my SMART Life

A European urban transition project towards more sustainable cities through innovative solutions, in the fields of mobility, energy and digitality.

Smart City

Global project

Coordination: CARTIF
European grant: 18M €
30 partners, 6 countries

Period: Dec. 2016 - Nov. 2021
Demonstrators:
Hamburg, Helsinki, Nantes

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Helsinki demonstrator site

Coordination:
The City of Helsinki
European grant: 5,6 M€
7 partners

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City Infrastructure
District Heating

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ACTION OVERVIEW

Integration and Optimisation of Renewables in District Heating and Cooling systems

This action was implemented by VTT Oy in collaboration with Helen Oy. A full report (D 4.5), written in English in November 2019, is available on https://mysmartlife.eu/publications-media/public-deliverables/

▶ OBJECTIVES

- To analyse the effects of increasing self-sufficiency in terms of heating
- To optimise the renewable energy production and hourly operation of heating
- To find the most suitable energy production mix consisting of various renewable energy sources

▶ IMPLEMENTATION

CONTEXT

As modern buildings become more energy-efficient, the share of domestic hot water in total heat demand grows. It can be observed in a yearly heat demand duration curve and, in the long run, it will increase fluctuation and amplify morning and evening peaks in heat demand. With the share of 50% of the total heating capacity, residential buildings are the biggest customer segment in Helsinki´s district heating (DH) system. Increasing fluctuation causes challenges in heat production and distribution. In newly built areas, domestic hot water-based demand is already defined for network design.

Due to the island nature of the energy grid in the Tali area in Helsinki, it is ideal to study the levels of Helsinki’s DH temperature variations as a function of outdoor temperature or local heat production, for example, by heat pumps. Decreasing the DH supply temperature, results in lower heat losses and provides an opportunity to increase renewable energy sources in the network. The area of Tali consists mainly of residential buildings built in ‘90s and it is therefore representing a quite common residential city area.

PROGRESS

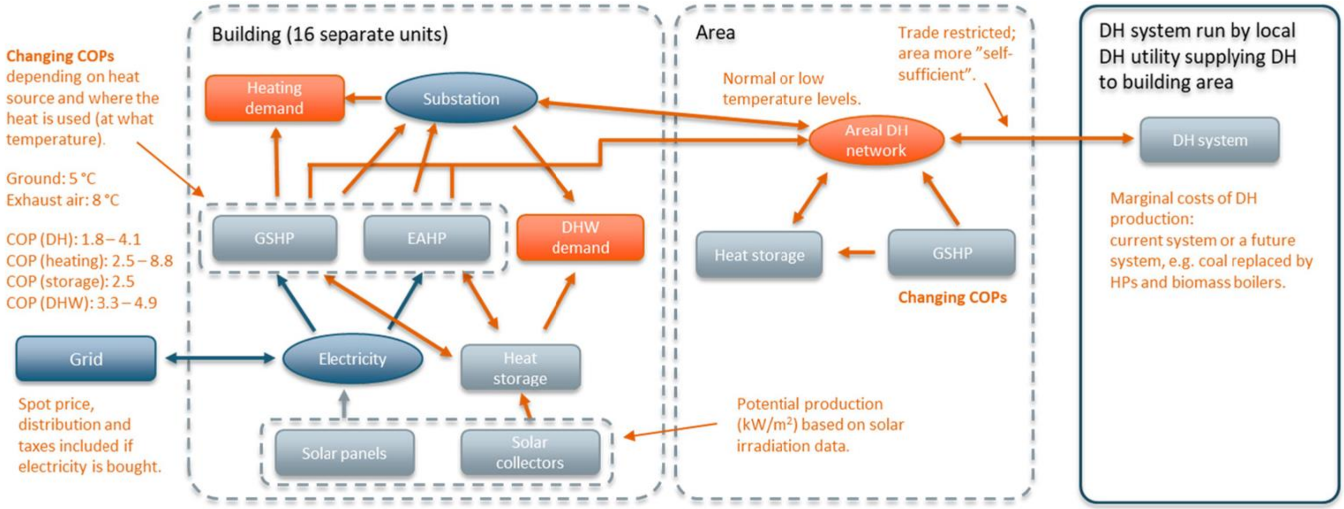
Simulation models are used to analyse and predict the performance of various systems in the real world. The models are based on parameters and variables such as capacities of the energy production system(s), weather and, for example, previously monitored energy consumption data. The flow rates and temperatures of the Tali area have been collected in order to analyse the future development for the network.

A simulation model was created at VTT for Tali residential building area in Helsinki. The studied area is connected to the Helsinki's DH (District Heat) system and consists of 16 residential buildings with an average annual heat demand of 5.6 GWh. The capacities of heat pumps utilising the heat sources, in addition to rooftop photovoltaics and solar collectors, were optimised in an energy system with a heat supply consisting of both owned and purchased DH.

In the simulations, the system was allowed to invest in both buildings specific systems and in a local ground source heat pump supplying all the buildings in the area. The share of DH in heat supply was decreased gradually to analyse the effects of increasing residential self-sufficiency. Surplus heat produced in buildings can be transferred through the network to other buildings or can be sold to the main DH network. The optimisation was carried out both for current (90 °C supply) and low (65 °C supply) DH temperature levels.

Limiting DH supply increases building-based ground heat pump production. However, with low shares of DH, the production of a centralised ground heat pump, in combination with a centralised heat storage, increases. In the simulated 2018 case, the heat pump production in buildings reaches a share of 85% (77% in 2015) of system heat supply. Ground source heat pumps outperformed solar collectors and weakened air heat pumps in the simulated scenarios. Building based investment in photovoltaics-based electricity generation and heat storage increases if the share of purchased DH in the area is limited in the model.

With the marginal cost-based price curve of sold DH, volumes of sold surplus heat into the DH network were marginal in all cases. In the case of normal DH supply temperature, the most cost-efficient manner for a building to disintegrate from the district heating network is to invest in a package consisting of a ground heat pump, heat storage and photovoltaics. The results indicate that the cost increases due to limiting DH supply into the area and investing in distributed heat pump-based heat supply is modest. However, completely removing the areal DH network increases the total costs considerably, 22-37 % (compared to 0 % and 100 % DH share cases) in 2015 and 15-43 % in 2018.



► LESSONS LEARNT

- The optimal solution for the Tali area is a package consisting of a ground source heat pump, heat storage and PVs
- Selling surplus heat back to the DH system is marginal in all cases
- The constraints on the use of centralised DH increase the total costs of running the system. On the other hand, the cost increases with moderate constraints are small and could be argued to be worth the new, added renewable heat supply. However, if this development hurts the economic feasibility of having a DH system in the first place, it is interesting to note that the costs of a system without a network at all are significantly higher.

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