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7th International Conference on Smart Energy Systems
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#SESAAU2021

Smart Energy Systems ERA-Net

A hierarchical control algorithm with yearly and daily horizons for optimally managing district energy systems

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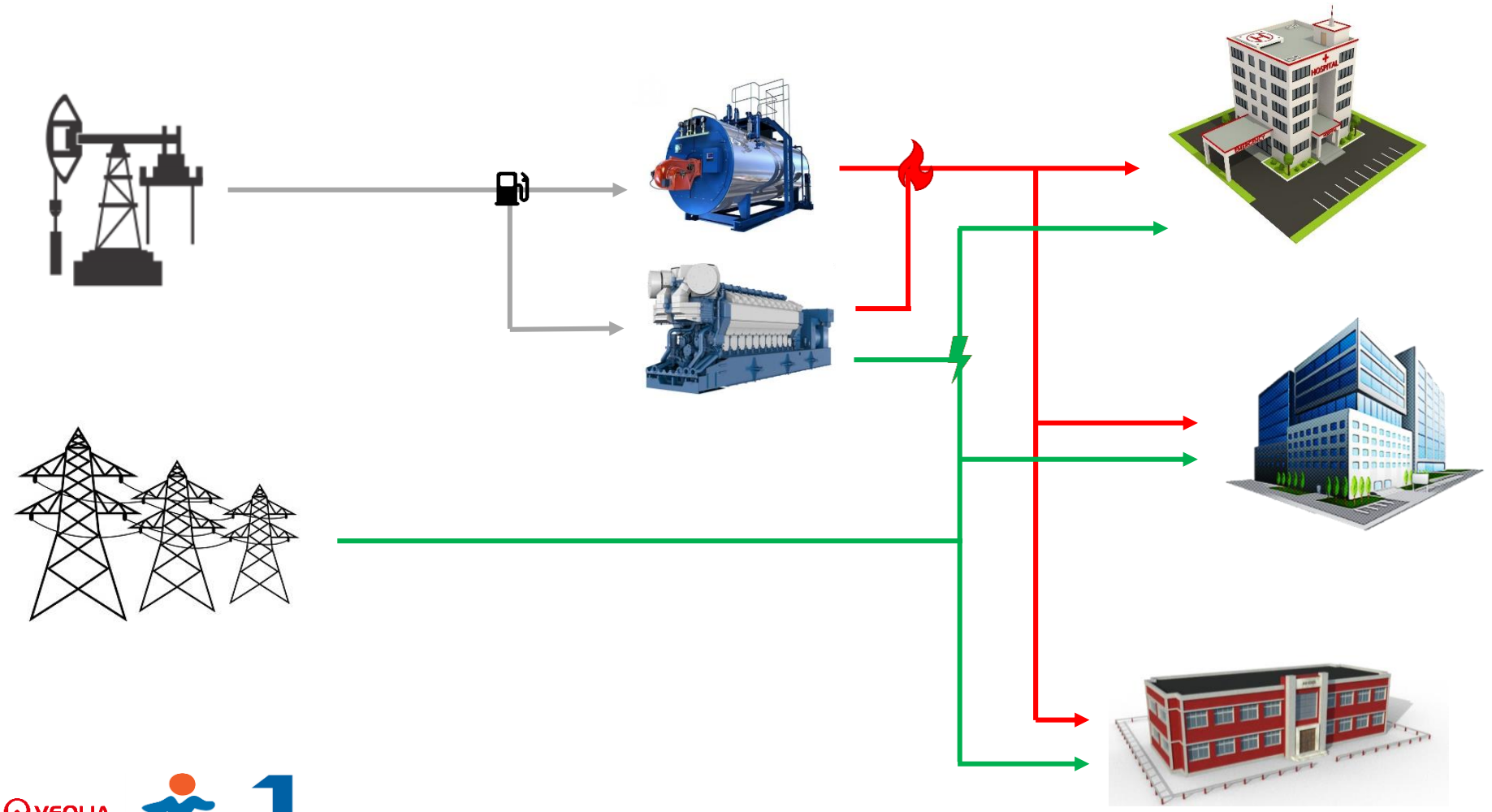
FIRST CONTROL

This project has received funding in the framework of the joint programming initiative ERA-Net Smart Energy Systems' focus initiative Integrated, Regional Energy Systems, with support from the European Union's Horizon 2020 research and innovation programme under grant agreement No 775970.

Multi-energy systems have become widespread as **sector integration** is the new frontier of energy efficiency and distribution



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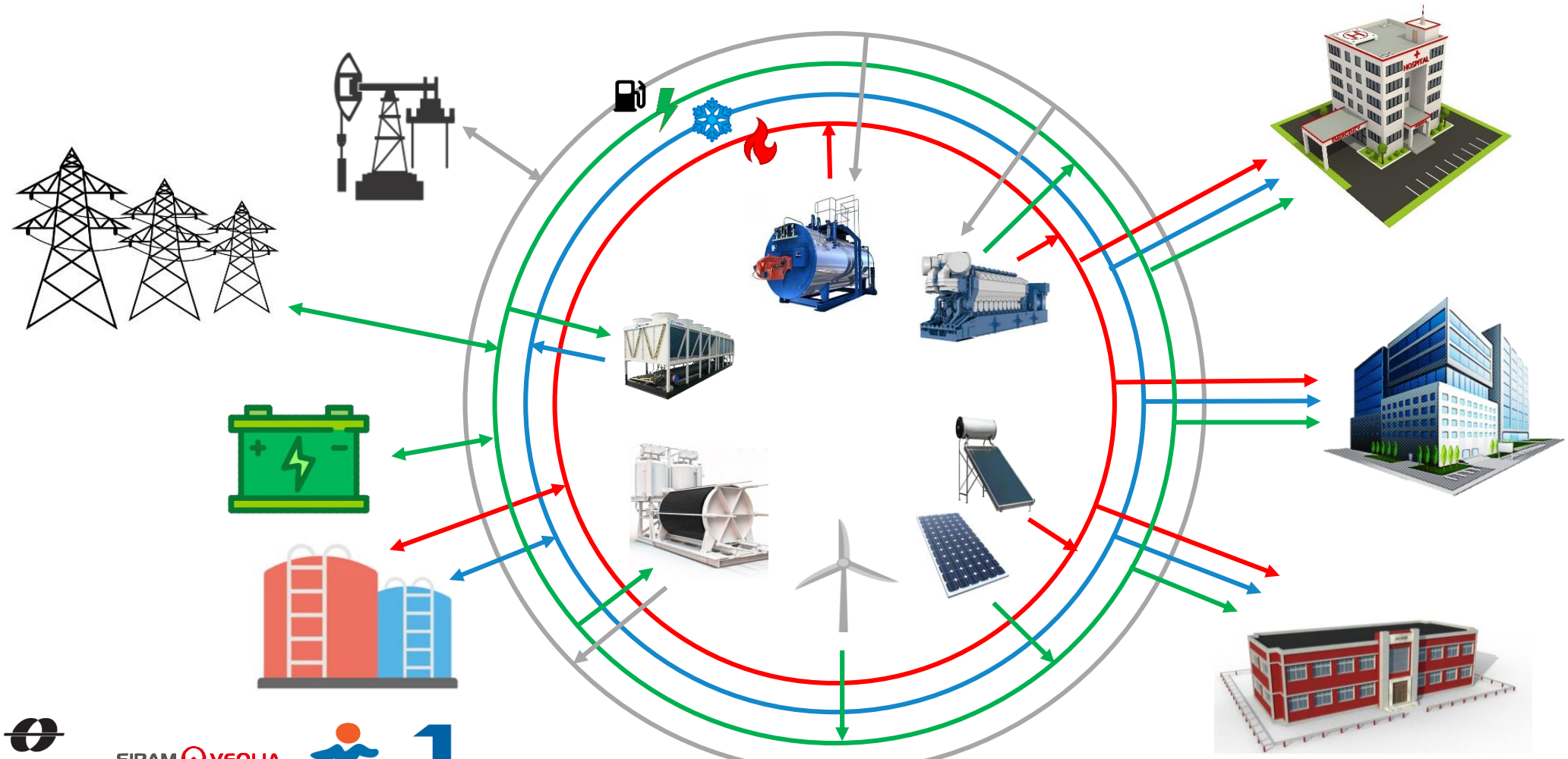
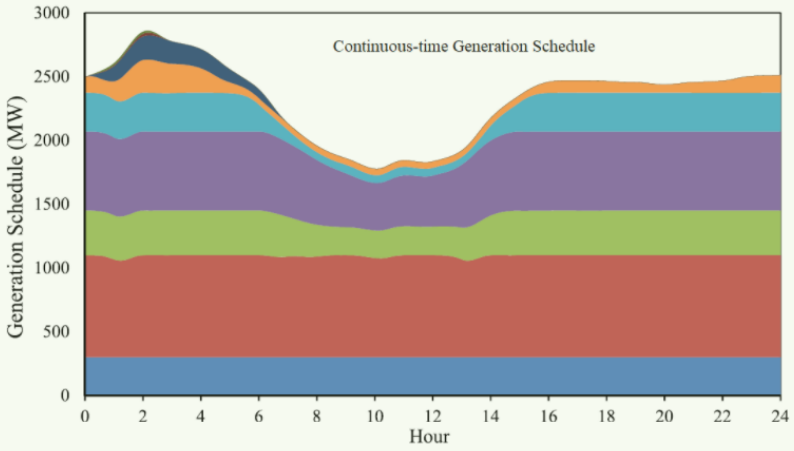


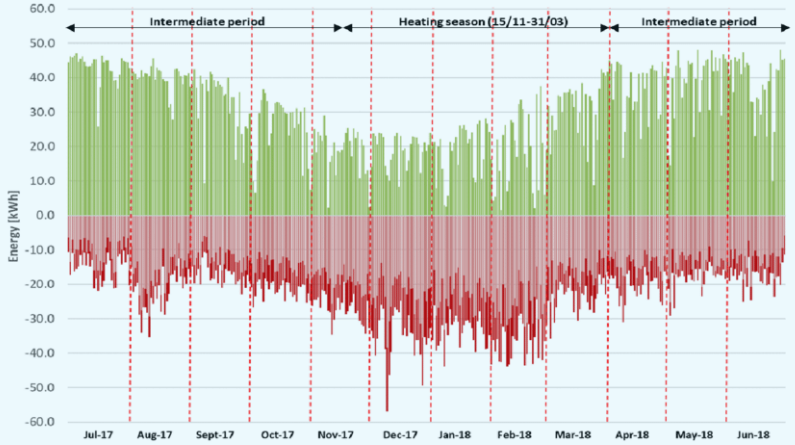
System operation is generally optimized through **short-term** unit commitment or **yearly** scheduling

Short-term optimization



- ✓ Day-ahead
- ✓ More reliable forecast
- ✓ Small-scale problem
- ✓ Control purposes
- \- Only short-term objectives

Long-term optimization



- ✓ Yearly objectives
- ✓ Long-term evaluations
- \- Less reliable
- \- Real-time control not feasible

The scope of this work is to develop an optimization algorithm with **multiple time-scales** for managing the entire multi-energy systems

Goals

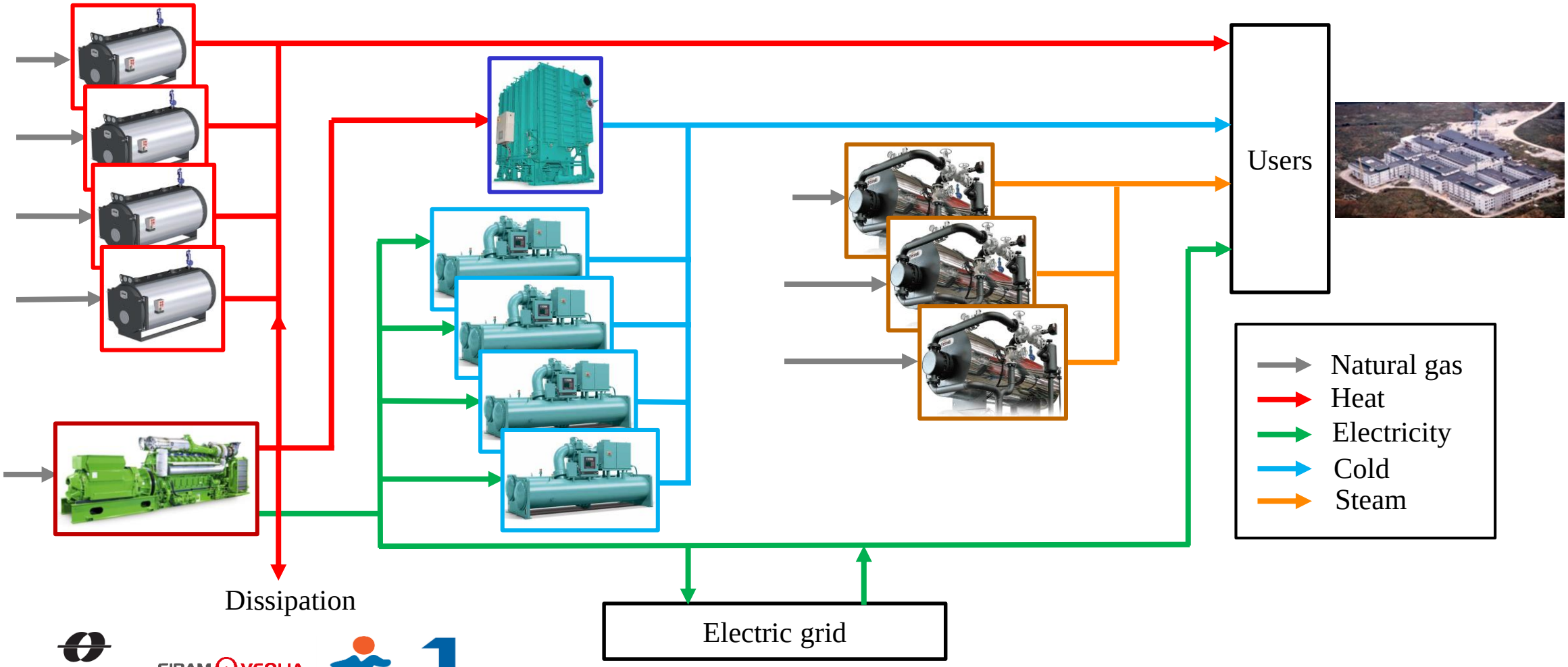
- Suitable for Model Predictive Control
- Optimize both **energy distribution** and thermal station **management**
- Include **short-term** (daily) and **long-term** (yearly) factors and objectives

Application

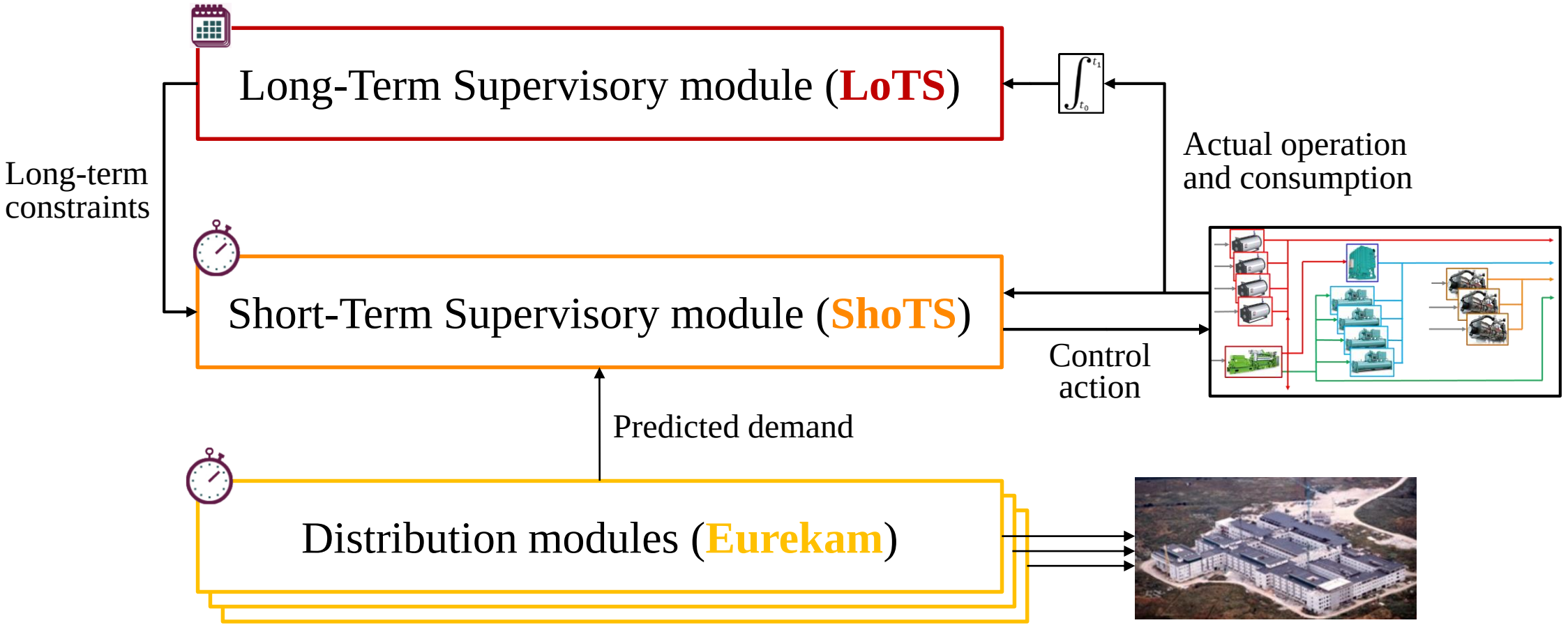
Cona Hospital

- Small-scale district heating and cooling
- Multi-energy conversion system

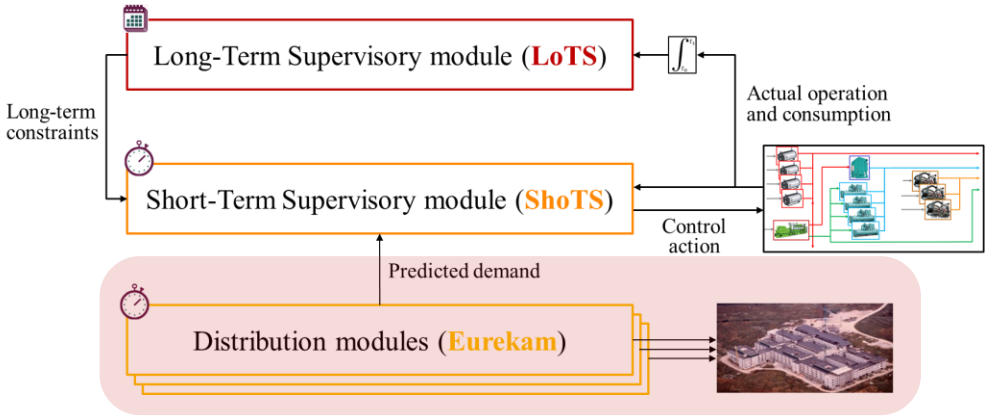
The multi-energy system includes several **energy vectors** and interacting **energy conversion plants**



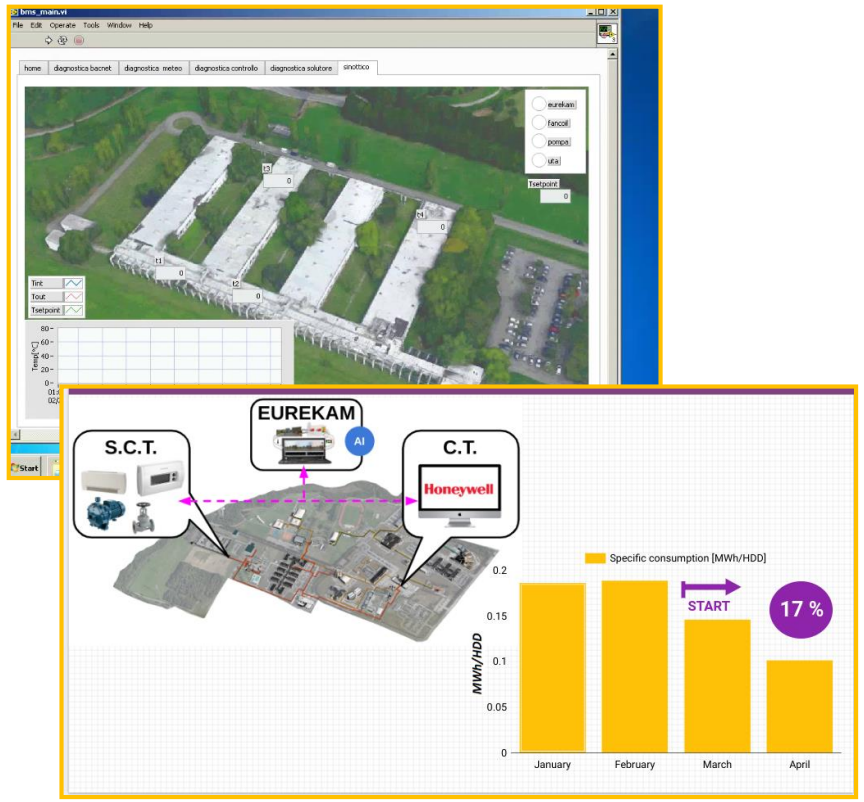
The algorithm architecture is multi-agent hierarchical with **three layers** and a double time-scale



The **distribution layer** is a novel prototype which optimizes the energy delivered to each branch of the heating and cooling network

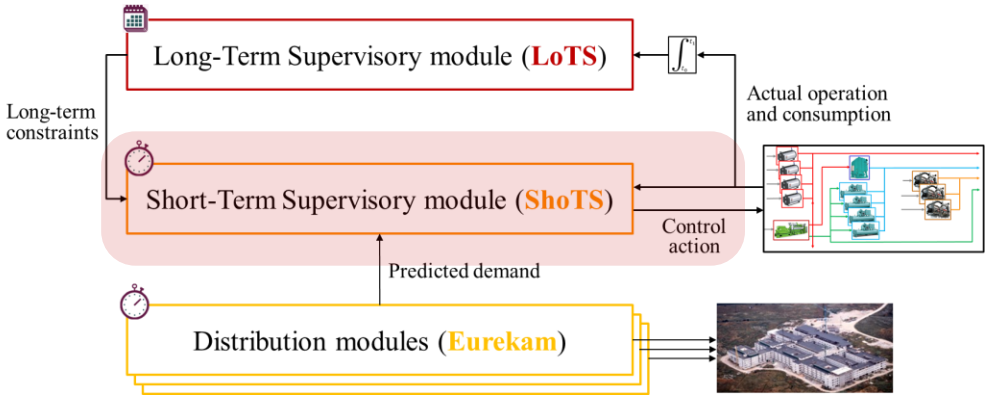


- Minimize energy supplied to building
- Keep indoor comfort
- Prediction horizon of three days
- Updated every 15 minutes



De Lorenzi et al. Energy 2020, 205, 118054.
https://doi.org/10.1016/j.energy.2020.118054

The **ShoTS module** optimizes the short-term operation of the plants by solving a high-detail unit commitment problem

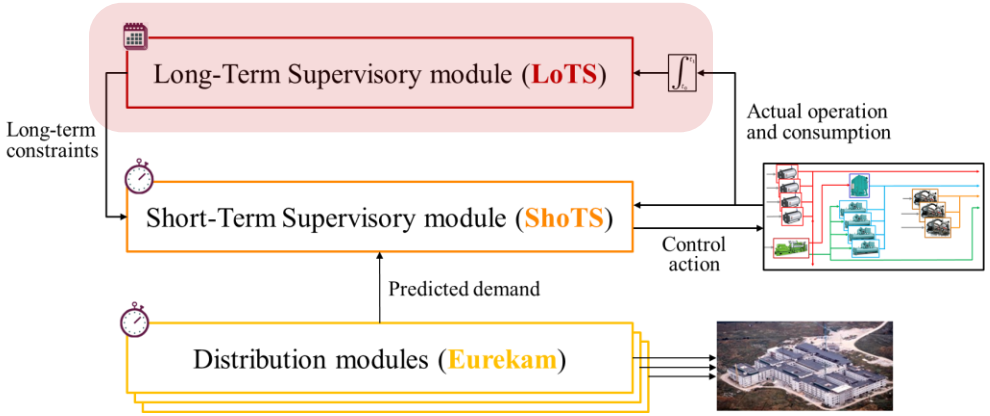


- Minimize system operating cost
- Prediction horizon of three days
- Updated every 15 minutes
- Mixed Integer Linear Programming

Constraints

- Meet demand of all energy vectors
- Plant boundaries
- Operation ramps
- Minimum up-time and down-time
- Meet long-term constraints from **LoTS**

The **LoTS module** is based on yearly factors and provides optimal bands of operation as long-term constraints for ShoTS

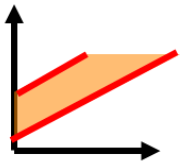


- Minimize total yearly cost
- Collect actual system operation
- Prediction horizon of one year
- Updated every day

Update **cumulated** energy and fuel consumption

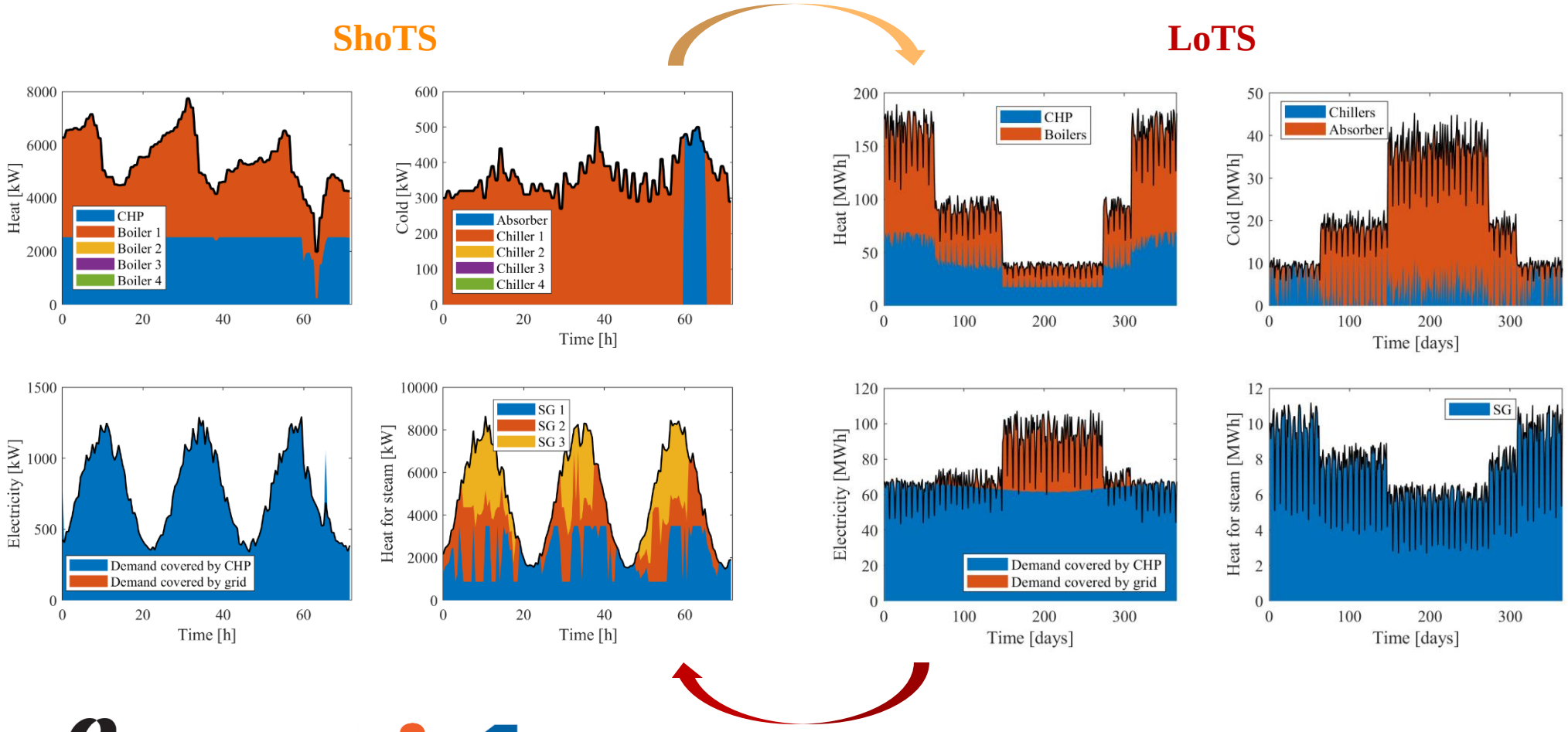
- Meet daily demands
- Regulation and contracts
- Maintenance schedule

Create optimal bands of operation for **ShoTS** and repeat **daily**



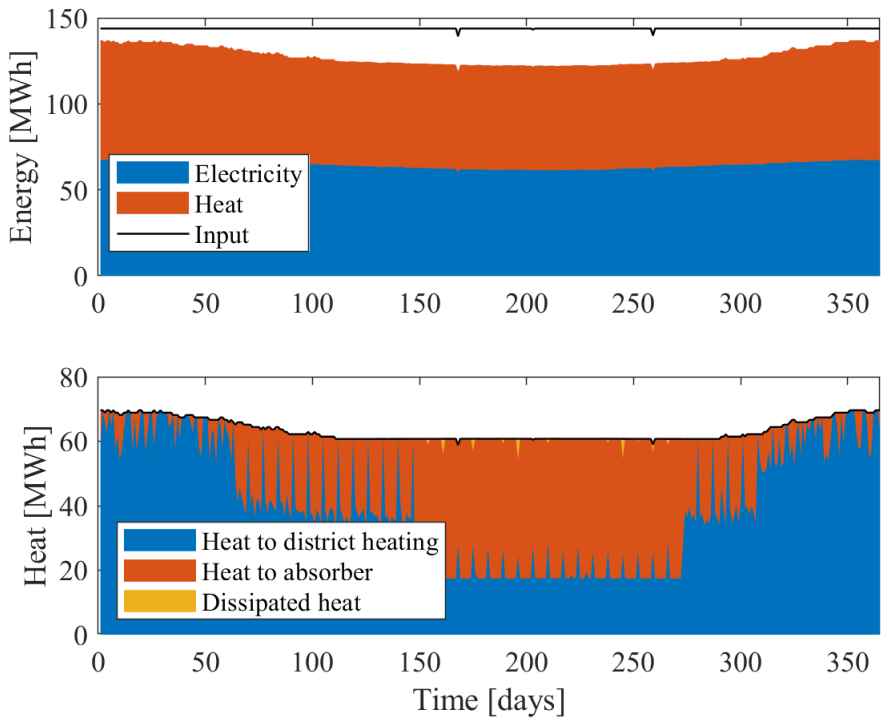
The **results** show that the production is distributed among the different plants for both optimization levels

ShoTS → **LoTS**

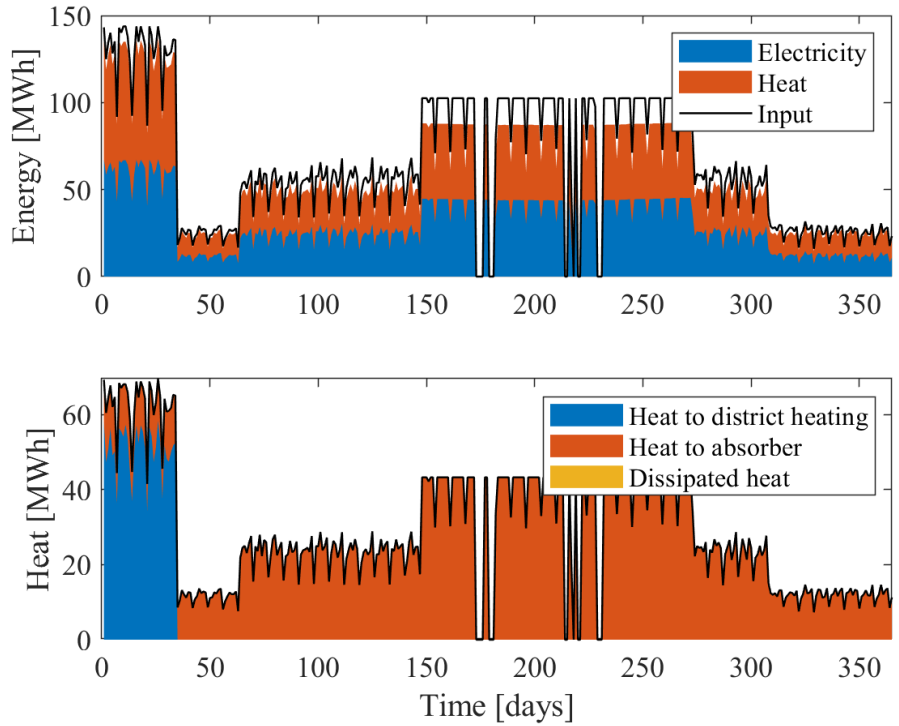


All plants are **optimally managed** based on the given operating and contractual boundaries

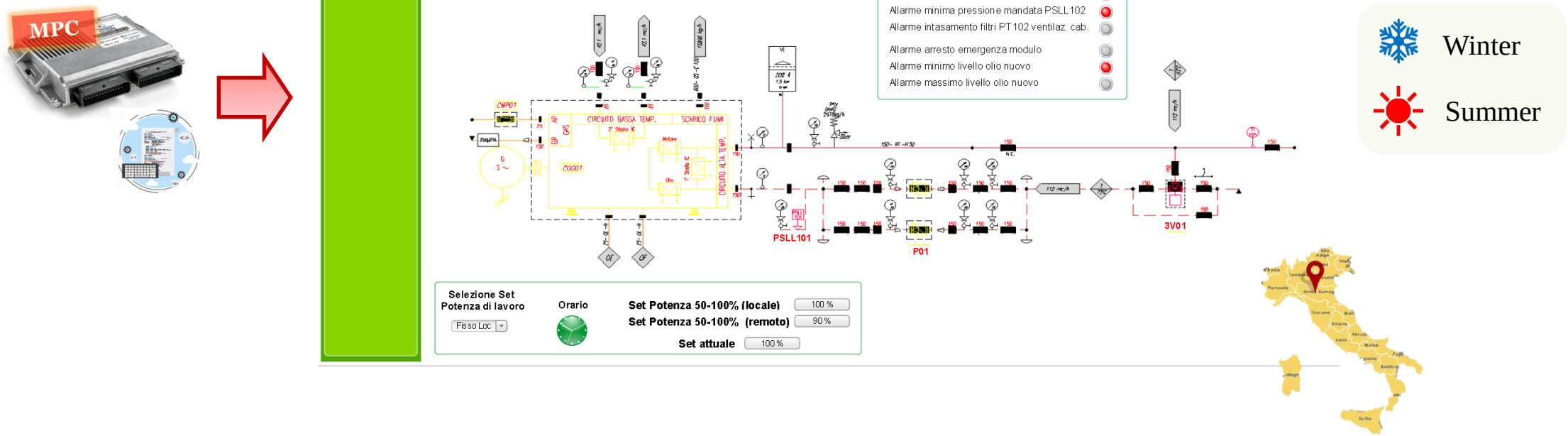
CHP max operation: 8760 hours



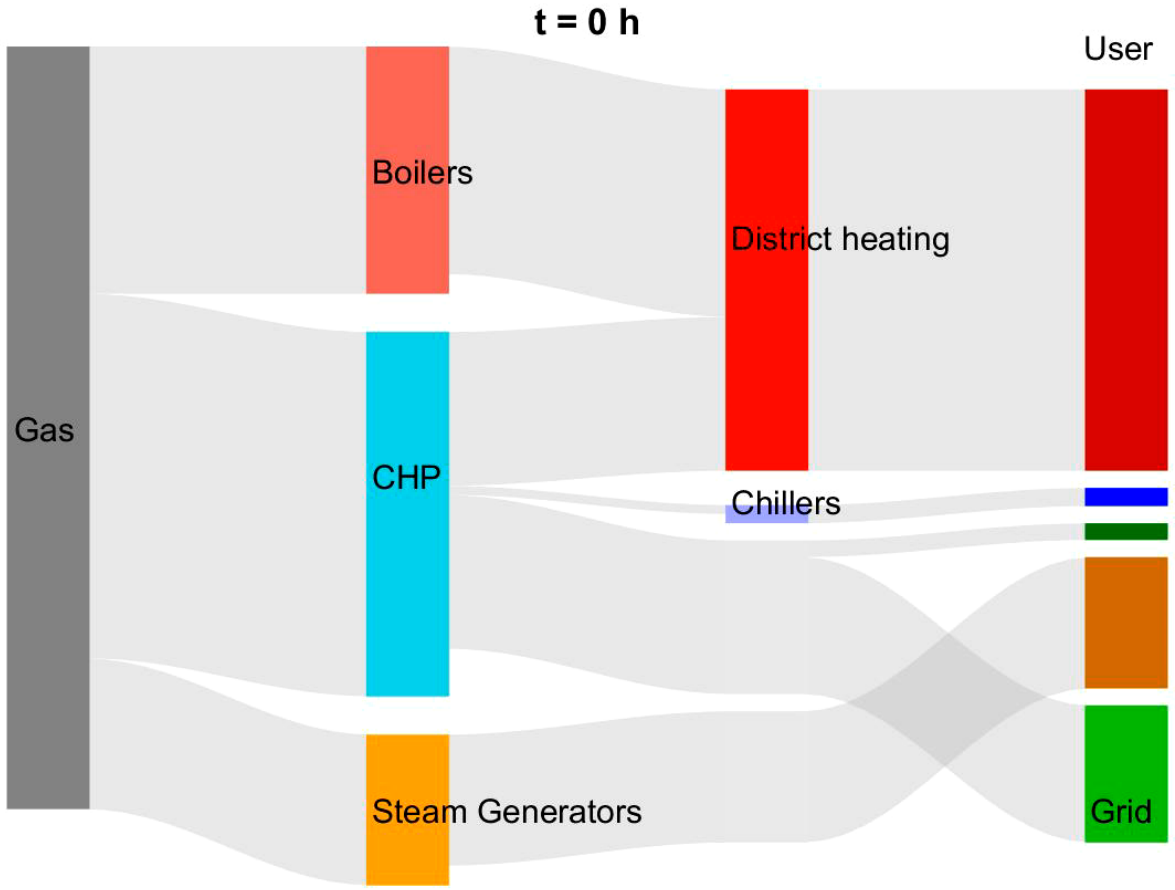
CHP max operation: 4000 hours



Within the project, the controller will be tested in operating condition in the **real case**



Overall, this solution may be a valuable tool for district energy **optimal control** and visualization



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Thank you for your attention!

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Stay tuned for project webinar
and virtual study visit:
21 October 2021

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