Optimal prosumer-based district heating and cooling using reinforcement learning agents

Challenges for the future energy systems

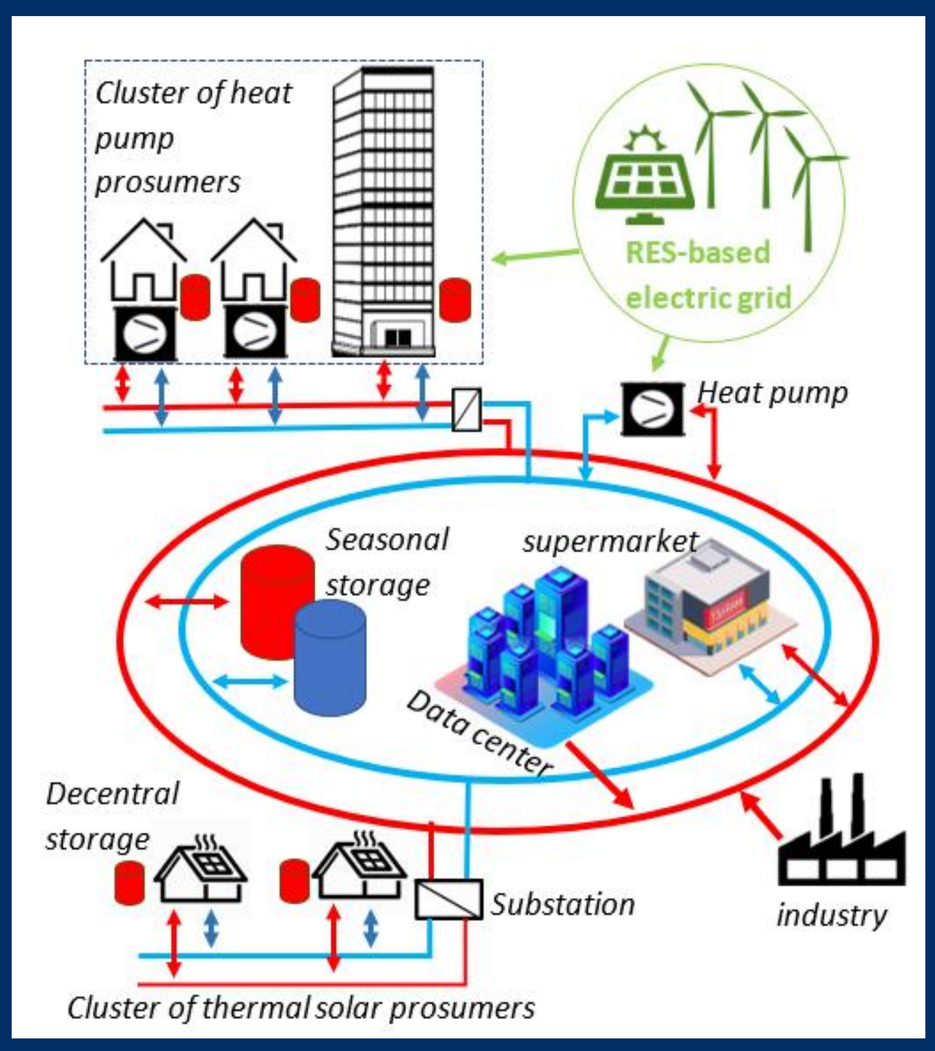
District heating and cooling (DHC) is promising to shift to a **sustainable energy supply**, and **offering flexibility** to the future electric grid based on renewable energy sources (RES). Thermal storage and conversion techniques can balance production of these intermittent electrical RES and demand. Furthermore, DHC facilitates the use of thermal RES, decreasing the use of fossil fuels. The DHC is evolving towards more flexible, **prosumer-based grids**. In this respect, decentralised production and storage tanks are used. Such flexible energy networks need **advanced control** methods to **optimally manage** (i) **the energy flows**, (ii) the **temperatures** in the hot and cold pipe and (iii) the **hydraulic integration of prosumers**. Moreover, the requirements of every DHC-user need to be taken into account.

Optimisation problem of prosumer-based DHC

The managing of energy flows requires a data-based control algorithm, which is **similar to electrical grid data-based controls**, but **more complex** due to some physical limitations:

1. Heat transfer depends on **temperature level** (different requirements).
2. **Flow rates** depend on temperature difference and could be **bi-directional** in prosumer-based networks.
3. Larger **time delays** because of the limited water velocities and duct sizes.
4. The **hydronic configuration of prosumers** is fixed in design. However, a flexible hydraulic connection could improve the flexibility and control, depending on the situation (i.e. available temperatures, power, etc.).

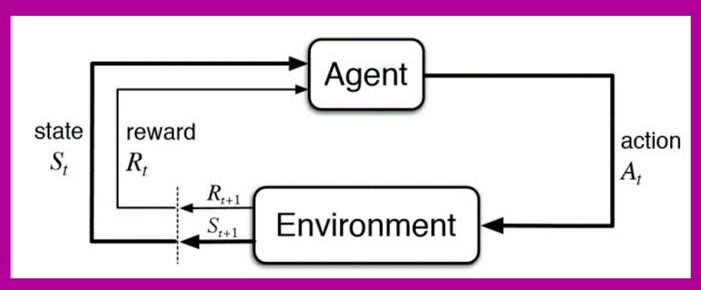
Integrating a multi-agent reinforcement learning (MARL) with neural networks to tackle this optimisation problem!

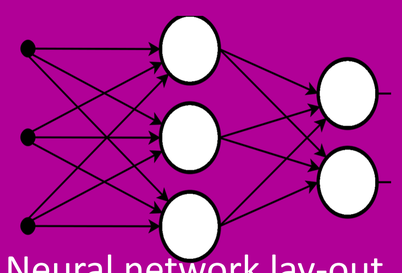


Concept of prosumer-based DHC, connected to RES-based electric grid

Reinforcement learning and neural networks

State and action spaces define the inputs and outputs of the agents. Based on the **reward function**, the optimal behaviour will be learned.





Neural network lay-out

In order to learn the optimal behaviour (**policy**), the RL-agents require a huge amount of data. The **data will be provided by a simulation environment**, representing the DHC's behaviour. The agents' objectives are to **optimise the indoor comfort and energy costs**. The energy tariff structures are **CO_2-based** in order to learn to cope with a RES-based electrical grid.

Research objectives

1. Develop an appropriate **simulator** of prosumer-based district heating and cooling (DHC), considering the **thermo-hydraulic aspects**.
2. **Pre-training** the MARL to optimally **control** DHC.
3. Design these agent to cope with the **future** energy systems and demands.

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