KU LEUVEN

MPC framework for all-air systems in non-residential buildings

Numerical and experimental study

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AIVC webinar

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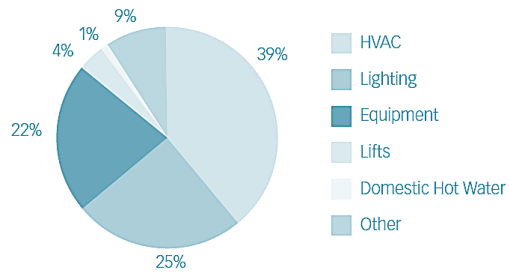
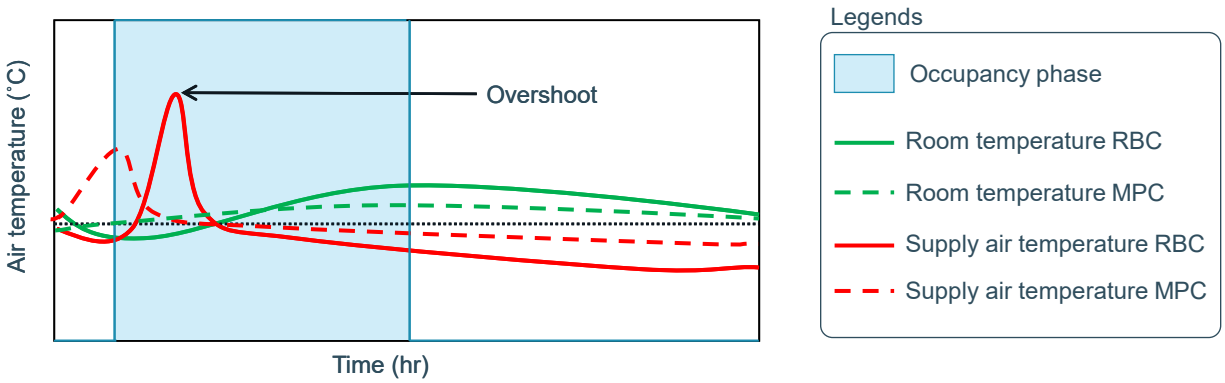
High energy use in buildings
Measures taken
- Improved insulation layer
  - More airtight envelope
  - Better design and optimization of energy efficient HVAC systems



There is still energy waste in buildings due to inefficient operation

Smart control of HVAC systems

Reactive control (RBC) vs. predictive control (MPC)

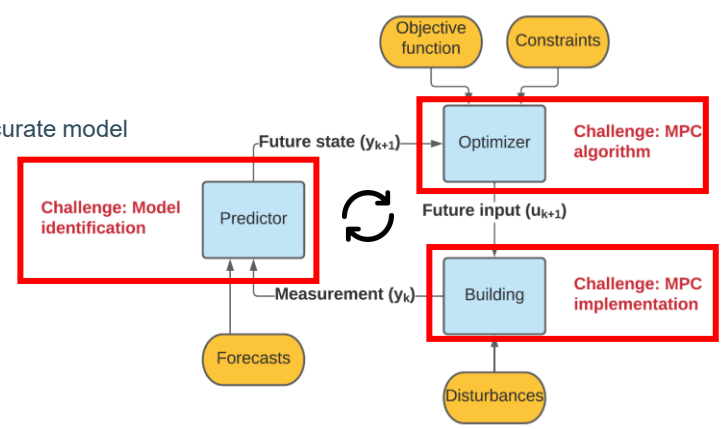


Objectives

- Proof of concept for an MPC framework in non-residential buildings with an all-air system
  - To identify suitable models for application in all-air systems
  - A robust MPC algorithm for application in all-air systems
  - To demonstrate the potential of MPC for all-air systems

- MPC is a promising technique to optimize the control of the all-air system

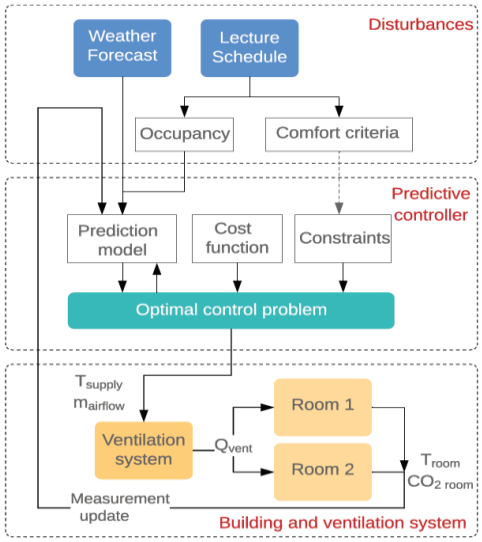
Simple but accurate model



Conflicting targets

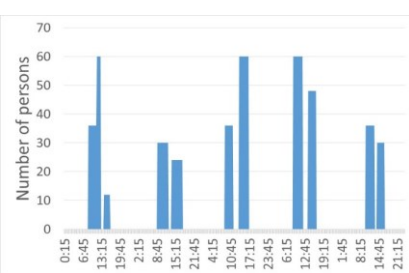
Integration with BAS

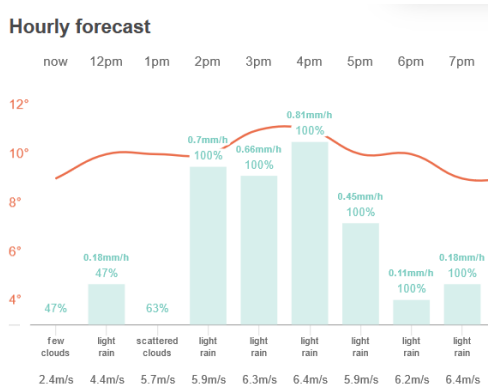
MPC framework



Disturbances

- Collection of forecast data





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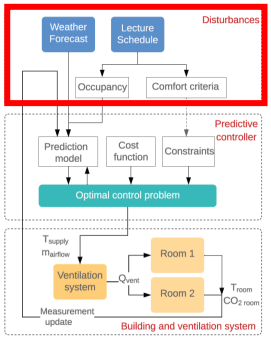
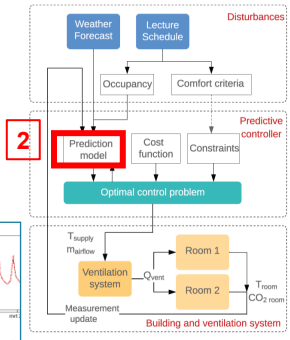
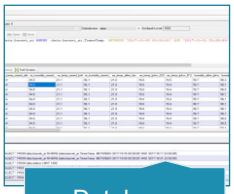
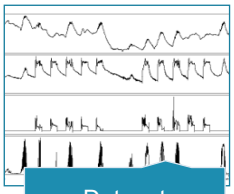
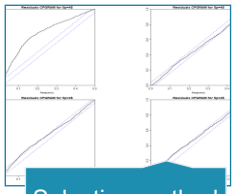


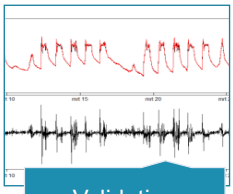
- Multi-zone RC and ARX-models for CO_2 and temperature predictions




Database

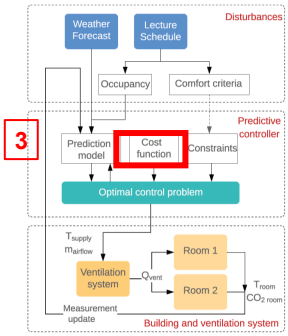

Dataset


Selection method


Validation

Cost function with comfort and energy parameters

$$Min: \sum_{k=O}^{Hp} w1 * (zCO_2)^2 + w2 * (zT)^2 + w3 * (Q_{elec})^2 + w4 * (Q_{thermal})^2$$



- Case study: Test lecture rooms, Ghent, Belgium
- Educational building with 2 lecture rooms
- All-air system (CO_2 + T)
- Integration of MPC through BACnet

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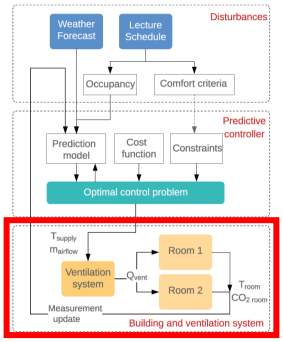
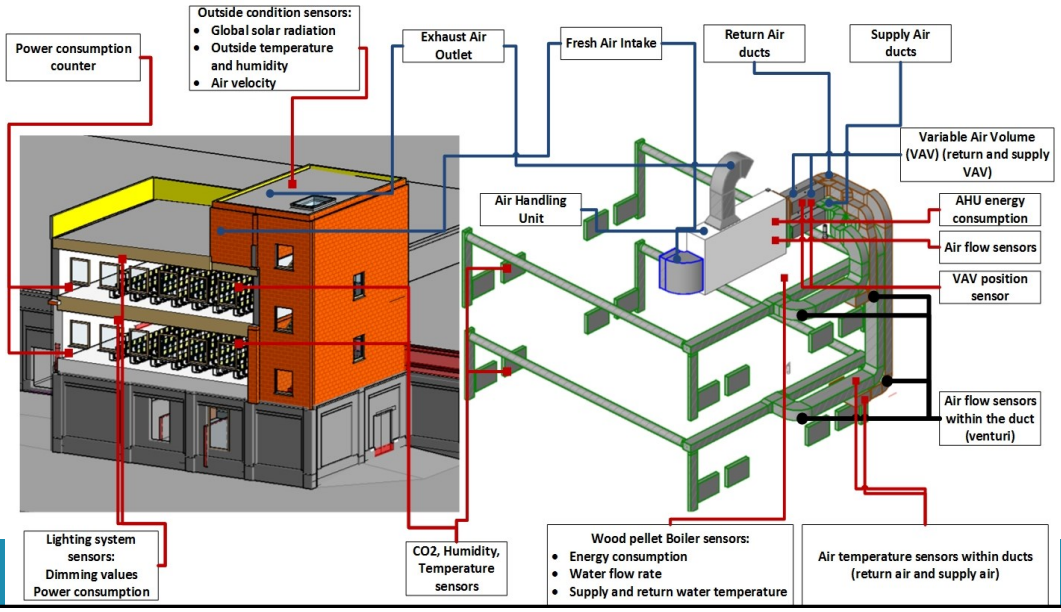


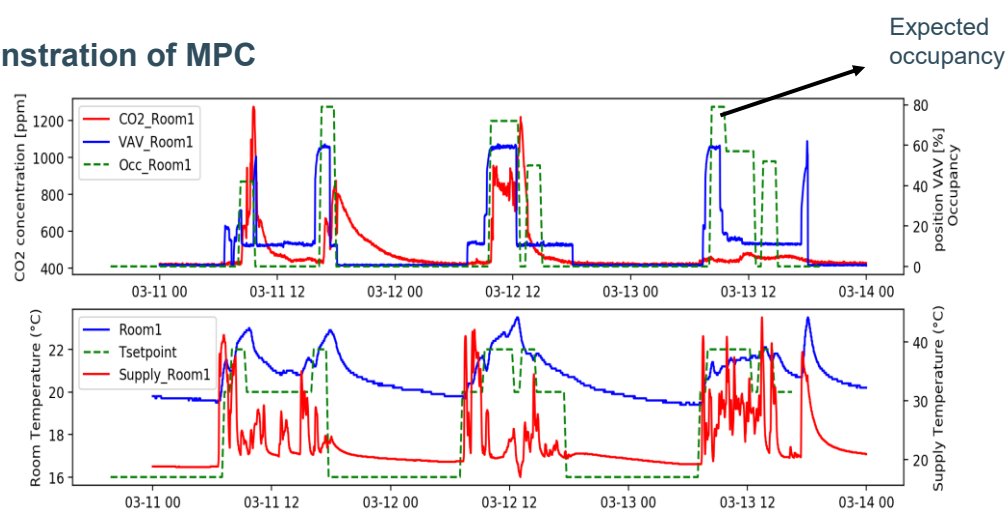


- Design of experiments: Feb-May 2020 and Sep-Dec 2020

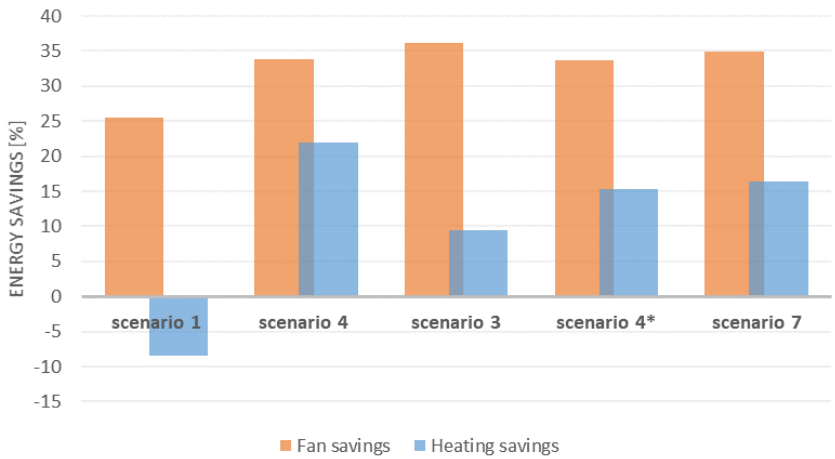
	Horizon		Model		Timestep		Occupancy based
	2 h	4 h	RC	ARX	15 min	5 min	
Scenario 1	x		x		x		-
Scenario 2	x			x	x		-
Scenario 3	x		x		x		x
Scenario 4	x			x	x		x
Scenario 5		x	x		x		x
Scenario 6		x		x	x		x
Scenario 7	x		x			x	x
Scenario 8	x			x		x	x

Introduction | Methodology | Results | Conclusions

Demonstration of MPC



Energy savings MPC compared to RBC



Introduction Methodology Results Conclusions

	Thermal discomfort [Kh]		CO2-discomfort [ppmh]	
	RBC	MPC	RBC	MPC
Scenario 1 (RC-MPC)	11.9	6.81	1535	1607
Scenario 4 (ARX-MPC)	11.0	5.78	1460	1617
Scenario 3 (RC-MPC)	1.31	0.24	706	764
Scenario 7 (RC-MPC)	1.98	0.13	502	79

- The developed all-air MPC can cope better with the intermittent use of the space compared to a RBC
- MPC strategies can control the IAQ and reduce the energy use
- Energy savings demonstrated for MPC compared to RBC: Fans 33-36%, heating coil 10-22%

Thank you for your attention!