DISTRHEAT

8th International Conference on Smart Energy Systems
13-14 September 2022
#SESAAU2022

Smart Energy Systems ERA-Net

# Implementation and testing of a multi-level smart control strategy for the integrated energy system of a hospital


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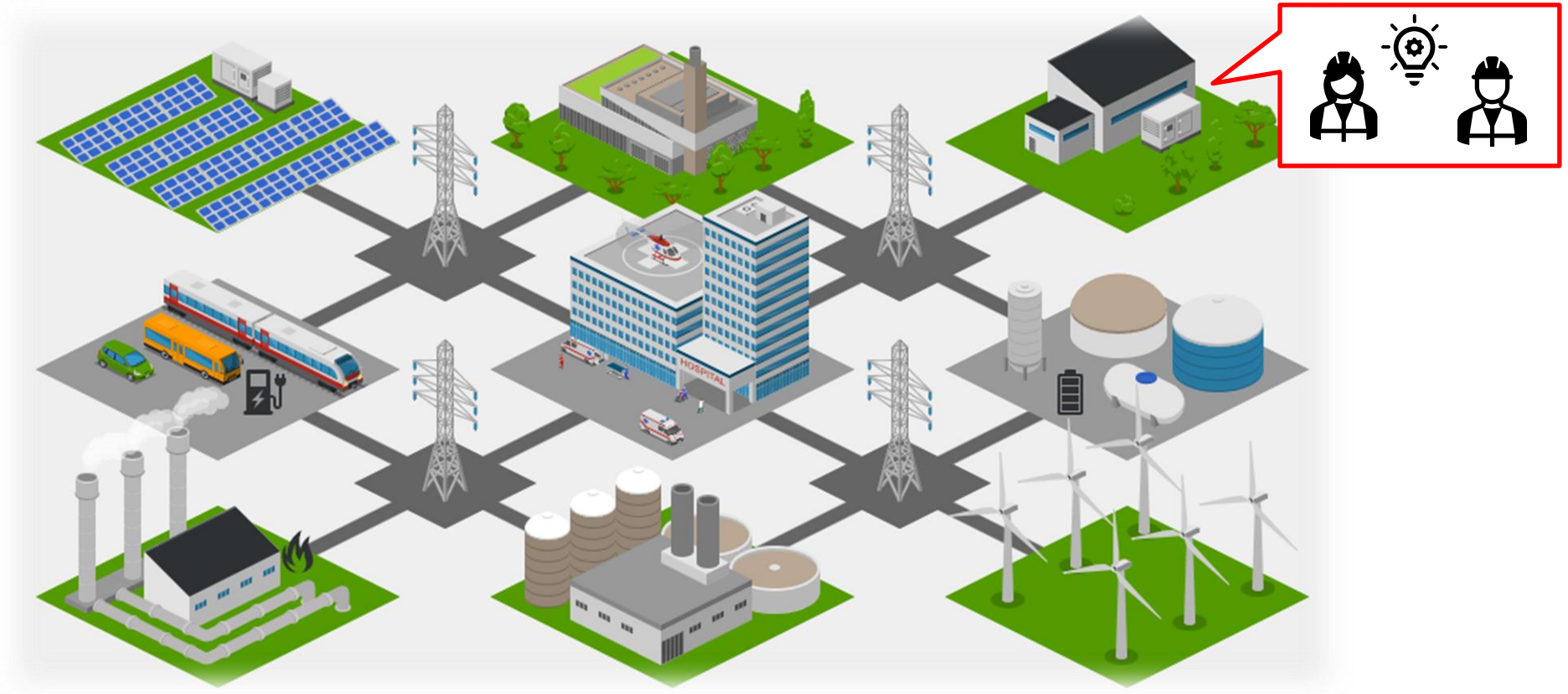
MälarEnergi

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.

# **Sector coupling** and the **optimization** of integrated energy systems are keys for the energy transition



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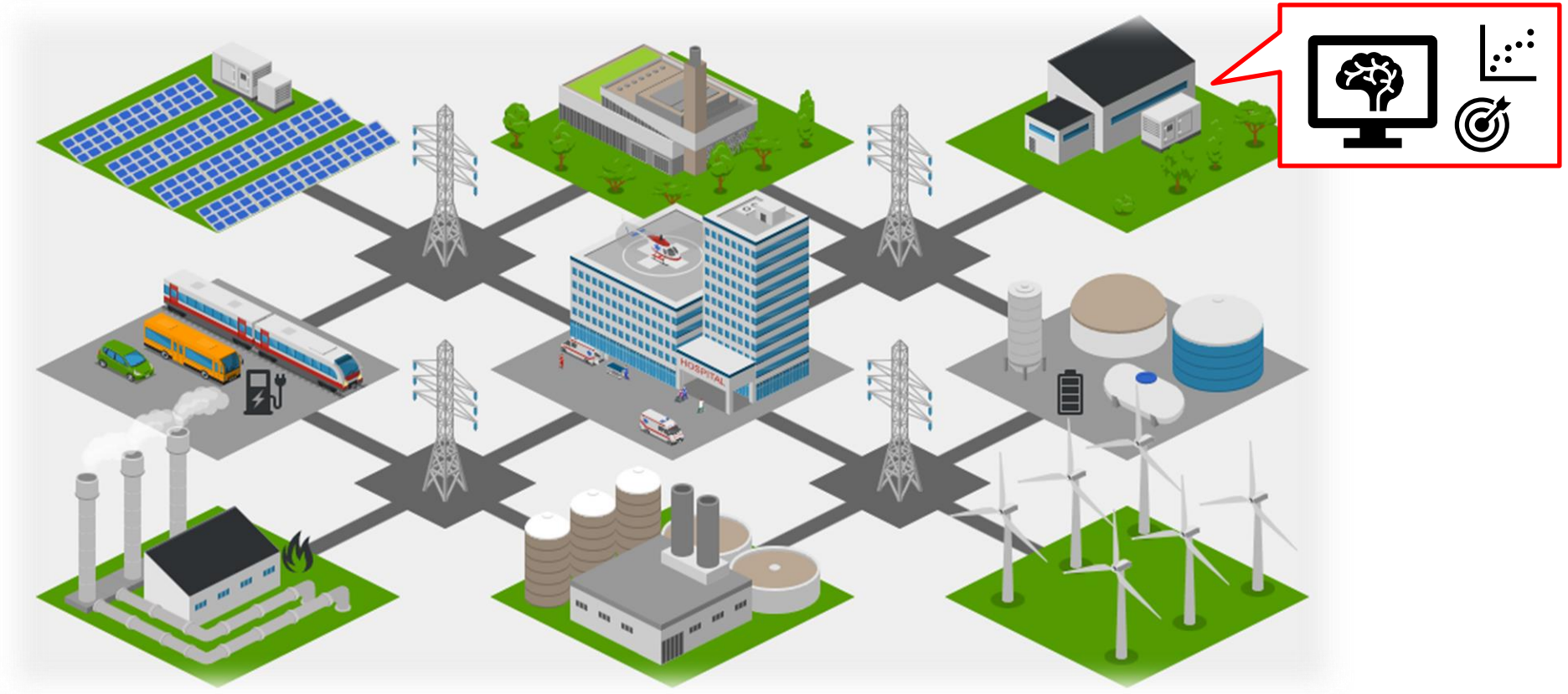
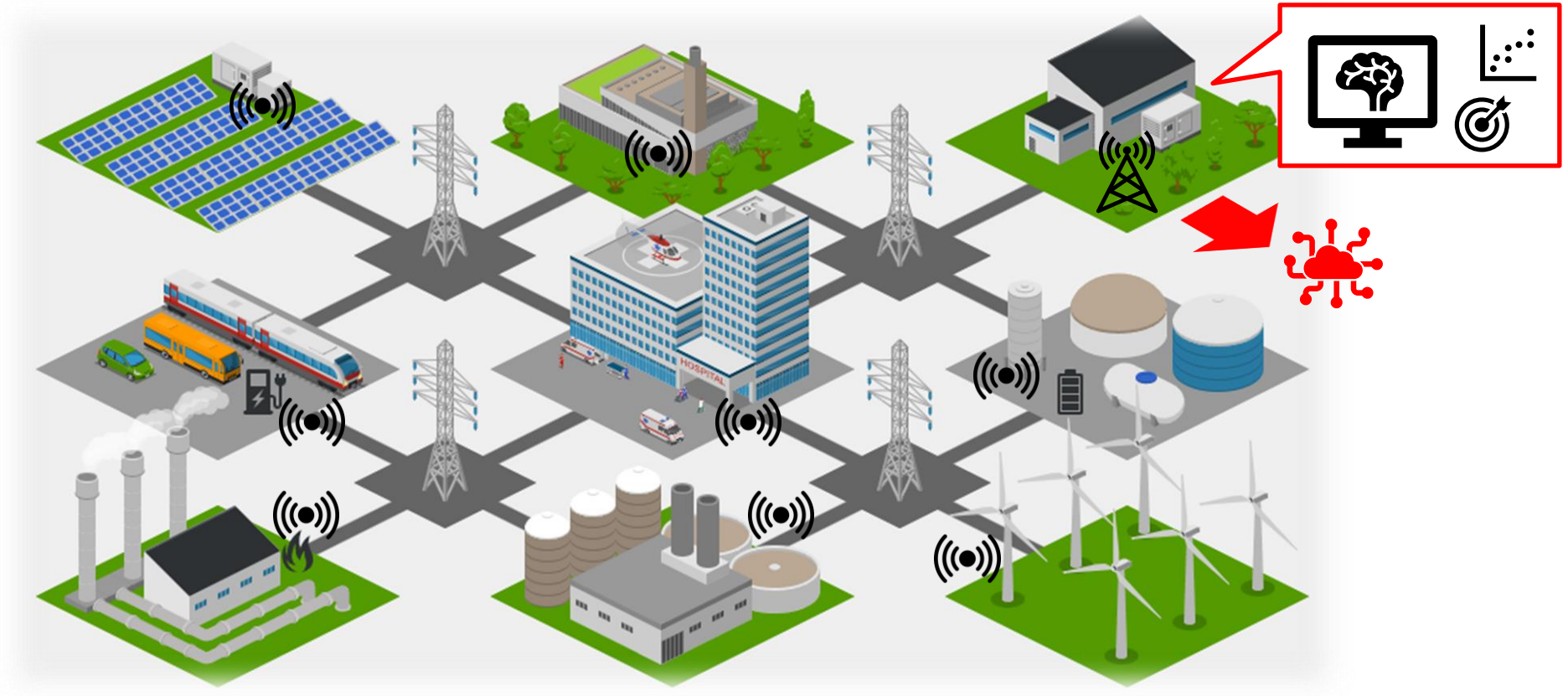
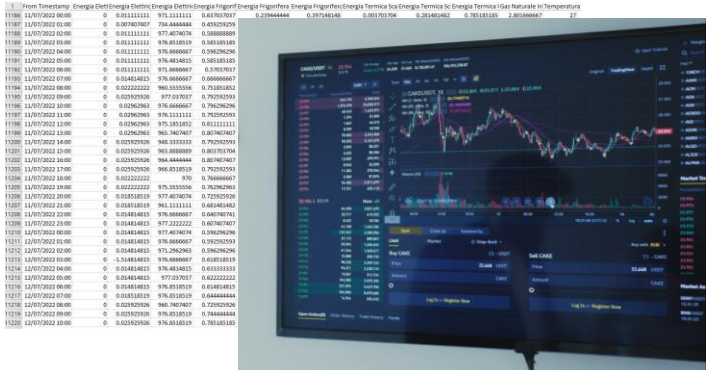


**Digitalization** (and **smart control**!) are required and enabled by IT technologies



# There are many innovative **tools**…

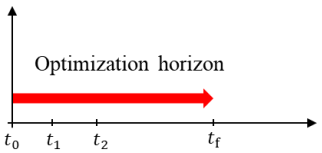
- **REAL-TIME DATA (AND BIG DATA?!)**



- **OPTIMIZATION ALGORITHMS AND SOLVERS**

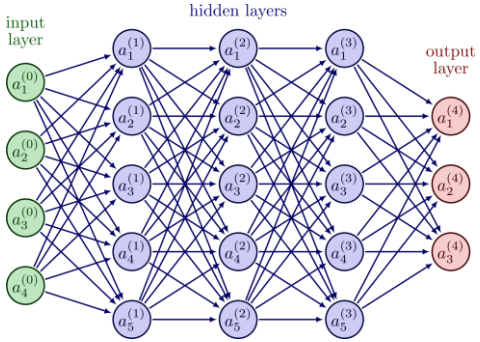
$$\min_{u(t)} J(x_0, u(t))$$

$$\text{subject to} \quad \begin{cases} \frac{dx(t)}{dt} = f\left(x(t), u(t), d(t), t\right) \\ x(t_0) = x_0 \\ x(t_f) \in X_f \\ x(t) \in X \quad \forall t \in [t_0; t_f] \\ u(t) \in U \quad \forall t \in [t_0; t_f] \end{cases}$$




$$\min_x c^T x \qquad \text{subject to} \quad \begin{cases} Ax \leq b \\ x \geq 0 \end{cases}$$

- **MACHINE LEARNING AND AI**

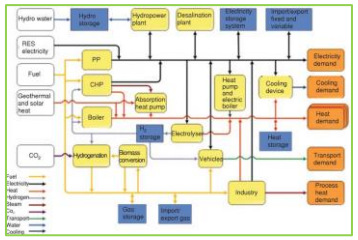


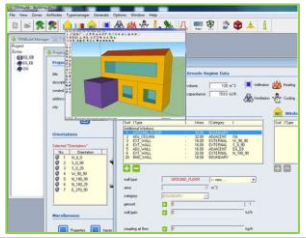

- **CHEAP AND FAST CONTROL SOLUTIONS**

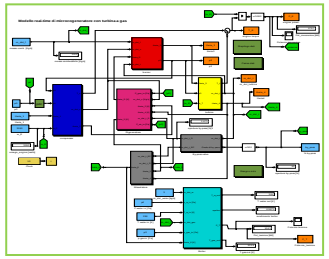
# …but very few real examples to **demonstrate** these tools in operational environment

TEMPO

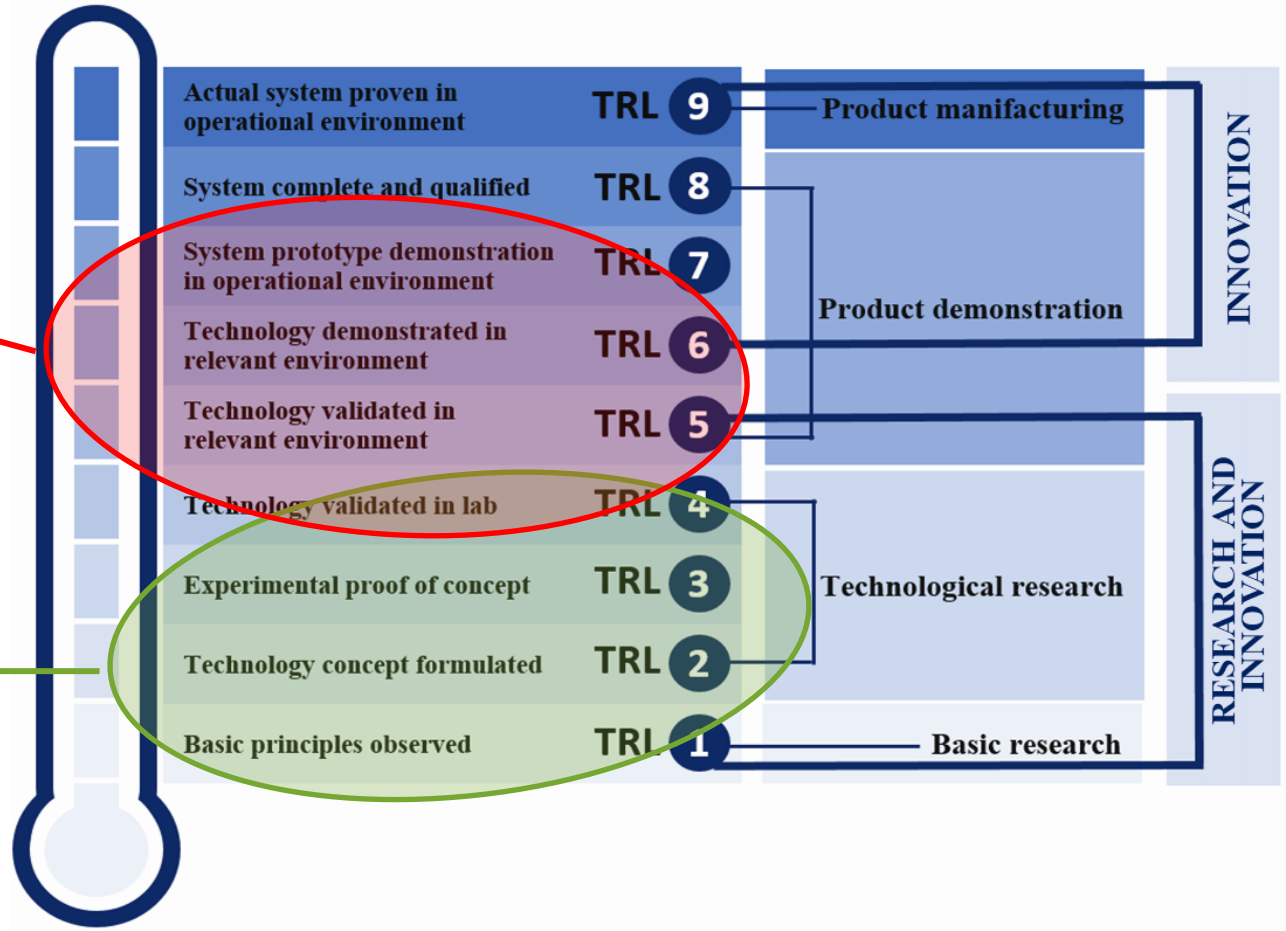
https://www.tempo-dhc.eu/report-on-the-integrated-innovations-in-a2a-network/







MiL, SiL, HiL…



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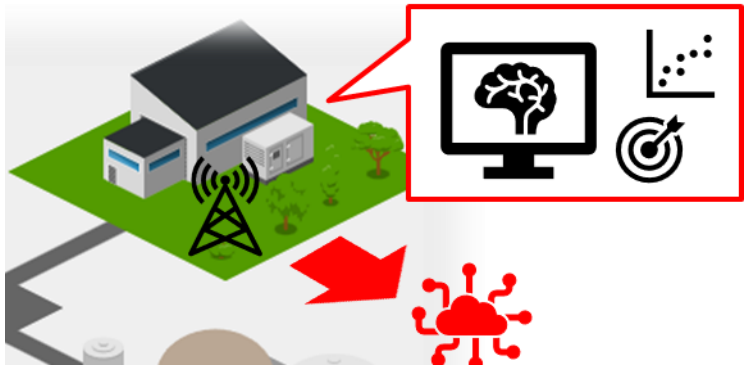
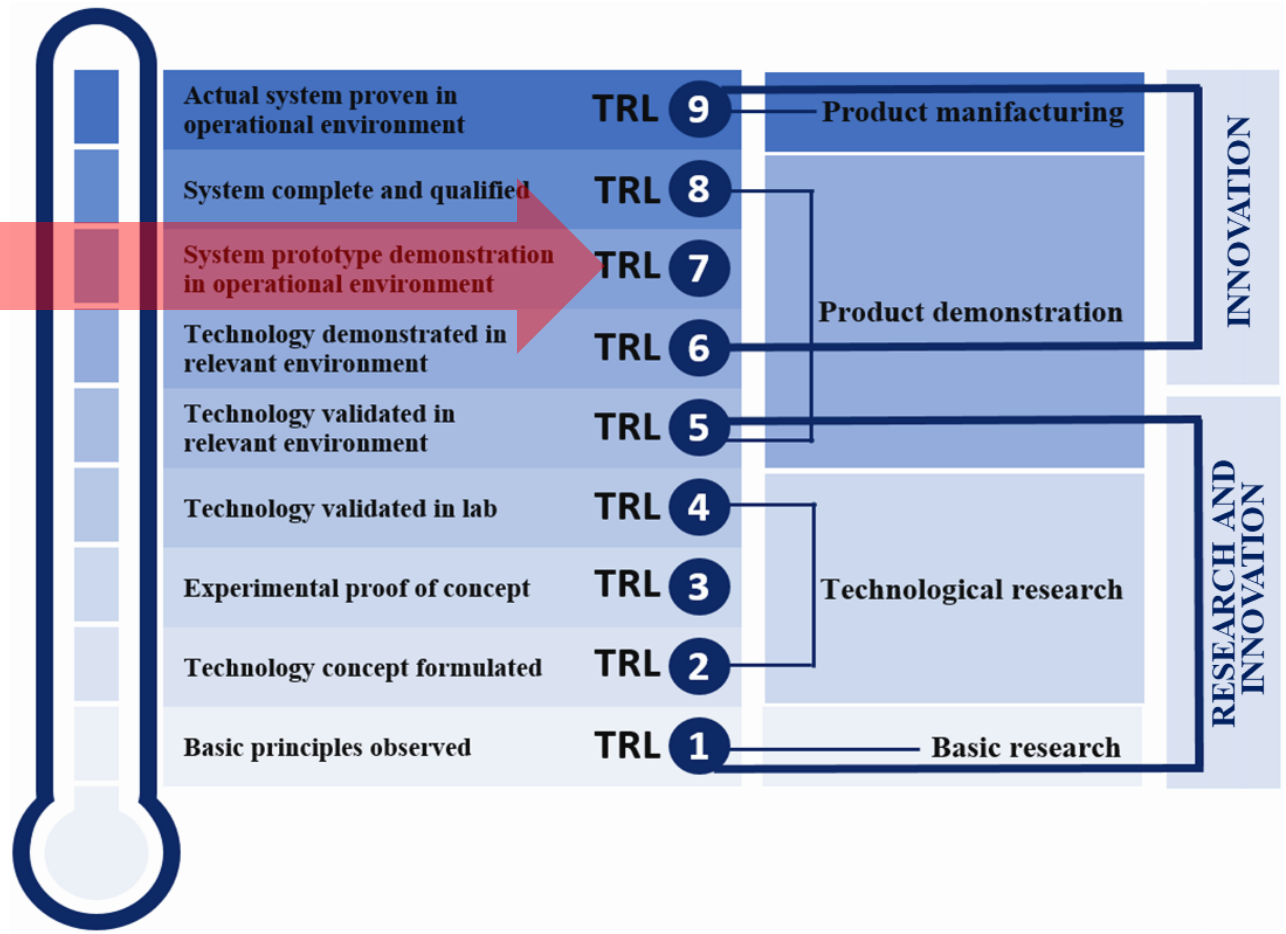




# **Our scope**: implement and demonstrate to **TRL7** our **smart controller** with multiple time scales

## Application

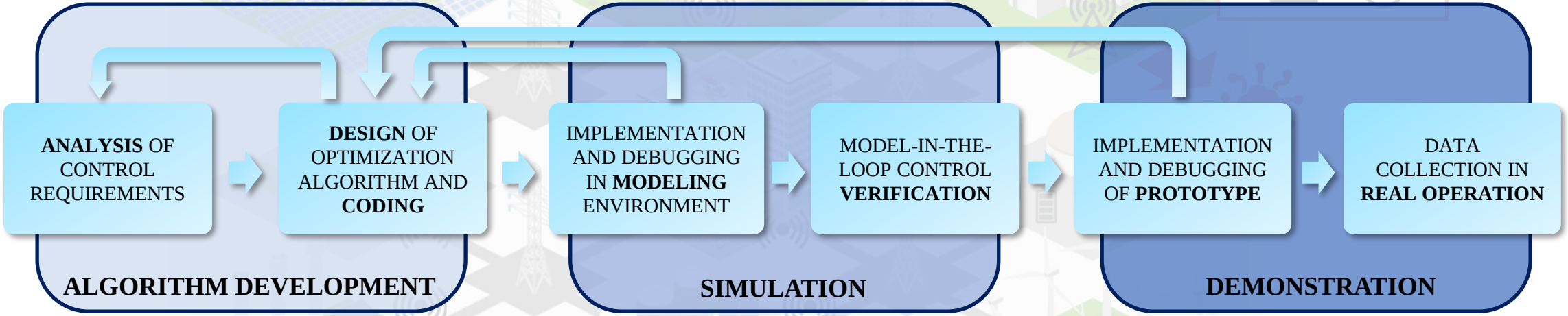
Hospital of Cona

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

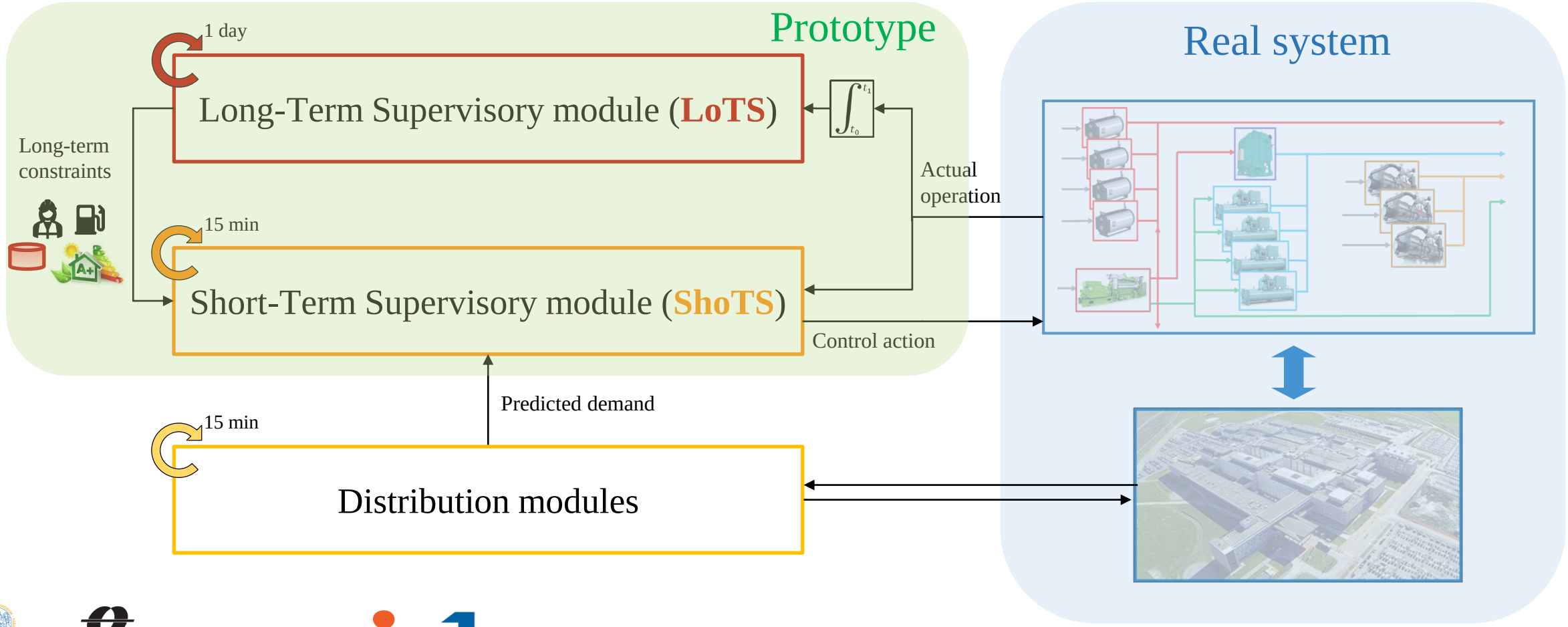

## Goals

- Optimize **energy distribution** and thermal station **management**
- Minimize operating cost
- Include **short-term** objectives
- Comply with **long-term** (yearly) incentives

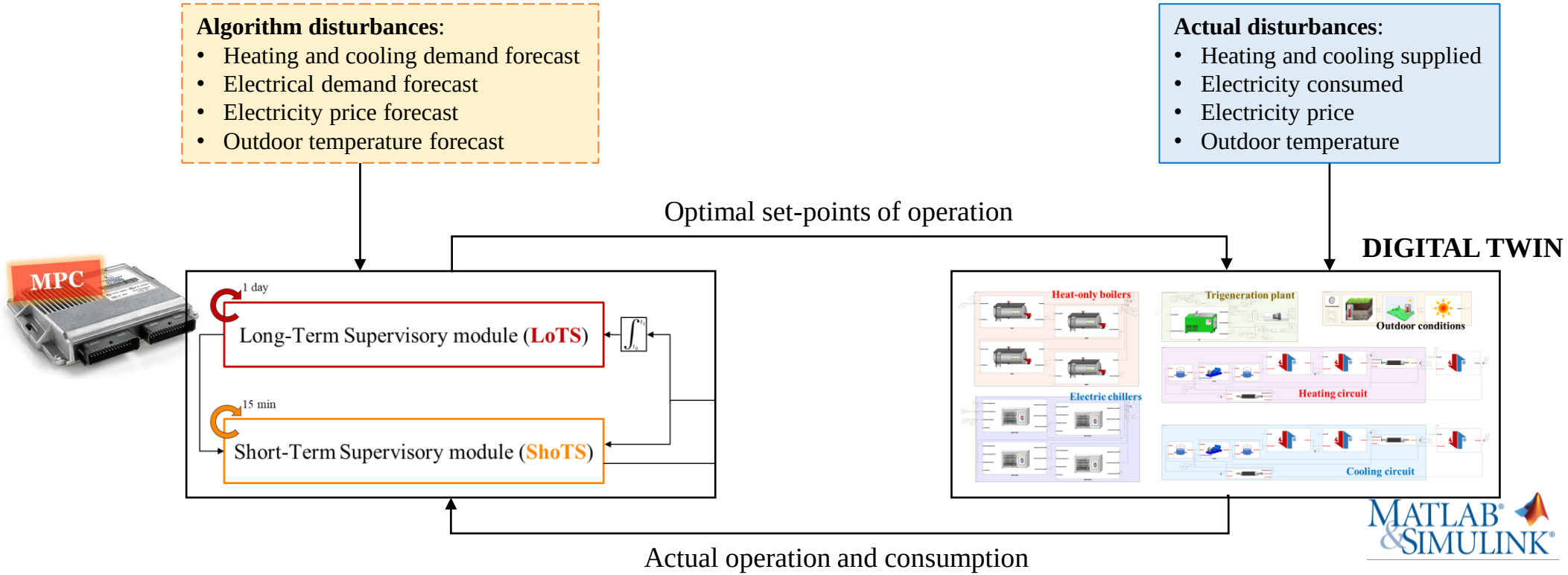
# **Our path**: from concept to simulation… to the controller prototype



**Our solution**: a **multi-level optimal** controller with a **double time-scale** which provides the control action every 15 minutes

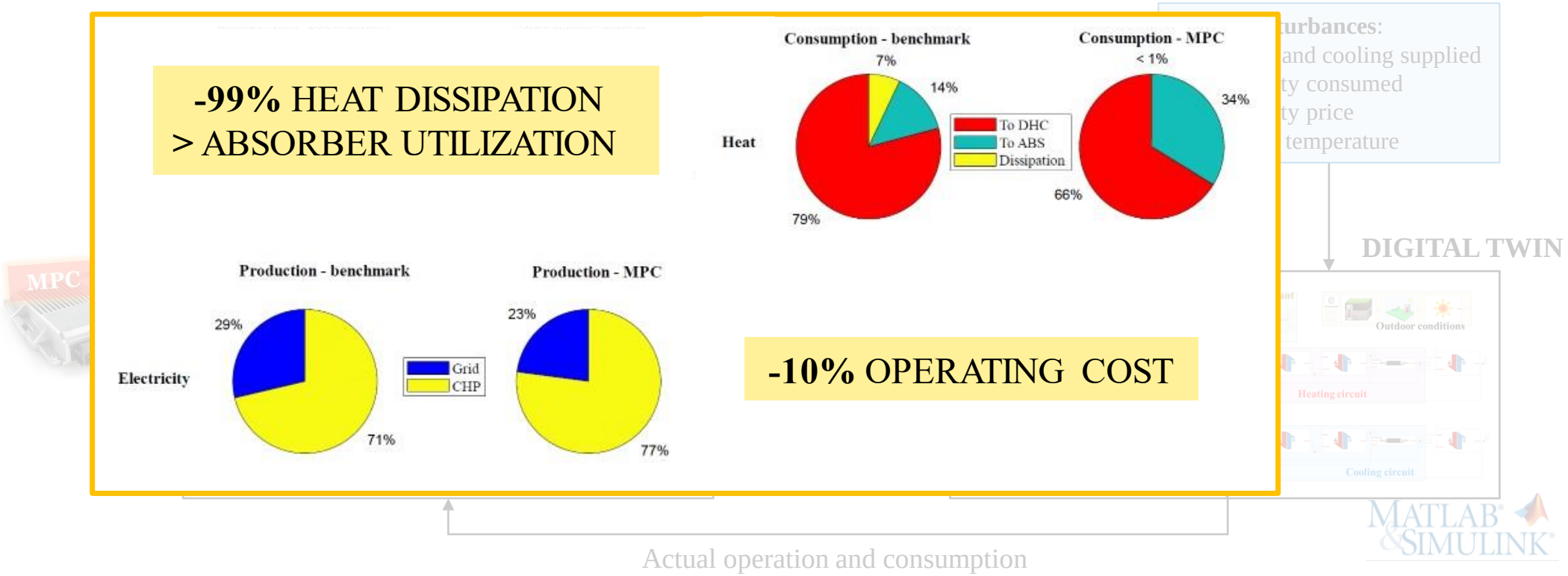


# The control algorithm was verified in **simulation environment** for an entire operating year…




Saletti C., Morini M., Gambarotta A. Smart management of integrated energy systems through co-optimization with long and short horizons. Energy 2022; 250, 123748. https://doi.org/10.1016/j.energy.2022.123748

# …providing a long-term perspective on the **control performance**

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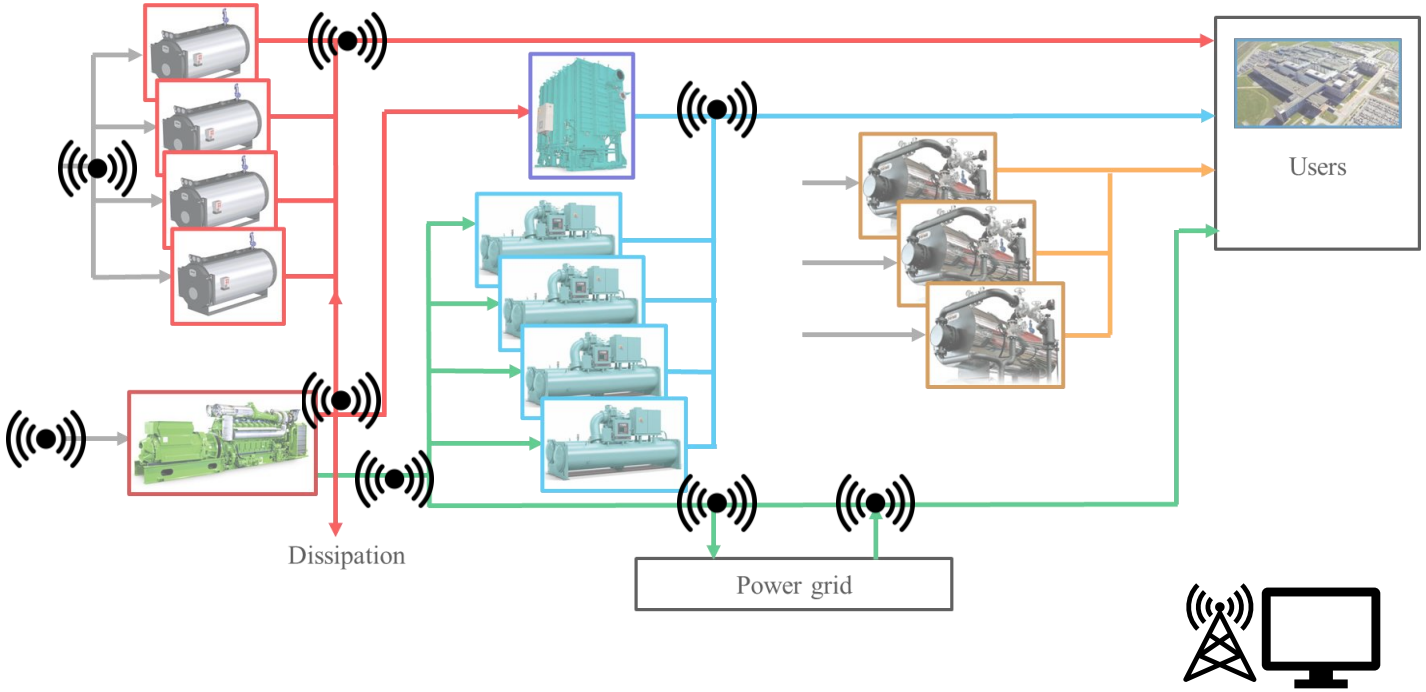
# The controller prototype was demonstrated in **operational environment**




**Monitoring equipment**

- Data collection and processing for baseline operation
- Implementation and debugging
- Data collection and processing for new operation
- Results and comparison

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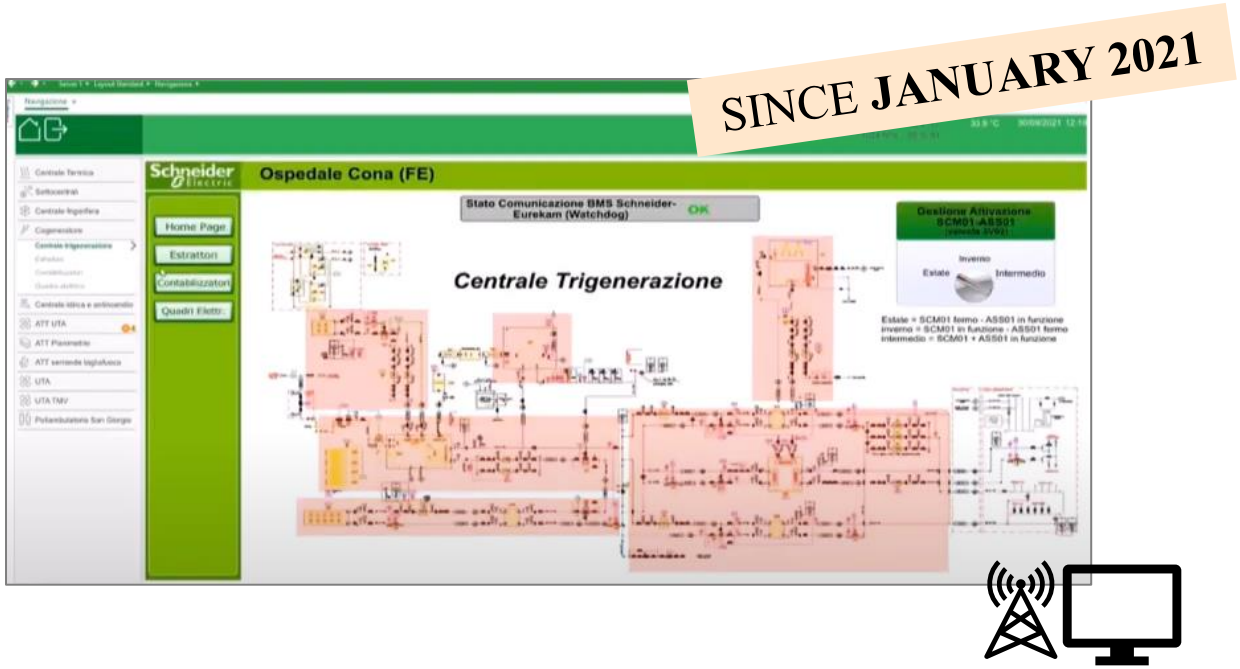


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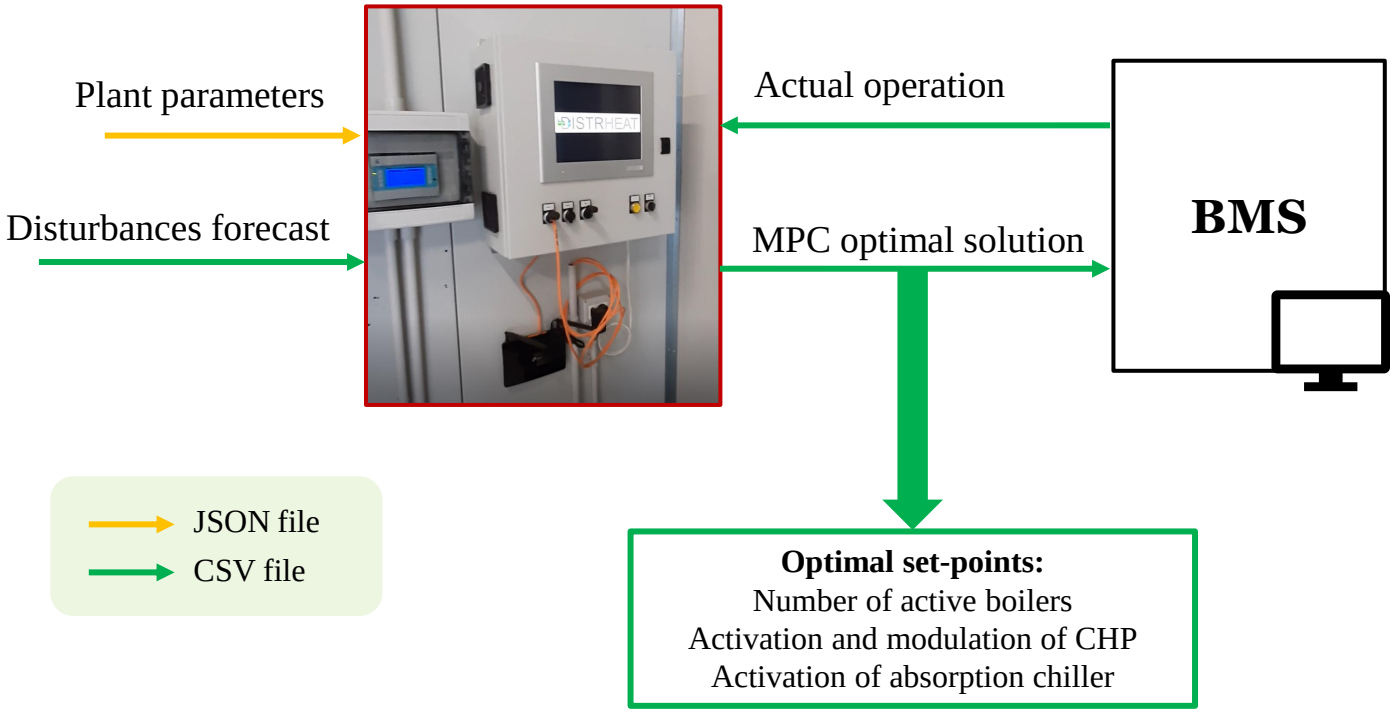


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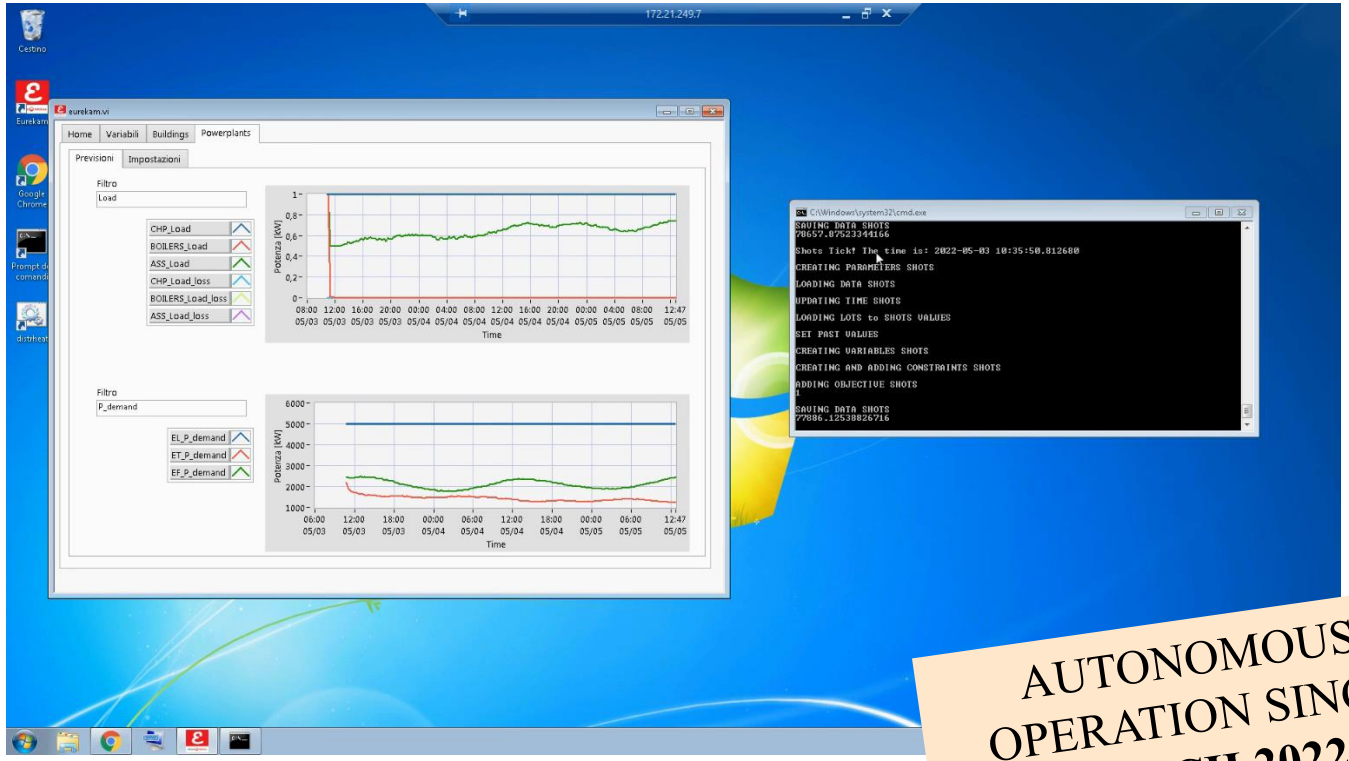
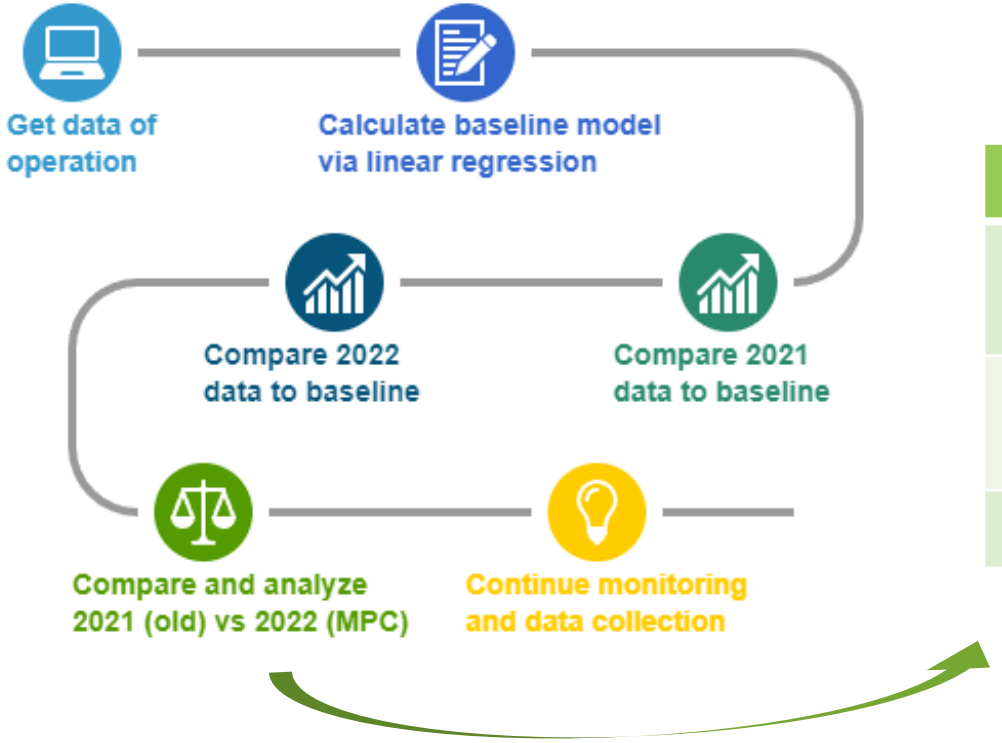



AUTONOMOUS OPERATION SINCE **MARCH 2022**

- Monitoring equipment
- Data collection and processing for baseline operation
- Implementation and debugging
- **Data collection and processing for new operation**
- Results and comparison

# After defining the baseline of operation, the results from **old** and **MPC control** were compared

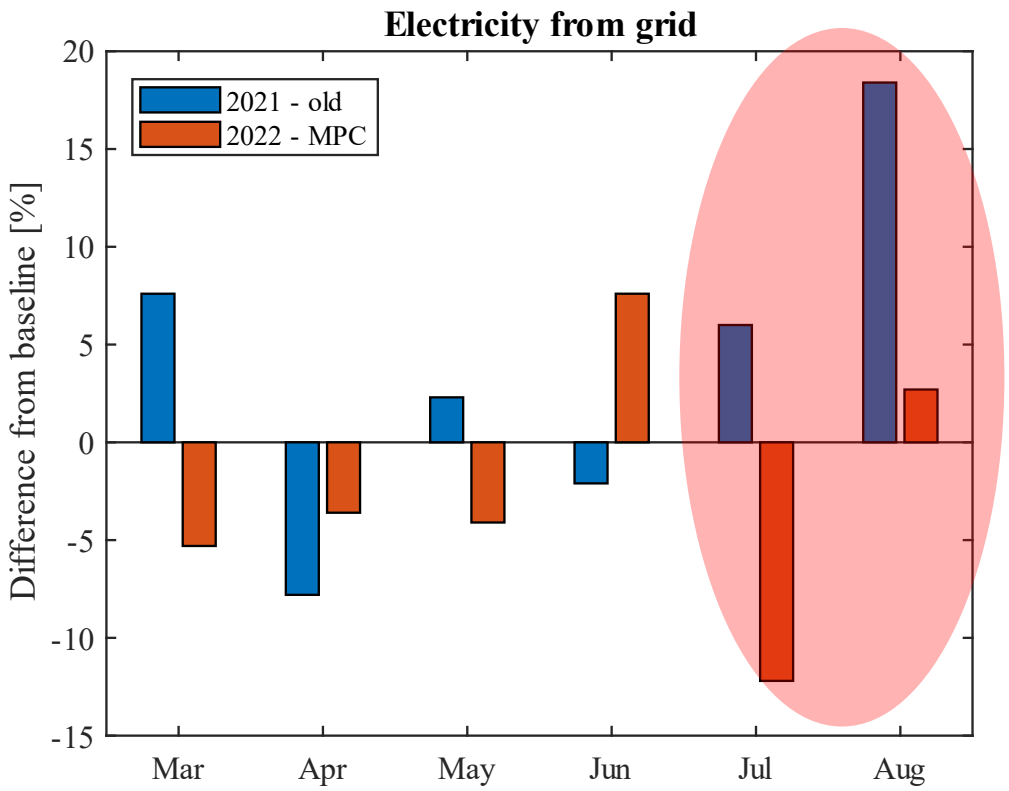


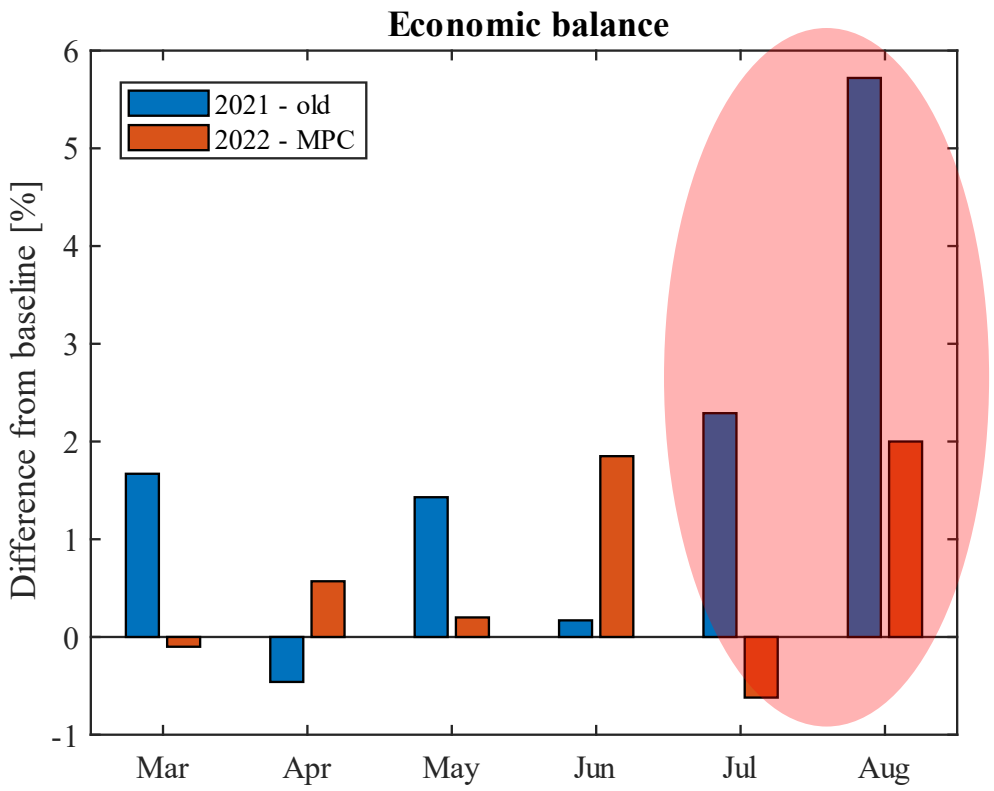

March to August

| | 2021 - old | 2022 - MPC |
|---|---|---|
| Natural gas for heating | -1.6 % | 3.4 % |
| Electricity from grid | 30.5 % | 4.5 % |
| Economic balance | **23.5 %** | **7.8 %** |

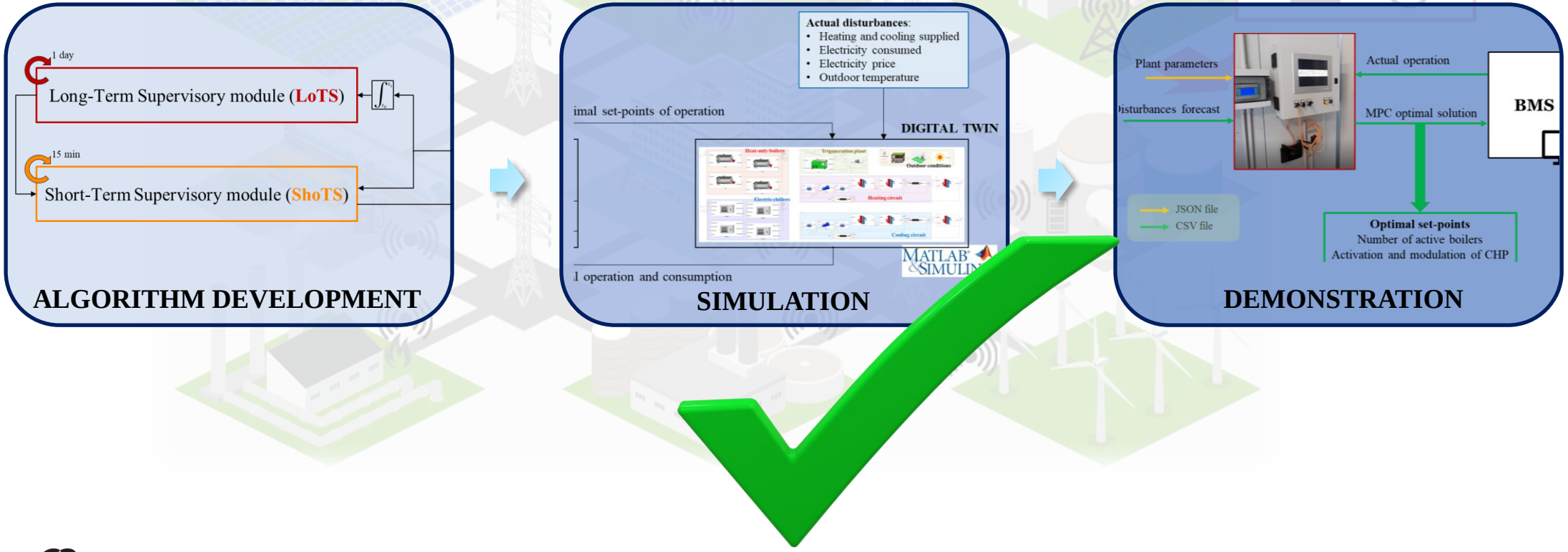
**Percentage differences compared to baseline**

# It was also possible to evaluate the difference from the baseline **month by month**, or even hour by hour



# It may be seem a long road… but **smart energy systems** are feasible!



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# Thank you for your attention!

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https://www.distrheat.eu/

Stay tuned for our Final Conference:
**18 October 2022**

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