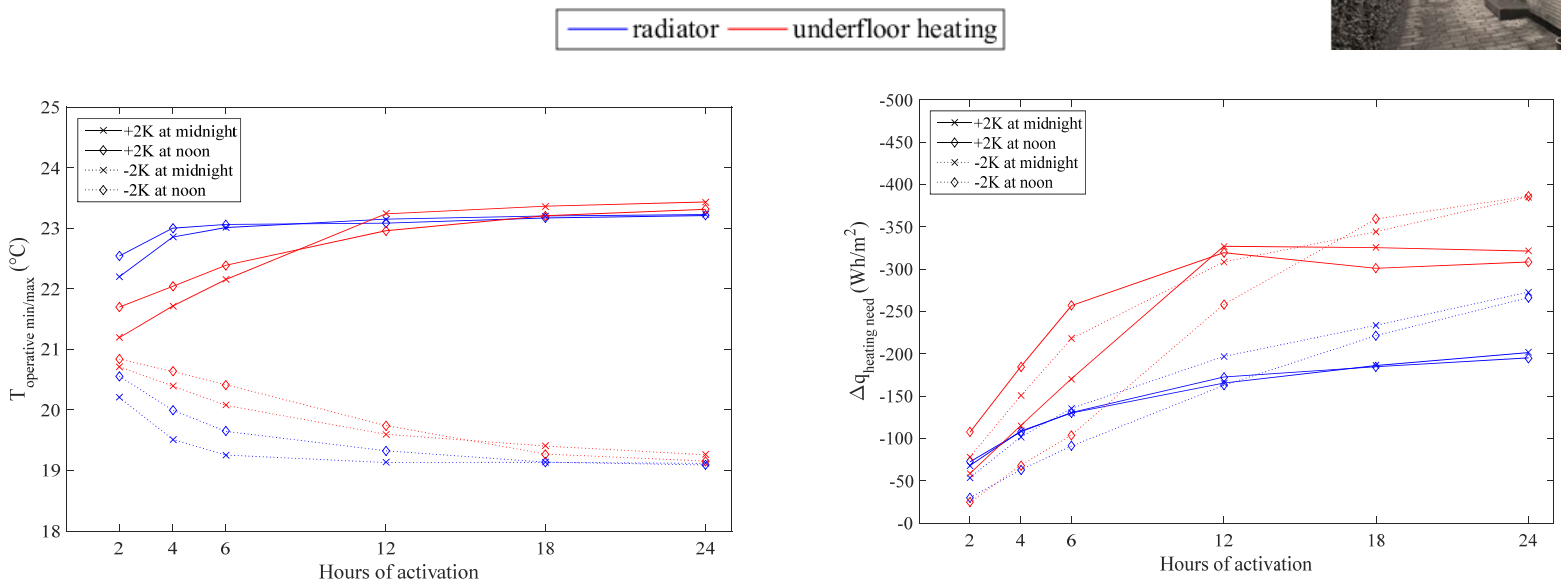
- Larger charging potential of UH, but risk of overheating
- Nbr of hours of decreased charge on the grid:
  - 2-5 hrs for radiators
  - 2-15 hrs for UH

  but large fluctuations…

Radiator vs. Underfloor heating *[15th of January]*

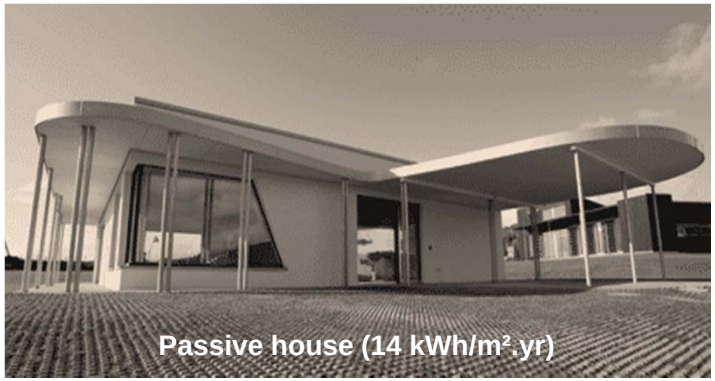


Radiator vs. Underfloor heating *[Summary]*



- UH disturbs less the indoor environment
- Charges/Discharges over 12 hrs not efficient
- Optimum solutions: increase of SP during daytime OR decrease during nightime

PASSIVE HOUSE



Passive house (14 kWh/m².yr)

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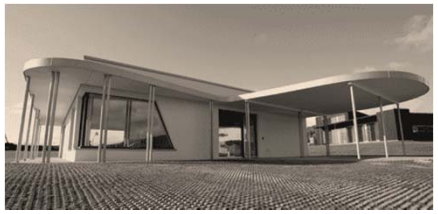
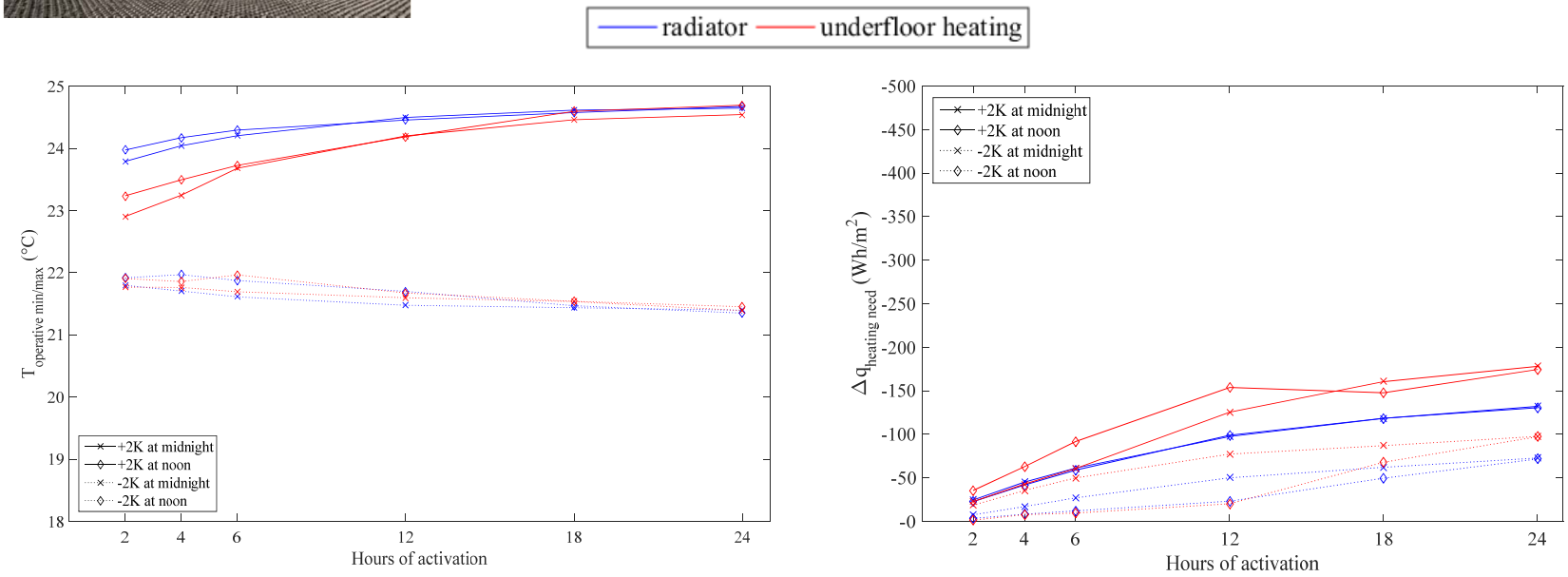
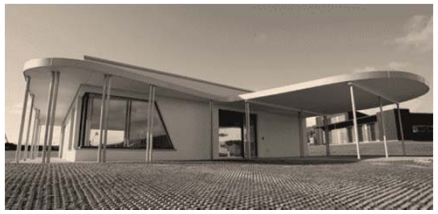


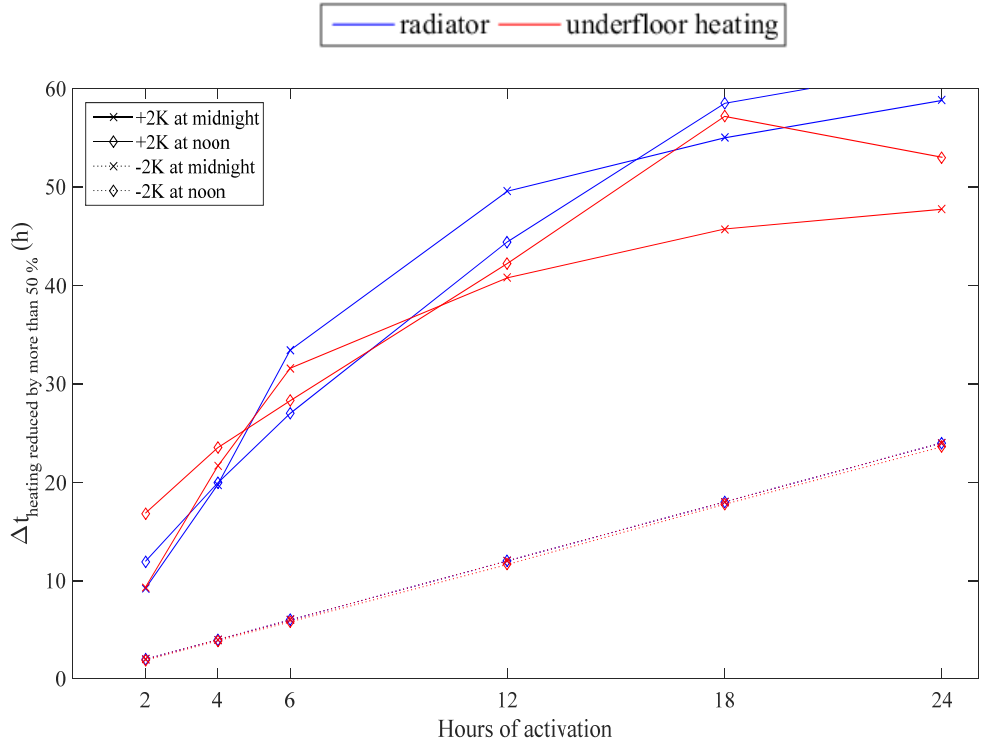
Radiator vs. Underfloor heating *[Summary]*



- Asymmetry between heat storage and heat conservation strategy
- Increase of SP: large storage potential, but large risk of overheating
- Decrease of SP: good storage potential if performed during nightime, low discomfort



Radiator vs. Underfloor heating *[Summary]*



- Possibility to fully disconnect the building for more than 24 hs
- Increase of set-points: up to 3 days

Conclusions

"Optimum" solutions for the SFH from the 80's:

- UH activated up to 6-12 hours, for an effect during a few hours
  Increase of set-point during daytime, or a decrease of set-point during night-time
- Radiator: only for short charges or discharges (2 to 4 hours), low efficiency

"Optimum" solutions for the Passive House:

- UH or Radiator, in discharge only
  Decrease of set-point during night-time
- UH with short charges (2-4 hours)… but high risk of overheating if no MPC!

Both buildings seem to be more flexible with a PV-based grid (day/night asymmetry).

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Future work

- Apply these strategies to existing grid prices and profile, and identify the possible savings.

		SFH 80's	PH
Underfloor heating	Yearly cost without activation		
	Activation 1		
	Activation 2		
Radiator	Yearly cost without activation		
	Activation 1		
	Activation 2		

- 1 grid scenario?
- Too rough?

- OR study multi-storey buildings, with higher time constant

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Lessons learned from the simulations

- Calculation of conduction through walls:
  - More influence than for “regular” simulations (faster activations)
  - Settings: importance of the time-step + type of solver (CTF vs. FDM)
  - Simplified models (i.e. RC models) will probably be difficult to define
- Sizing of heating systems is very important
- One pending question: what is the influence of the controller?
  - Radiator: default “perfect” controller
  - Underfloor heating: P-band setting $\Rightarrow$ the heating need would be more constant with a PI controller


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