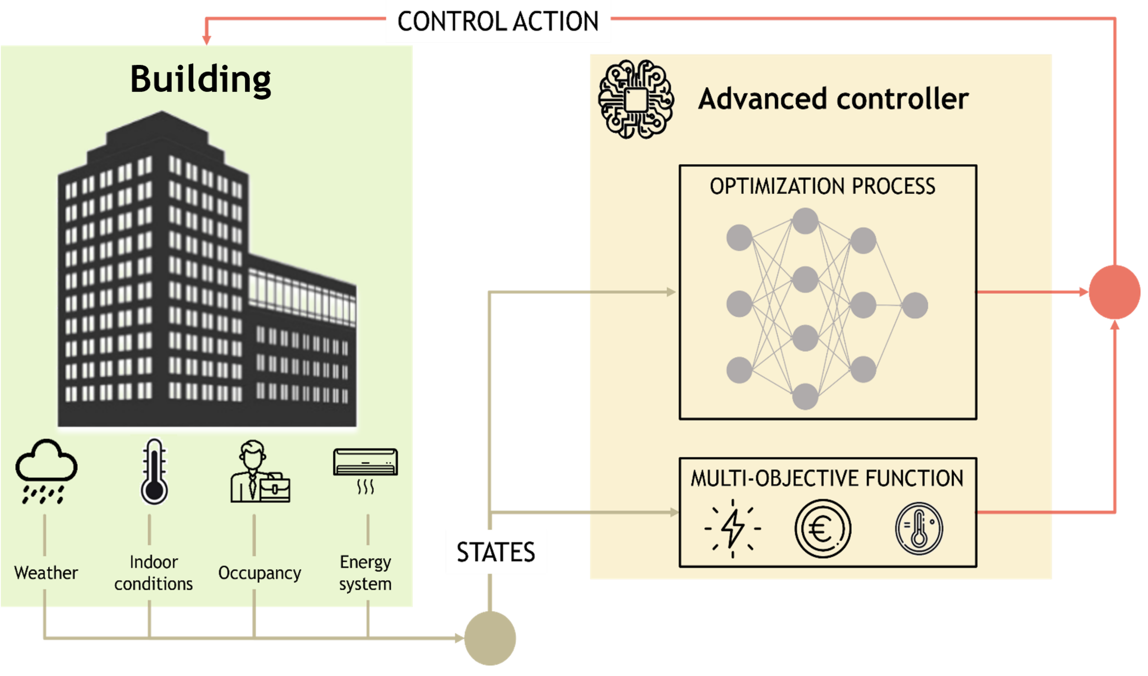
Politecnico di Torino

Department of Energy "G.Ferraris"

Transfer learning to enhance the scalability of artificial intelligence-based control strategies in buildings

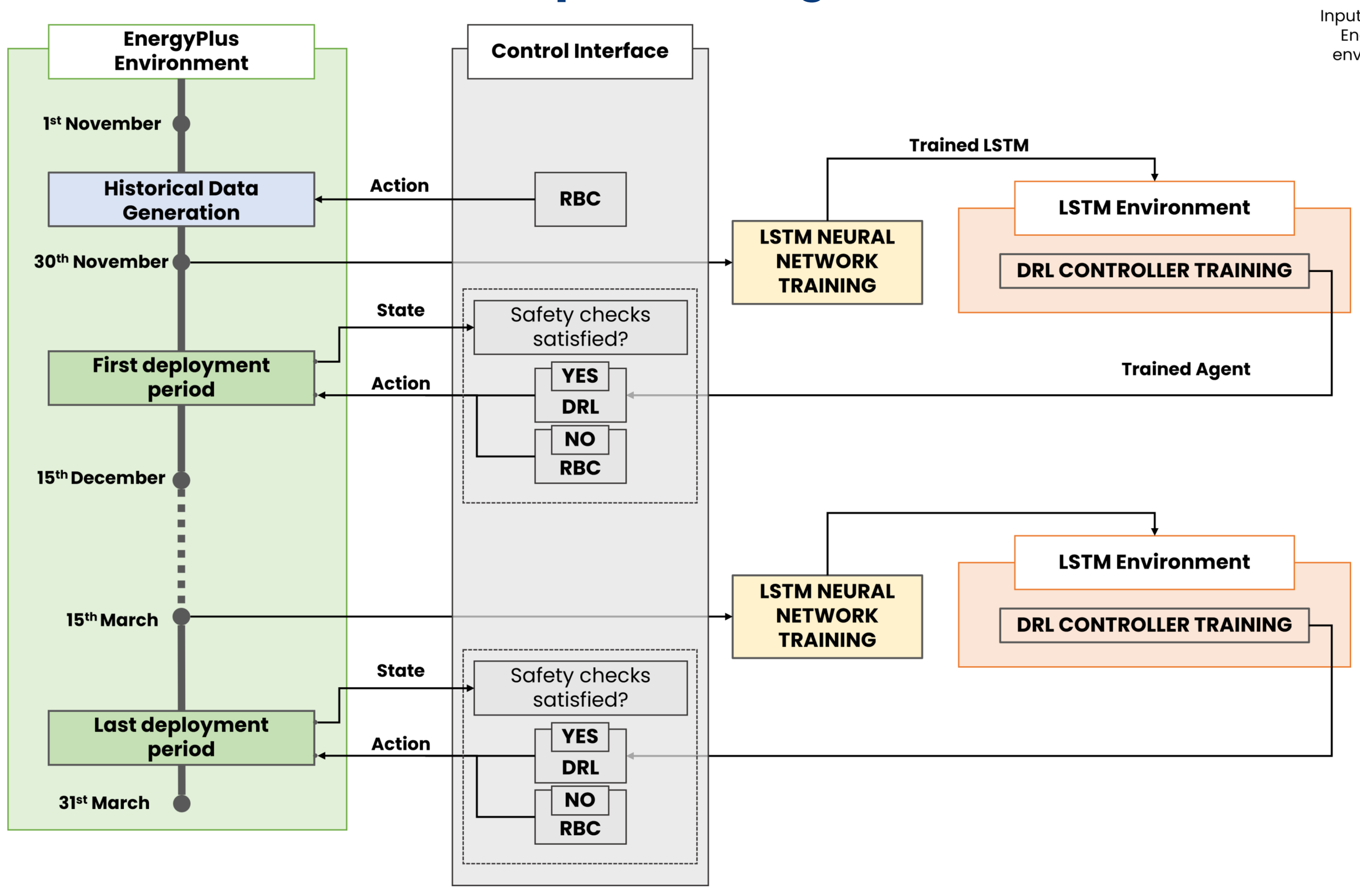
Smart buildings require advanced control solutions

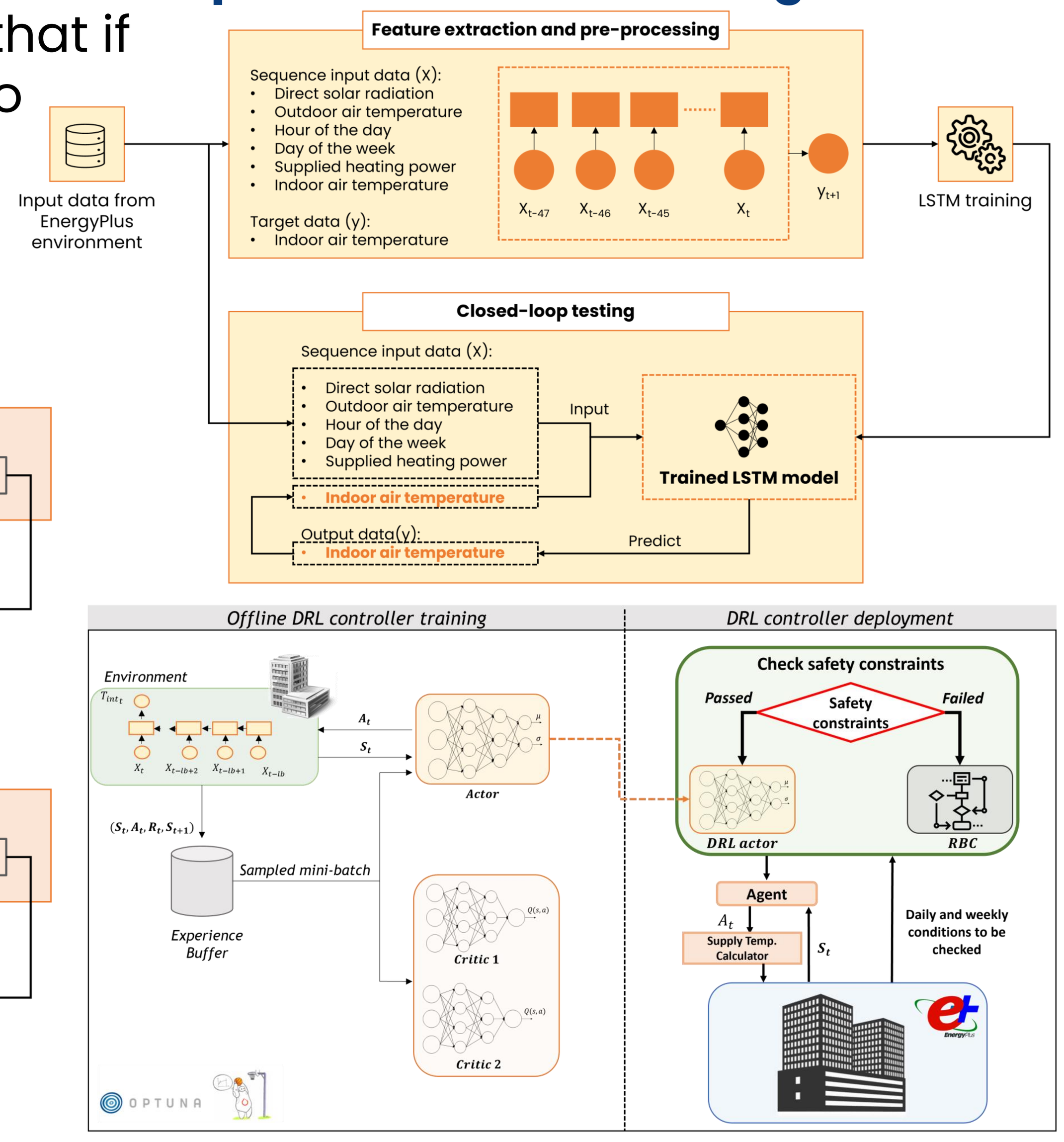
DRL controllers emerged as promising candidates to **exploit flexibility sources** in buildings as PV and storage systems. However, the **direct implementation** of DRL controllers is **not feasible** since they should be pre-trained offline on detailed/data-driven **building surrogate models** to ensure good performance and safe operation. However, the development of detailed building models needs a **considerable modeling effort and domain expertise.**



Effective pre-training of DRL controllers by means of LSTMs

An **automatic and recursive procedure** including safety constraints was designed for a heating system consisting of a boiler and radiators **to effectively pre-train a DRL controller** by means of a **LSTM model** emulating building dynamics. The DRL agent managed the supply water temperature setpoint to **minimize energy consumption** and **enhancing indoor temperature control.** From this applications emerged that if adequately trained, LSTM models could be employed to train DRL controller, **outperforming RBC.**

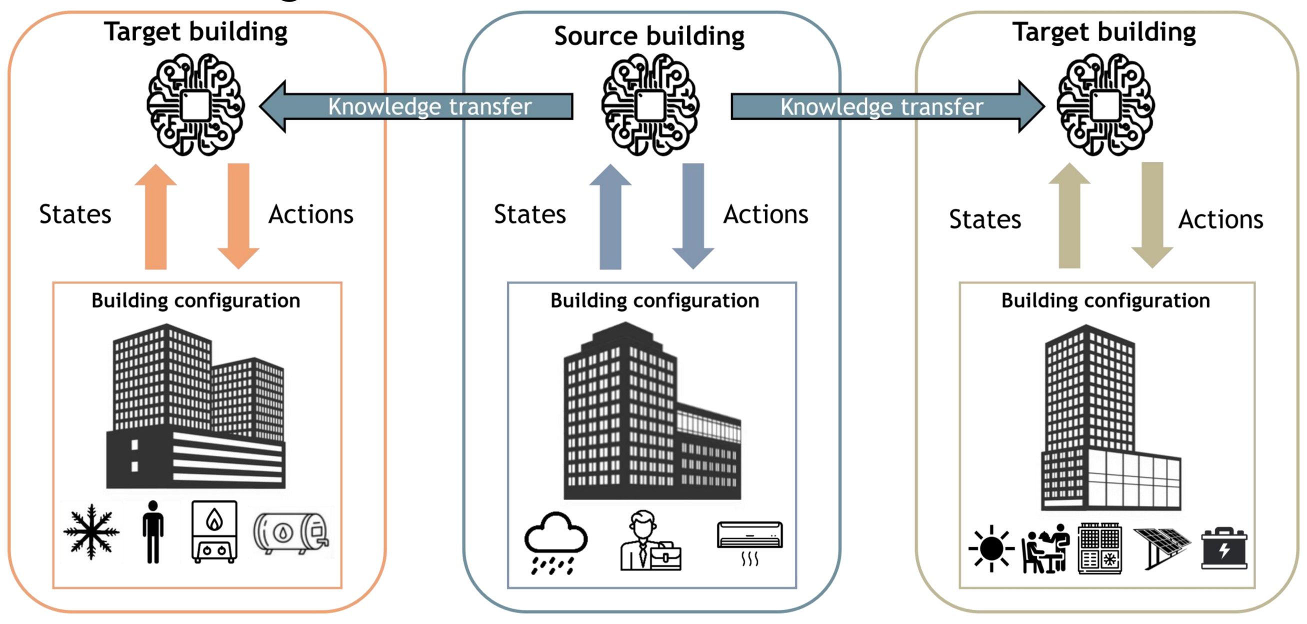




Transfer learning for DRL controllers

Transfer learning (TL) for building control applications have multiple advantages:

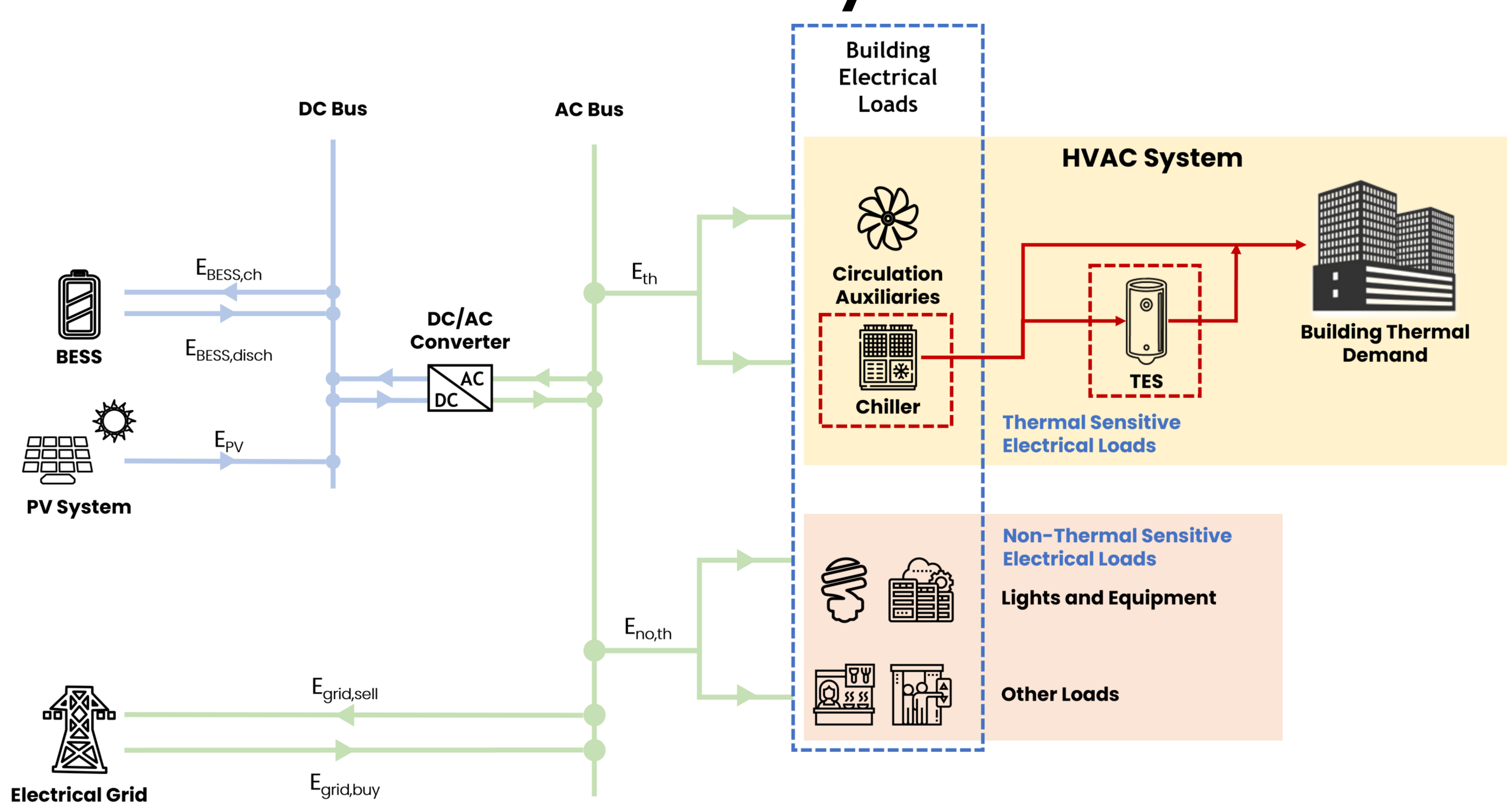
- ✓ **Speeding-up the training process for DRL controllers** to achieve an optimal control policy
- ✓ **Avoiding the development of surrogate models** to pre-train DRL controllers
- ✓ **Allowing the direct deployment** of DRL in real buildings



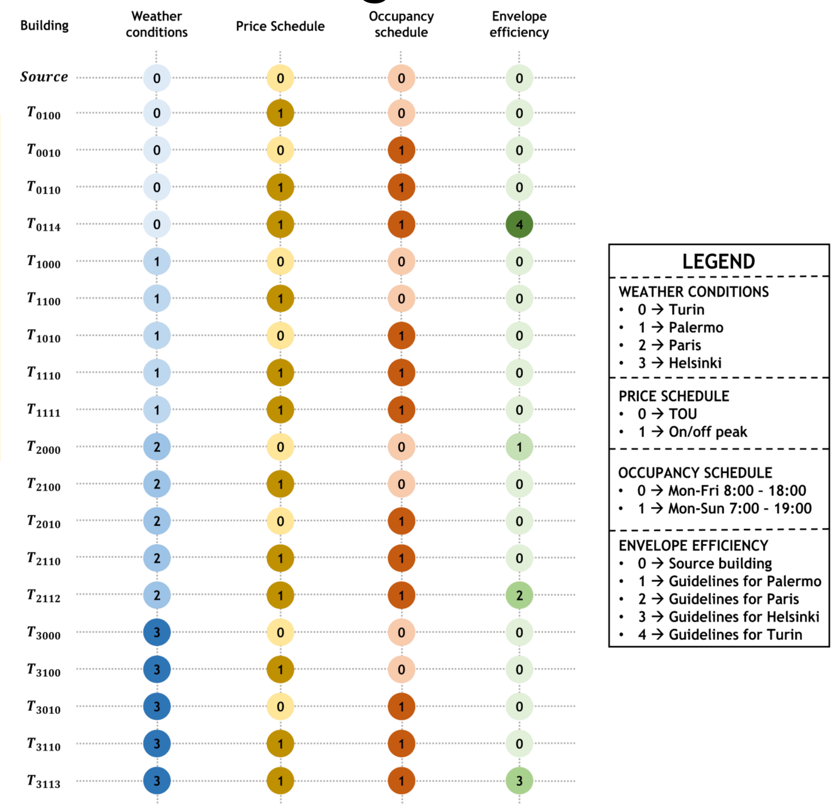
Online Transfer Learning applications

An **online TL strategy** is tested in **homogeneous and heterogeneous** (different energy systems) settings to **transfer a DRL agent** between buildings having **different weather conditions, price and occupancy schedules, building thermophysical properties.** The DRL controller selected the **operation mode** a cooling system consisting of chiller and TES and the **fraction of cooling energy** delivered to the building to **minimize electricity cost while enhancing indoor temperature conditions.**

Case study

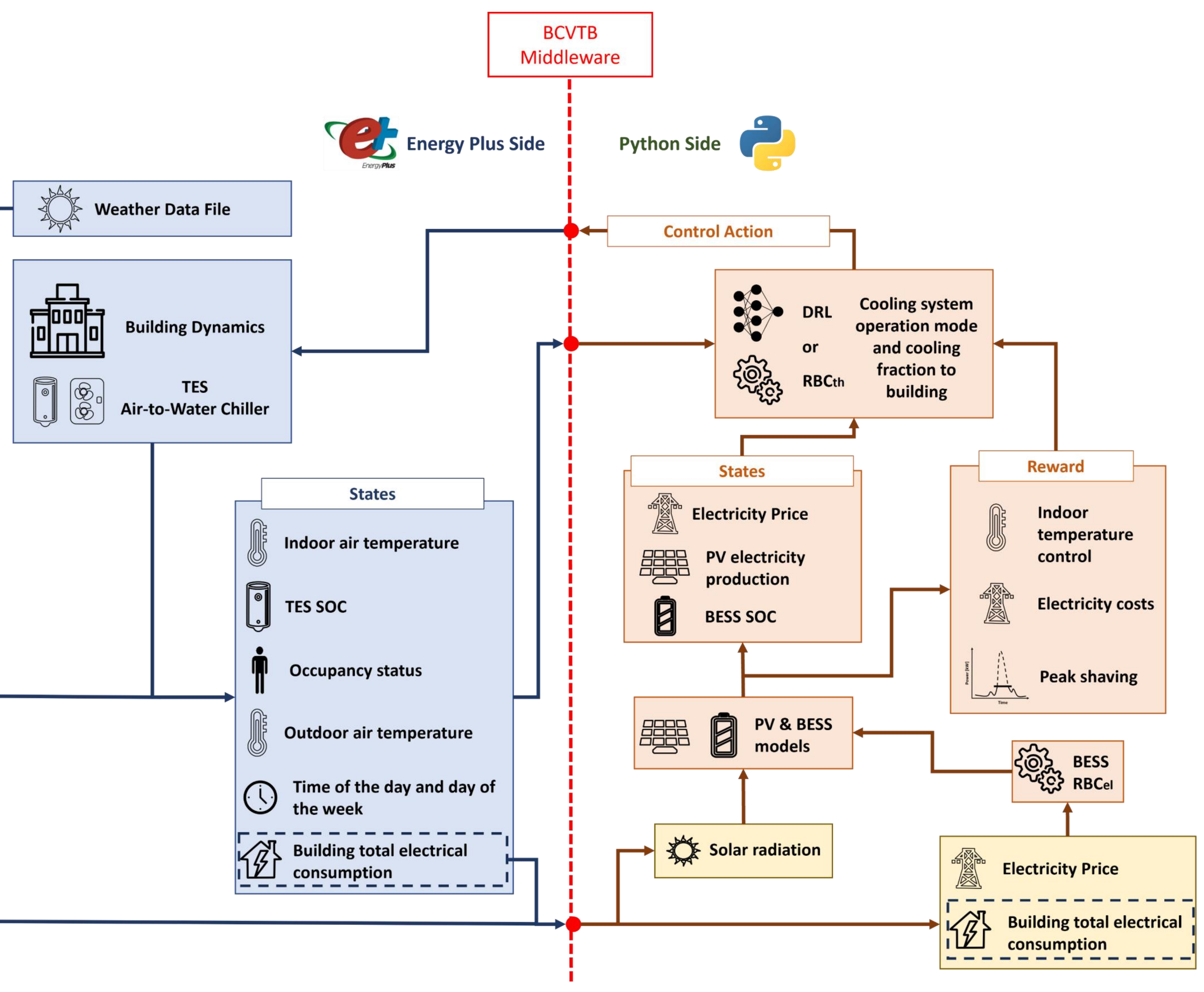


Target buildings configuration

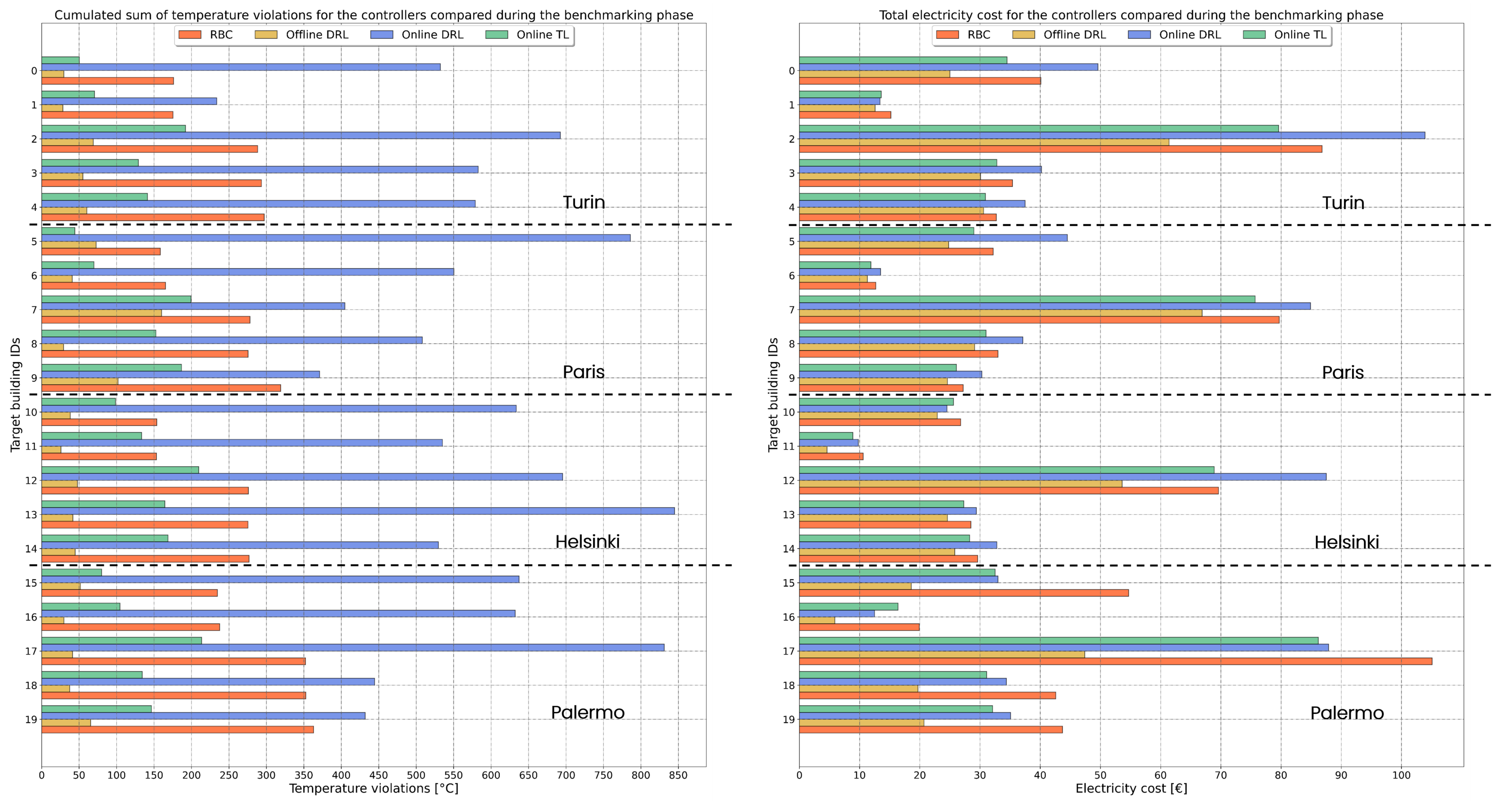


Simulation environment

The TL was implemented in an integrated simulation environment combining **EnergyPlus** and **Python**.



Performance benchmark for Online TL with RBC, Offline DRL and Online DRL



Energetics PhD XXXVII Cycle

PhD Day
Energy Center Auditorium
December 20th 2023

PhD student:
Davide Coraci

Tutors:
Prof. Alfonso Capozzoli
Dr. Tianzhen Hong

Publications

Coraci, D.; Brandi, S.; Capozzoli, A. ***Effective pre-training of a deep reinforcement learning agent by means of long short-term memory models for thermal energy management in buildings***. *Energy Conversion and Management* (2023), *291, 117303.* https://doi.org/10.1016/j.enconman.2023.117303

Coraci, D.; Brandi, S.; Hong, T.; Capozzoli, A. ***Online transfer learning strategy for enhancing the scalability and deployment of deep reinforcement learning control in smart buildings***. *Applied Energy* (2022), *333, 120598*. https://doi.org/10.1016/j.apenergy.2022.120598

Coraci, D.; Brandi, S.; Hong, T.; Capozzoli, A. ***An innovative heterogeneous transfer learning framework to enhance the scalability of deep reinforcement learning controllers in buildings with integrated energy systems*** (2023). Submitted to Building Simulation journal on 21st November 2023

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External Collaborations: BERKELEY LAB, ETH zürich