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#SESAAU2019

A smart controller for small-scale district heating and cooling networks: development and testing

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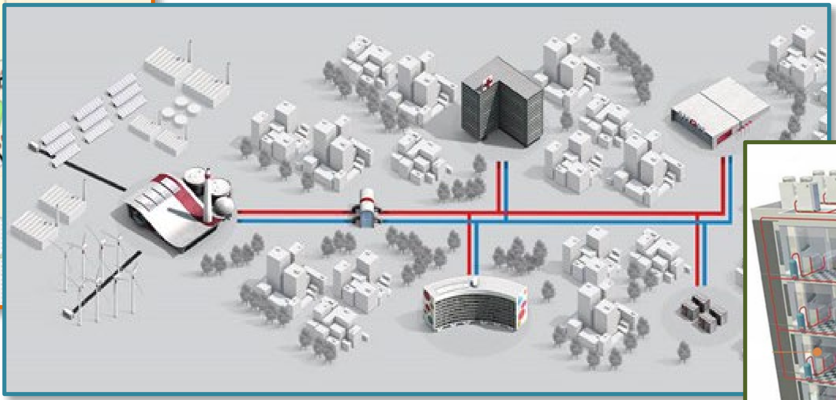
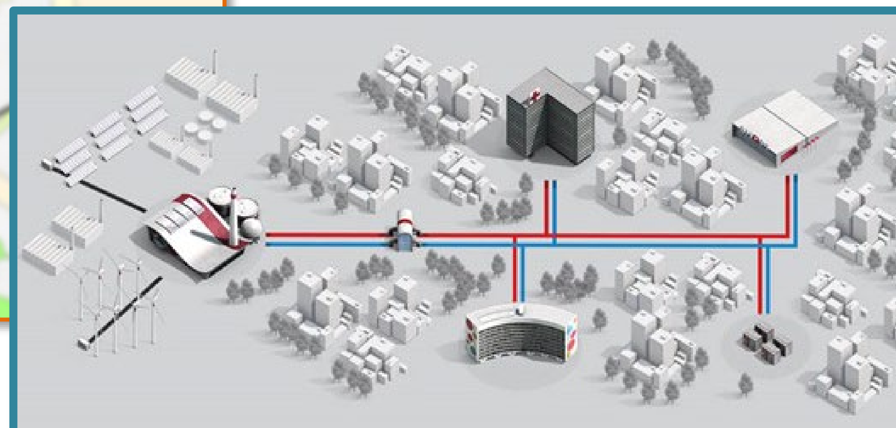
Powered by

Heating and Cooling networks efficiently distribute thermal energy at **different scales**

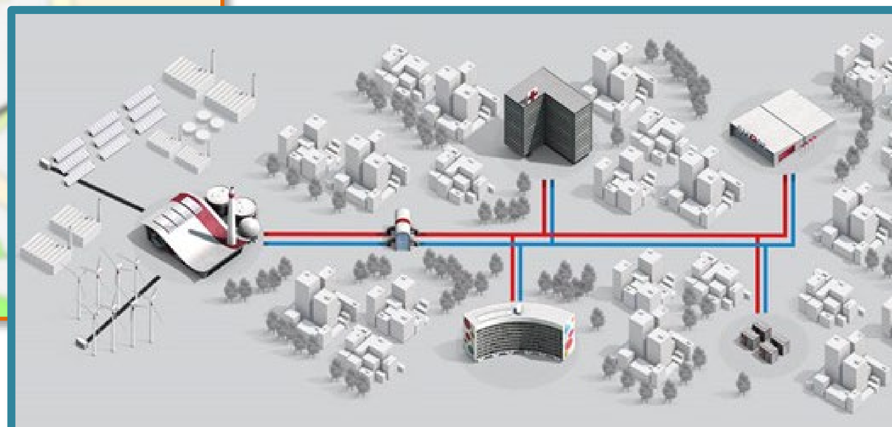


There are significant advantages also at **small-scale level** compared to single boilers…



- Flexibility
- Integration of renewables
- Energy efficient buildings

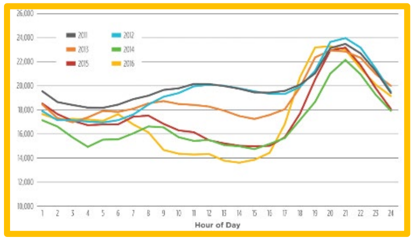
…but, together with **opportunities**, these multi-source networks introduced new **challenges**

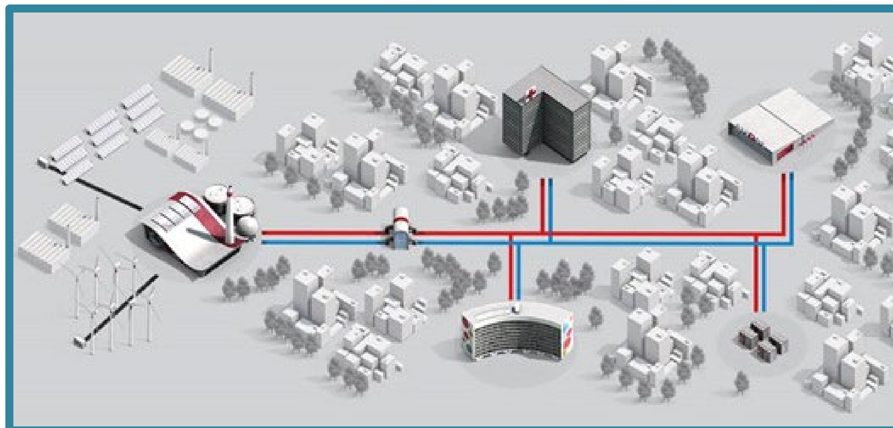


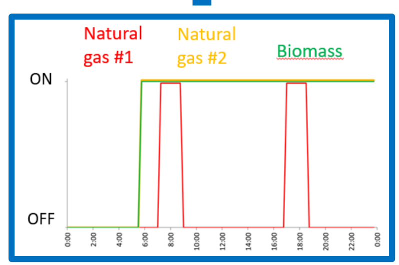
- Flexibility
- Integration of renewables
- Energy efficient buildings

- Load allocation
- **Management** of the system
- **Real-time control**

Today, energy systems are managed through day-ahead schedule, rule-based or, in the best of cases, adaptive strategies

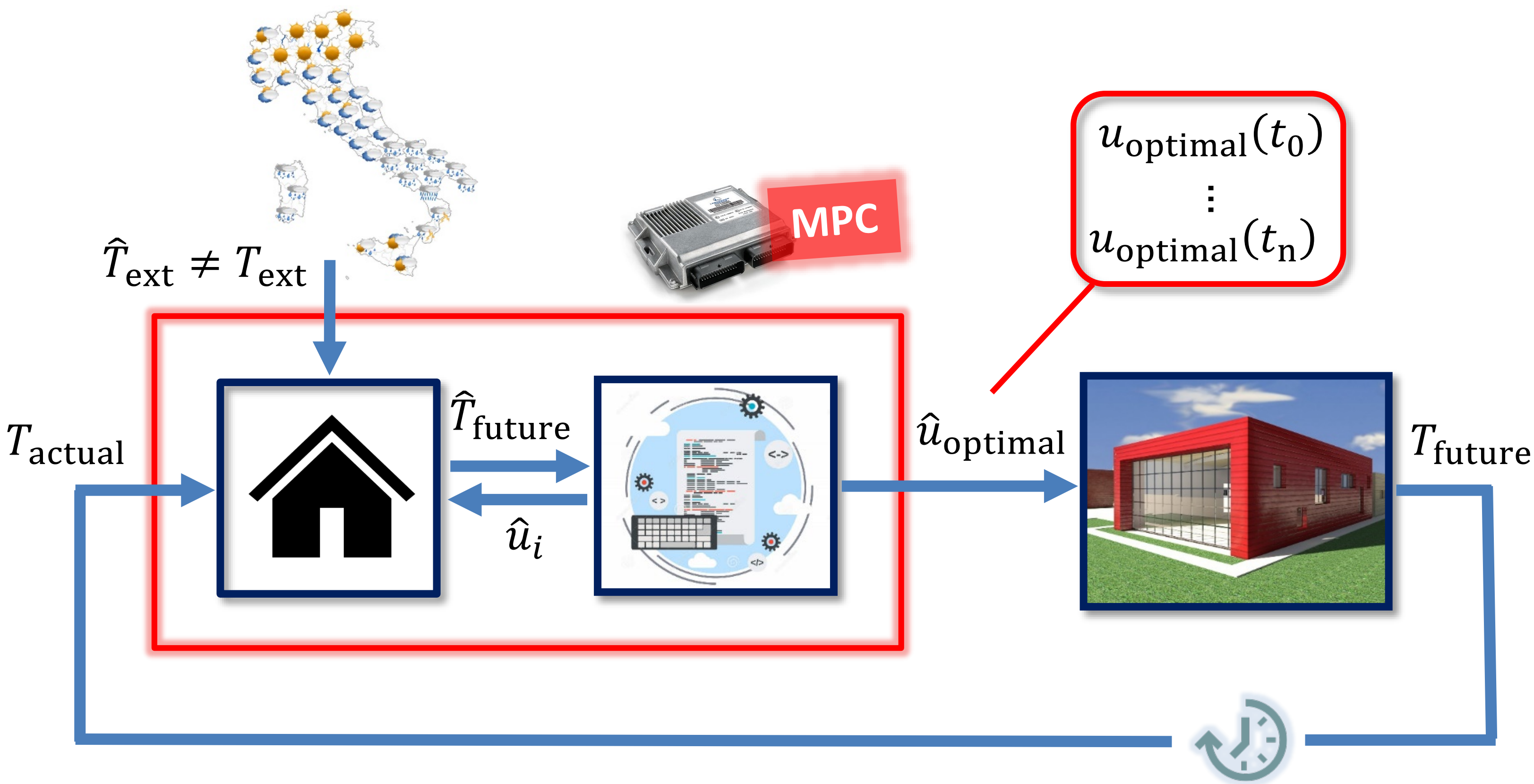






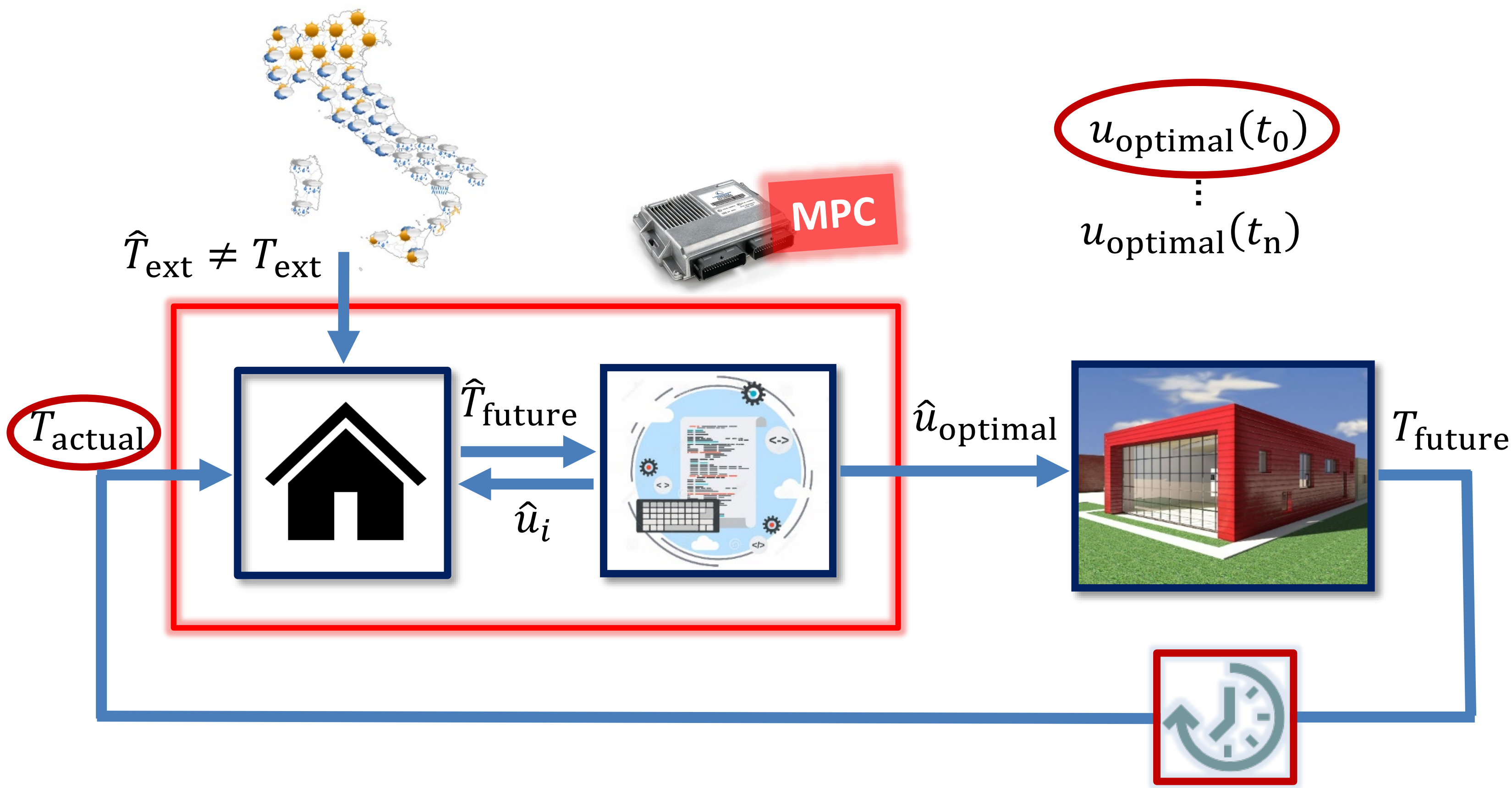
But, in order to face **extreme** climate conditions and to achieve optimal management of the system, **predictive control** strategies are necessary

Model Predictive Control uses a model to predict the **future** behavior of the system and compute **optimal** control sequence



Gambarotta et al. Energy Procedia 2019;158:2896-2901

Each time-step, time horizon is moved one step forward, model variables are updated and optimization is repeated (**receding time horizon**)



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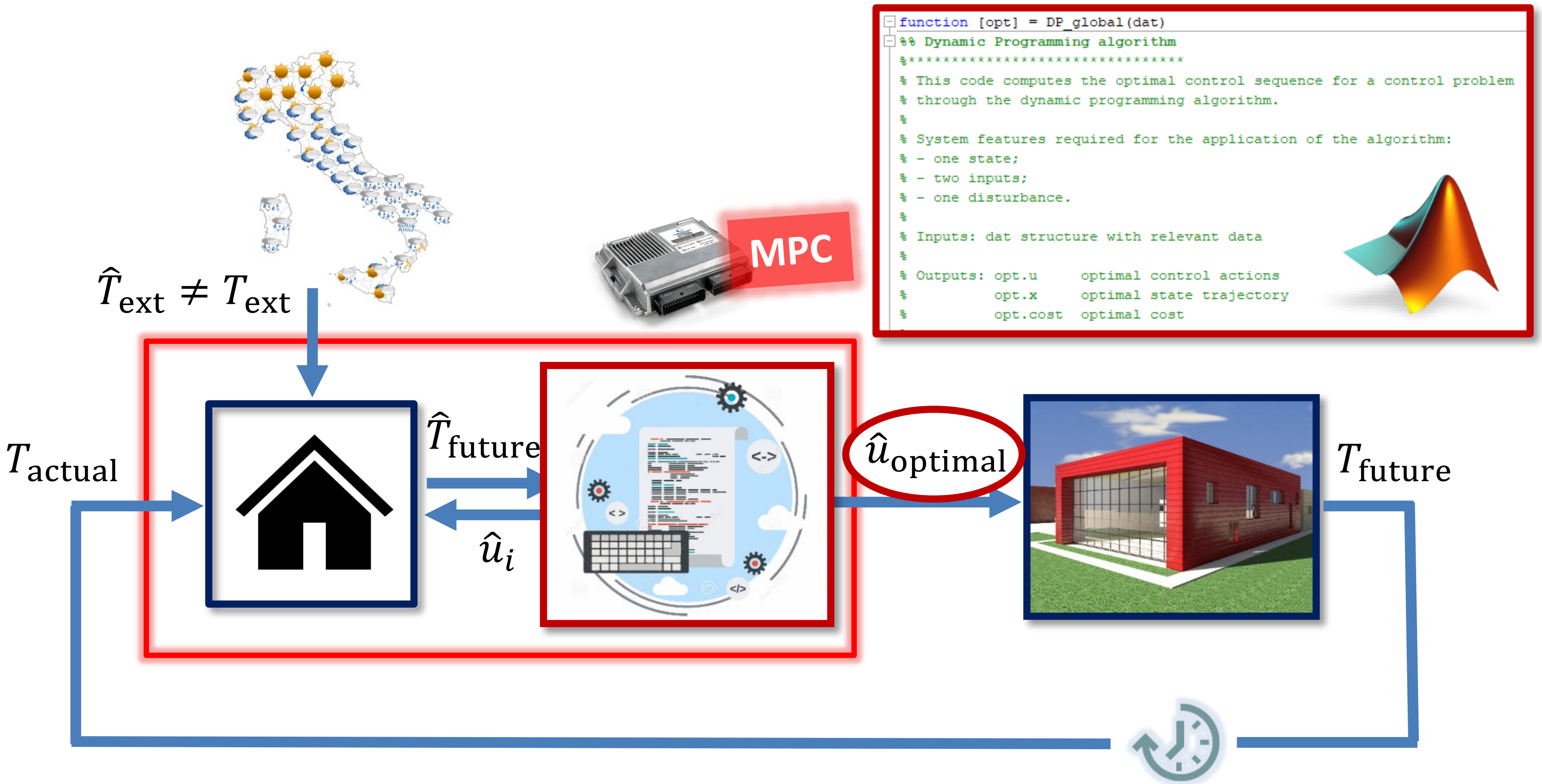
Each optimization problem is solved through a **Dynamic Programming algorithm** previously developed



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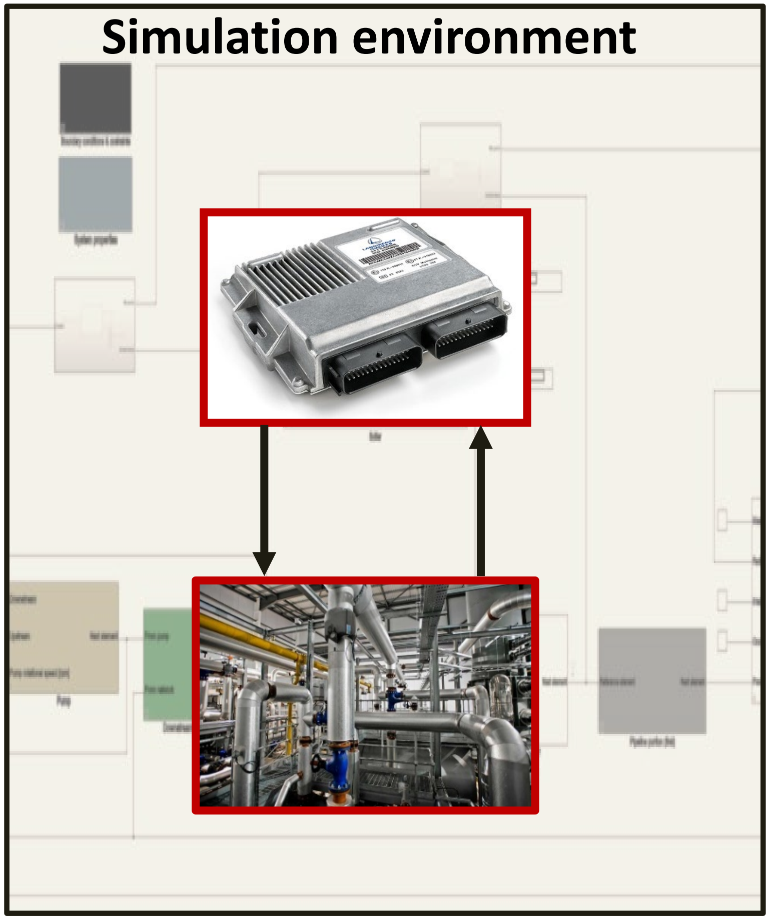
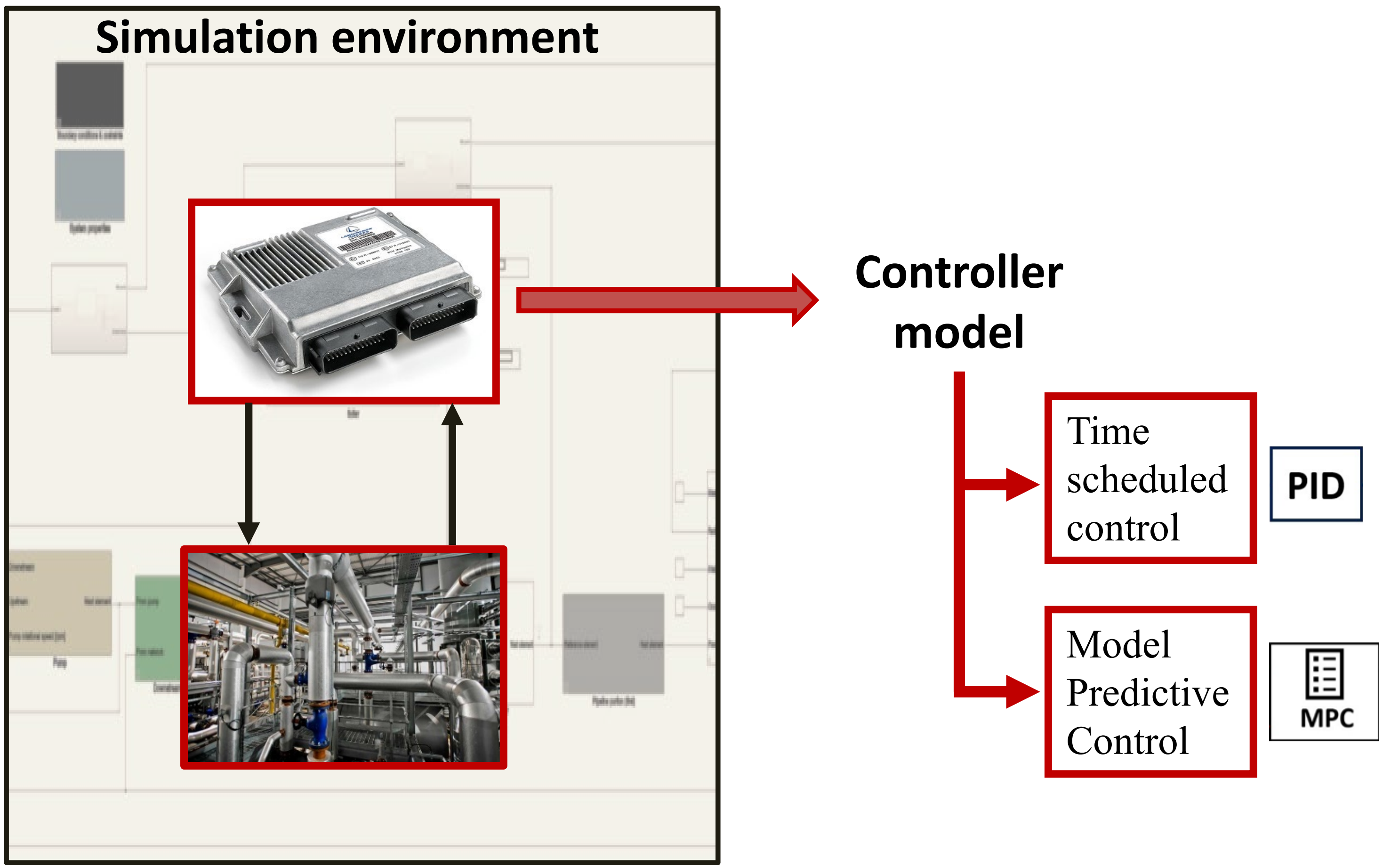
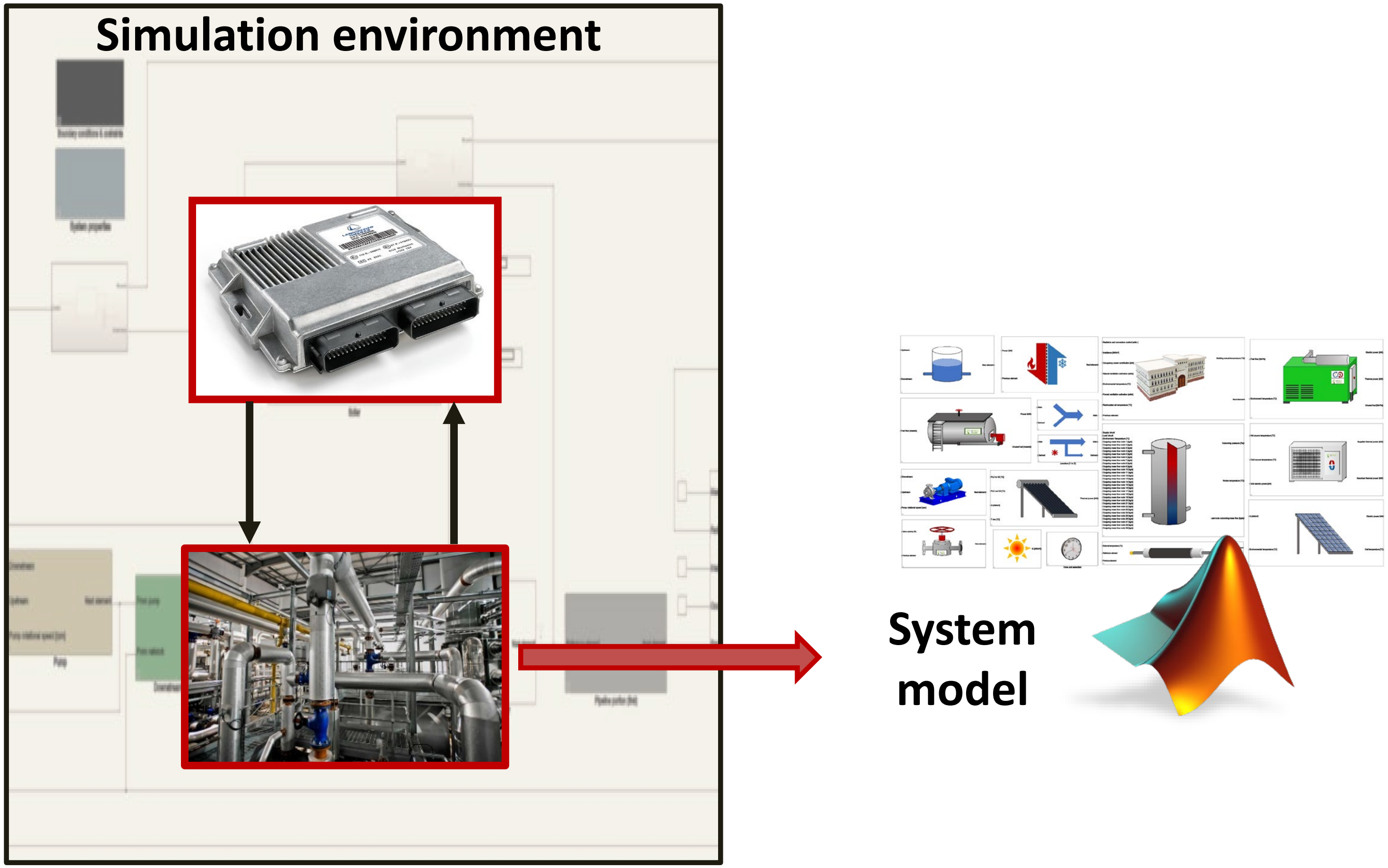
A **Model-in-the-Loop** platform is used to test and compare different control strategies



A conventional controller (baseline) and the innovative **Model-**based **Predictive** controller are implemented



The **detailed model** of the real system is built with the components of a library and used as test bench



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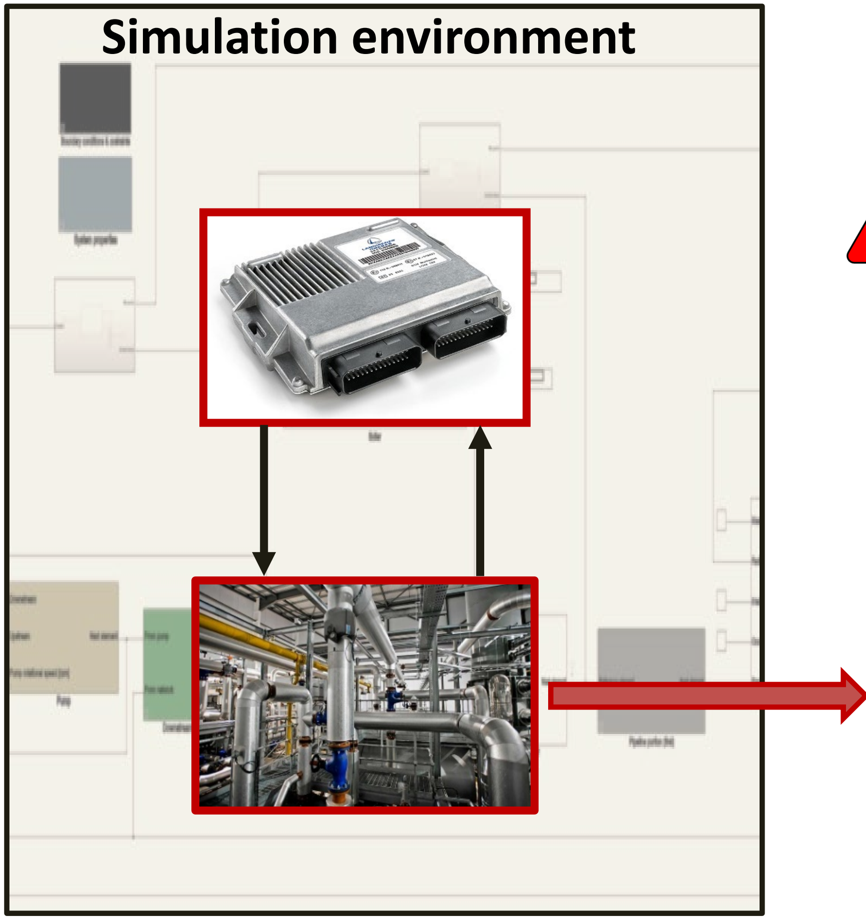
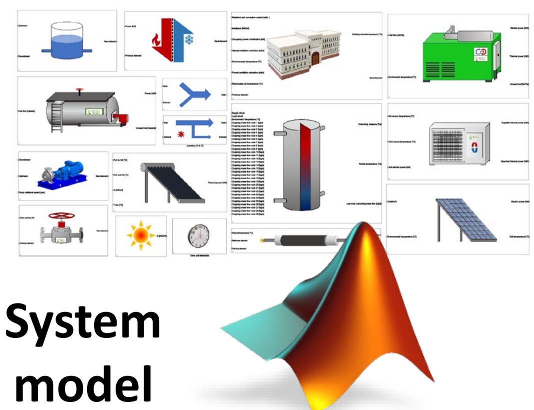
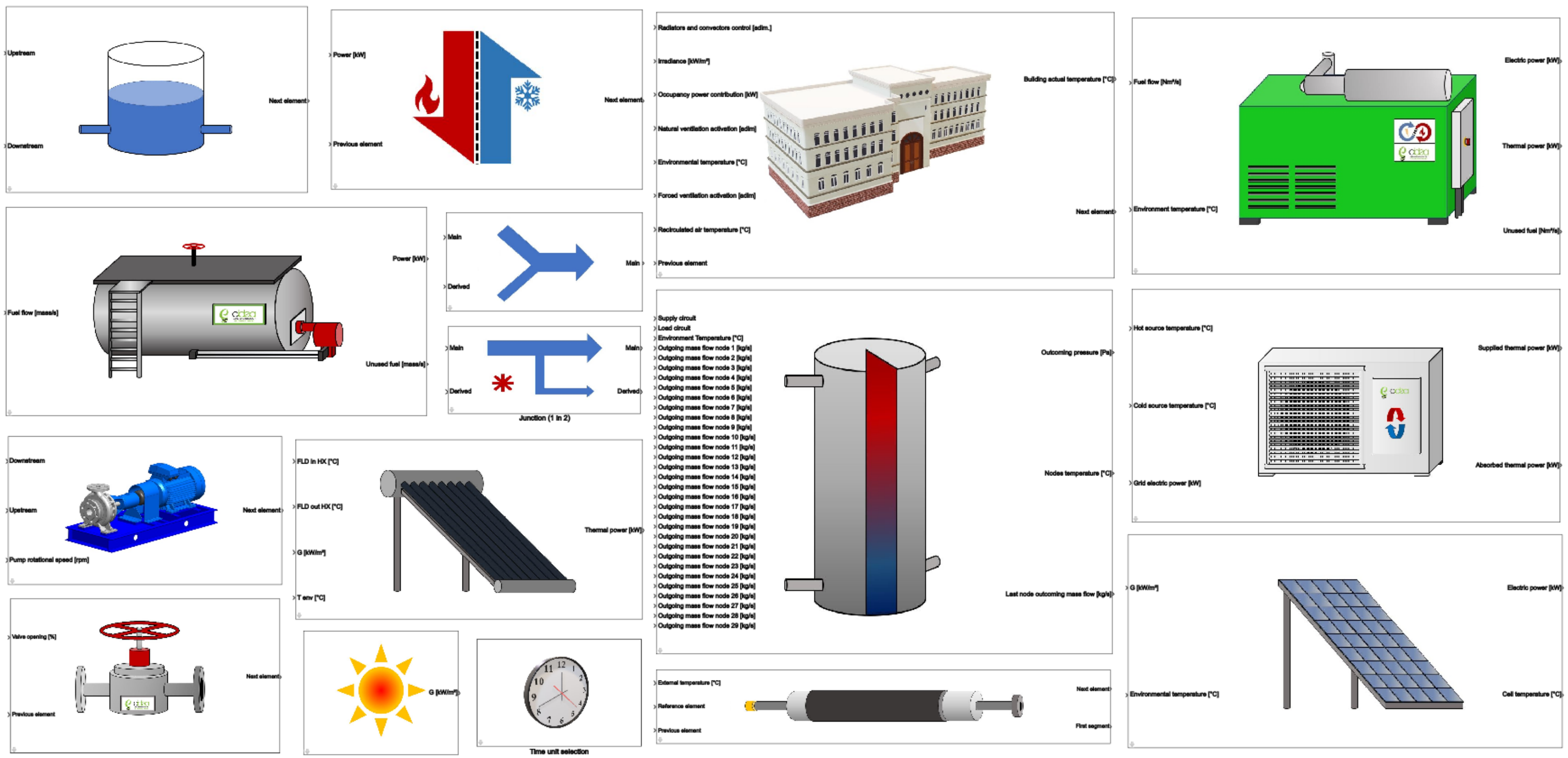


MPC-model ≠ Detailed MiL-model since it must be simplified for **real-time** optimization

System model



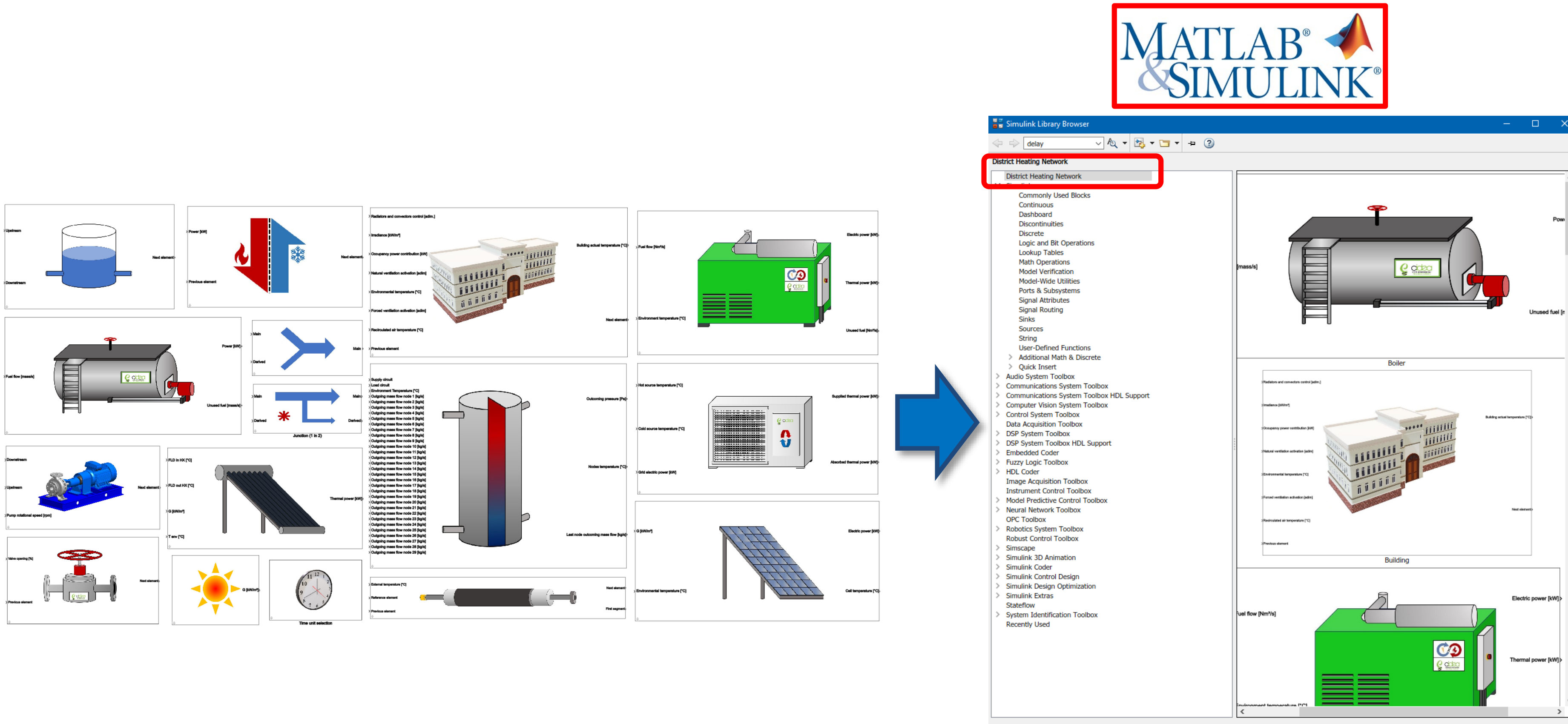
The **standard components** of energy systems has been modeled…



EFFICITY efficient energy systems for smart urban districts

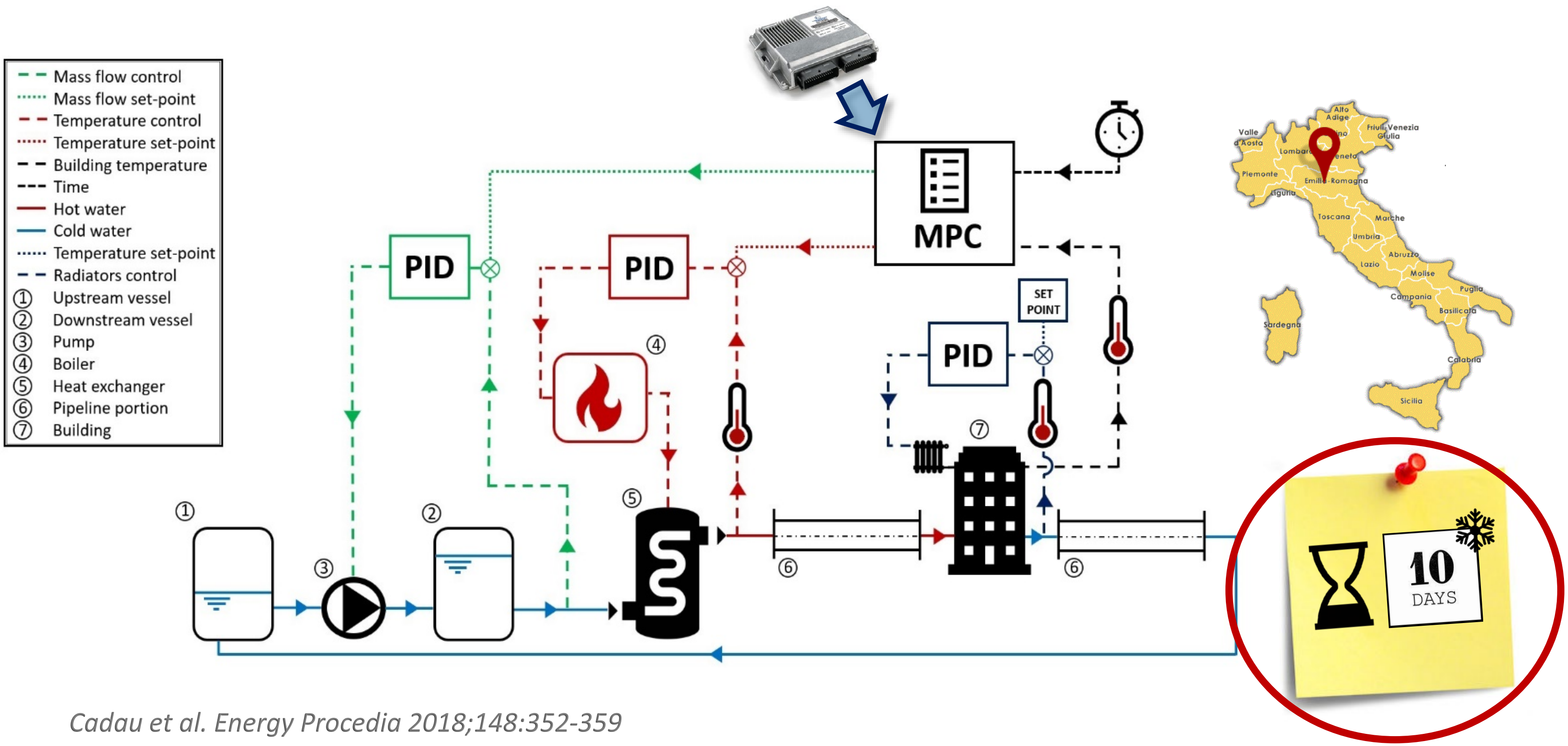
Co-funded by Regione Emilia-Romagna through the European Regional Development Fund POR-FESR 2014-2020 (CUP E38I16000130007)

...and collected in a **library** with a **modular approach** ideal for the application to **different layouts**



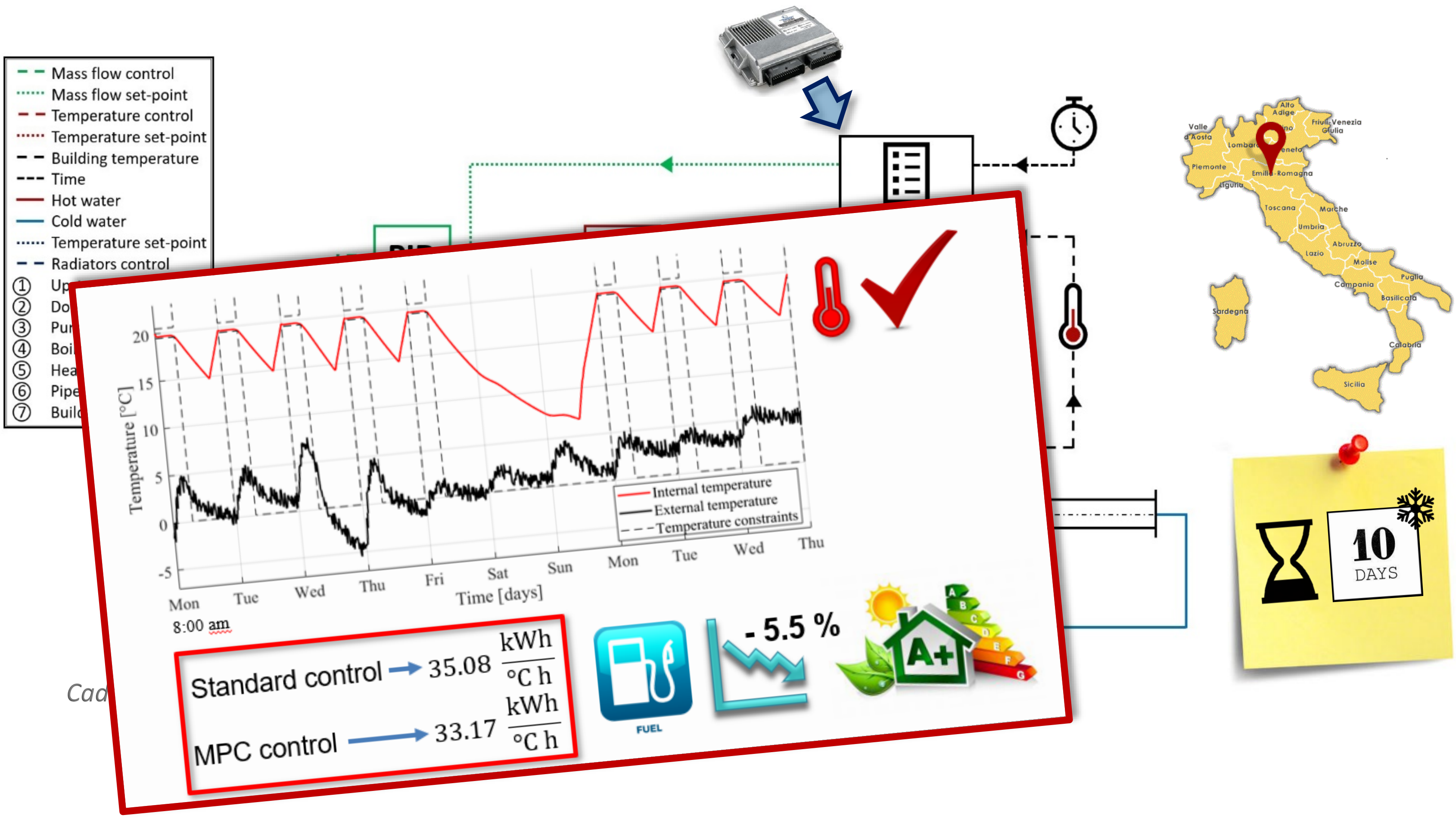
Cadau et al. Energy Procedia 2018;148:352-359

The **preliminary test** has been performed on the heat distribution network of a single end-user



Cadau et al. Energy Procedia 2018;148:352-359

This first case study has shown promising results in terms of **energy efficiency**



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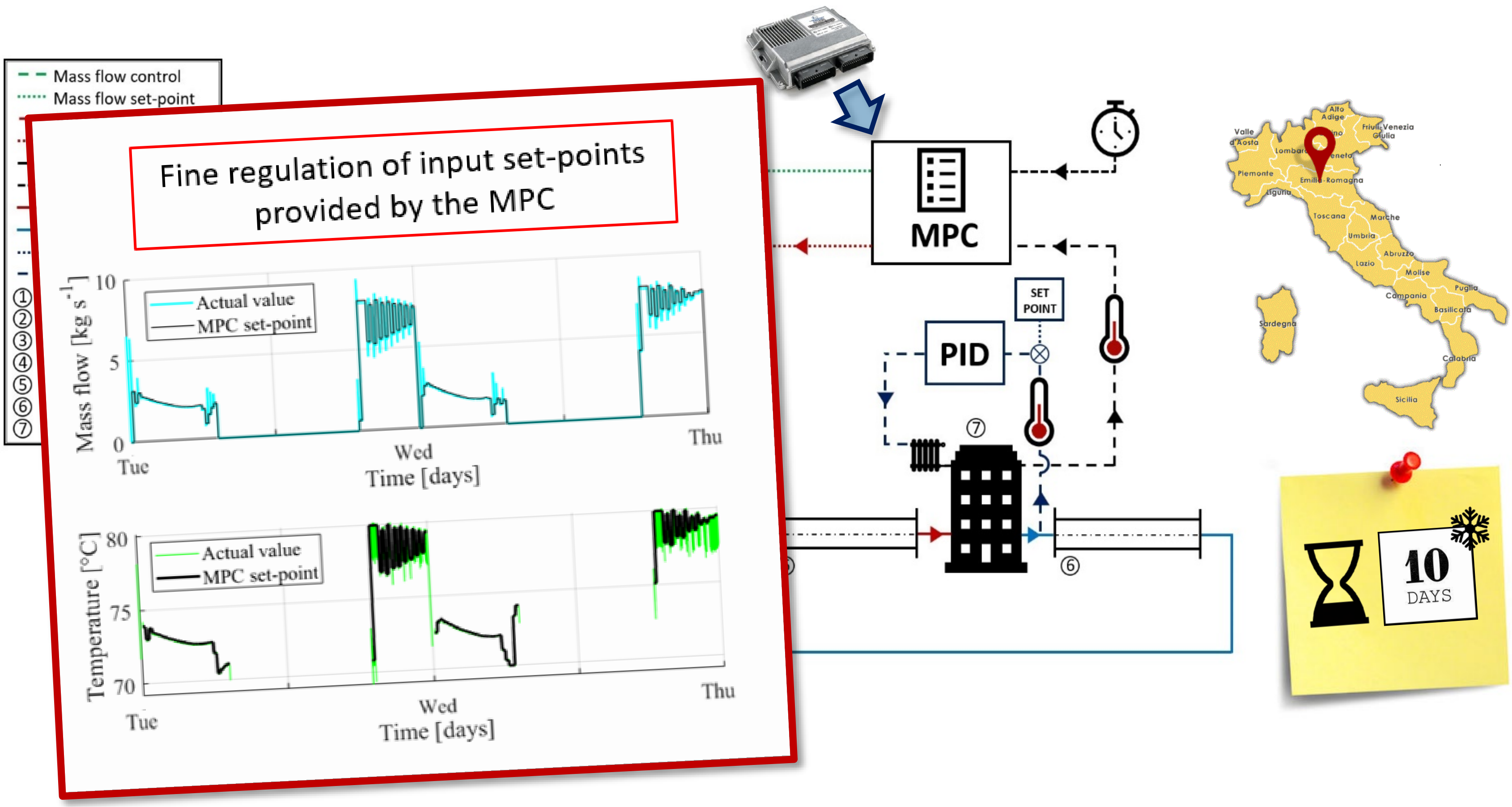
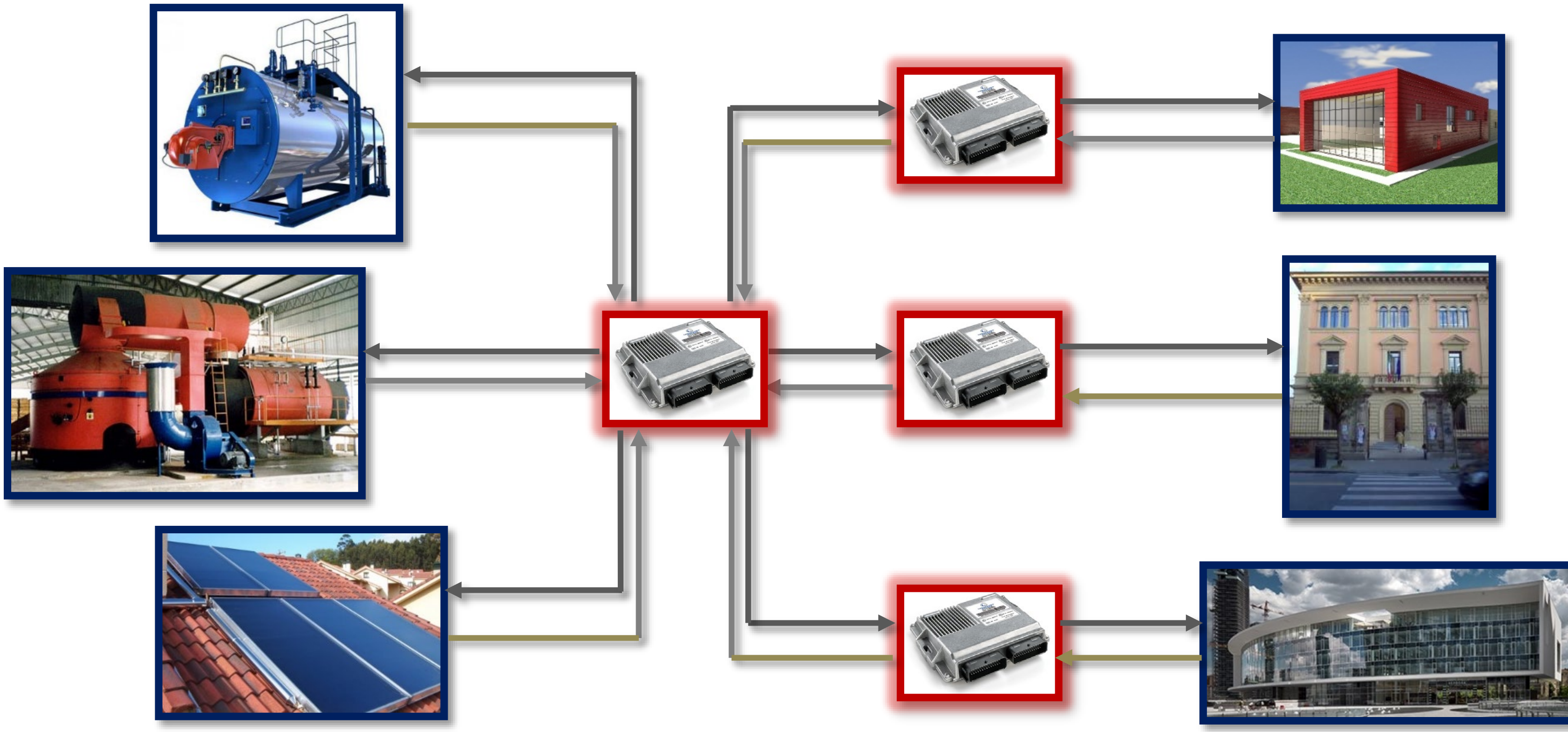
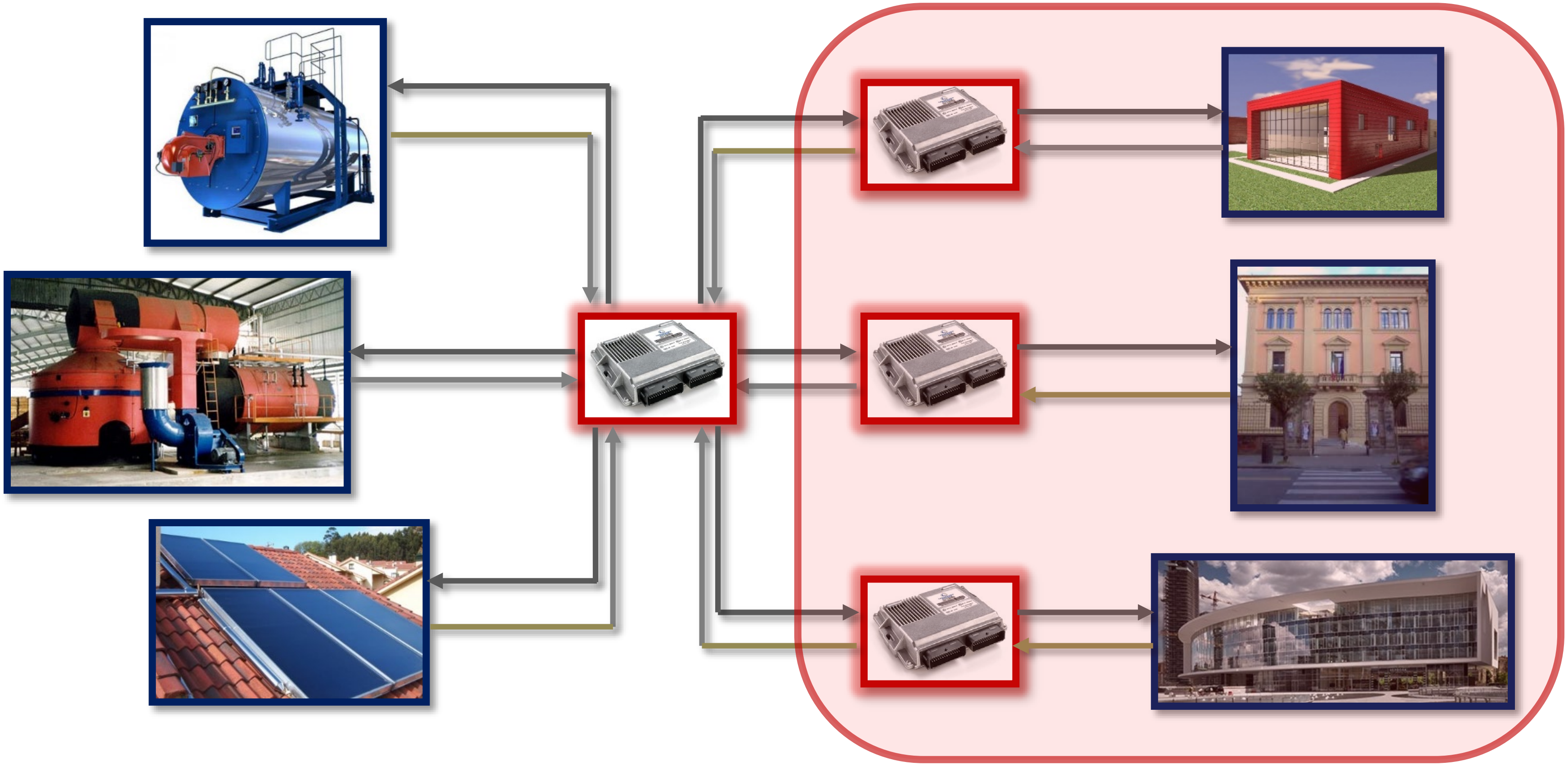


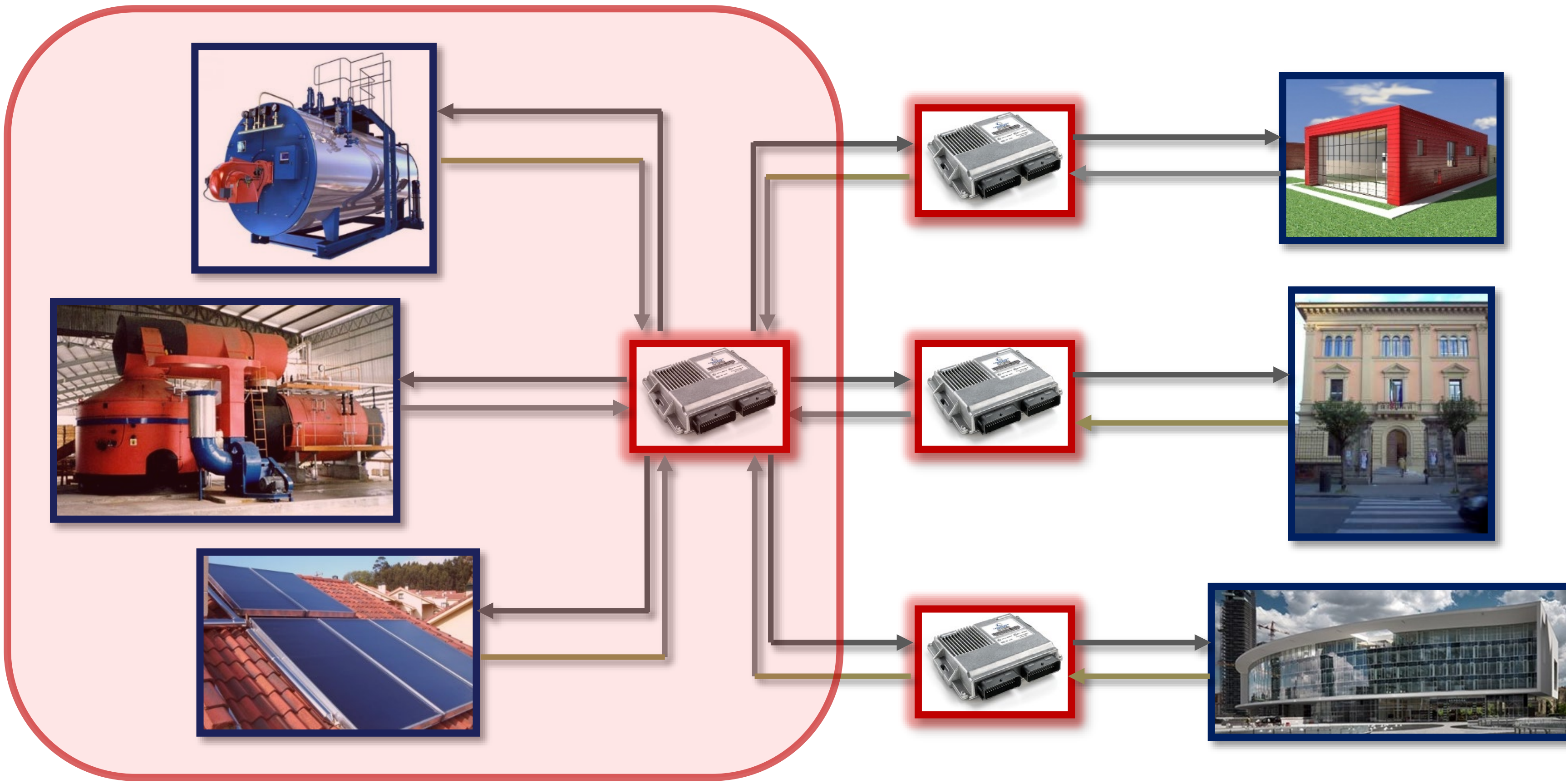
The controller has been applied to more complex energy systems according to a **multi-agent hierarchical strategy**



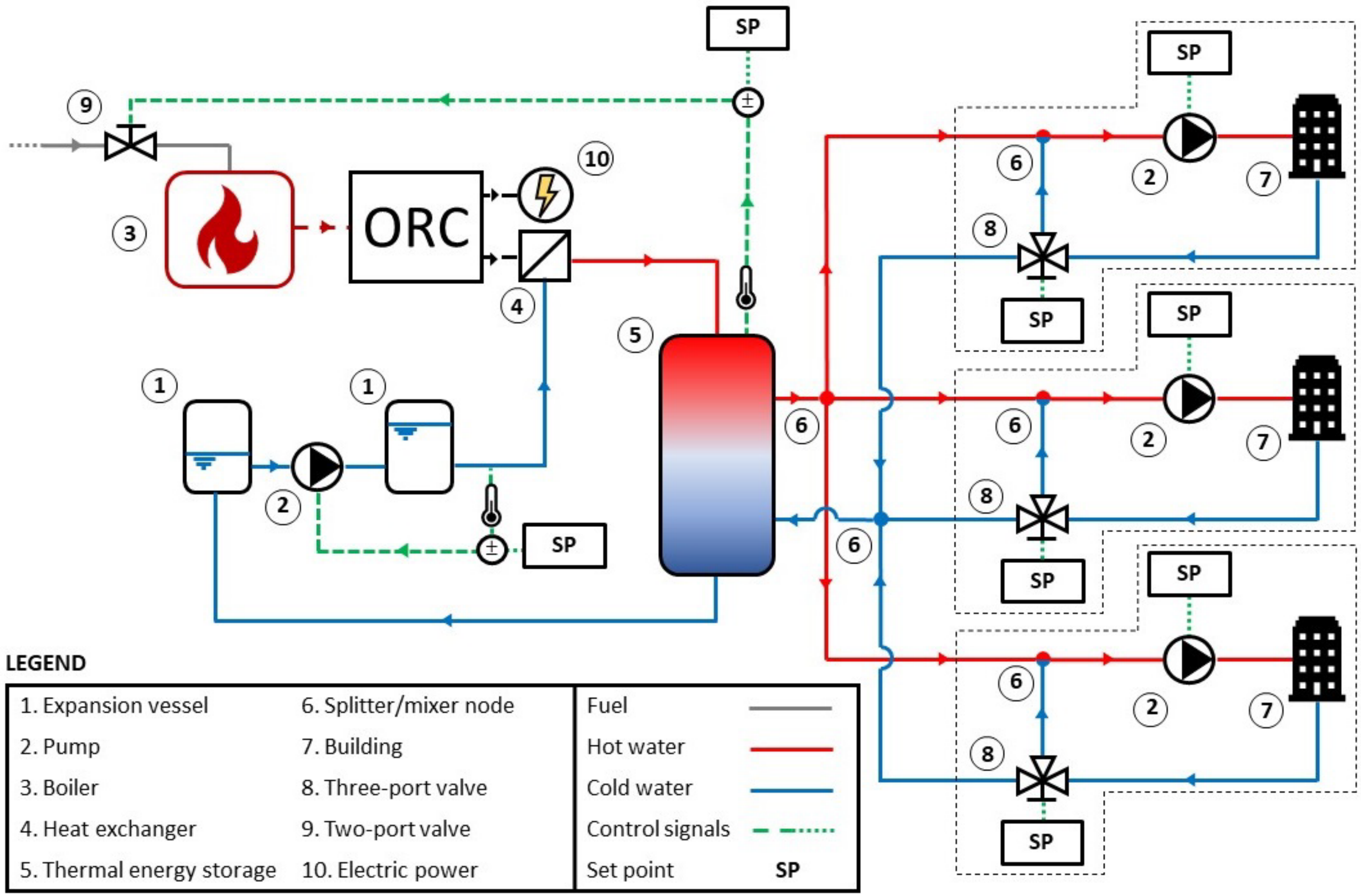
In each branch, an **MPC** controller minimizes the energy required for each user…



…while another MPC controller optimizes the **production** side starting from the optimal demands calculated downstream



The case study is a district heating network supplied by an **ORC** and a **thermal energy storage** tank



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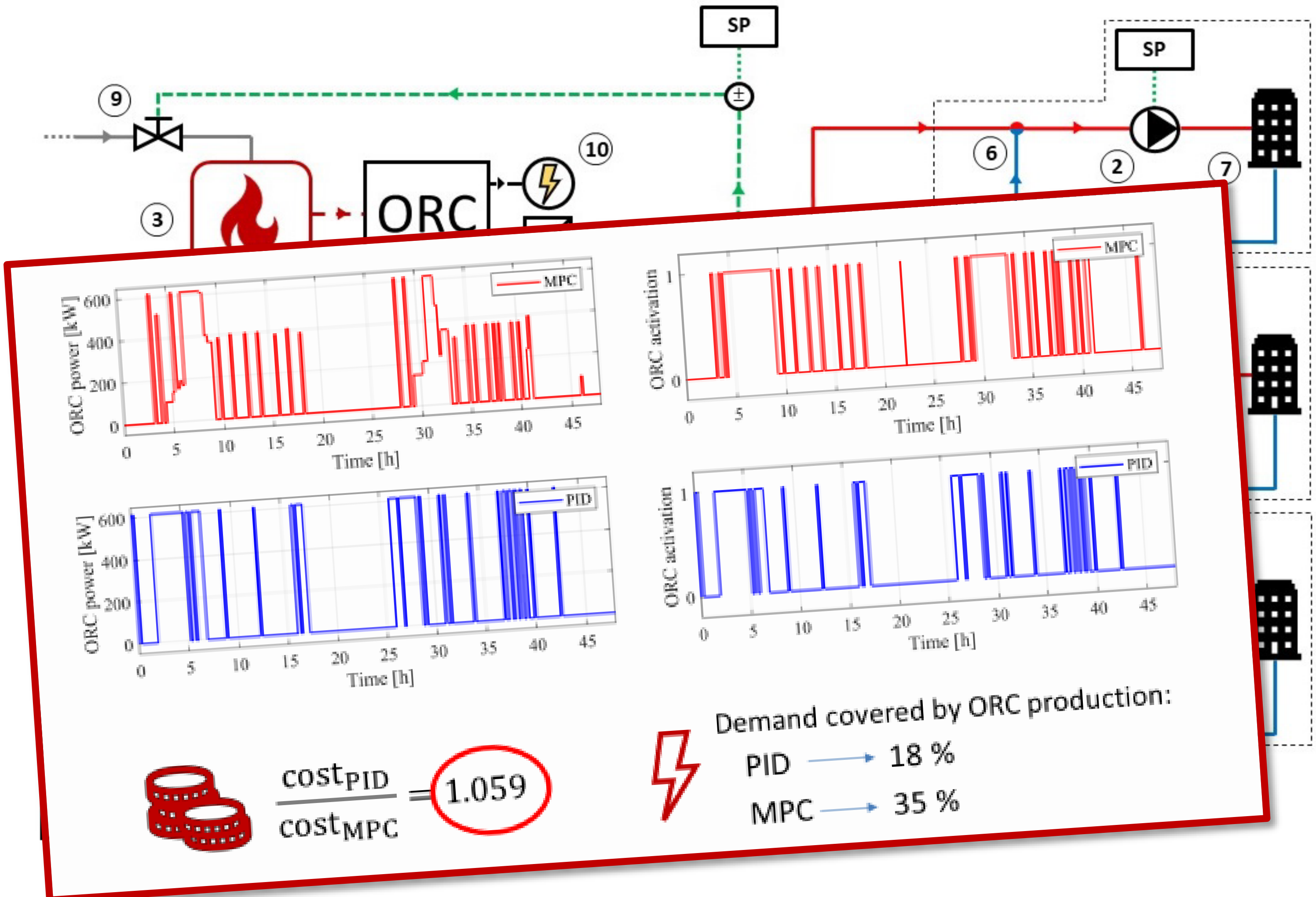
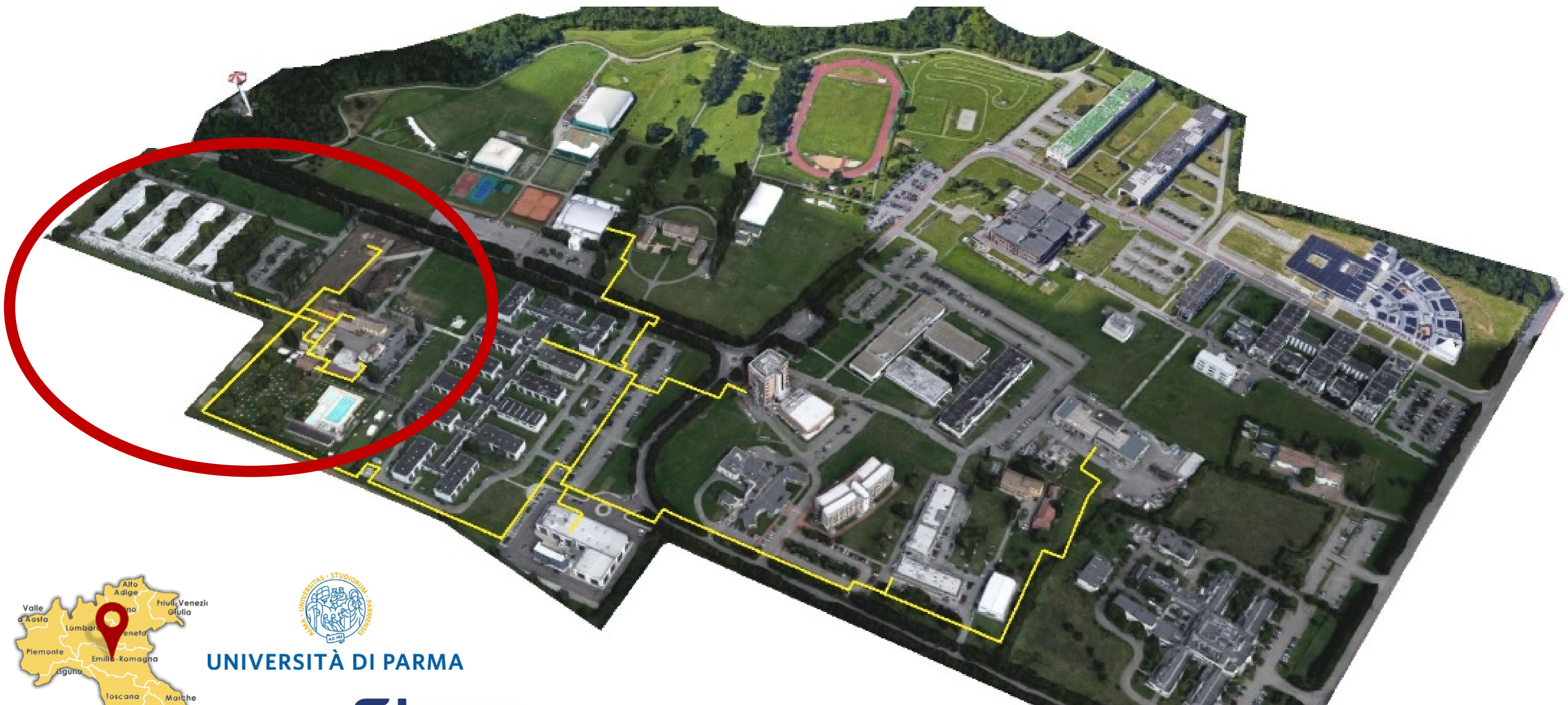


After its development and demonstration, the controller has been exploited in real case studies…



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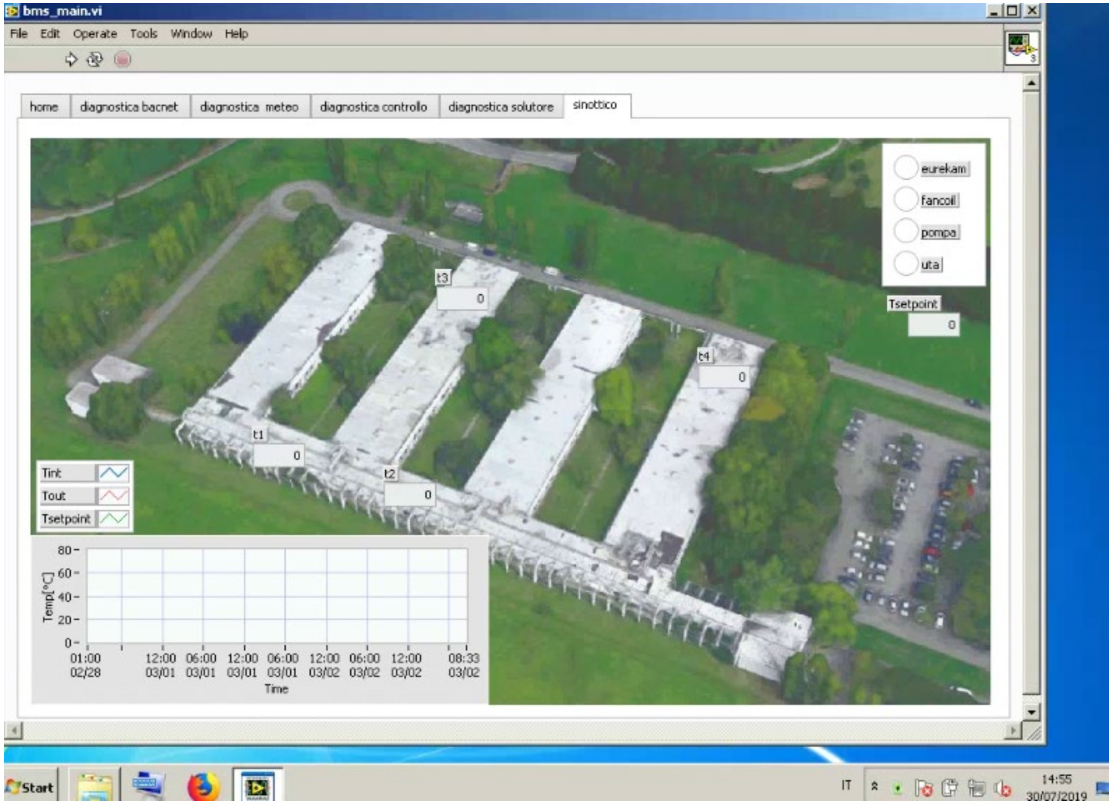
Siram by VEOLIA

…demonstrating its **effectiveness** and **reducing** the **energy consumption** substantially



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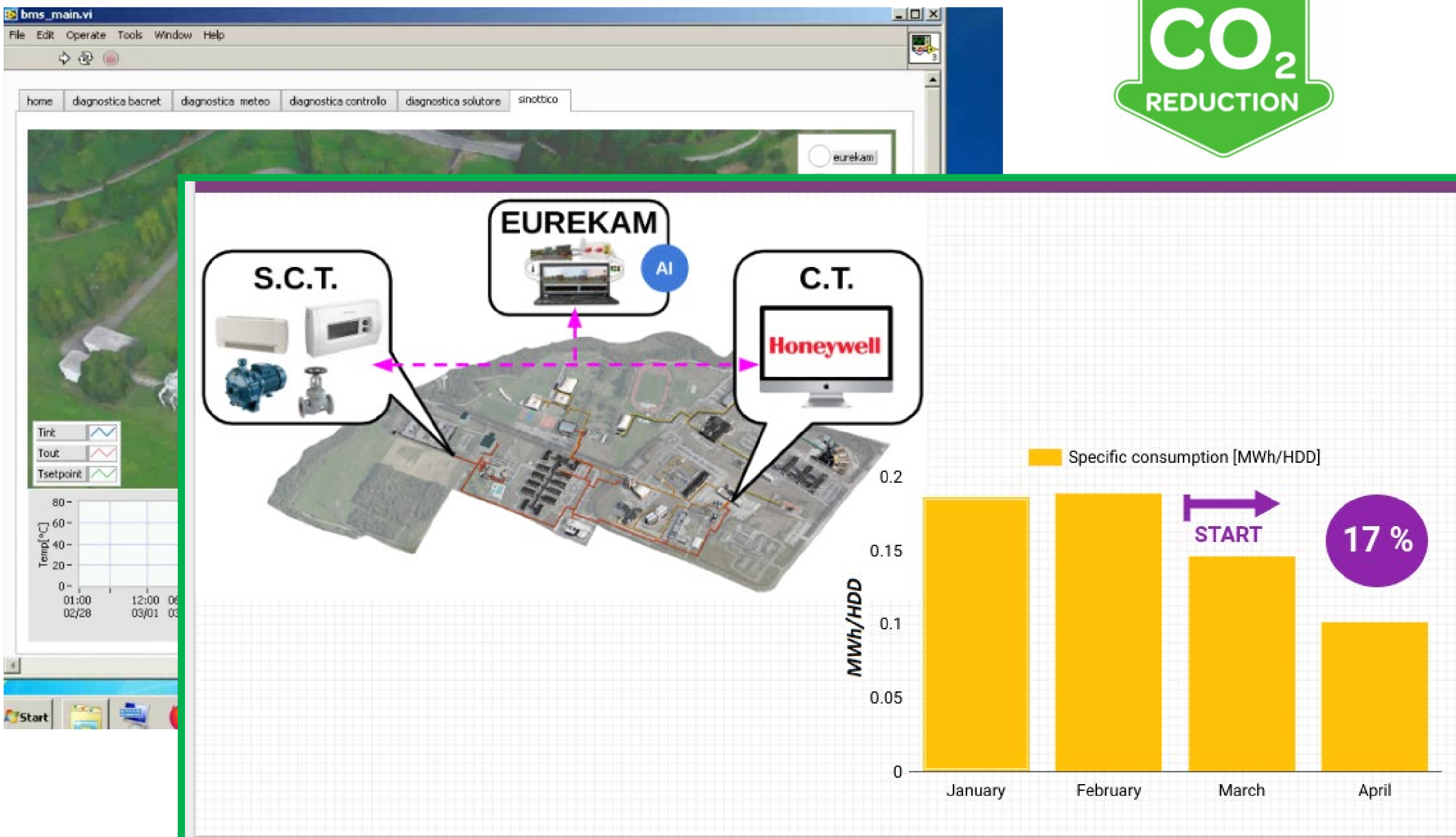


Our project **DISTRHEAT** proposes a scalable MPC for district heating networks and will start at the end of the year

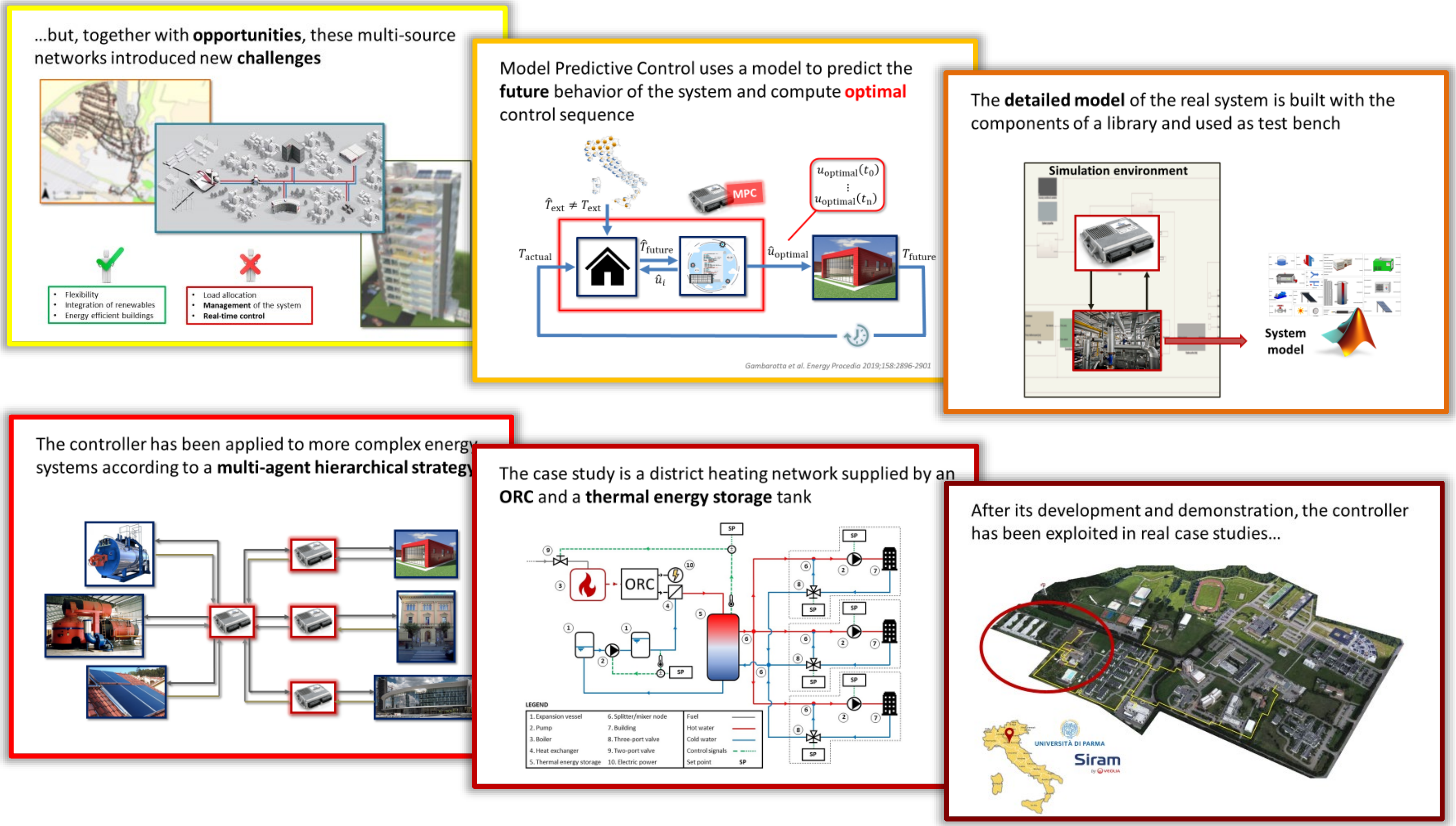
DISTRHEAT ⟹ **D**igital **I**ntelligent and **S**calable con**T**rol for **R**enewables in **HEA**ting ne**T**works

Duration: 01/11/2019 – 31/10/2022

Call: Smart Energy Systems ERA-Net

Partners: Università di Parma; Mälardalen University Sweden; Siram by Veolia; MälarEnergi; First Control Systems AB (Winner of IEEE CSS Technology award)

In future developments, the presented approach will be replicated in **multi-source smart energy networks**



BACK-UP SLIDES

The MPC controller is implemented on a standard workstation and the communication is set up from sensors to actuators