

Heating flexibility in buildings

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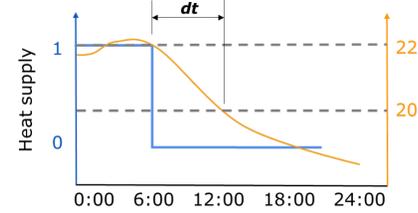
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Research questions

The aim is to use building thermal inertia to provide heat flexibility for district heating systems to reduce/avoid the operation of peak load boilers.

- How long is the time duration?
- How much load can be shifted?
- How to control?
- How to extend the scale from a single house to a community?

How long time can buildings maintain comfort without heating supply?



Old house
1851-1930



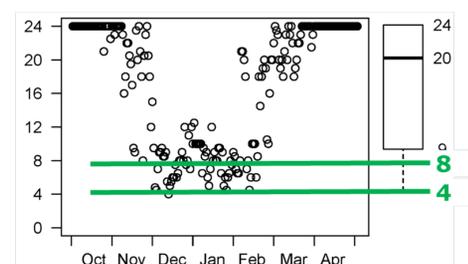
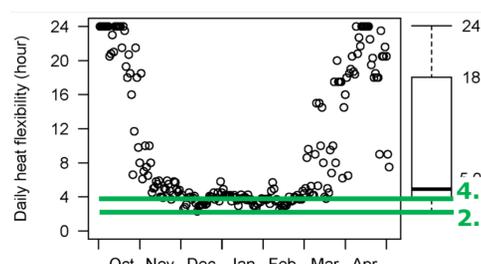
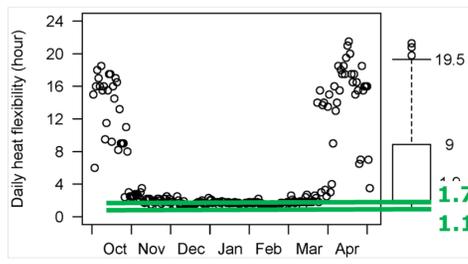
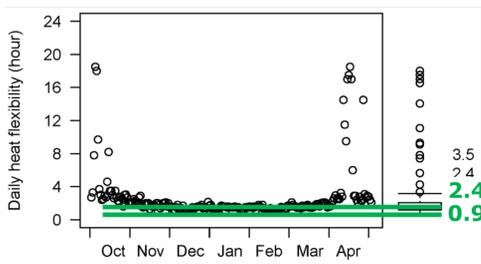
Old house
1961-1972



Renovated
1851-1930 house



New house
2007-2010



How much load can be shifted from peak hours?

Rule based control

Scenarios	Difference from reference operation				F1	F2
	Energy [%]	Cost [%]	Average temp. [°C]	Morning load reduction [%]		
Reference-22°C	-	-	-	-	-0.20	0.08
22°C/21°C	-11.0%	-14.0%	-0.4	-81.5%	0.23	0.22
Preheat-23°C/21°C	1.4%	-5.8%	0.1	-96.5%	0.67	0.34
25%-23°C, 50%-21°C	4.2%	-8.0%	0.0	-30.8%	0.07	0.54

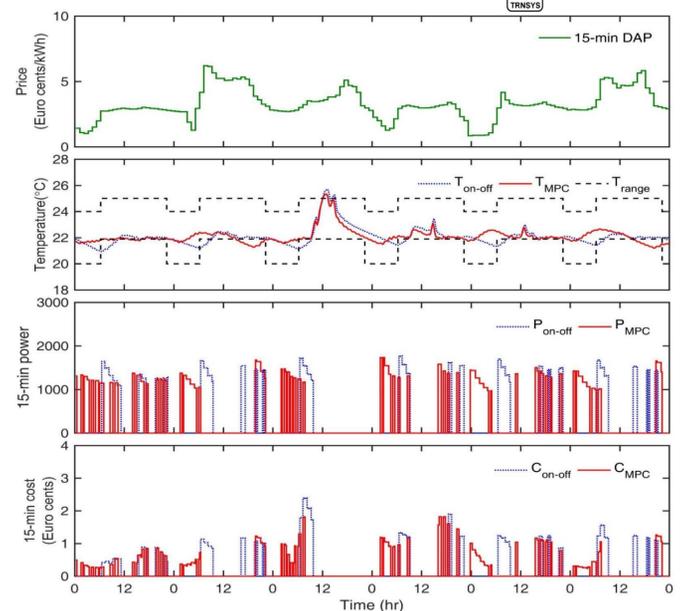
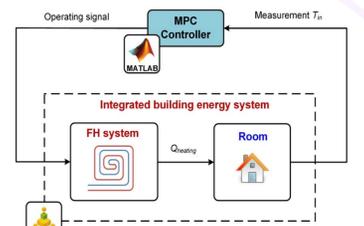
$$F_1 = \frac{E_{low\ load} - E_{high\ load}}{E_{low\ load} + E_{high\ load}}$$

$F_1 = 1$, heating is used only during low-load hours, i.e. 21:00-6:00 next day
 $F_1 = -1$, heating is used only during high-load hours, i.e. 6:00-21:00

$$F_2 = \frac{E_{low\ cost} - E_{high\ cost}}{E_{low\ cost} + E_{high\ cost}}$$

$F_2 = 1$, heating is used only during low production cost period
 $F_2 = -1$, heating is used only during high production cost period

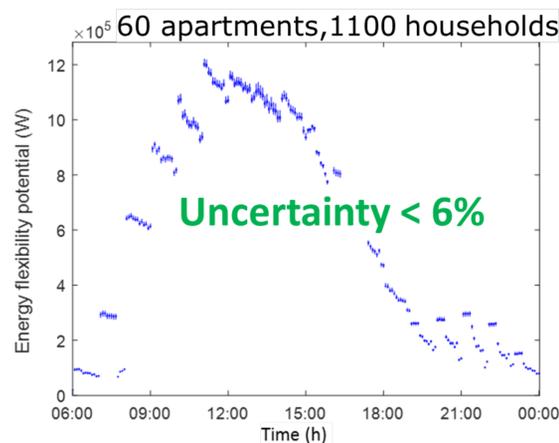
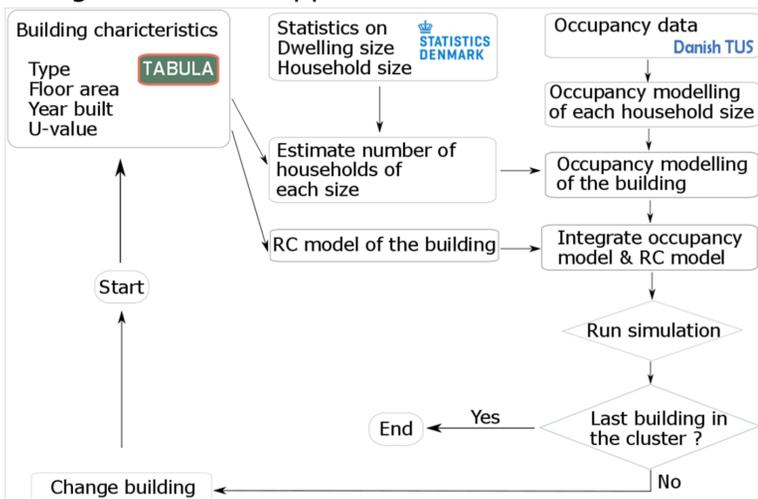
Model predictive control



Energy flexibility of a community?

Uncertainty of energy flexibility decreases when the aggregated number of buildings increases

A big-data driven approach



Acknowledgement

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