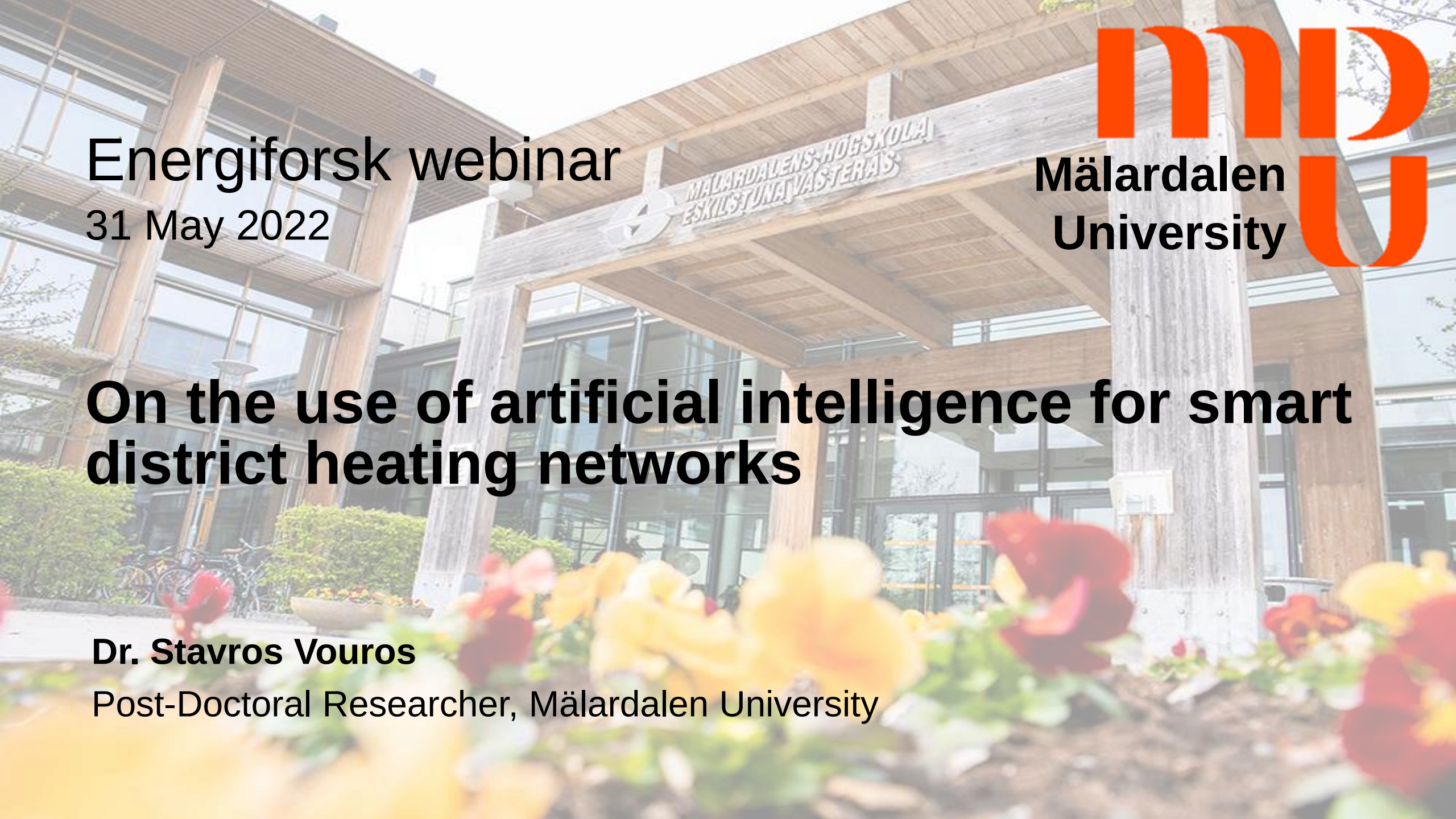


Energiforsk webinar

31 May 2022

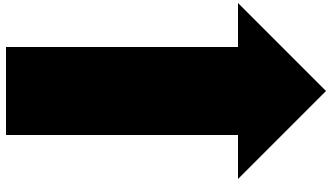
Mälardalen University

On the use of artificial intelligence for smart district heating networks

Dr. Stavros Vouros

Post-Doctoral Researcher, Mälardalen University

Mälardalen University



The Future Energy Center at MDU

Mälardalen University

Renewable energy

Wind & hydro
Solar
Biomass
Heat & power
Wastewater
Hydrogen

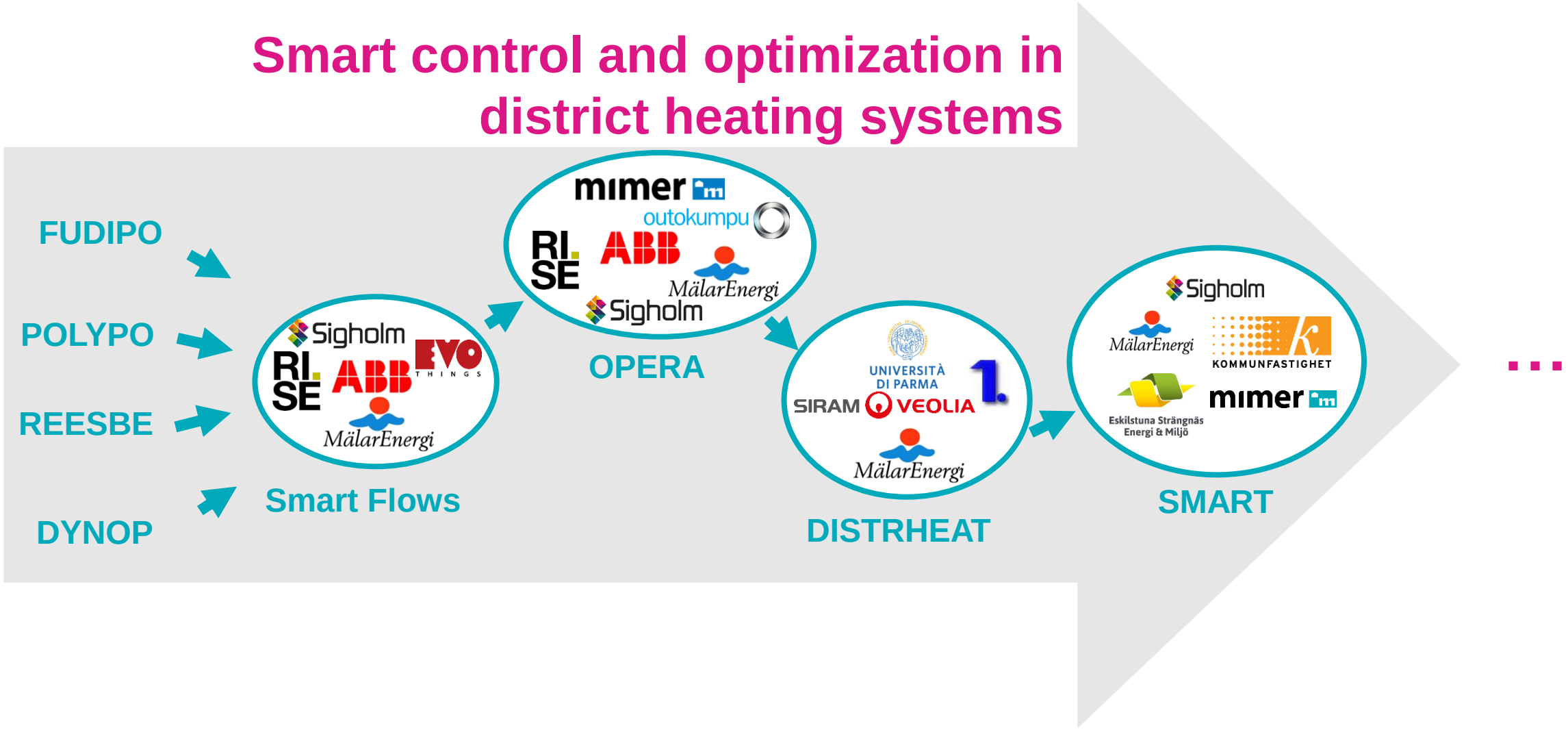
Resource efficiency

Electrification
Hybrid systems
Flexibility
Storage
Environmental impacts

Digitalisation

Modelling
Control
Optimization
Artificial Intelligence
Digital twins
Diagnostics
Smart sensors

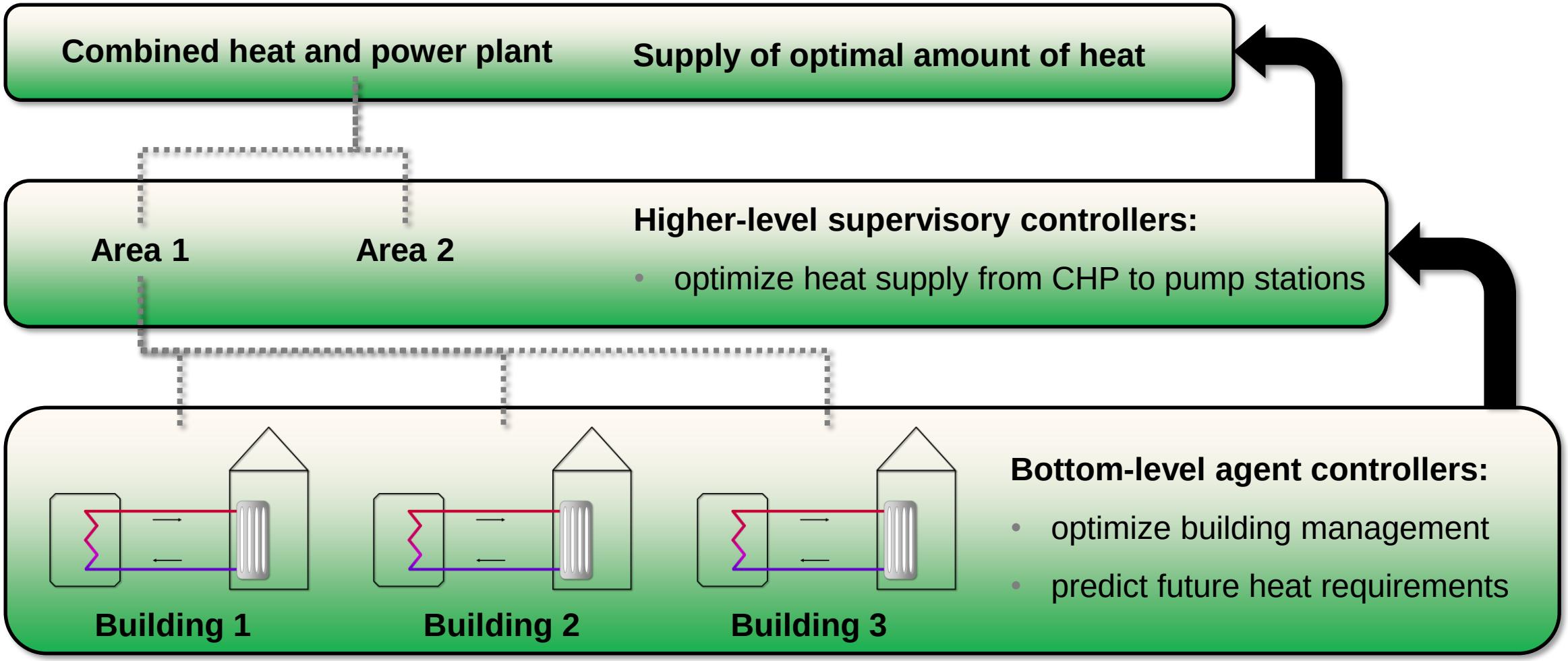
DHN digitalization: our recent projects



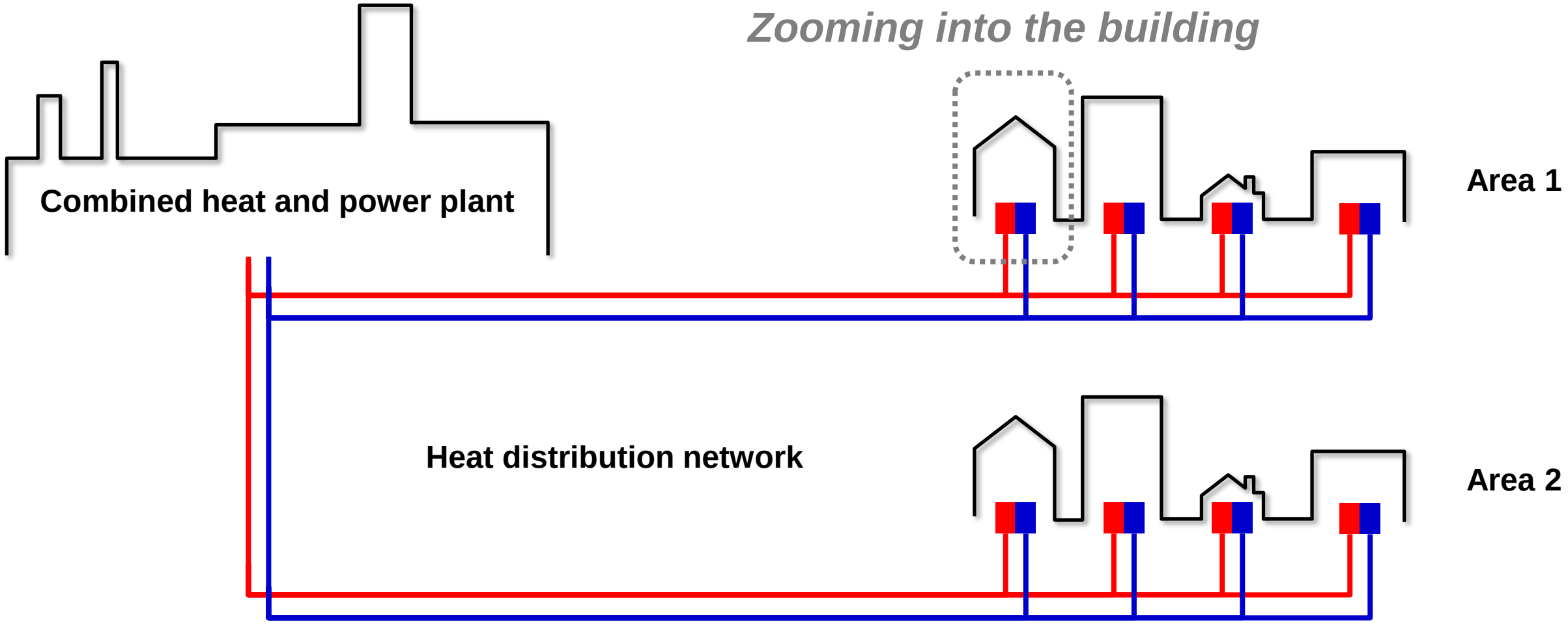
The CHP plant of Västerås

- Operated by Mälarenergi AB
- Heat distribution network: 800+ km
- Heat production: 1800+ GWh
- Electricity production: ~700 GWh

Multi-agent control of DHNs

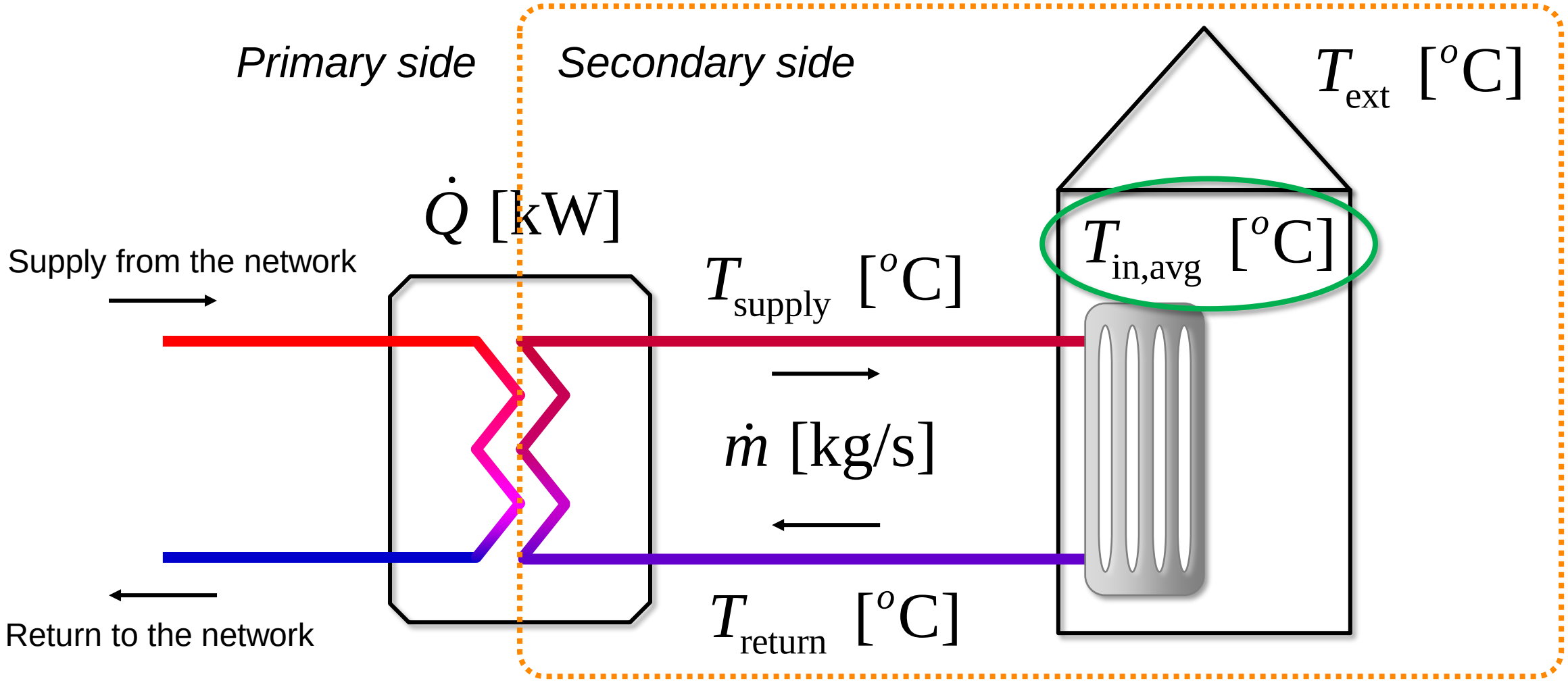


Network overview



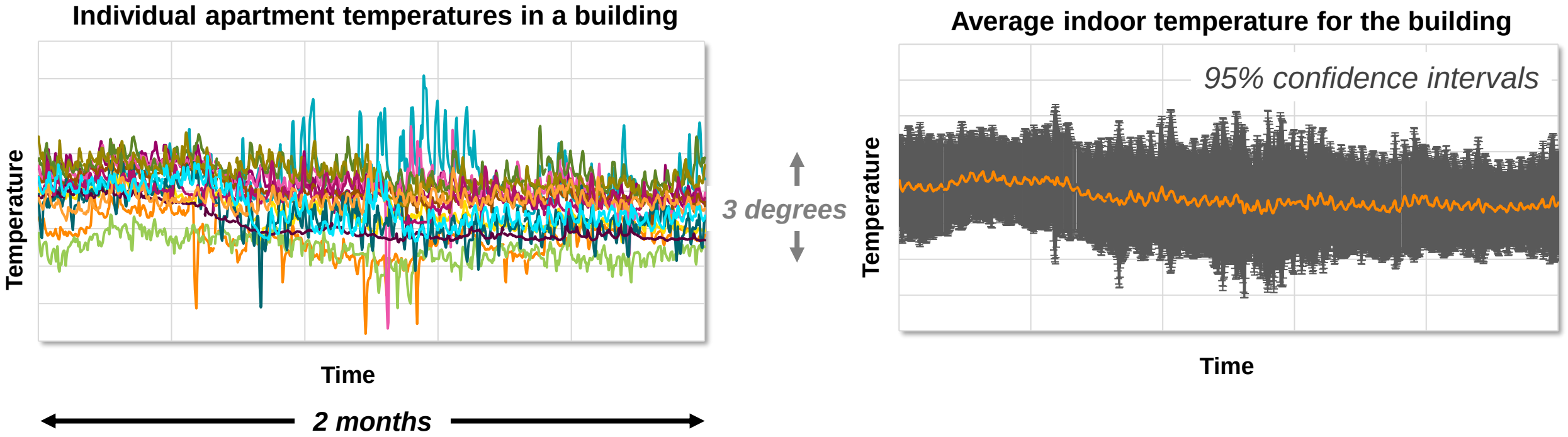
Zooming into the buildings

Substation layout



Zooming into the buildings

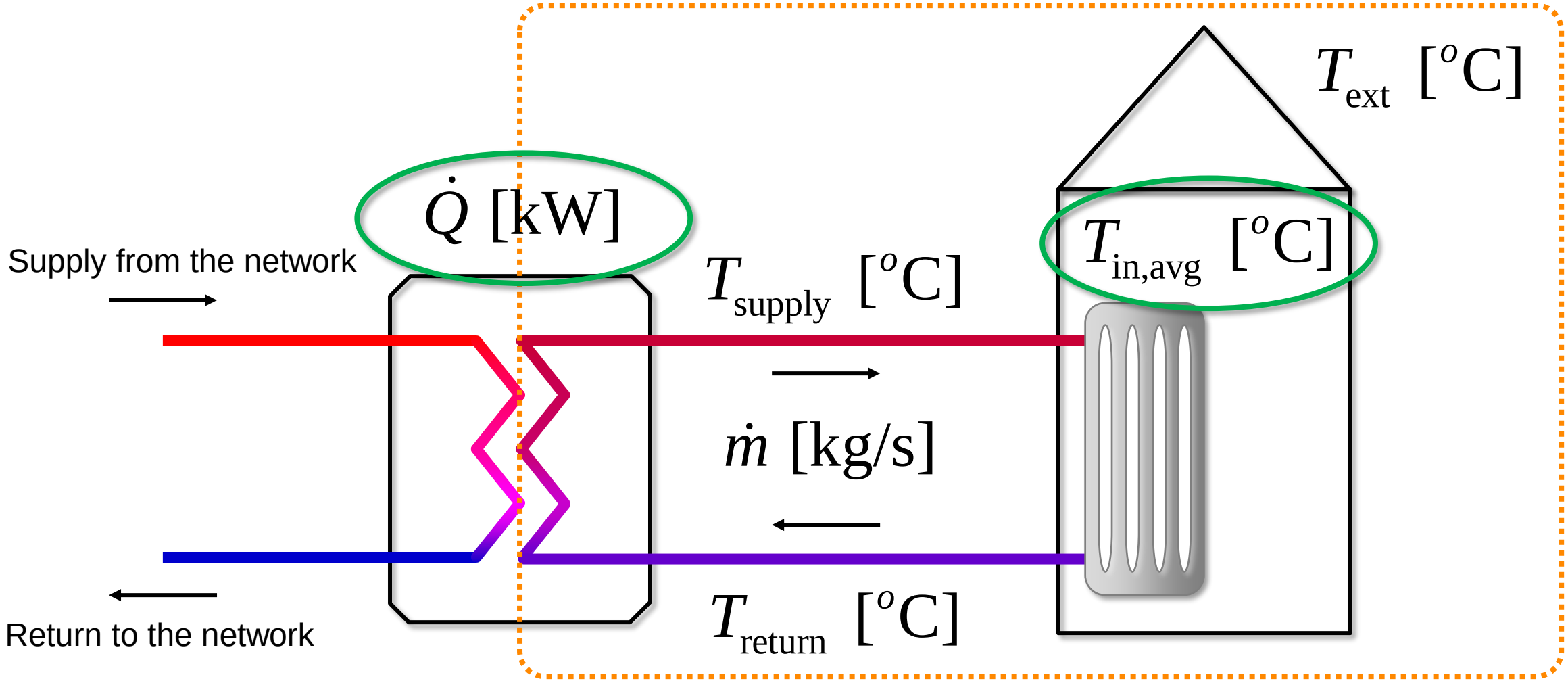
Dealing with indoor temperatures



- **Average indoor temperature:** metric of indoor comfort
- **Spread of indoor temperatures:** metric of social patterns and building technology

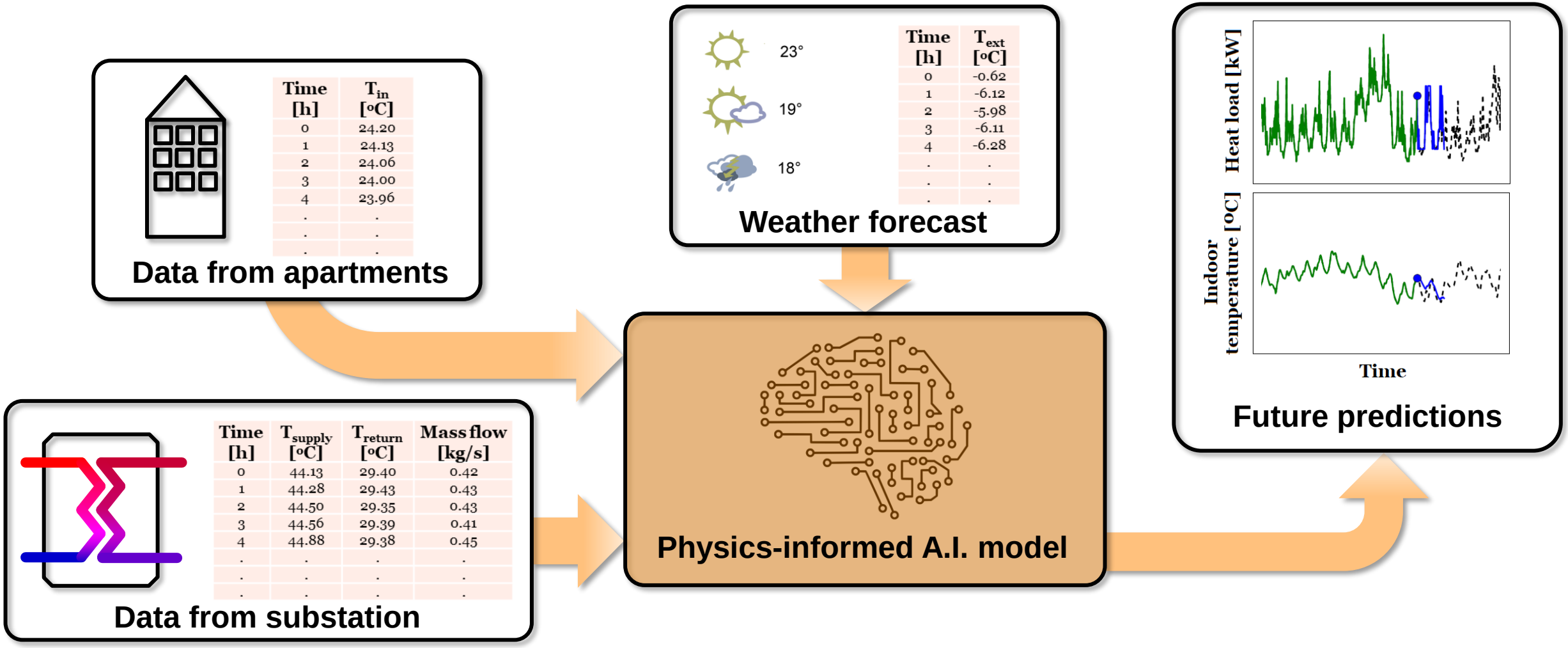
Zooming into the buildings

Key performance indicators



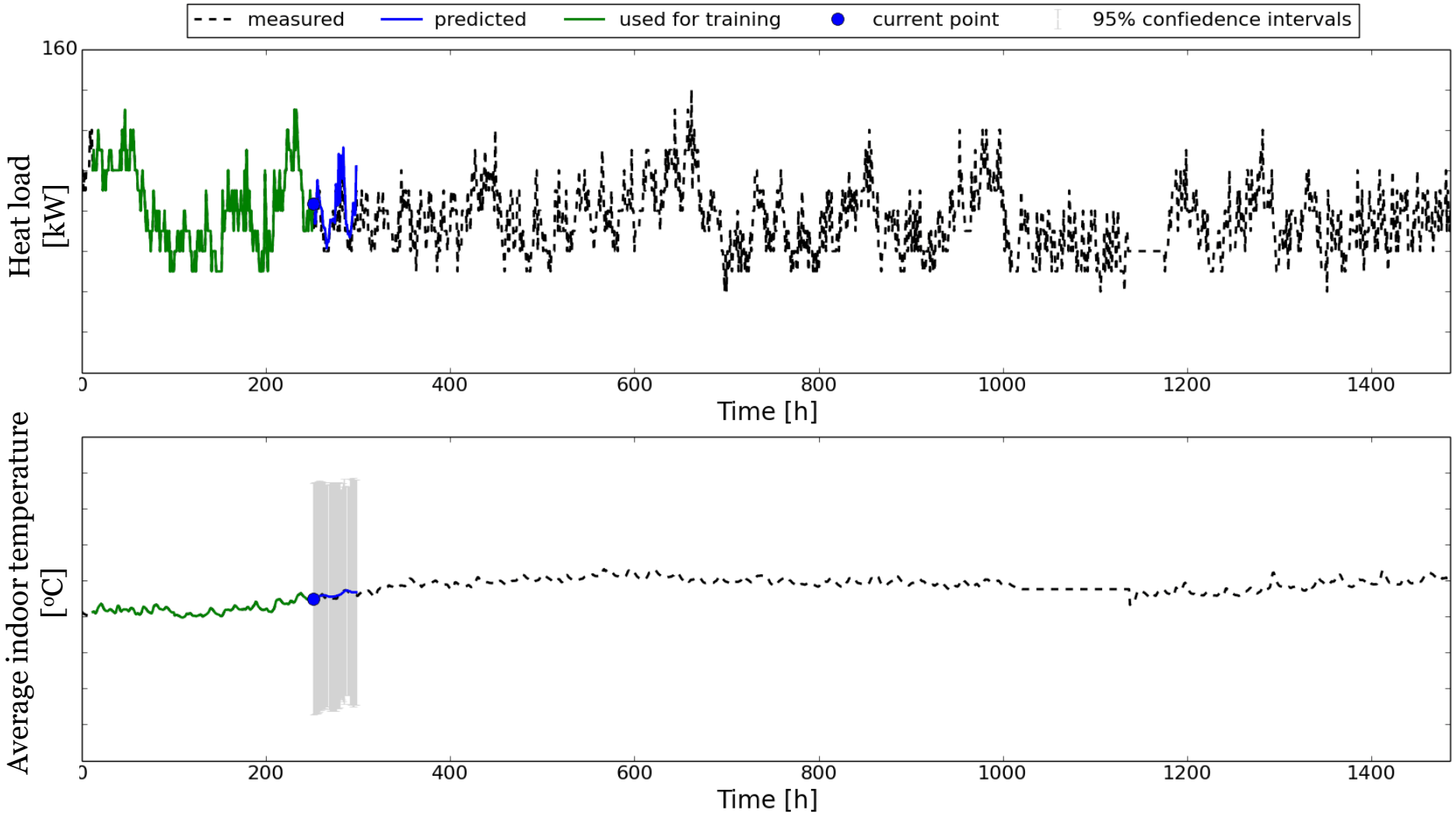
Artificial intelligence in buildings

Load model architecture

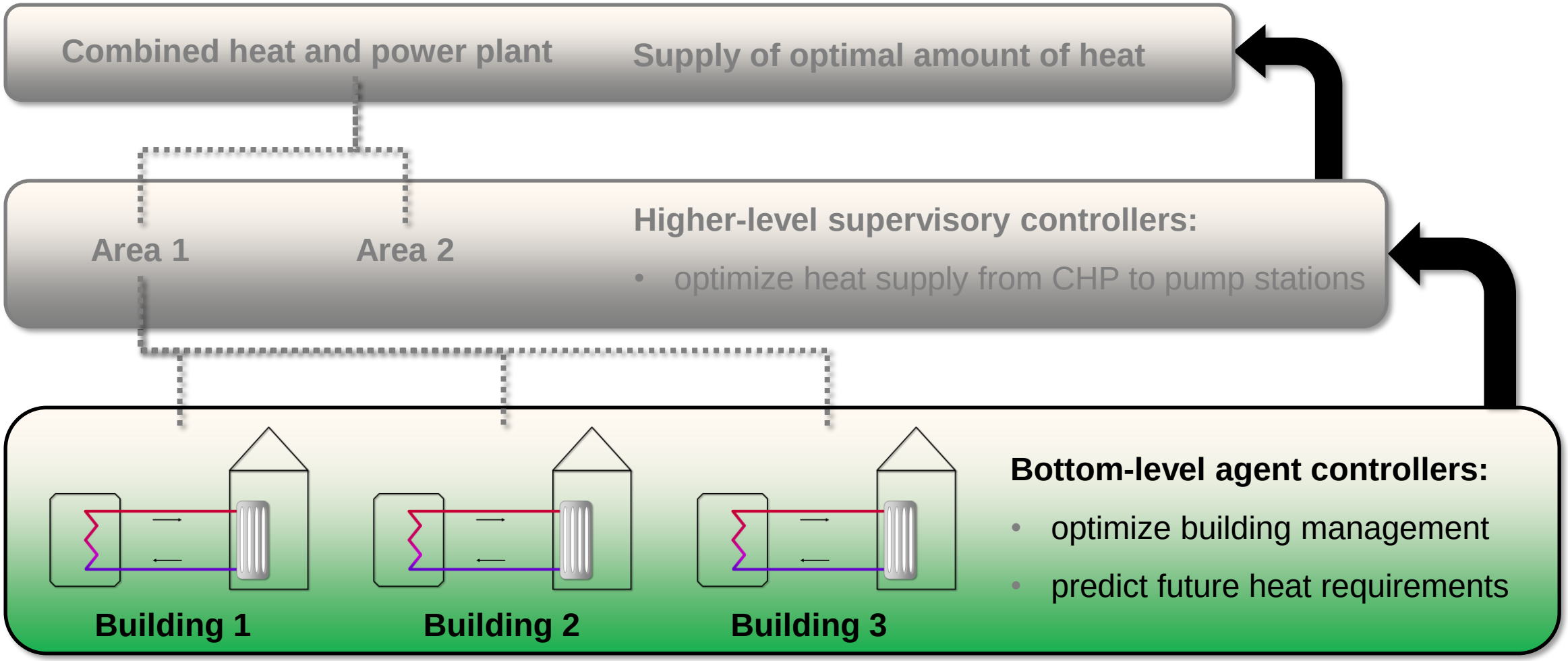


Artificial intelligence in buildings

Real time adaption & learning

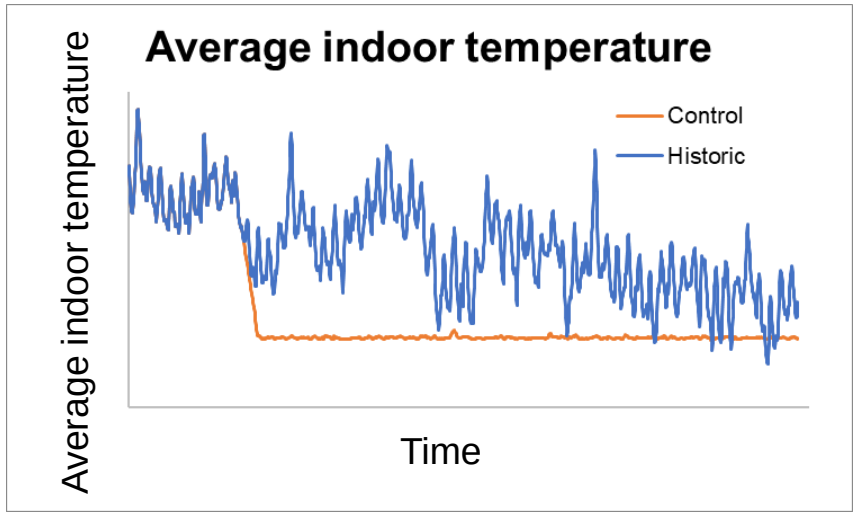


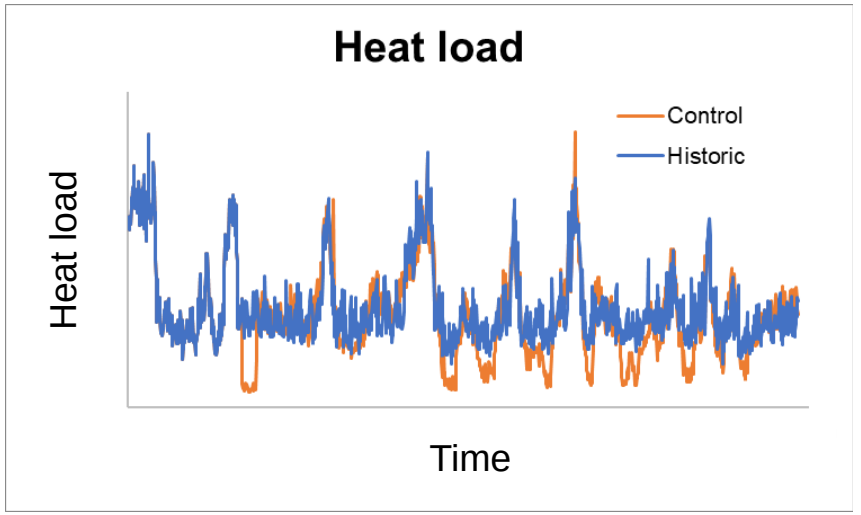
Multi-agent control of DHNs



Smart control in buildings

“Comfort” mode

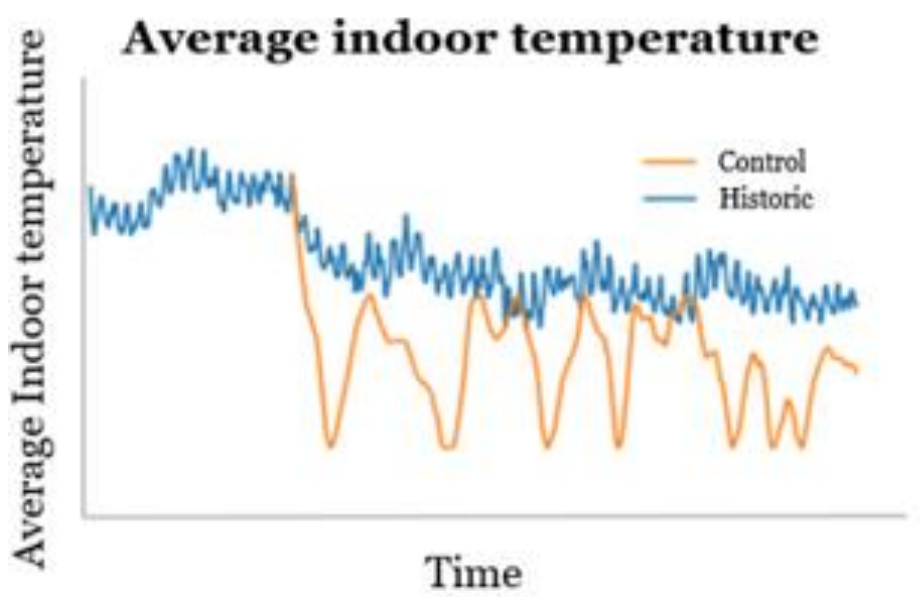


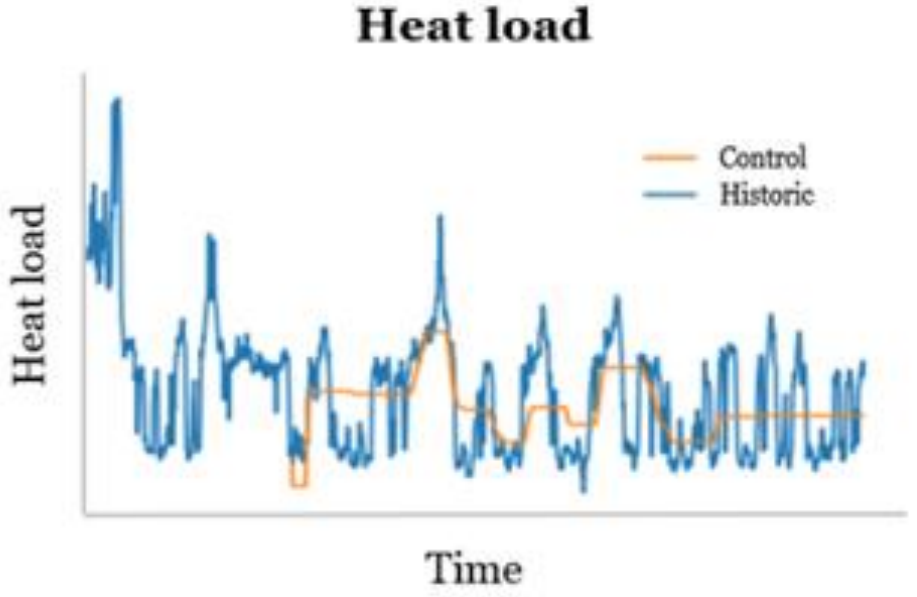


[1] Vouros S., Monghasemi N., Vadiee A., and Kyprianidis K.G., 2022. Data-driven control of district heating substations. *Energies, MDPI (in preparation)*

Smart control in buildings

“Flex” mode



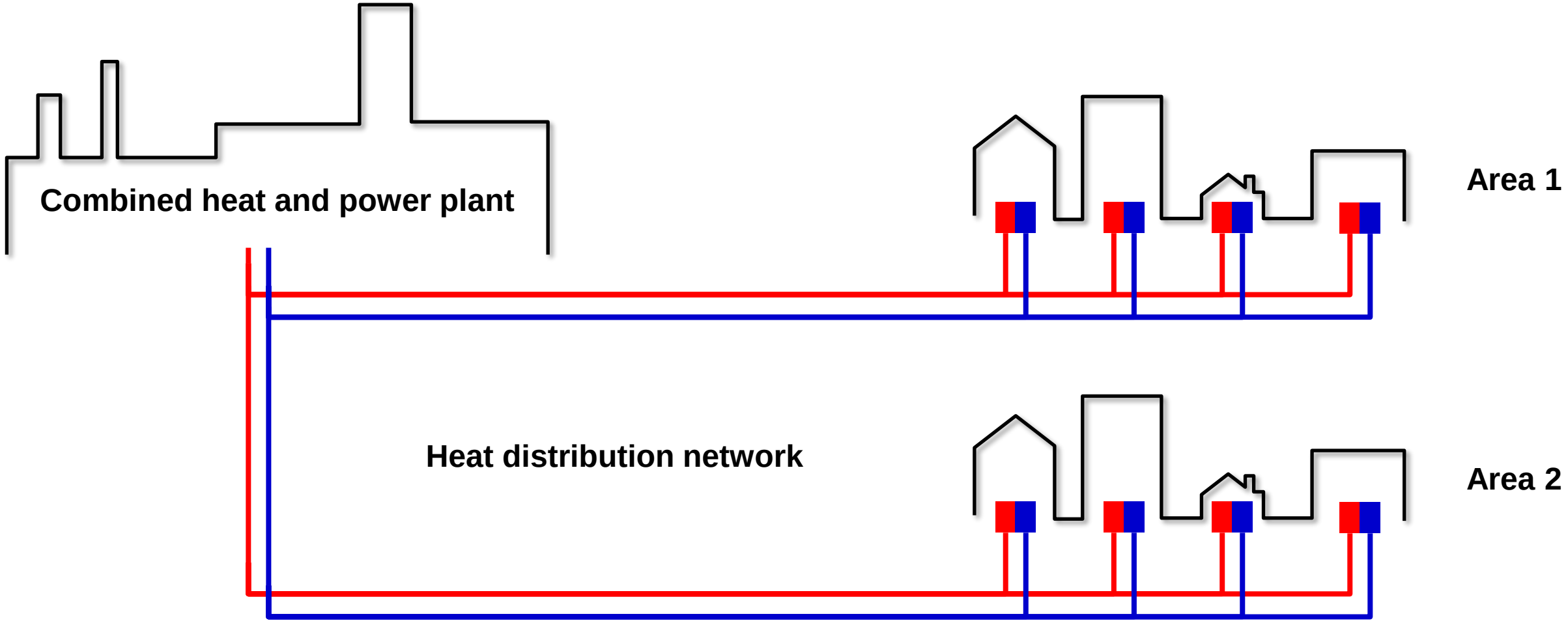


[[2] Cederblad M., and Dahlberg A., 2022. Heat storage in buildings: achieving thermal peak shaving through indoor temperature flexibility. *MSc thesis, Mälardalen University*

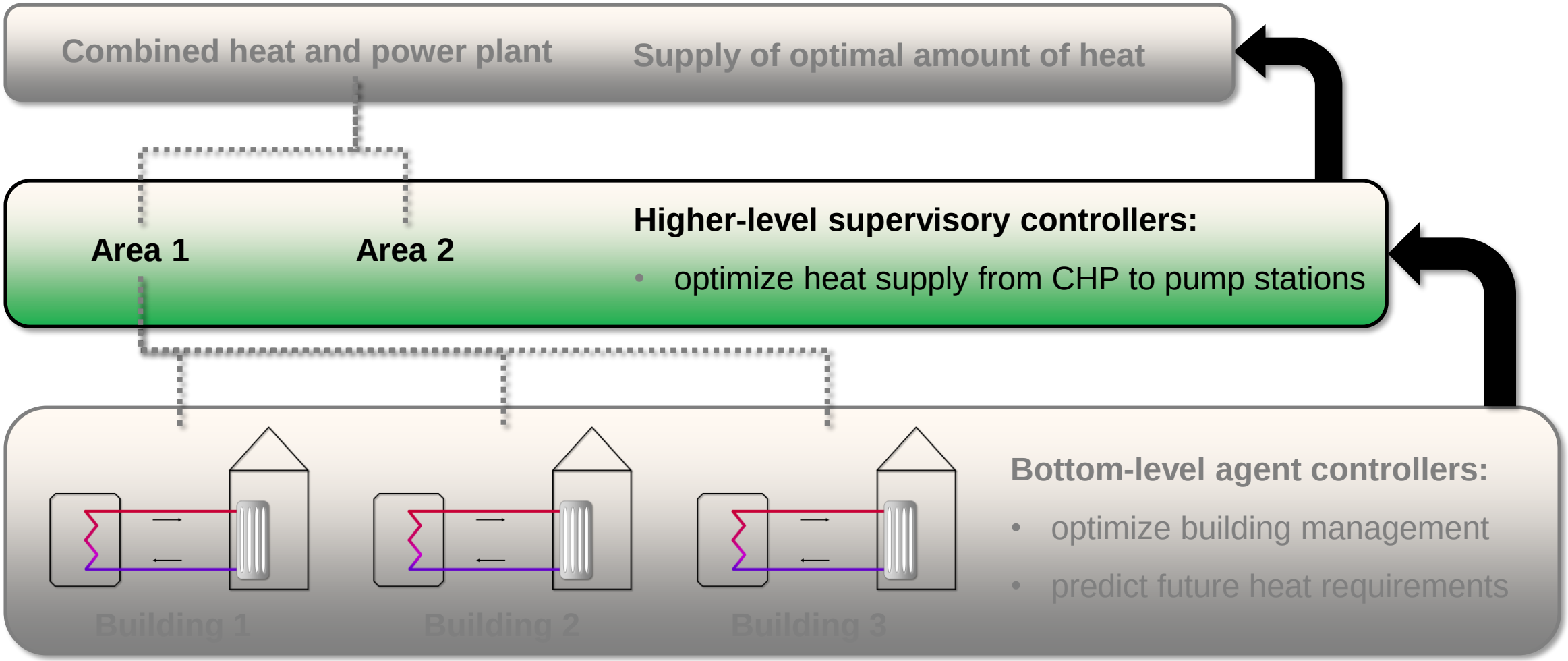
Bringing it to the real world

- XC05 micro-conroller by First Control AB
- Hardware-in-the-loop demonstration done
- Installation in test building in Västerås
- Demonstration planned for the upcoming heating season

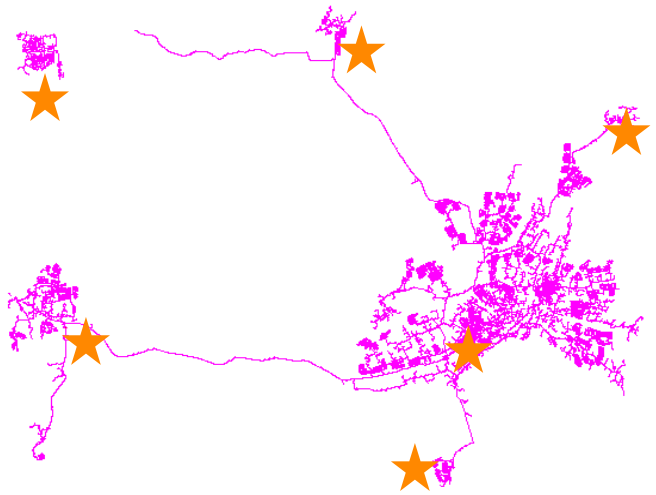
Zooming out to the network

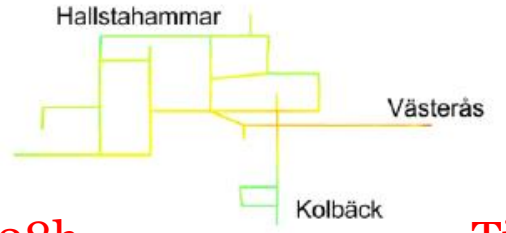


Multi-agent control of DHNs

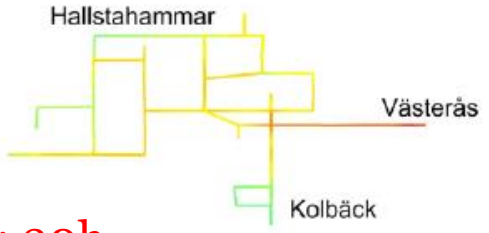


Network modelling

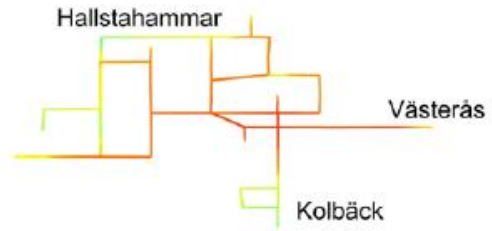




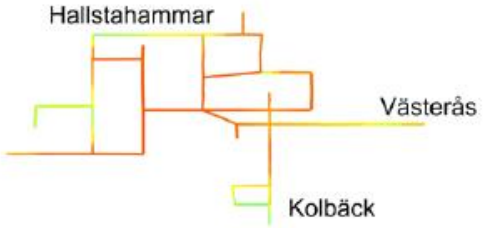
Time: 28h



Time: 30h



Time: 32h

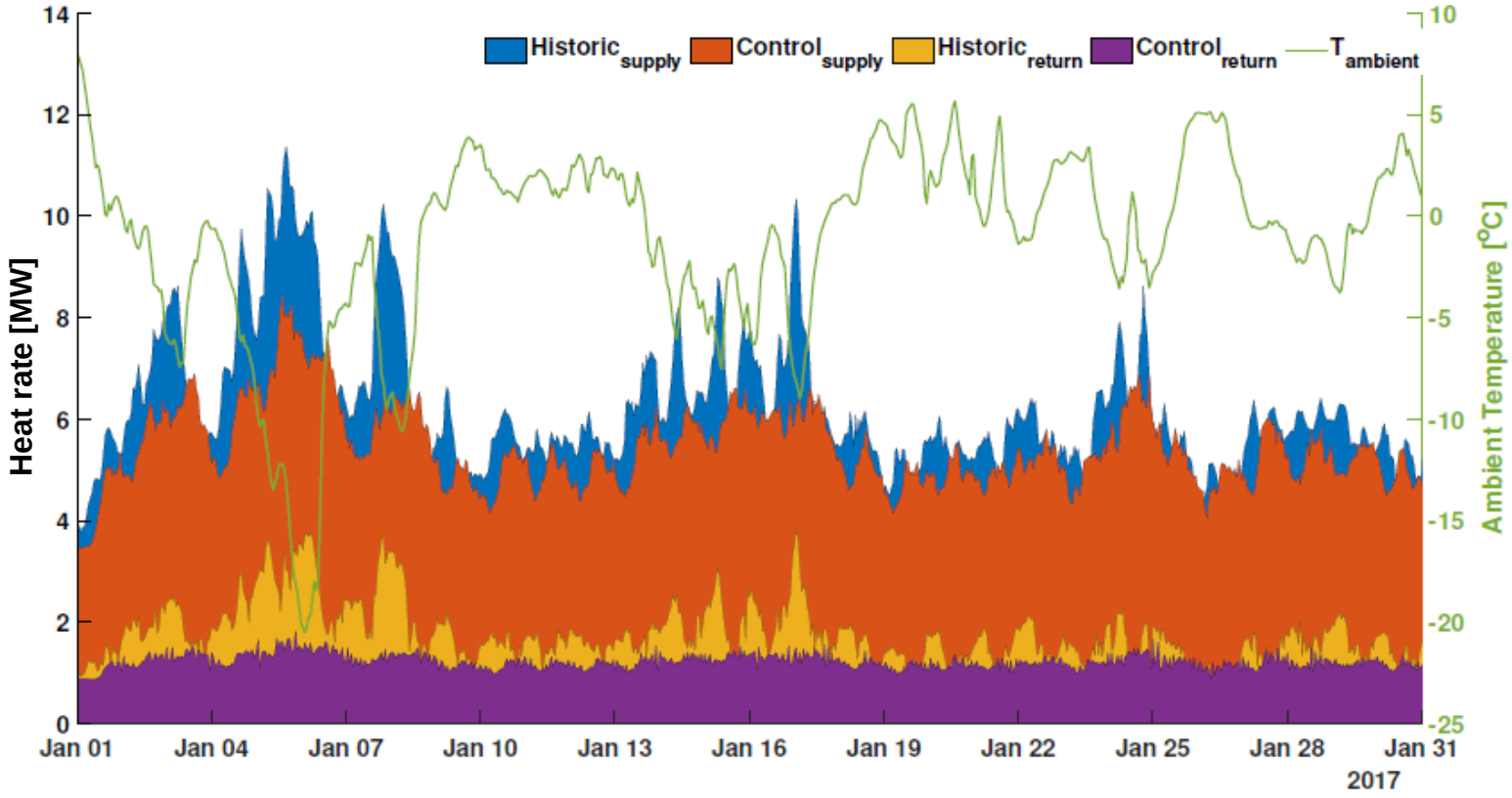


Time: 34h

- Visualization and simulation
- Aggregated regions
- Highlights bottlenecks

Hermansson, K., Kos, C., Starfelt, F., Kyprianidis, K., Lindberg, C.F. and Zimmerman, N., 2018. An automated approach to building and simulating dynamic district heating networks. *IFAC-PapersOnLine*, *51*(2), pp.855-860.

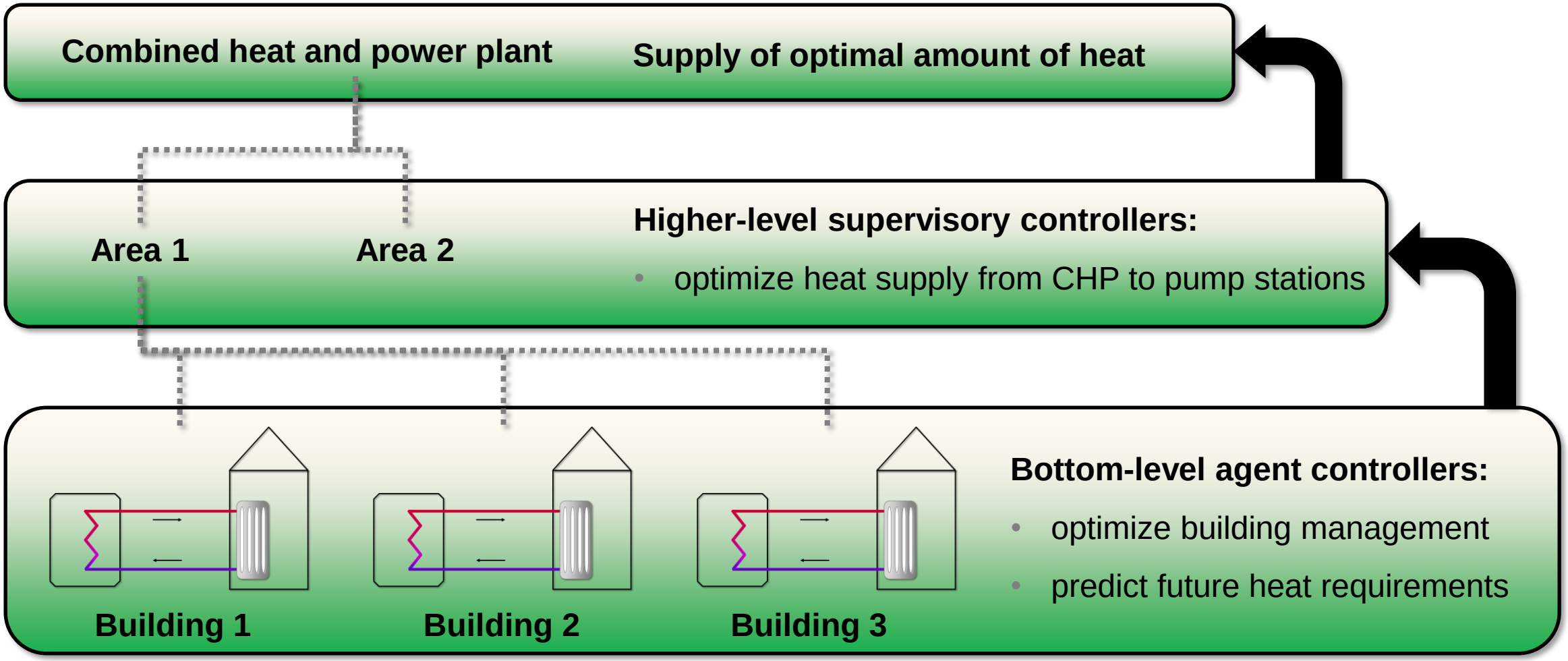
Network control



- Reduction of network supply and return temperatures
- Heat saving of 12% at the powerplant without sacrificing on the end-user heat supply *(case-specific)*

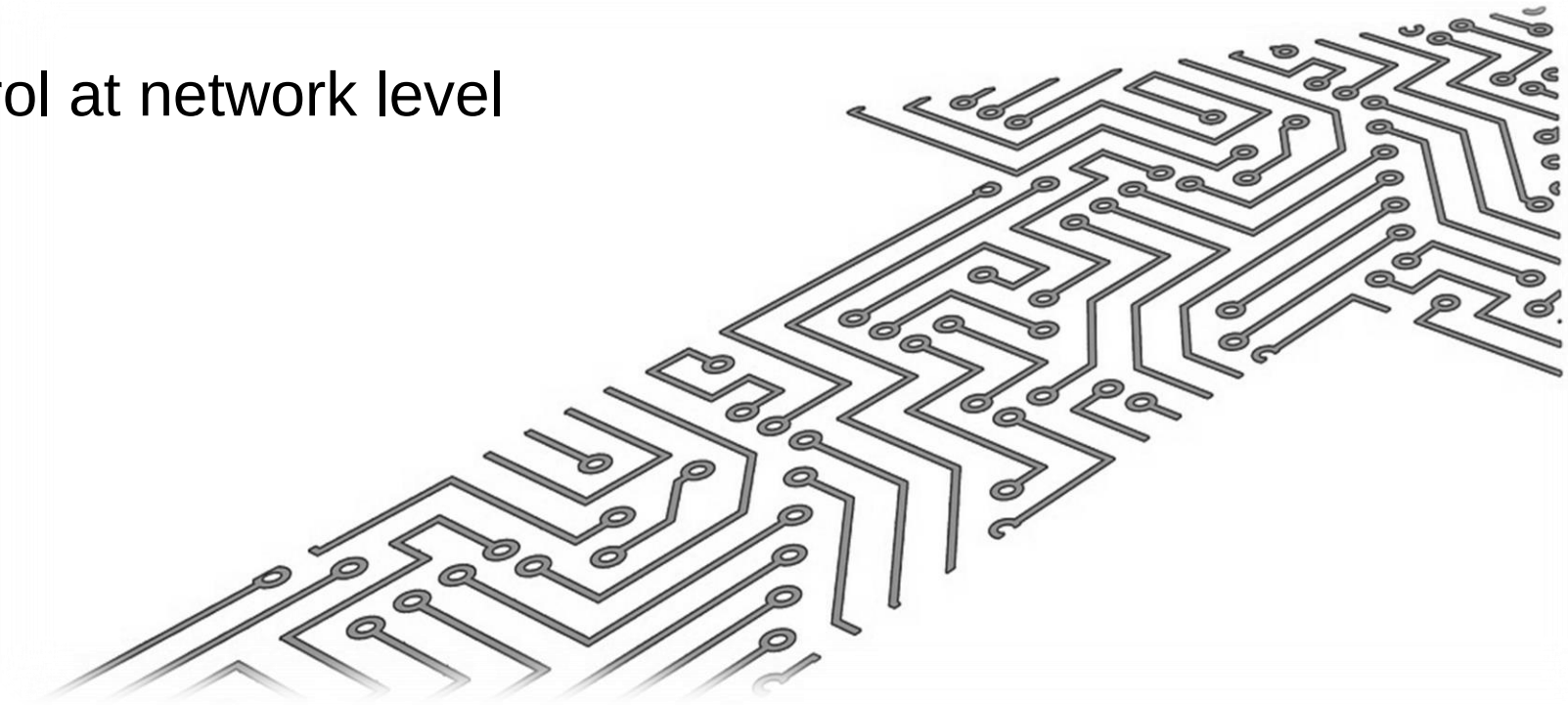
Zimmerman, N., Kyprianidis, K. and Lindberg, C.F., 2019. Achieving lower district heating network temperatures using feed-forward MPC. *Materials*, *12*(15), p.2465.

Multi-agent control of DHNs



Looking ahead

- Integration of multi-agent control architecture
- Demonstration of controller at building level
- Demonstration of control at network level
- Inclusion of prosumers
- Business model
- Social barriers



Mälardalen University

Energiforsk webinar

31 May 2022

Thank you for your attention!

Dr. Stavros Vouros

Post-Doctoral Researcher, Mälardalen University