TERMONET: Modeling and Control of District Heating and Cooling Networks

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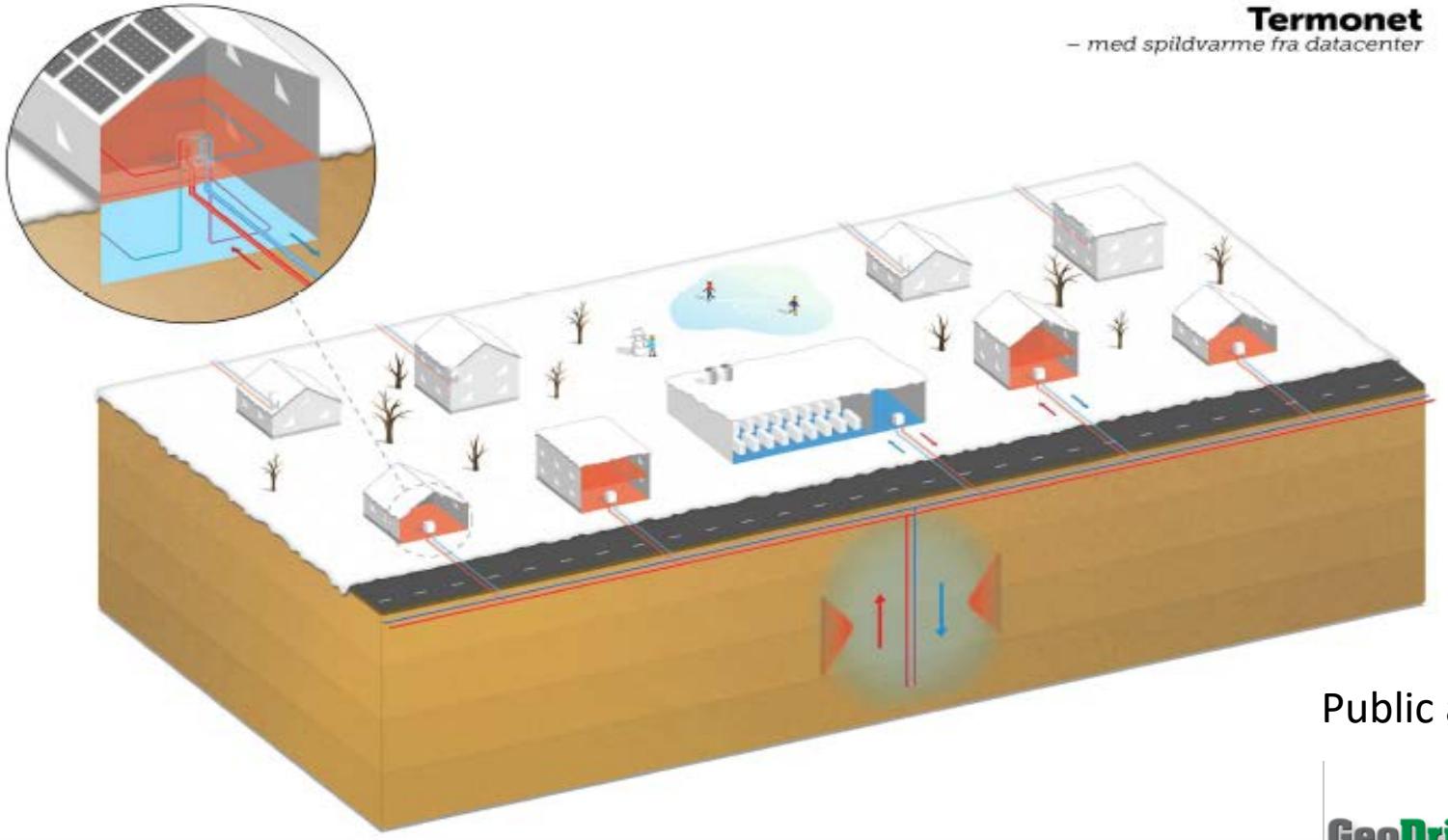
Termonet Concept

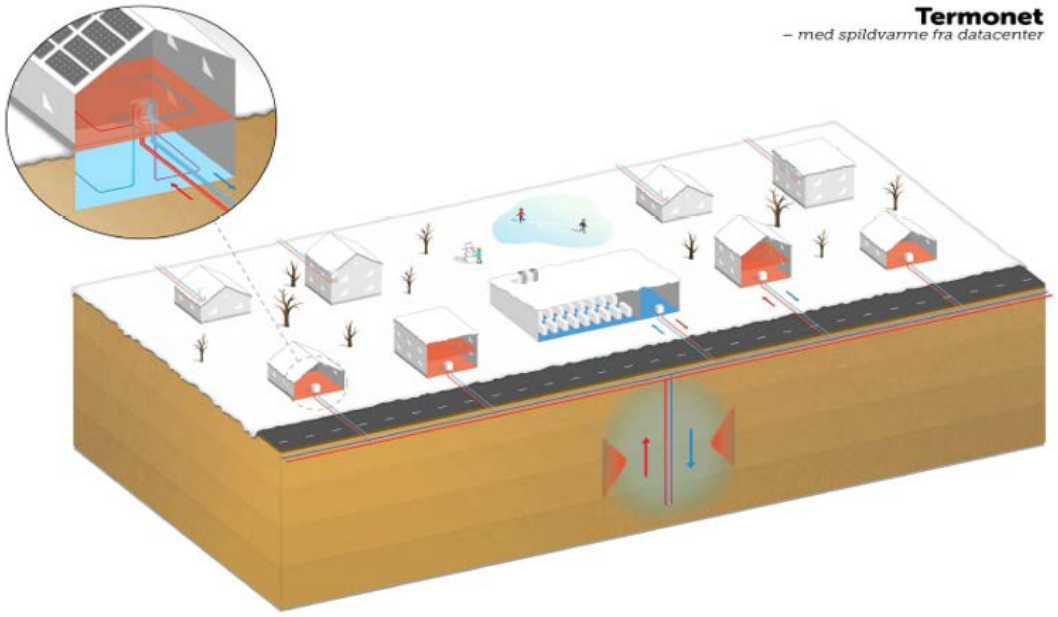


- Buildings equipped with individual heat pumps
- Shared boreholes and horizontal piping
- Non-insulated pipes
- Both heating and cooling functions
- Possible utilization of industrial waste heat from, e.g. from data centers

Public and private partners:

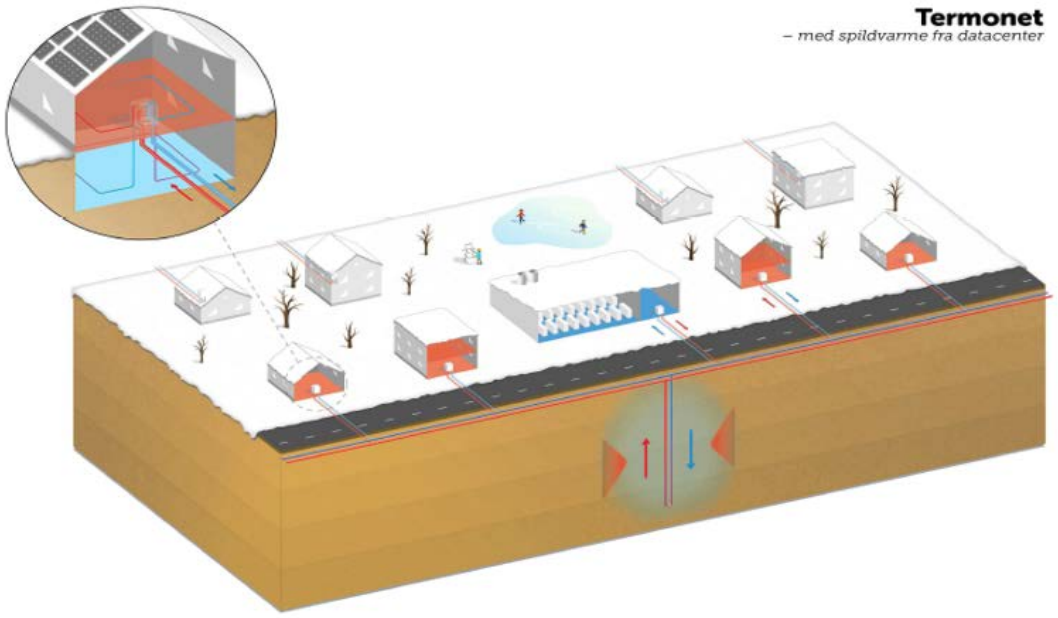
Challenges

- Sizing
  - How to take into account future buildings?
  - No suitable modeling tools on the market
- Control
  - Individual control is suboptimal
  - Centralized control is difficult to implement
  - For how many building it is economically viable to implement centralized control?

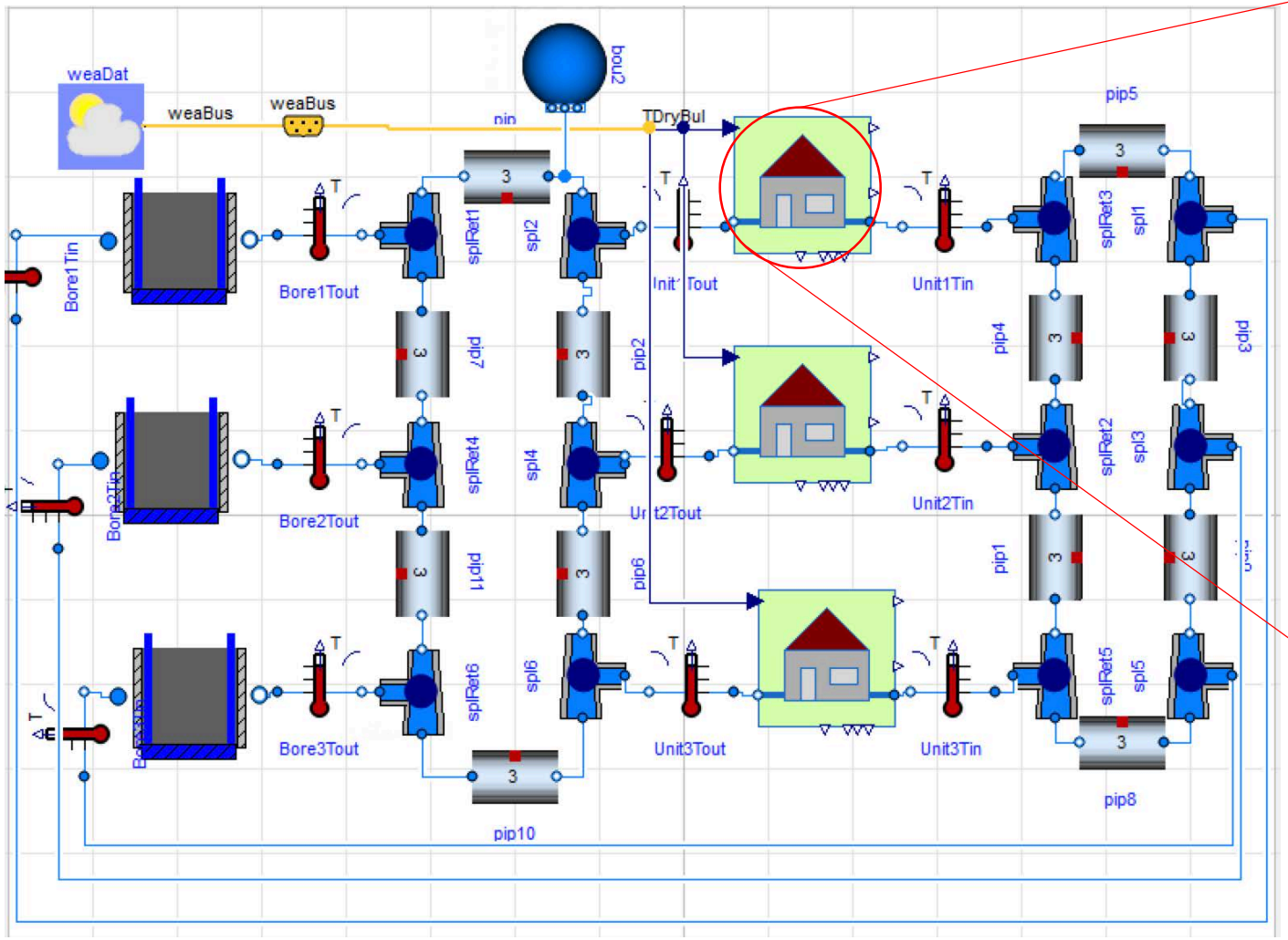


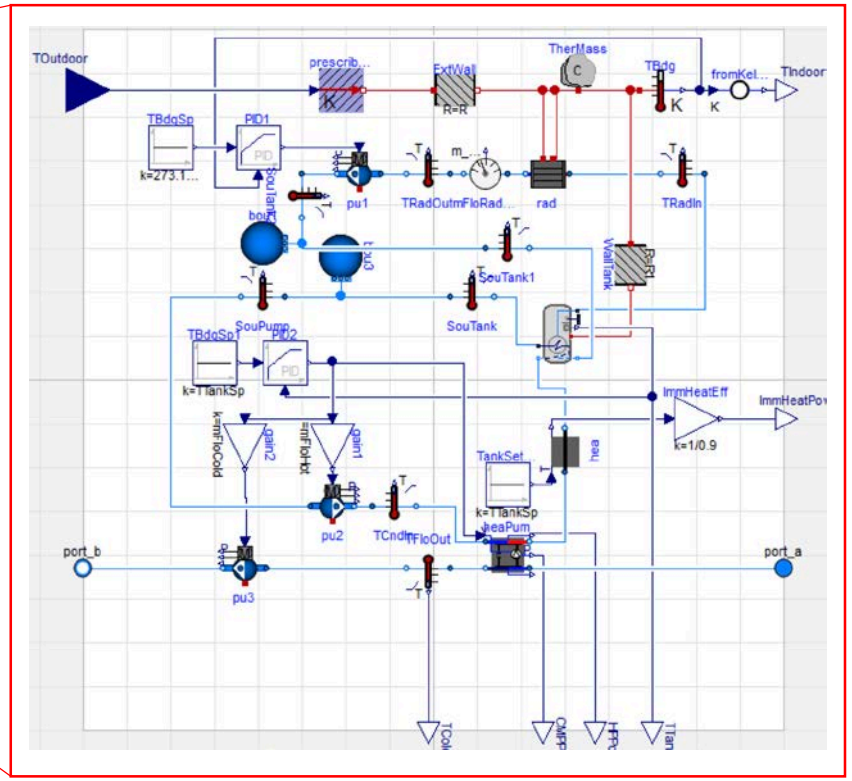
Approach

- Modelica
  - High order models for design and sizing
  - Medium/low order models for control optimization
- Model Predictive Control
  - Which formulation?
  - Which models?
  - Scalability?
  - Centralized or distributed MPC?



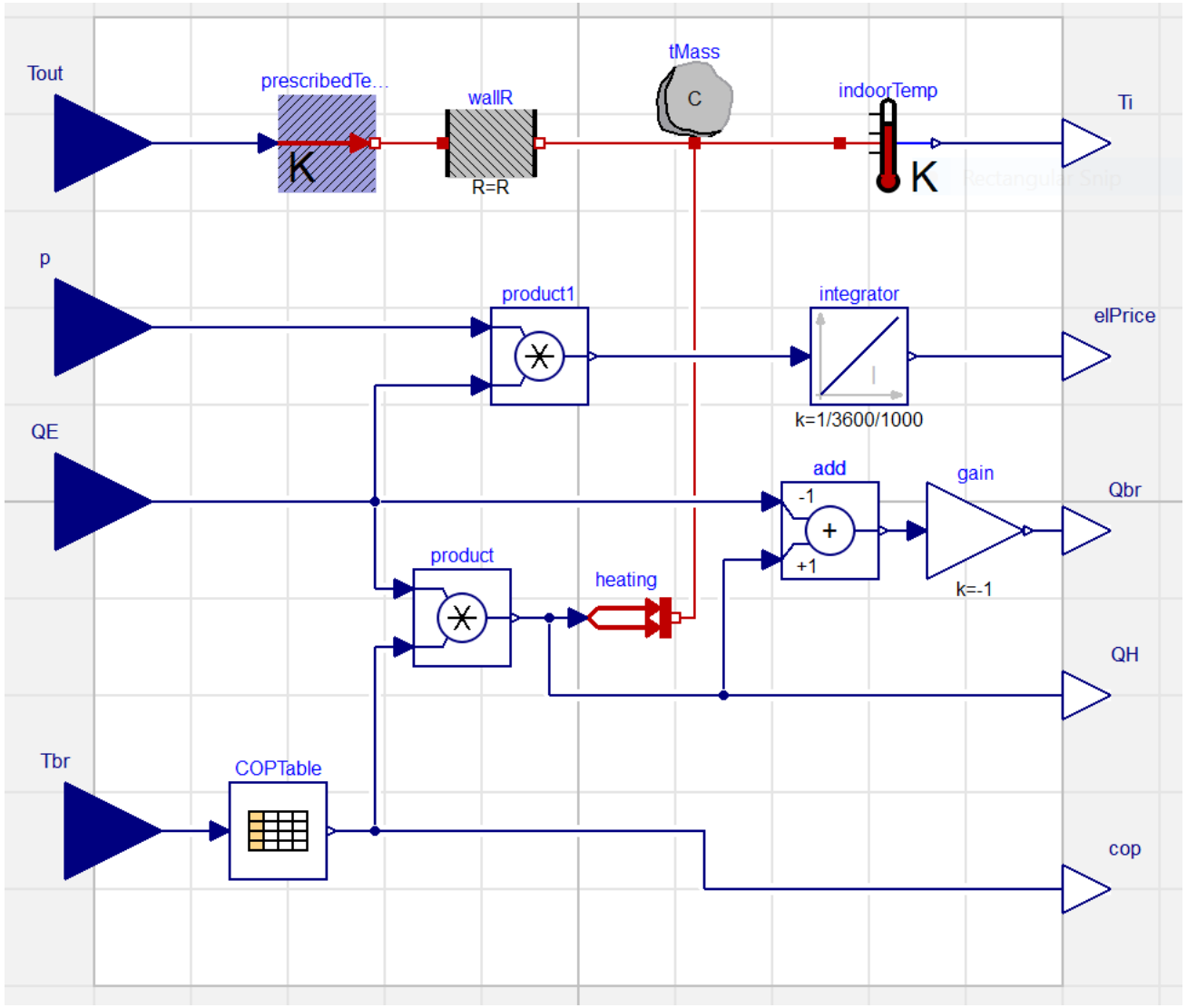
High Order District and Building Models



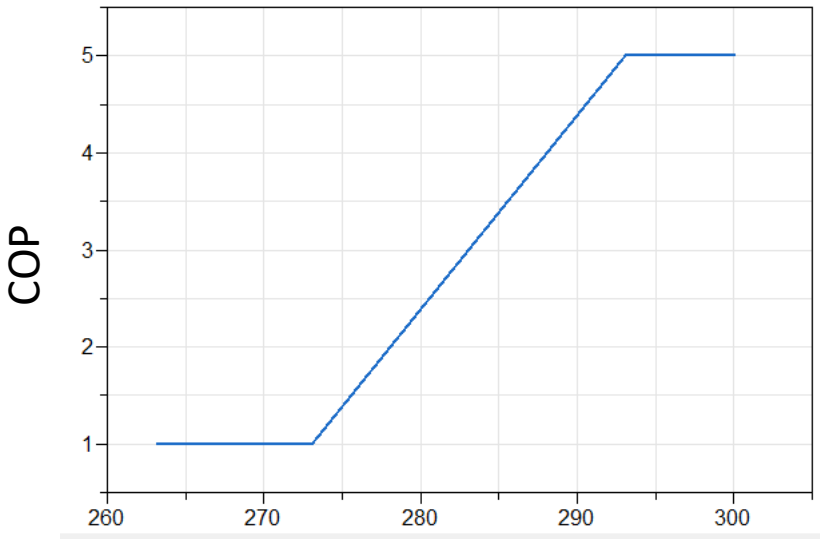


- R1C1 thermal network
- Detailed heating system: heat pump, immersion heater, storage tank, radiator, pumps

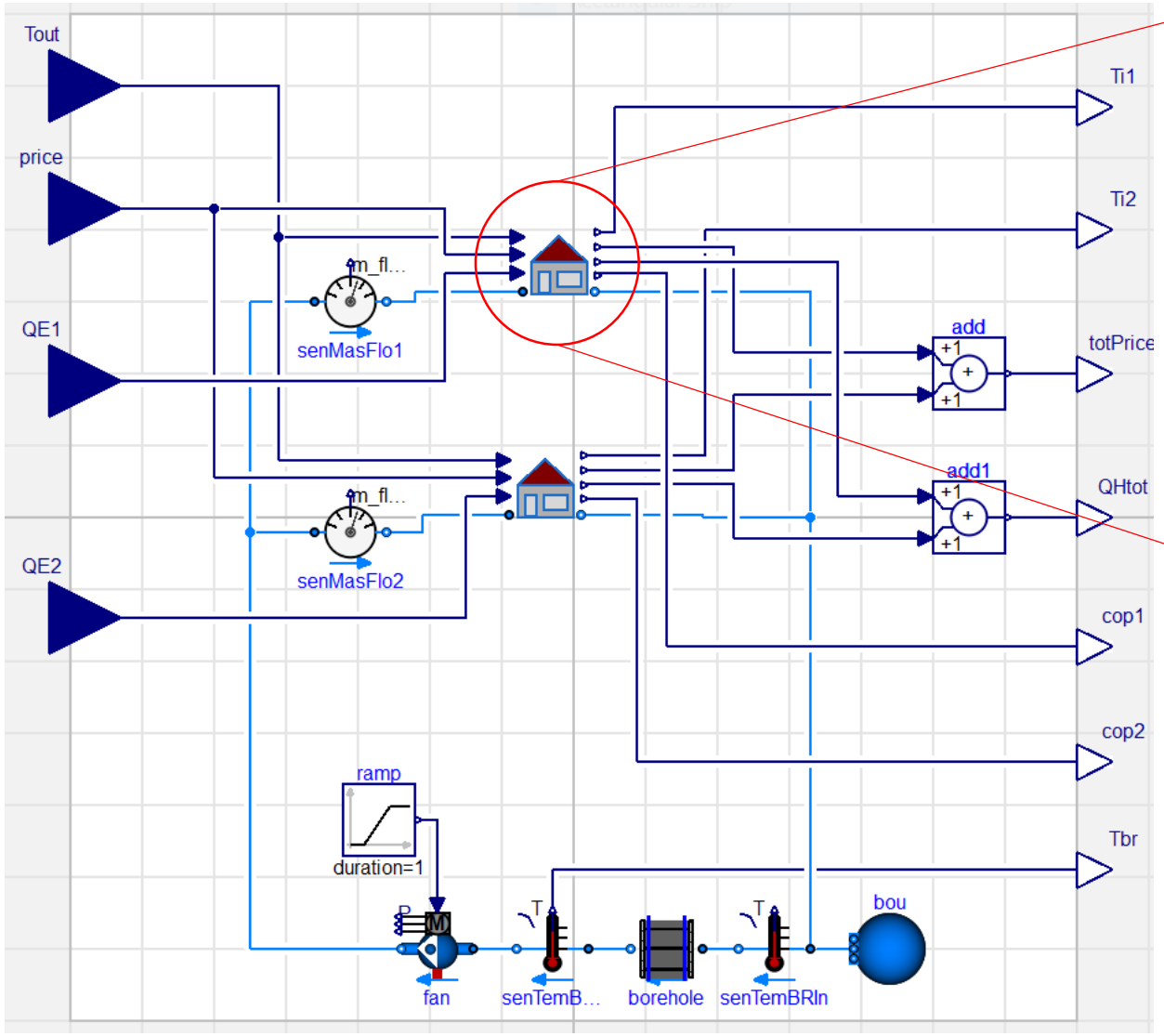
Low Order Building Model

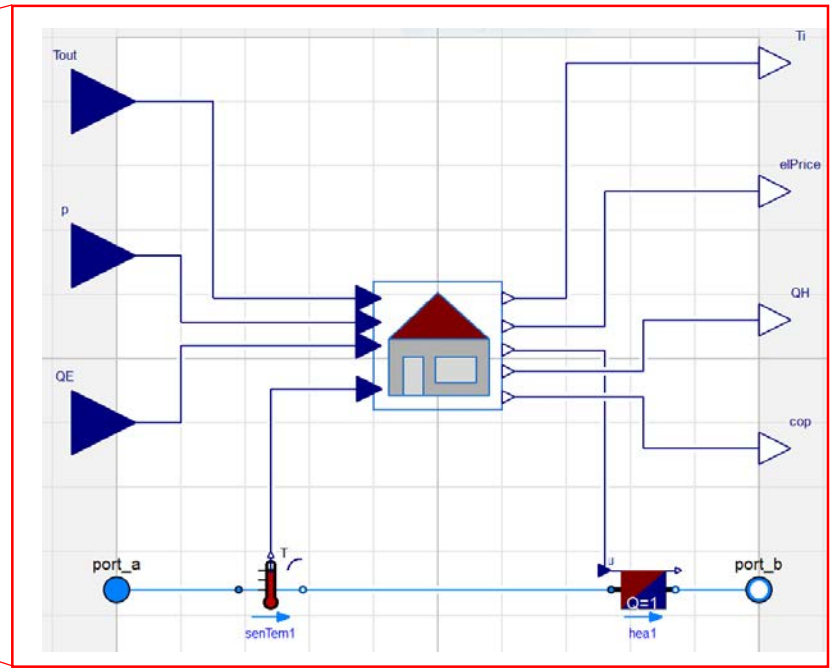


- R1C1 thermal network
- Heat pump supplying heat to the building thermal mass
- Heat pump model based on COP table:



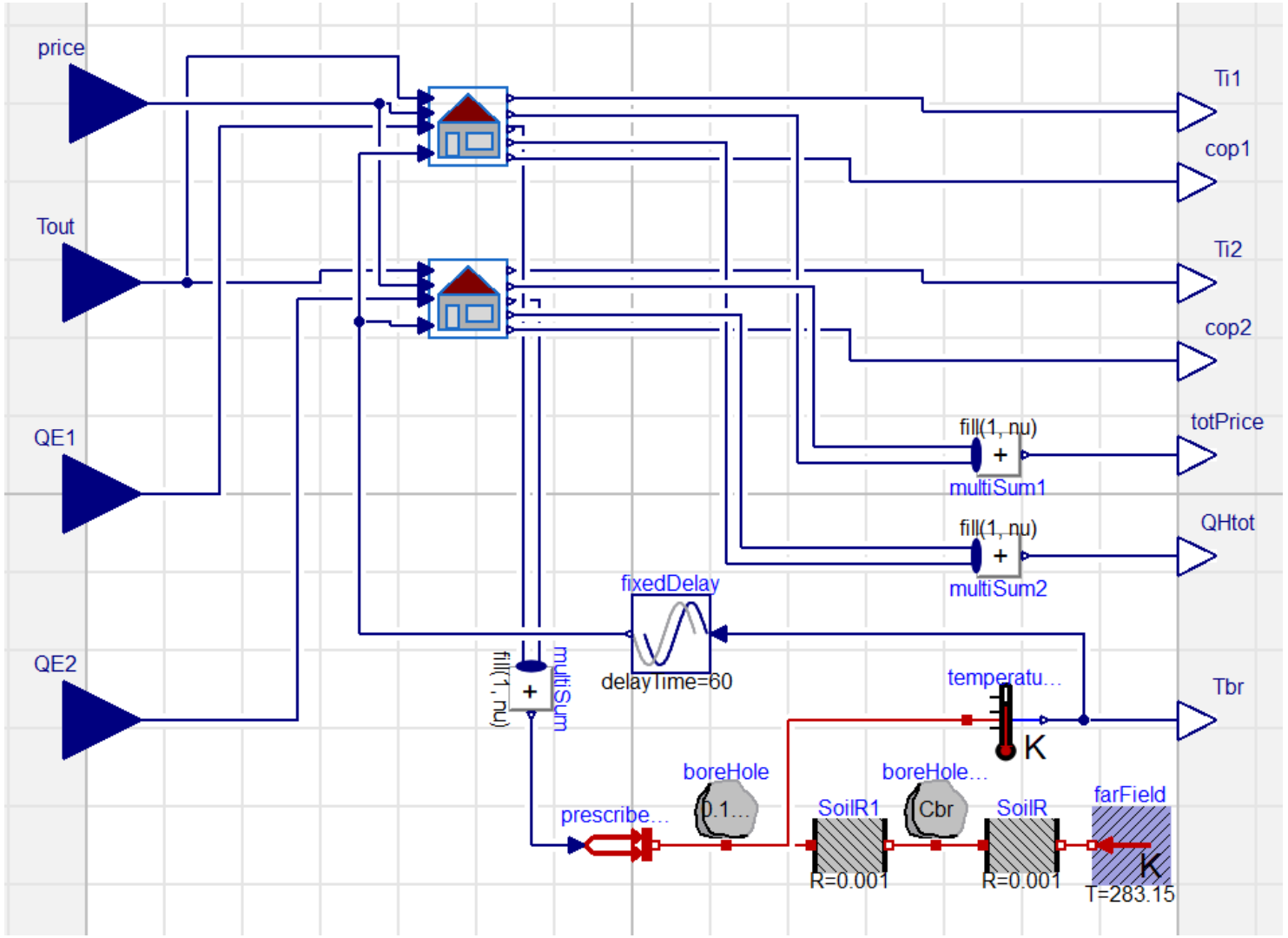
Medium Order District Model





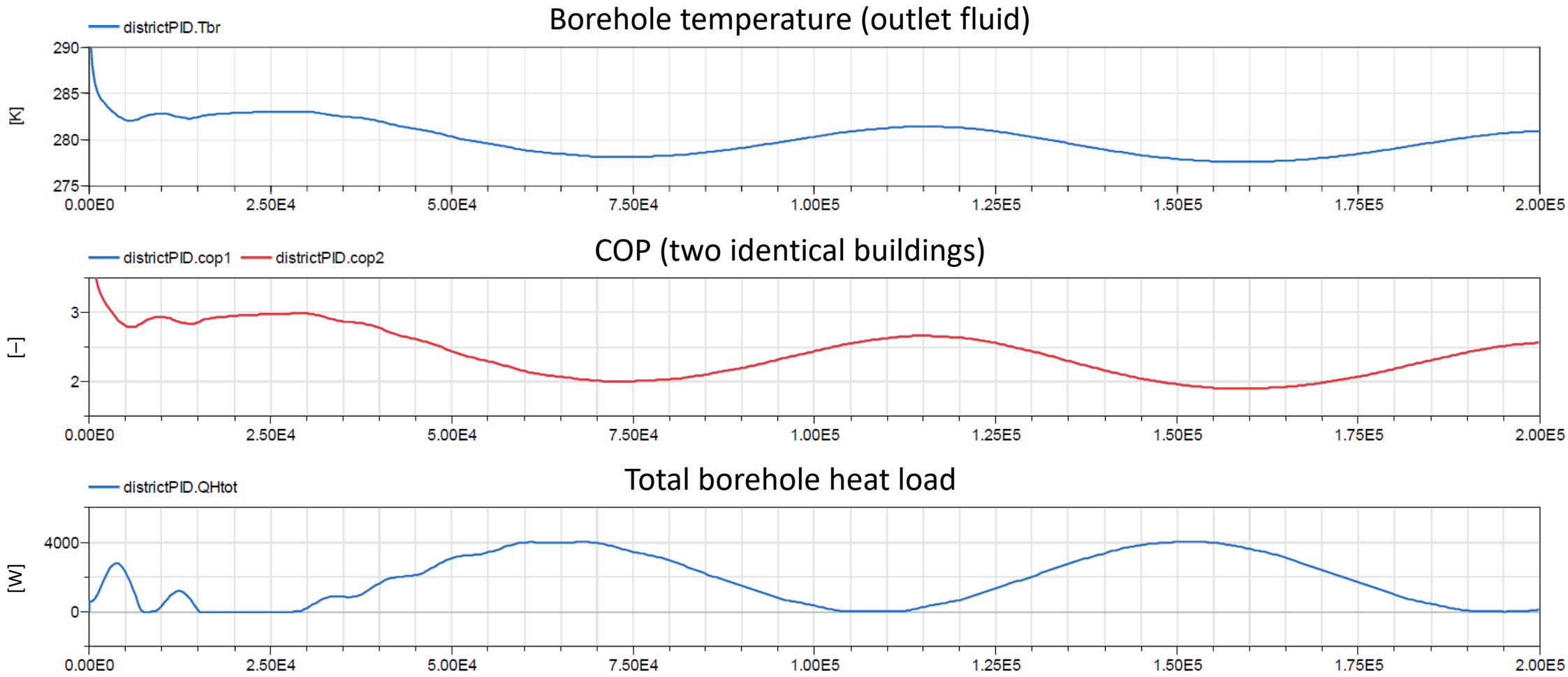
Low order building + fluid connectors

Low Order District Model



- Low order building models
- No fluid components
- Borehole model based on R2C2:
  - 1st capacitor for fast dynamics
  - 2nd capacitor for slow dynamics

Suboptimal Individual Control (PID)



Medium order district model

Suboptimal Individual Control (PID)

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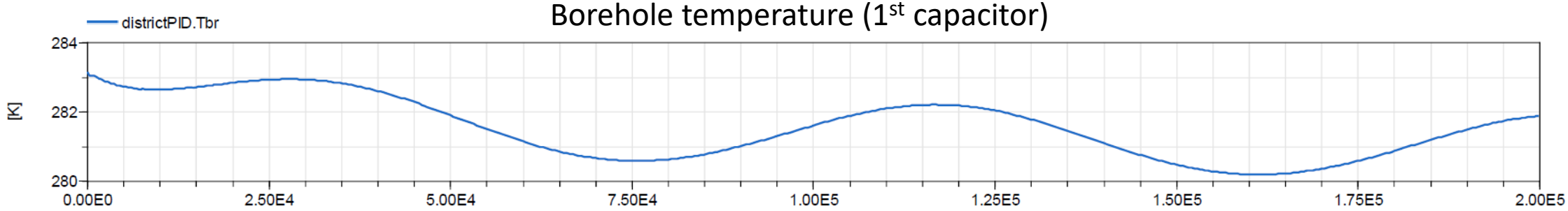
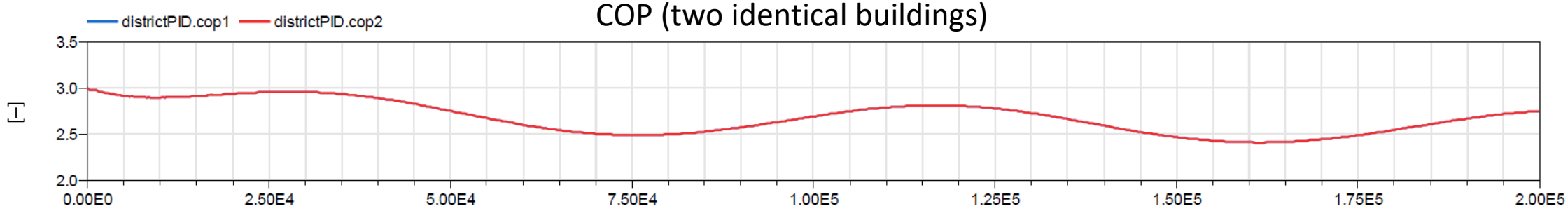
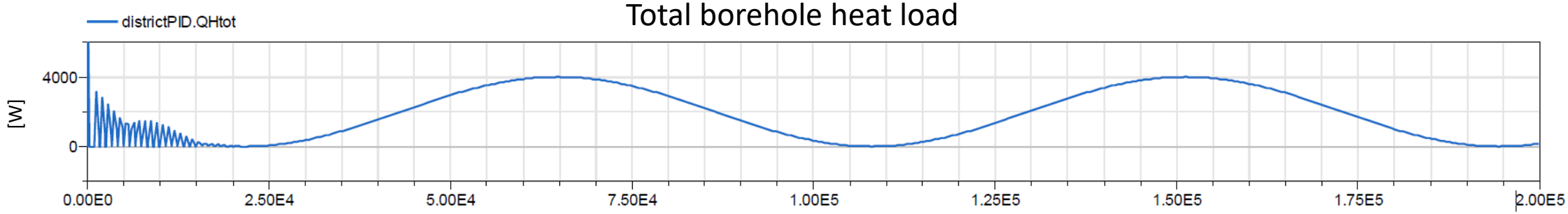
Borehole temperature (1st capacitor)



COP (two identical buildings)



Total borehole heat load

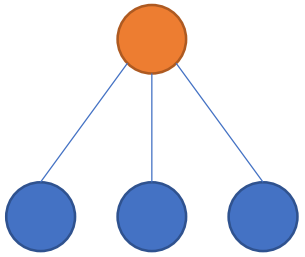


Low order district model

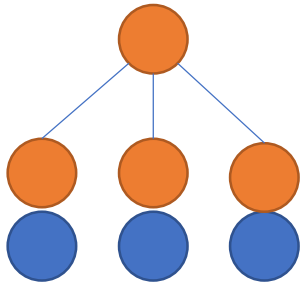
Goal: Load Shifting

- Not clear how to formulate the optimization problem
  - Single objective or multiple objectives?
  - Changing objectives or static?
  - Centralized MPC vs. distributed MPC

Centralized MPC



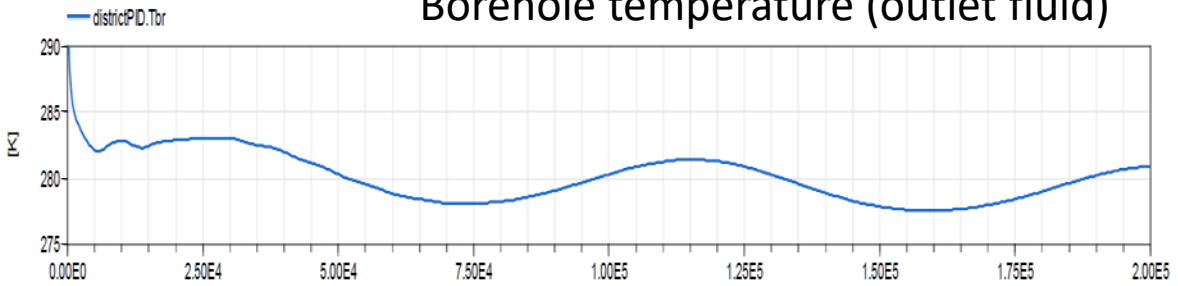
Distributed MPC



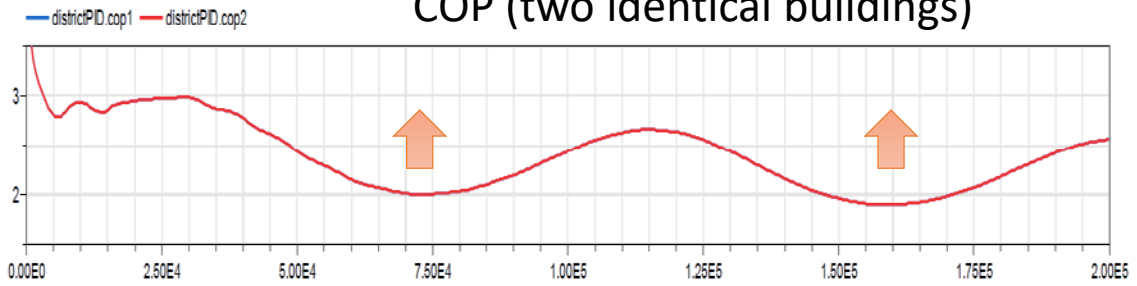
Predictive controller

Building

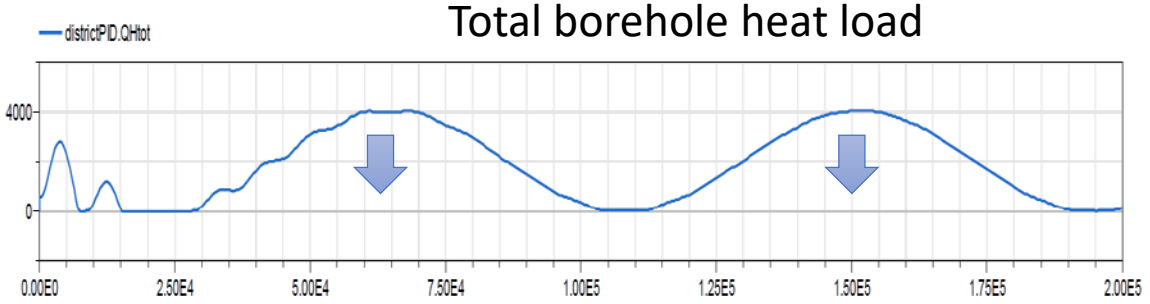
Borehole temperature (outlet fluid)



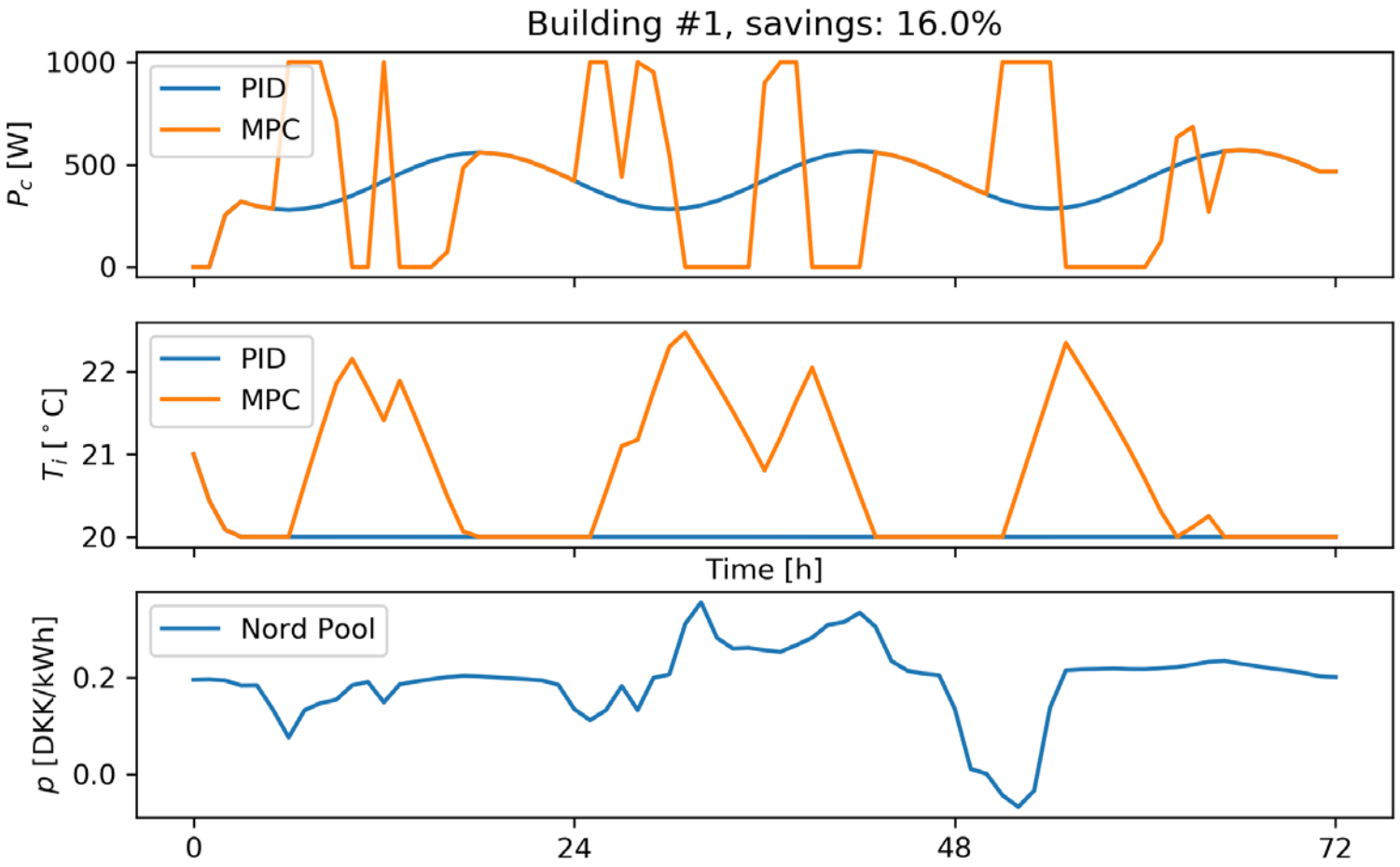
COP (two identical buildings)

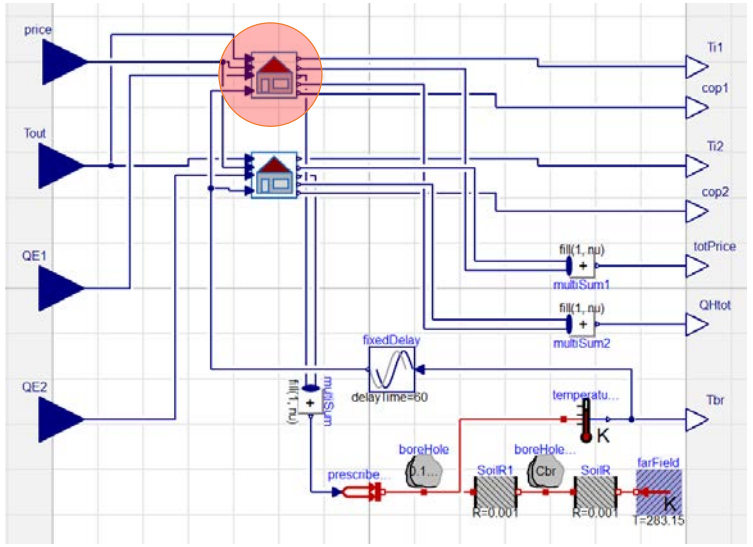


Total borehole heat load



Optimal Control: Cost Optimization





Collaboration

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Private and public partners

- Measurements and test sites

International projects

- Model predictive control with Modelica
- Modelica application examples

Future Work

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- Termonet Modelica library
- Proof of concept: load shifting → COP maximization → more optimal operation
- Optimization scalability and robustness