

A Reinforcement Learning Framework for AI-Driven Control of Validated White-Box Building Models

Qiong Huang¹, Haozhen Cheng², Hüseyin Kemâl Çakmak², Benjamin Schäfer¹

¹ Data-driven analysis of complex systems (DRACOS), ² Energy System Analysis (ESA)

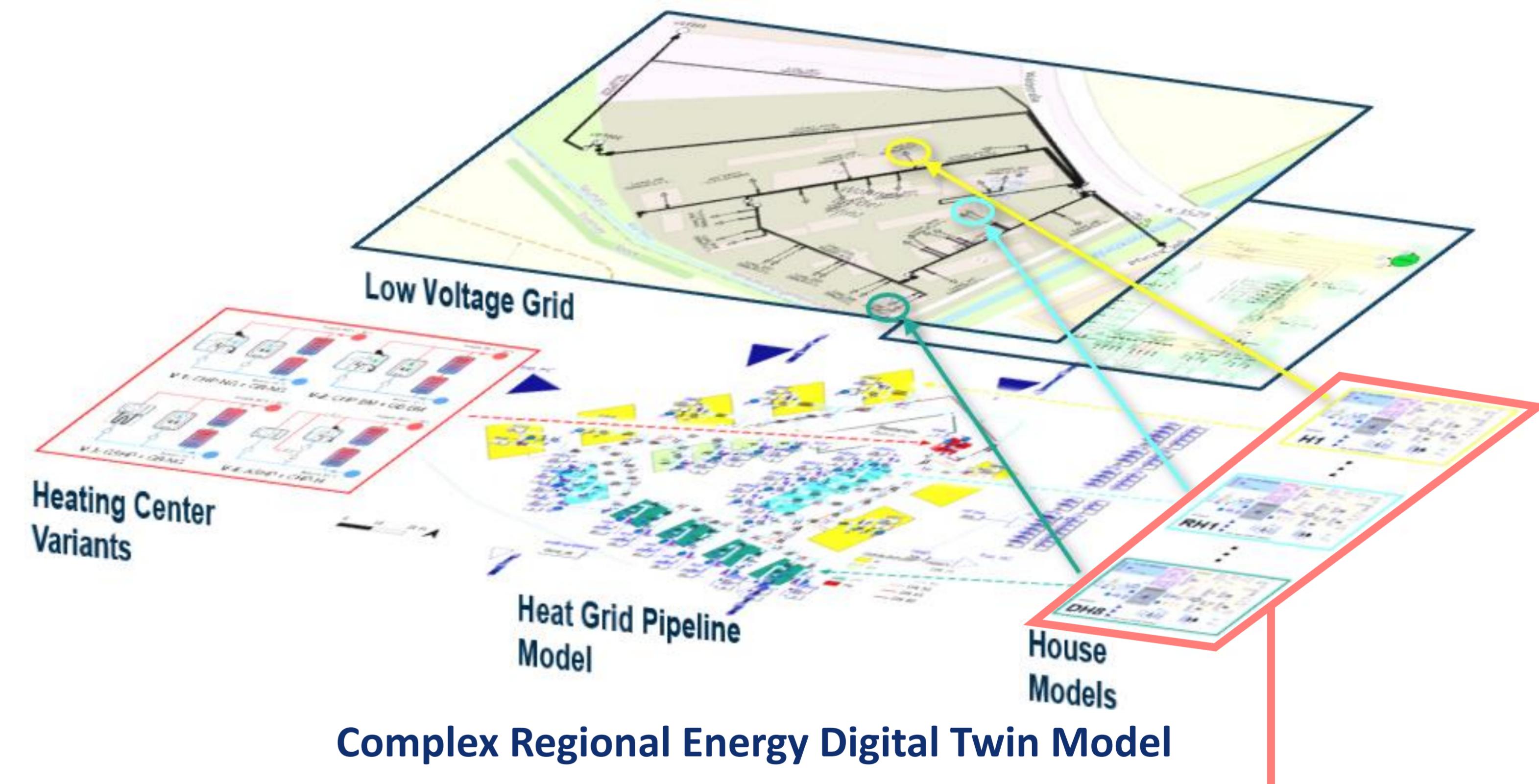
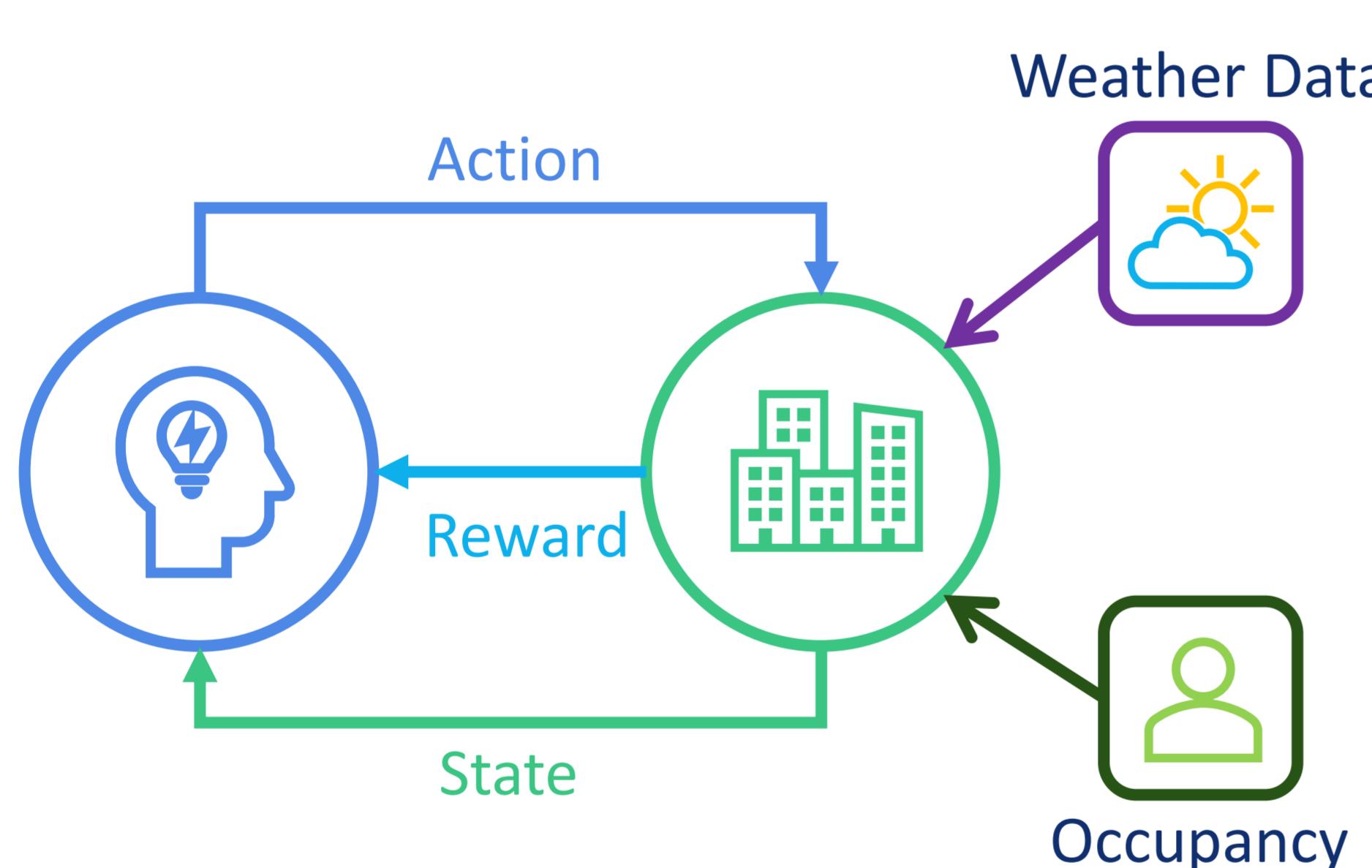
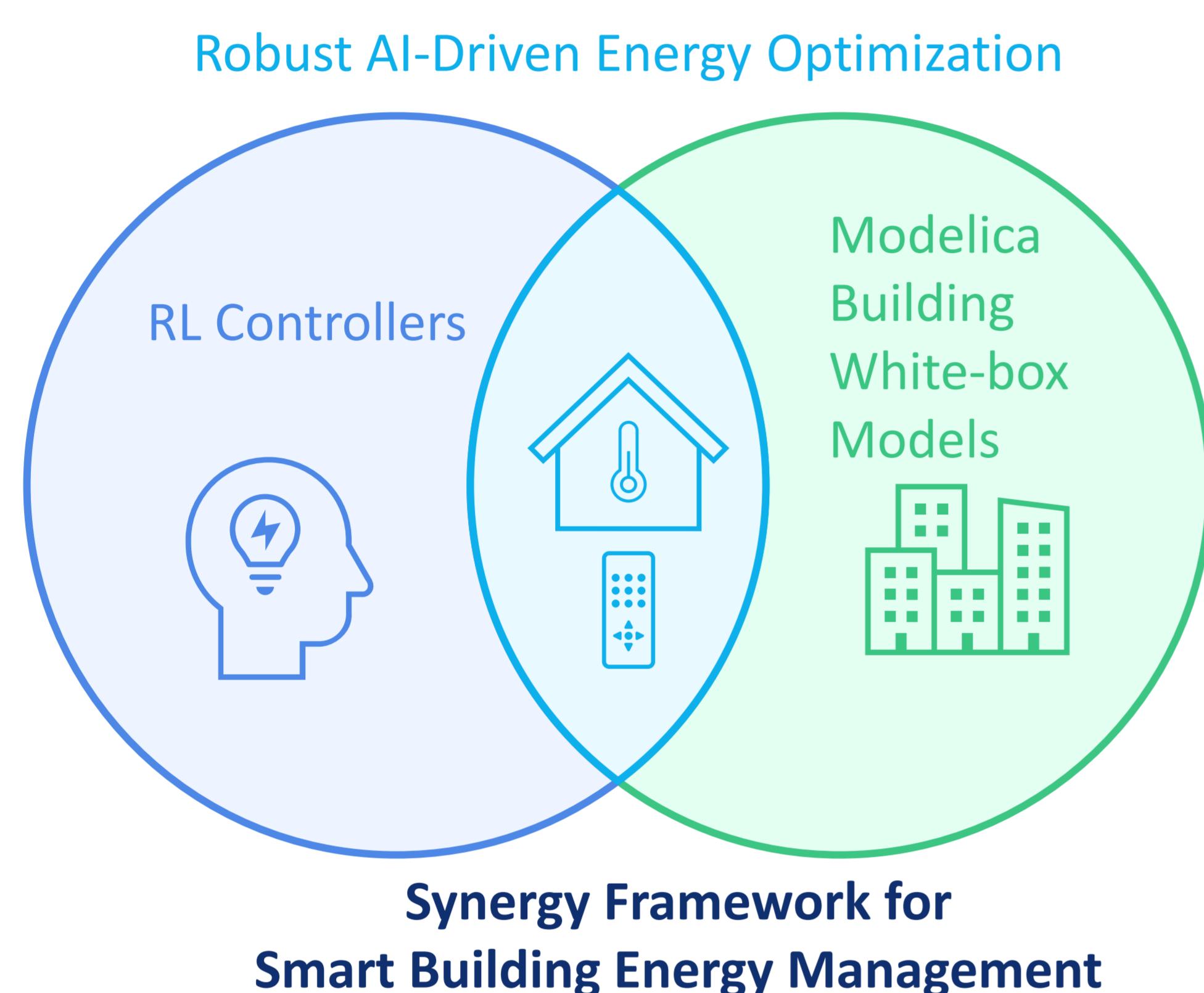
Institute for Automation and Applied Informatics (IAI), Karlsruhe Institute of Technology

Introduction & Motivation

- Buildings account for ~40% of global energy use;
- High-fidelity **simulation** are essential before deployment;
- Reinforcement Learning (RL) offers promising AI-driven control for building systems instead of fixed rule control;

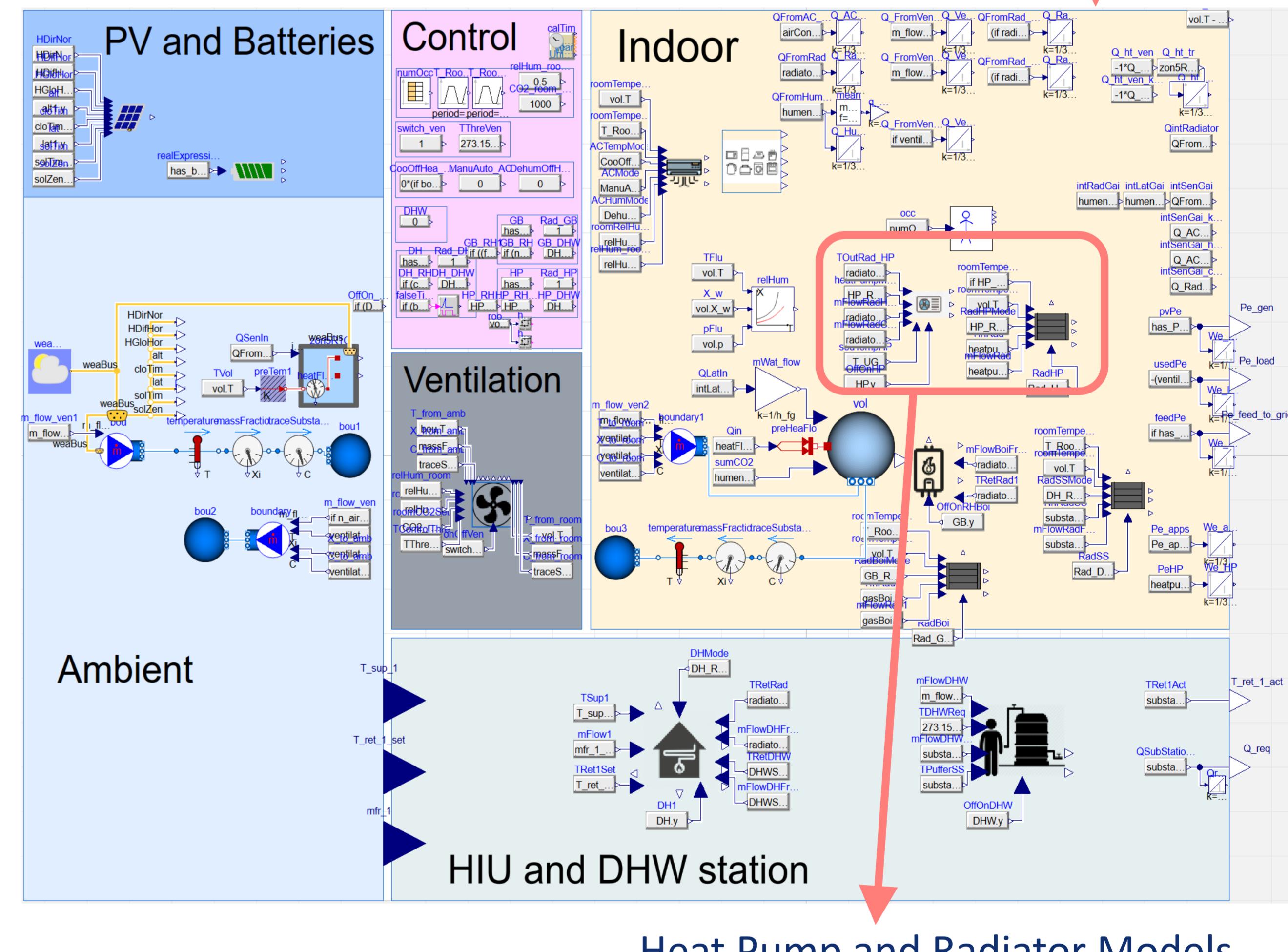
- Combines RL agents with Modelica-based white-box building models;
- Supports real-time closed-loop interaction between control and simulation.

Framework



Control Strategies & Algorithms

- State:**
 - weather Data, temp_room, m_flow, occupancy;
 - m_flow_min & max (water flow rate limitation);
 - building configuration parameters (U-values, floor area, etc);
- Action:**
 - water flow rate (continuous);
 - Reward balances energy efficiency, comfort, and operational constraints;
 - Goal:** minimize the heating cost over time;
 - PPO, SAC, DDPG methods align with the building model.



Conclusion

- ✓ Modular framework bridging RL with validated simulations;
- ✓ Real-time interaction using verified white-box models;
- ✓ Synthetic data generation for training.

Future Work

- ✓ Modelica model for experimental houses from the Living Lab Energy Campus (LLEC);
- ✓ Validating by comparing simulation outputs with real-world data;
- ✓ Deploy trained agents in real-world buildings;
- ✓ Extend framework to generalized building models (transfer learning) and grid scenarios.

REFERENCES

- Cheng, Haozhen, et al. "Construction and Control of Validated Highly Configurable Multi-Physics Building Models for the Sustainability Analysis of Multi-Energy Systems in a Co-Simulation Setup," IEEE SoutheastCon'25, 2025.
- Cheng, Haozhen, et al. "Economy and Sustainability Analysis with a Novel Modular Configurable Multi-modal White-box Building Model," ANNSIM'25, 2025.
- Huang, Qiong, et al. "Distributed reinforcement learning for dc open energy systems," ICLR 2023 Workshop on Tackling Climate Change with Machine Learning, 2023.