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: 5,6M €
7 partners

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ACTION OVERVIEW

Helsinki

Heat Demand Response

This action was implemented by Helen Oy in collaboration with Fourdeg Oy, Salusfin Oy and VTT Oy. Full reports (D 4.23, D 4.4 and D 8.9) are available on https://mysmartlife.eu/publications-media/public-deliverables/

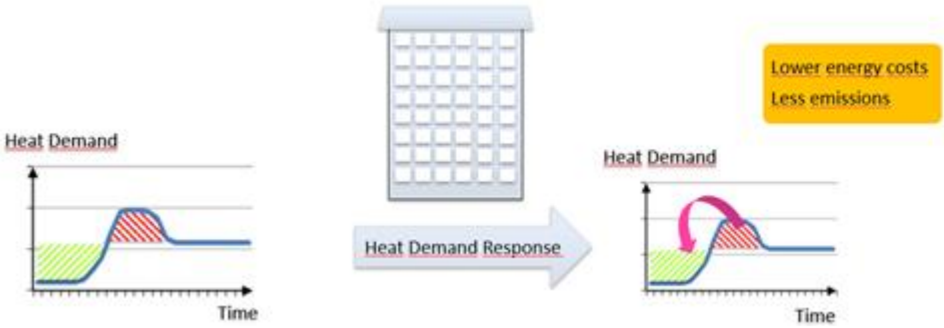
► OBJECTIVES

› To evaluate capabilities of heat demand response in district heating
› To test smart heating management systems for heat demand response
› To collect residents' and office workers' feedback on demand response

► IMPLEMENTATION

CHALLENGE / CONTEXT

The purpose of heat demand response is to reduce the need for heat during peak consumption hours and enable a greater system-level flexibility. Generally, the peak production that follows peak consumption is more expensive than the basic production due to more expensive energy sources, fuels and energy procurement. Therefore, peak consumption times increase the costs as well as emissions of energy production. By shifting consumption to a different time of the day, demand response aims to flatten out consumption peaks. In this way, the urban building stock can act as a very short-term heat storage to balance district heating consumption peaks.



PROGRESS

Heat Demand Response Business Scenarios

The potential benefits of heat demand response at the system level, and the possibilities to implement the heat demand response were evaluated in Helsinki. The ways of deployment were assessed from different perspectives using business scenario analysis. The perspectives included: production optimization of district heating network, the current technologies of demand response of a district heating, operability with building automation, and the consumer perception. For the technical part of the tests, an API interface was developed to deliver heat demand response requests from the district heating production system to be used by smart heating management systems in the buildings.

Pilot Projects

Smart heating management systems were piloted in a residential apartment building in Merihaka (the smart heating solution of Salusfin) and an office building in Viikki Environment House (the smart heating solution of Fourdeg). The heating control systems used smart thermostats to manage room level temperatures. In the heat demand response research pilots, the commands for the smart thermostats were -1, 0 or +1 Celsius degrees in thermostat setting value, reflecting the estimated production status and need for demand response in Helsinki. The same commands were used in both pilots. In addition to technical tests, the temperature sensation feedback from apartment residents and office workers were collected.

Residential apartment building heat demand response pilot in Merihaka

In Merihaka/Vilhonvuori, a total of 167 flats were equipped with a system comprising of smart thermostats and connected to the district heating with the help of IoT and cloud-based intelligence to load the balance of the network. Apartment level heating is managed and controlled by the smart heating management system. For the heat demand response, Helen published the demand response commands in an REST API interface, Salusfin requested the commands via the interface for smart heating control actions, and the smart thermostats executed the commands.

Office building heat demand response pilot in Viikki

The Viikki Environment House original high tech HVAC system was upgraded by Fourdeg Smart Heating(R) water radiator heating control. The demand response signal controlled the water radiator's heating, but the HVAC operated independently. The building heat demand response was tested in two phases by Fourdeg and VTT: 1) The consumer perception was first tested carefully by deviating the room target temperature by +/- 1C and then analysing the occupant feedback. The result was that in an office building such deviations were acceptable by the occupants. The occupant satisfaction with the indoor air quality actually improved during the test. 2) The demand response commands' impact on the Viikki Environment House district heat energy consumption was measured at different times of the day and week as well as in different outdoor temperatures. The main learnings were a) During the office working hours, while HVAC (ventilation) was running with gear, the impact of the water radiator control was compensated, and the demand response signal needed a very long cycle (>3hrs) before any impact on the heat demand was detected. b) During the evenings, nights and weekends, while the HVAC (ventilation) was running on low gear, even a short demand response cycle (1h) made a clear impact on the energy consumption. It is obvious that in addition to the water radiator heating, the HVAC should also participate in the implementation of the demand response to achieve the maximum impact. The overall pilot proved, however, that district heating demand response is both acceptable for the occupants and impacts the energy consumption of office buildings.

Thermal sensation testing

During the heat demand response testing phases, the thermal comfort of the residents in the Merihaka building and the occupants in the Viikki office building were analyzed by frequently asking the occupants to provide feedback on their thermal comfort. The questionnaires were accessible for the occupants via their mobile devices through a QR code application. In Merihaka, the thermal comfort was not observed to be affected by the heat demand response testing runs. In the office environment, a slight correlation between decreased thermal comfort and the heat demand response was detected while analyzing the feedback.

This project has received funding from the European Union's Horizon 2020 research and innovation programme under agreement n°731297.

LESSONS LEARNT

Business scenario analysis gave the information on the capabilities of heat demand response in Helsinki. The business-as-usual scenario, including the connection of 550 residential buildings and 50 business premises, schools and similar type of buildings, showed that investment in heat demand response can be profitable with a reasonable payback time (10 years). Helen has also centralized heat storages, including a recently opened cavern heat storage. To some extent, the centralized heat storages weaken the profitability of heat demand response due to their economies of scale.

According to the pilot experiences, the implementation of smart thermostats and piloting the heat demand response functionality was easier in a non-residential building. In residential buildings, an internet connection by the housing company (instead of personal internet connections of the residents) would be needed if the communication of the device is done via internet. This would offer a reliable communication channel for the smart thermostats which is a prerequisite for heat demand response functionality.

Smart thermostats could be suitable for heat demand response if the residential building already has them. However, currently, smart thermostats are still rare, and therefore the solution is not easily scalable. Other technical solutions to implement heat demand response are more promising in residential buildings (such as an integration to the building's automation system).

The Office building pilot showed that an office building can be harnessed for heat demand response so that the rooms of the building will contribute with their own capability. Buildings and premises, especially with known usage schedule, are efficient for heat demand response use.

BENEFITS

For an energy company, heat demand response is one option for optimizing heat production and reaching lower emissions. Since the heat demand response benefits actualise on the system-level, the direct economic incentive for an individual building owner to participate is small, although system-level benefits could reach the customer in the long run. In order to attain the system level benefits (emission reductions, savings in the energy procurement), participation of a sufficient number of customers is crucial. Nevertheless, it seems that the motivation for customers arises from carbon neutrality targets and responsibility, not necessarily from the individual energy savings or economic point of view.

FURTHER DEVELOPMENT

Helen decided to invest in a production optimization system, a real-time extension to existing automation and production planning system. The optimization system enables effective control of heat demand response in the future. The system optimizes the supply water temperature, pressure differences and pumping of the district heating network, and coordinates the power of the heating. A preliminary evaluation project contributed to the decision to invest in the extension to the existing system, but the extension itself was not done under mySMARTLife project.

Currently, in Helsinki, the heat demand response solution is not implemented. However, since the aim is to constantly develop the system and improve optimization as well as efficiency, the aim of the future energy system is to include customer-owned assets (buildings in this case) to the energy system. It is foreseen that the demand response of district heating is to be deployed in the future at least to some extent.

Fourdeg has a pending EU patent about the district heating demand response method. However, as long as the district heating companies are not incentivizing their customers to the demand response, the feature does not have any economic value for Fourdeg. The developed functionality is currently applied to limit peak energy consumption and certain other special heating scheduling.

Salusfin has been able to take the lessons, learned from the project, into account for its roadmap. When one building is working in this way, the company can start thinking about buildings working together. A natural step forward is to study an energy district. The company can investigate how the various energy sources work together or apart, via simulations. The intention would be to find ways to combine different heating systems, such as hybrid solutions, and map down other heat sources that are in use.

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