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Analysis and optimisation of a renewable energy hybrid system operation

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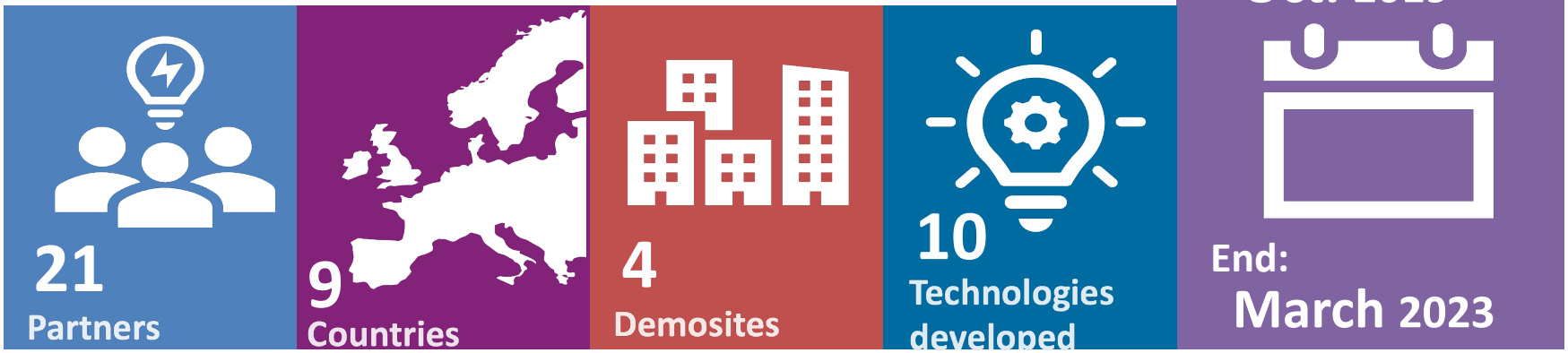
WEDISTRICT Main data

Smart and local reneWable Energy DISTRICT heating and cooling solutions for sustainable living (WEDISTRICT) project is born with the objective of demonstrating 100% fossil free heating and cooling solutions by optimally integrating multiple sources of renewable energies and excess heat in new and existing DHC systems.



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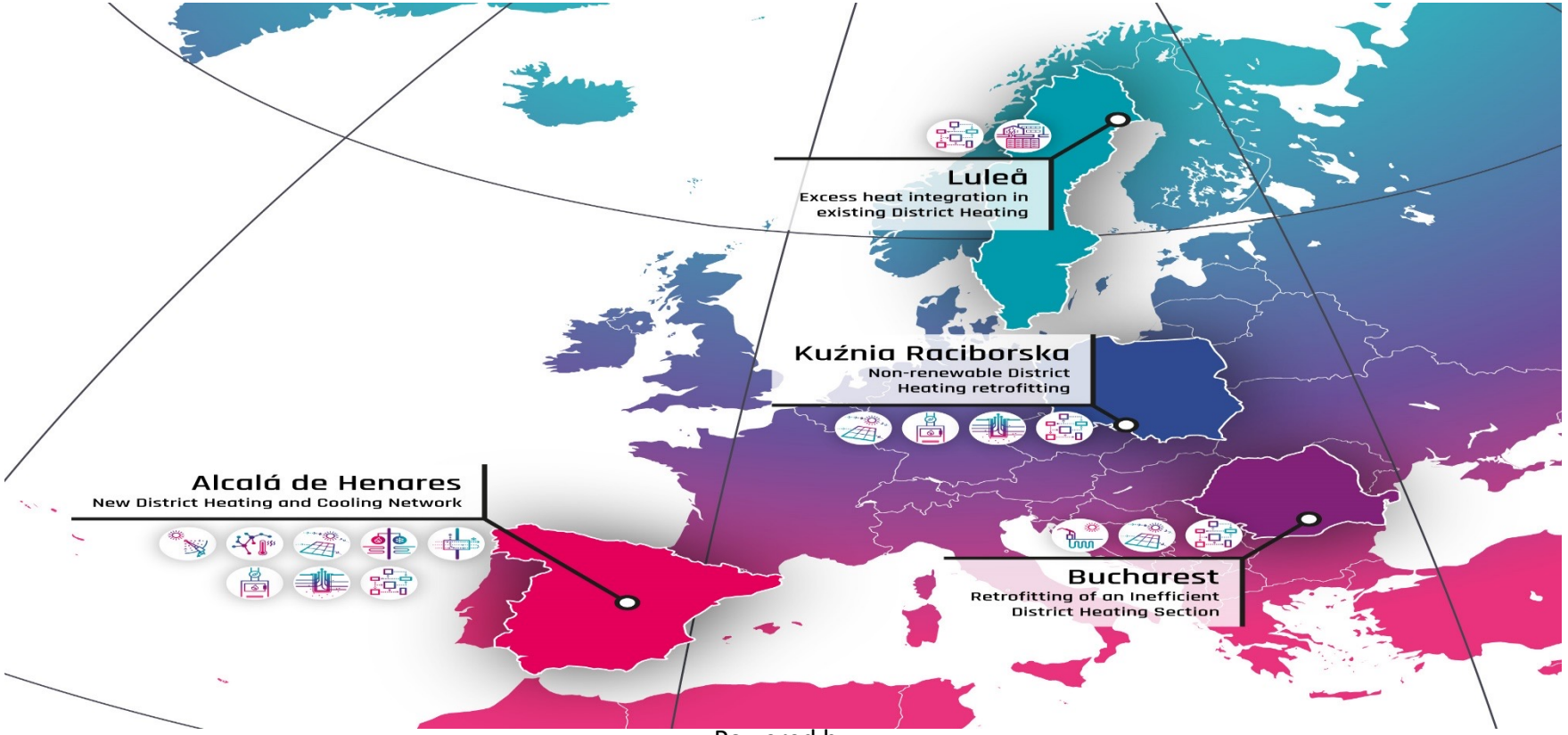

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Bucharest demo site

Retrofitting of an inefficient district heating section

TECHNOLOGIES PLANNED:

- **Photovoltaic panels** installed on the rooftop of two buildings
- **Hybrid photovoltaic-thermal panels** for domestic hot water production, connected to the buffer tank
- **Geothermal heat pump** to provide the heating and cooling of the building. The heat produced by the heat pump is stored in the buffer tank and used depending on needs to heat the spaces by means of fan coil units
- The cooling demand will be assured by a **passive and active cooling system** using the borehole heat exchangers and fan coil units connected through a heat exchanger
- The equipment operation and control will be integrated into an **intelligent energy management system**

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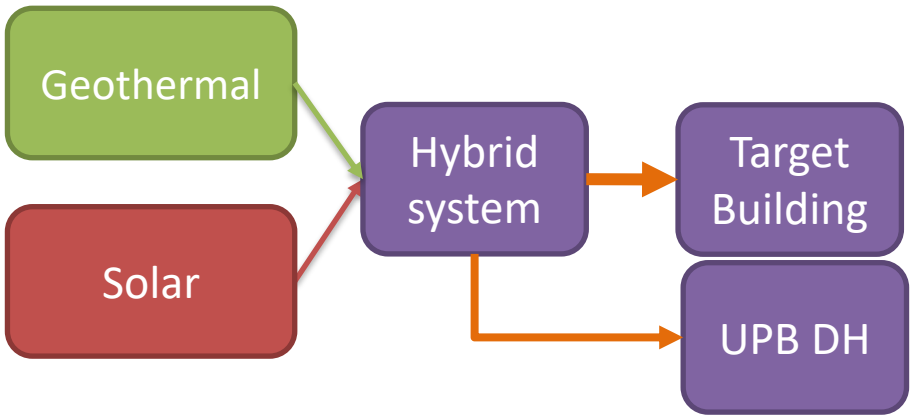
Description of the hybrid system

The hybrid system is structured modularly, respectively it is composed of two functionally interconnected subsystems.

The two modules are:

- Thermal subsystem:
  - Heat pumps
  - TES tank
  - Distribution system
- Electrical subsystem:
  - PV panels
  - EES system



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Theorethical approach for heat demand

The duration curve during the heating period for the target building was determined:

- According to national standards.
- Maximum and minimum values of the design heat demand of target building.
- A total number of 4392 hours of the heating period with continuously heat supply.

$$q(\tau) = q_M \cdot \left[1 - \left(1 - \frac{q_{min}}{q_M}\right) \cdot \left(\frac{\tau}{\tau_{year}}\right)^{\beta}\right]$$

Where:
q_M and q_{min} represents the maximum and the minimum design heat demand value
τ represents the timestep considered in the analysis (24h)
τ_{year} represents the duration of the heating period (4392h)
β is a power factor based on the minimum design heat demand value and duration of heating period.

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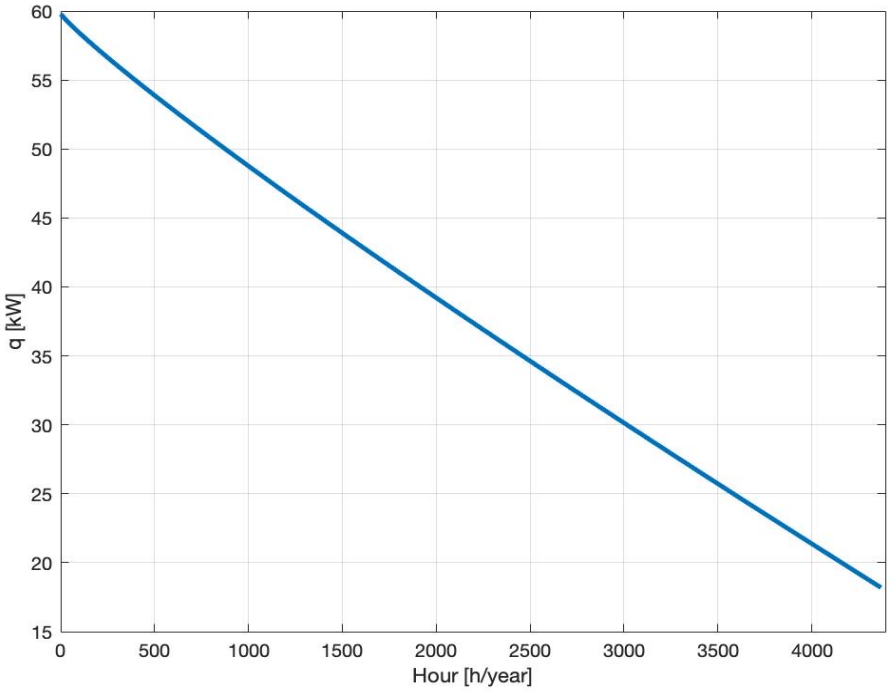
Theorethical approach for heat demand



Annual heat demand: 165,5 MWh/year

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Definition of working regimes

Setting the working regimes for Bucharest demo-site was performed having in mind the main goal of the project: the injection of heat into UPB district heating system while maintaining the thermal comfort of the target building.

The following working regimes and hypothesis were considered:

- Typical days based on target building's activity:
  - T1 – Monday to Friday from 9 AM to 6 PM
  - T2 – Periods of time when there is no activity in target building (outside working hours, holidays and weekends)
- DHW demand is less than 1% of the heating demand therefore it was not considered within the analysis.
- Annual electrical energy production, by PV panels, of 64 MWh/year was assumed.

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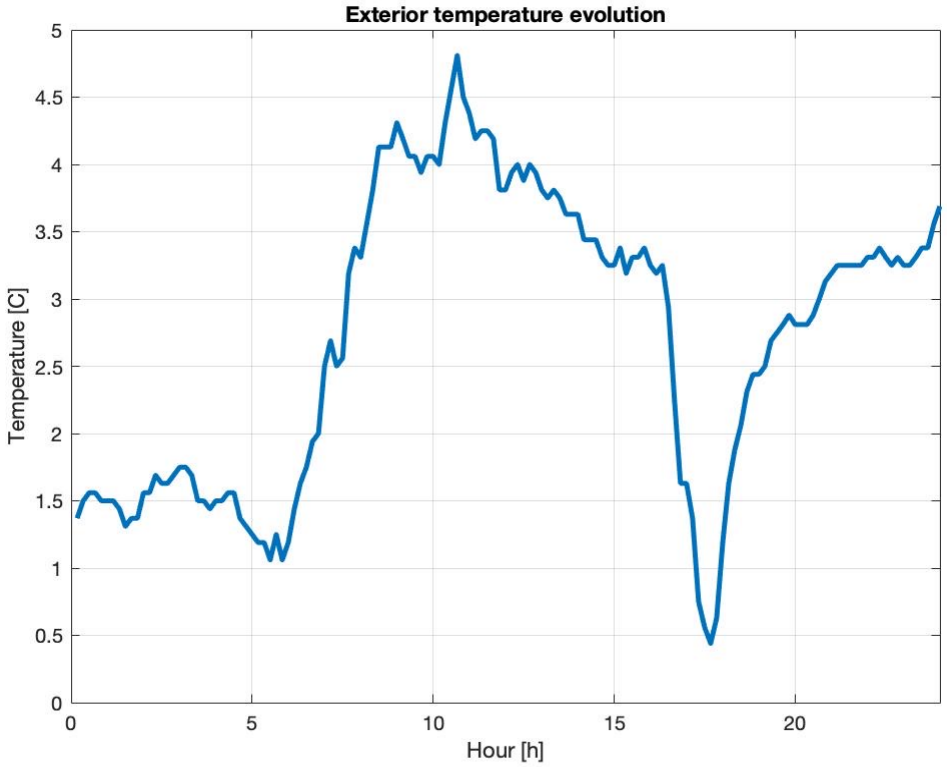
Definition of working regimes

All calculations were perfomed using onsite measurments of exterior temperature.



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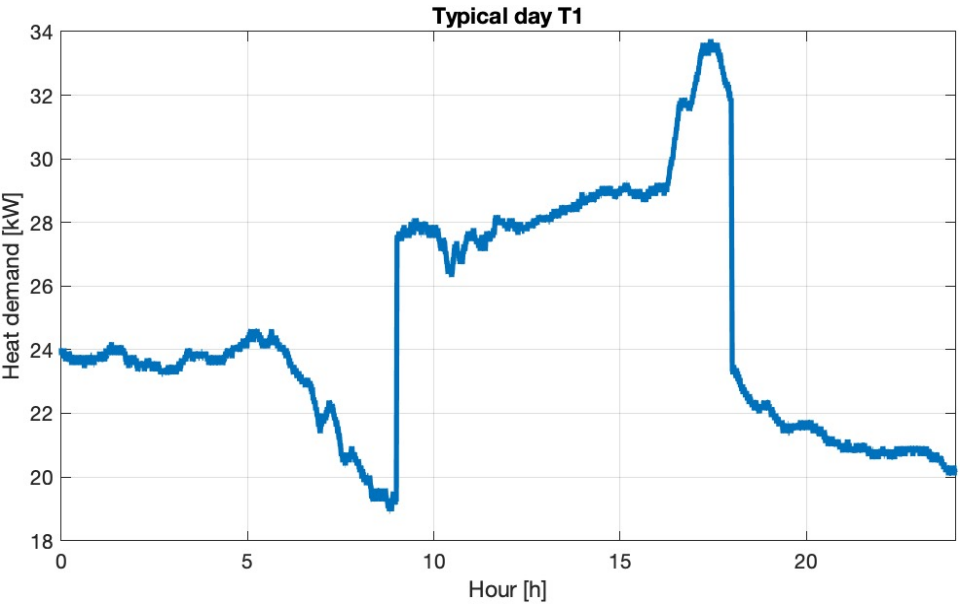
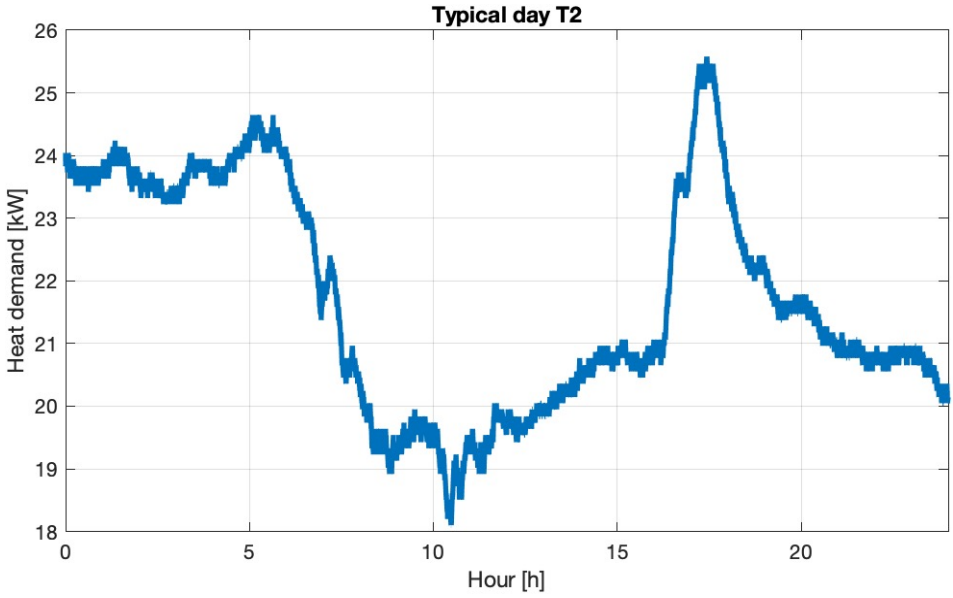
Heat demand results





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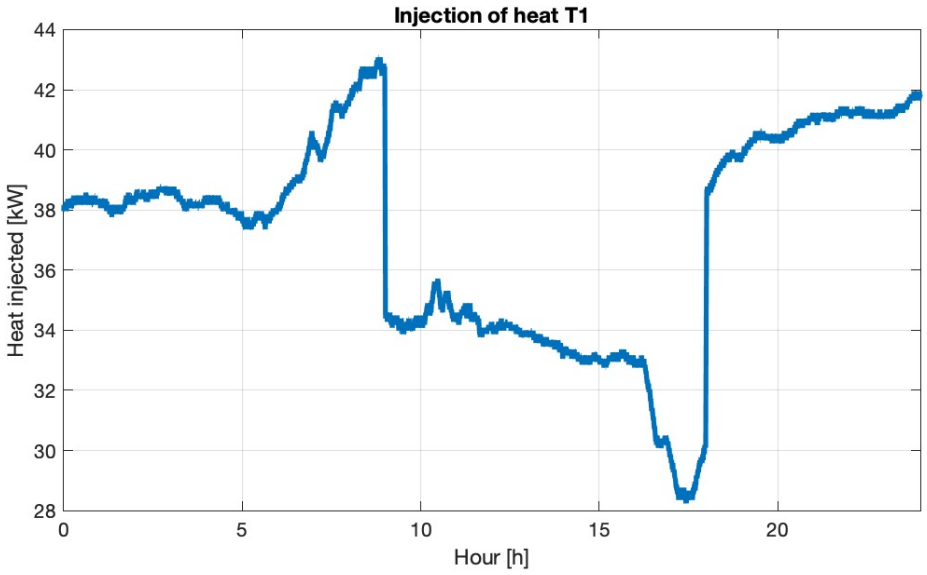
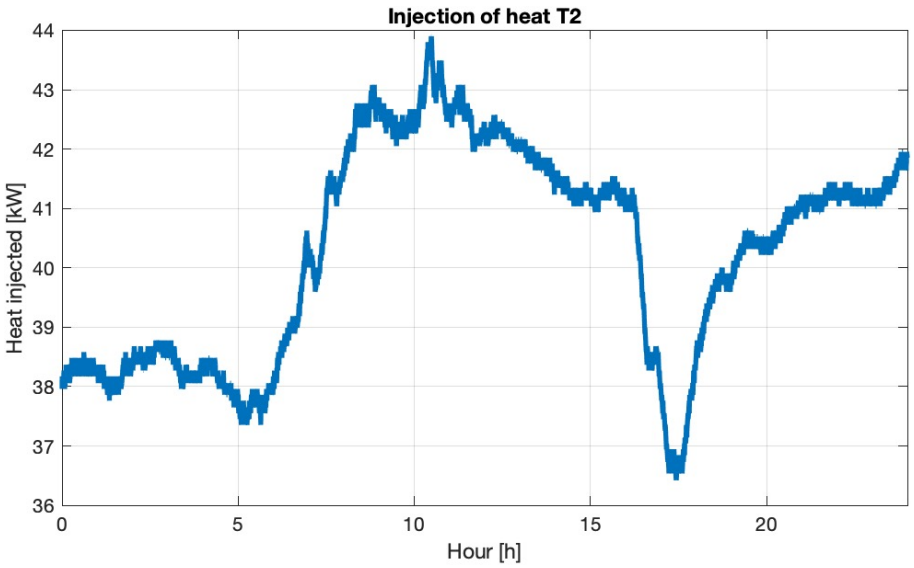
Heat injection for T1 and T2





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Analysis of the results

- The annual heat demand obtained through the simulation was 103,8 MWh/year which represents only 63% of the theoretical value.

- A higher amount of heat can be injected into the local district heating network.

Type	Hours [h]	Annual heat demand [MWh/year]
Working hours	1170	33,9
Non-working hours	3222	69,9
Total	4392	103,8

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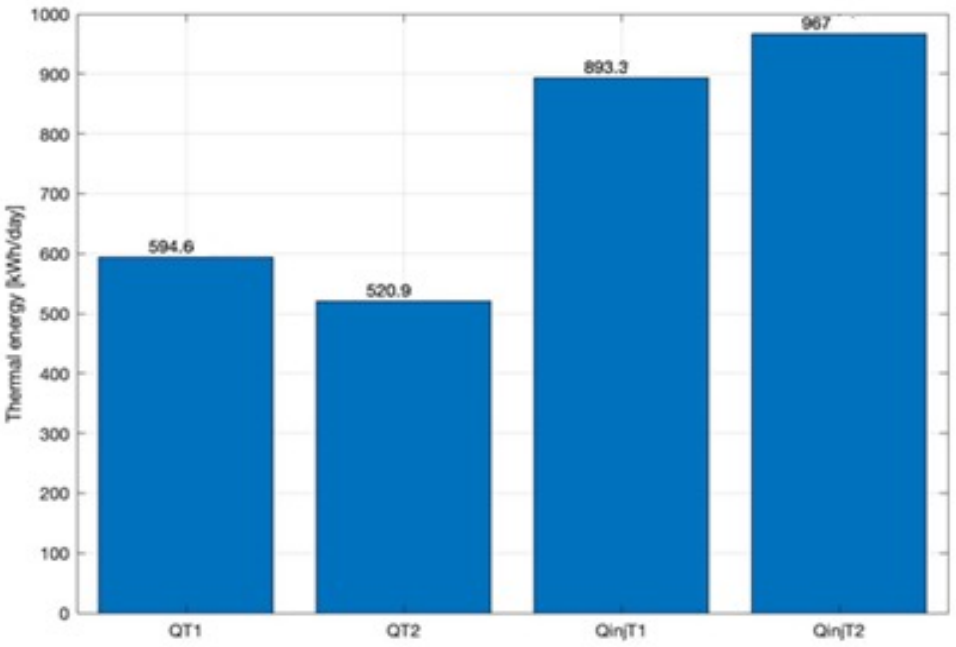
Analysis of the results

For a reduction of 12% of heat demand, between T2 and T1 typical days, the heat injected into district heating system can be increased with up to 8% maintaining the same working conditions for the heat pumps.



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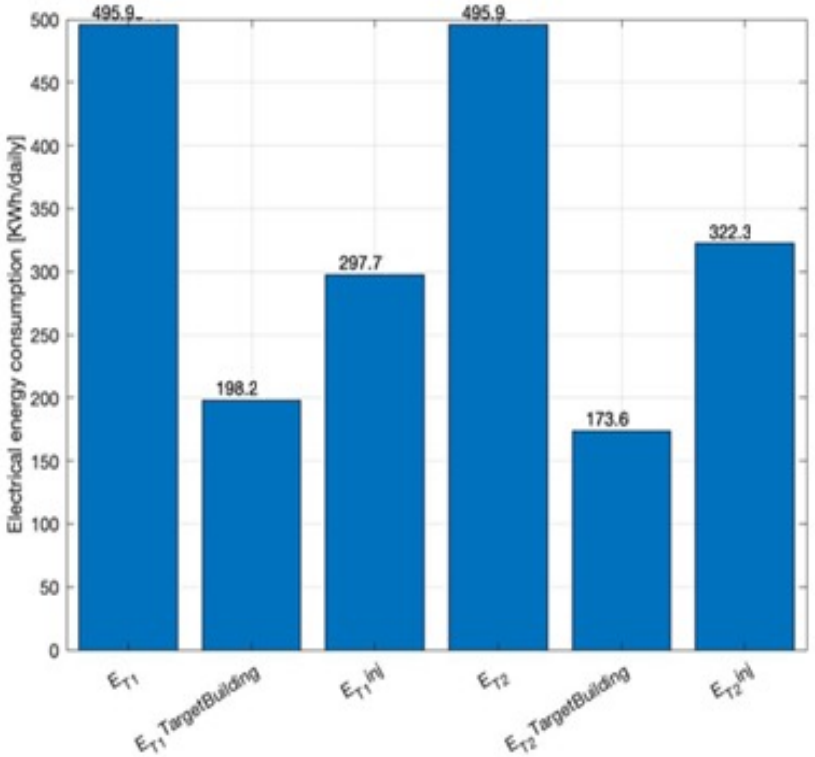
Analysis of the results

- The required electrical energy in order to satisfy the target building's demand, in either cases T1 or T2, is between 170 and 200 kWh/daily (considering COP = 3).
- Average yearly electrical energy demand to ensure the heat demand of target building: 35 MWh/year
- Estimanted electrical energy production by the PV panels: 64 MWh/year



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Conclusions

- The annual heat demand obtained through the simulation represents only 63% of the theoretical value which implies that a higher amount of heat can be injected into the district heating system.
- The analysis shows different ways to increase the injection of heat into DH based on target building activity.
- Considering the electrical energy production and demand, the analysis leads to the conclusion that the hybrid system can assure the heat demand, using only renewable sources, for another similar building.

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