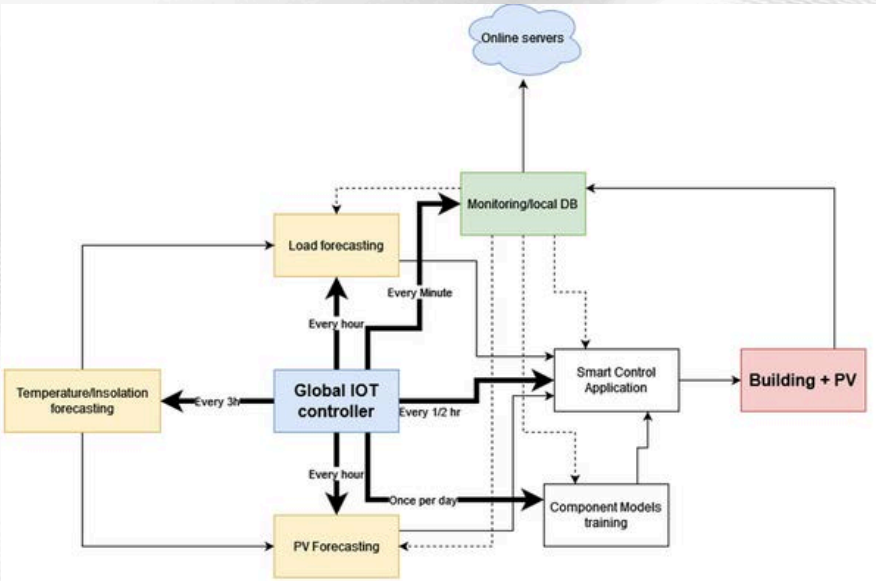
This is a collaborative PhD project, partially funded by EURAC, which aims to develop and implement an intelligent control system to optimise energy management in residential heating and cooling systems. The project aims to develop advanced optimisation methods that achieve near-global optimal performance and are able to operate in real time on constrained hardware. A key aspect of the project is the integration of dynamic programming (DP) techniques with reduced order models (ROMs) and novel approaches such as quantum optimisation.

The projected focuses initially on the development of fast, accurate component models for various parts of the heating and cooling system, like heat pumps, thermal storages, and electrical batteries. The research then explores methods for constructing these models based on laboratory testing, performance maps, and advanced forecasting techniques, see below. For example, physics-informed neural networks (PINNs) are employed to predict indoor temperatures and thermal loads, leveraging both historical monitoring data and real-time weather forecasts



Following the modelling phase, the project focuses on designing an optimisation framework to determine the optimal control strategy. In parallel, quantum optimisation methods are explored as a potential benchmark for classical approaches. Quantum optimisation, despite current limitations in hardware, offers a promising avenue for solving large-scale combinatorial problems. This research will examine whether the component models developed for the dynamic programming framework can be adapted to quantum optimisation contexts.

Ultimately, the project will culminate in the deployment of the developed control system in a real-world residential demonstration building. Field tests will validate the simulation results and quantify the potential energy and financial savings, providing a benchmark for advanced control systems in residential energy management. These endeavours will advance the state-of-the-art in smart energy management, offering a versatile and scalable solution for modern residential heating and cooling challenges.