PENTAGON
Power-To-Heat System

Newsletter # 2

March 17, 2019

PENTAGON aims to increase the electrical and thermal grid flexibility and to improve renewable energy systems penetration.

The structural change of the energy context of the last decades has developed more and more towards Smart Grid solutions where new figures such as prosumers take on a key role in the management of energy production and consumption profile. The development of systems powered by renewable energy has brought significant advantages in terms of reducing CO_2 emissions, but at the same time, excessive penetration at the district level, highlighting significant problems in the management of the electricity grid.

The district heating networks, a key element of the smart districts have consequently evolved with the development of new technologies and new renewable source systems. The figure below shows how the first steam-powered district heating systems evolved towards more complex, more efficient systems and where the thermal vector has a considerably lower temperature.

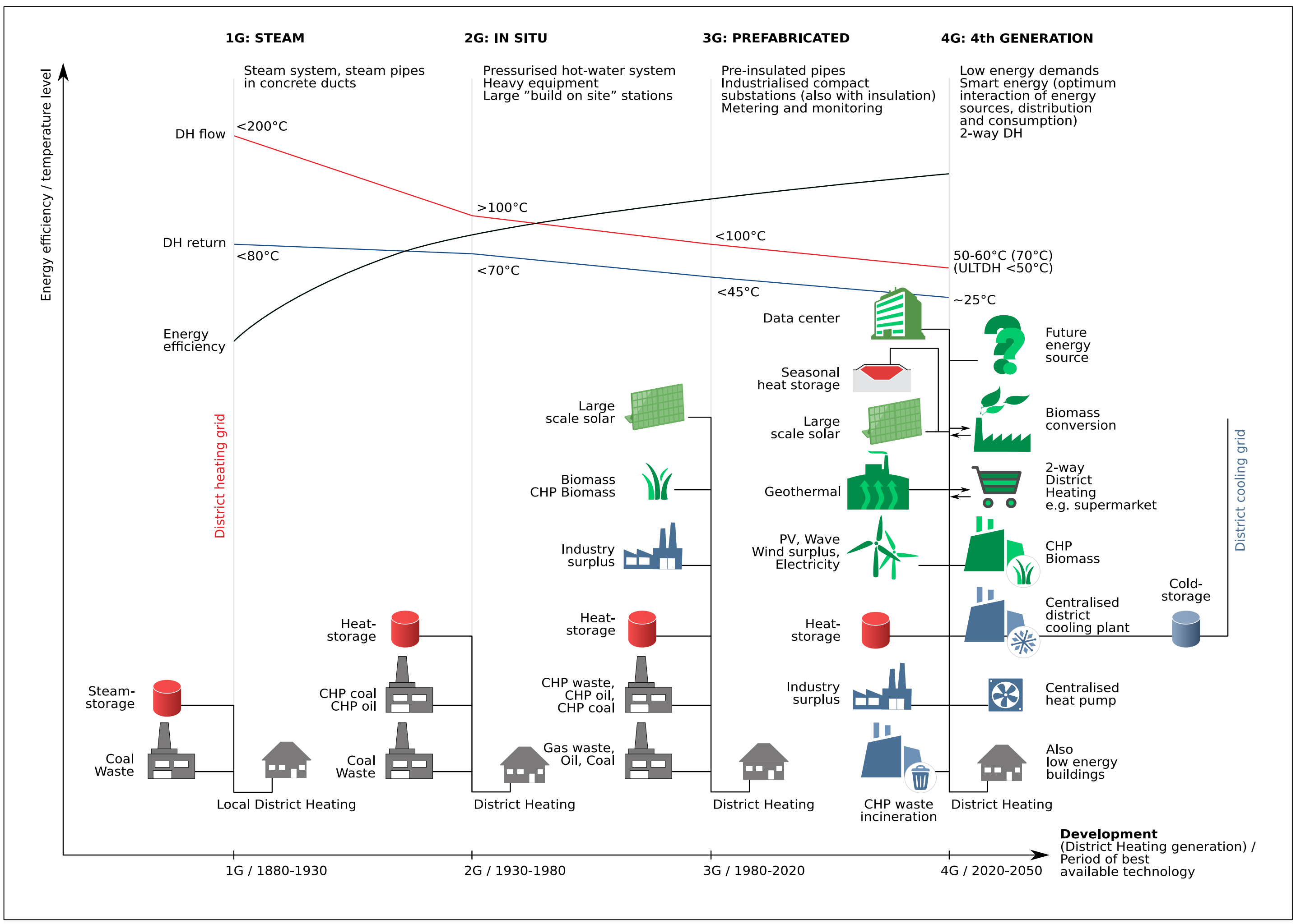

Figure 1. Evolution of District Heating Systems (source: Wikipedia)

The challenge in PENTAGON project is to improve the energy flexibility at building level, considering at the same time, the management of three energy vectors: electricity, thermal energy and gas.

This will be done by the application of a tailored Energy Management System, and two innovative energy conversion systems: Power to Gas system (P2G) and Power to Heat system (P2H).

Here we will focus the attention on the Power to Heat system that is one of the projects demo a developed in CEA-INES facility.

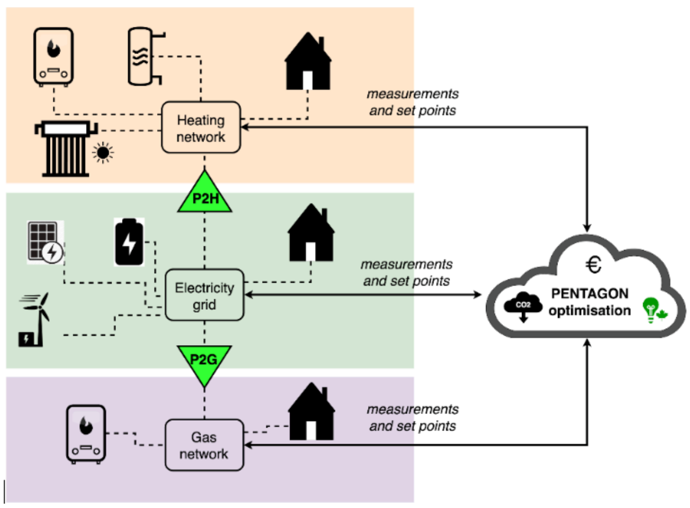

Figure 2. PENTAGON Multi-Vector management

The conversion of electricity into heat adds flexibility to energy systems and paves the way to the integration of renewable energy sources (RES) to the electricity grid. The challenge is to leverage the use of excess intermittent RES while adapting to external factors such as the price of electricity, the consumer heat demand and the level of CO_2 emissions.

Heat pumps technology are well suited to fulfil this challenge. In the frame of the PENTAGON project, a water-sourced heat pump has been deployed on the small-scale experimental heating and cooling network, on INES premises. It produces heat and cold simultaneously from an electricity source (Figure 3), and is used to test advanced control strategies for the operation of hybrid energy systems including gas, heat and electricity networks.

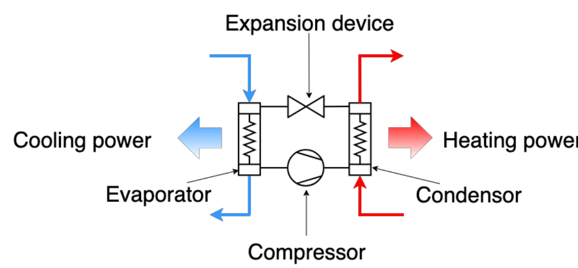

Figure 3. Operating principle of the simultaneous heating and cooling heat pump

In the demo plant in CEA-INES, a heat pump is hydraulically integrated to the existing heating and cooling network, by connecting the condenser side to the heating network, and by connecting the evaporator side to the cooling network.

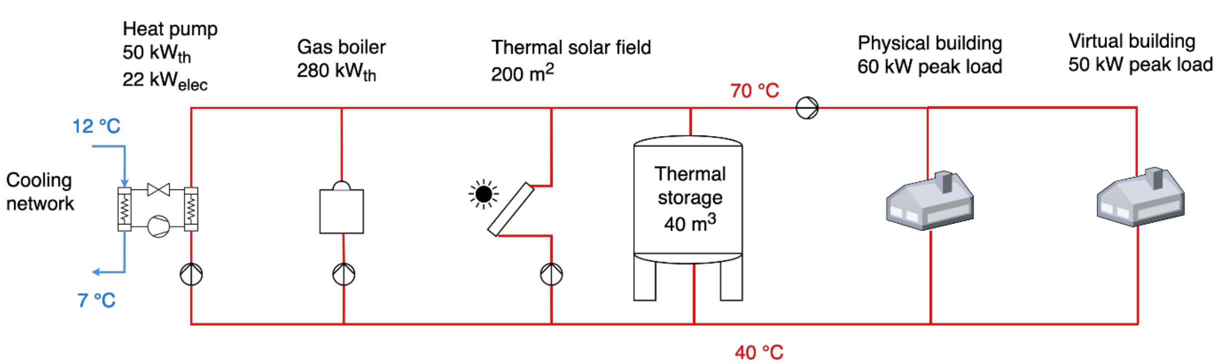

Figure 4. CEA-INES district heating network with the heat pump for P2H conversion

The network is equipped with solar thermal panels, a gas boiler, a thermal storage tank and two types of heating consumers: (i) a nearby building hosting an industrial process, and (ii) an experimental device to control the heat consumption (so called virtual building). In addition to the hydraulic connections, the heat pump equipment is integrated to the Supervisory Control And Data Acquisition (SCADA) system.

The heat pump has been tested in a range of operational modes in order to prepare the validation of the scenarios foreseen in the PENTAGON project. In particular, it is important to control the heat pump as part of an advanced energy management system.

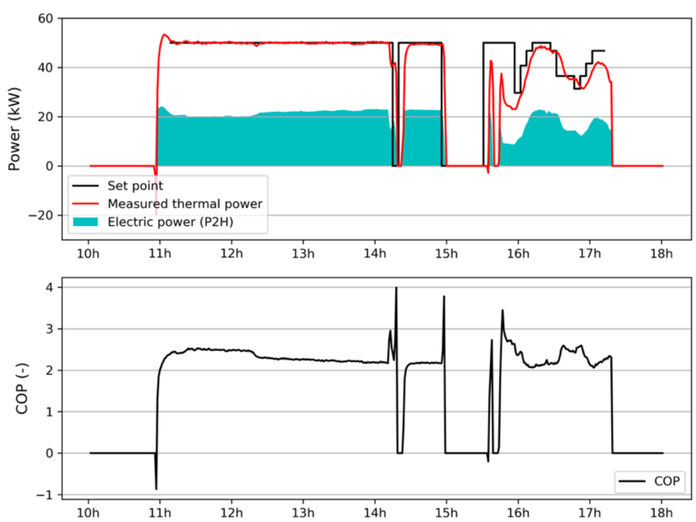

Figure 5. Profile of electric power (top), and Coefficient of Performance (bottom) during a control test

Figure 5 shows how the heat pump is able to provide the thermal power (red profile) to satisfy a given set point which is not related to a PENTAGON scenario in this test (black profile).

The blue profile represents the electric power consumed by the heat pump compressor, which is therefore the P2H contribution that the system generates to the electric energy in excess in the network, transforming it into heat power. In the bottom, the graph represents the coefficient of performance (COP) on the hot side. It should be noted that the heat pump provides cooling power to the cooling network, therefore a global COP combining the hot and cold side can be calculated, with values higher than just the COP on the hot side.

In future tests, the use case scenarios will be implemented on the district heating network of CEA-INES, and the PENTAGON platform will manage the heat production of the gas boiler and heat pump in real time. With the deployed heat pump, the coupling of electric and heating network is achieved, and the flexibility of the system is improved, together with the use of the thermal storage tank.

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