EnergyLab Nordhavn – Smart Components

Figure 1: Heat is recovered from a supermarket refrigeration system to the local district heating grid in Nordhavn, Copenhagen.

Summary of project

Within the project EnergyLab Nordhavn – Smart Components a heat recovery unit has been integrated into the refrigeration system of a supermarket (Figure 1). The supermarket uses a CO2 refrigeration system. Heat was recovered from the high pressure side of the refrigeration cycle and supplied to the local district heating grid or to the building itself for space heating and domestic hot water preparation. In this way, energy is recovered, synergies between local energy prosumers are unlocked and the available compressor capacity of the supermarket refrigeration system can be exploited better.

It was studied how the supply of cooling to the supermarket and heating to the district heating system could be decoupled by adaption of the gascooler pressure and by addition of an extra air-source evaporator. Simulations showed that these measures would allow to exploit the available compressor power and to increase the flexibility of heating and cooling supply.

Further, the control of the heat recovery system according to dynamic price signals has been demonstrated. It was shown that the implementation of the proposed control structure led to increased heat recovery during periods of low energy prices. Thereby this method could be useful for maximizing the revenue for the supermarket owner by an optimal real-time decision on selling the recovered heat to the district heating grid or self-consumed for space heating and domestic hot water of the supermarket.

The corresponding closed-loop control algorithm was executed in Matlab on a PC at the Technical University of Denmark. The control algorithm decides the optimal operation strategy based on real-time operational data and electricity and district heating prices. The connection to the physical system was realized via the Danfoss cloud that was used to retrieve data to the DTU cloud-based Data Management System (DMS) and to send control commands to the local controller. A sketch of the system is shown in Figure 2.

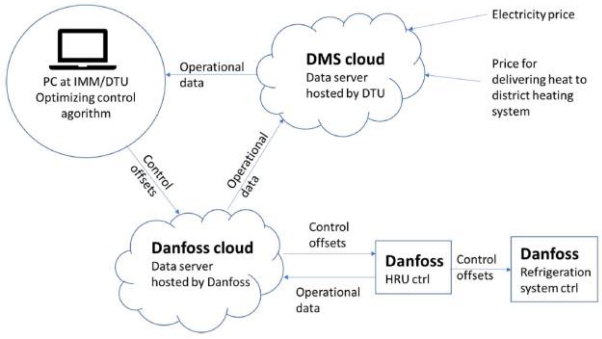

Figure 2: Sketch of the communication framework used for demonstration of the control of the heat recovery unit according to dynamic price signals.

Overall, it was shown how heat from supermarket cooling equipment can be exported to the district heating network, and how this heat export can be controlled in a

smart way based on online data exchange so that the system contributes as decentral peak load capacity for the district heating utility, while generating an additional income to the supermarket system operator.

Learnings and results

-The supply of district heating from the heat recovery unit integrated with the CO2 refrigeration system of the supermarket has been successfully demonstrated by Danfoss.

-Through system simulations, it was shown that the production of cooling for the supermarket appliances and heating to the local district heating grid can be decoupled cost efficiently by adapting the gas cooler pressure or by using an additional air-source evaporator. The first version results in cheaper heat supply cost, especially at lower gas cooler pressures and ambient temperatures. Providing additional heat using an additional air-source evaporator (e.g. part of the gascooler) is more efficient if the evaporation pressure level is independent from the MT cabinet pressure. This solution becomes feasible, when high gascooler pressures are required (due to high ambient temperatures or heat demand internally in the building).

-It was shown how heat from supermarket cooling equipment can be exported to the district heating network, and due to the nature of the CO2 based technology, this heat export can be controlled so that the systems contribute as decentral peak load capacity for the district heating utility, reducing the need for fossil fueled peak load boilers.

-The business case has been investigated (using 2019 prices) and it was found that by selling district heating to the local district heating company HOFOR, a payback time of 3-4 years for the heat recovery system may be achieved. The yearly profit for the supermarket were fund to amount to 11,600 €/year. In case, the supermarket was only to pay for its net heat consumption, the profit would be significantly higher.

-The heat recovery unit has been introduced as a product in combination with CO2 refrigeration systems by Danfoss and the marketing has started. Today solutions are implemented in the control systems that already now enable the possibility to utilize excess heat for district heating or building heating. The products also support the use of spare compressor capacity for providing extra heat. The implementation of these solutions is expected to follow the adaptation of CO2 for supermarkets refrigeration which is expected to increasingly spread globally during the coming 3-4 years – following the legislative requirements for use low GWP (Global Warming Potential) refrigerants.

-A range of data streams and data series have been made available on an online platform supporting secure real-time data sharing between the stakeholders. In this way, a smart energy system encompassing electricity, heat, buildings, transport, and residents can be realized. The

FACTS ABOUT THE PROJECT

IoT Category: Heat as a service
Goal: Unlocking synergies between small-scale excess heat sources and district heating networks
Beneficiary: Supermarket owner, District heating utility
Data required: Operational data, electricity prices, marginal heat generation cost
Analysis method energy engineering, control engineering
Modelling requirements: Simple energy balances, control algorithm
Quality-of-Service: real-time
Project participants: Danfoss - DHS Application Centre, Danfoss Refrigeration and Air-Conditioning, DTU Wind and Energy Systems - Center for Electric Power and Energy, DTU Construct – Section for Thermal Energy
Time schedule: 2016-2020
Technology availability: 9
Link to webpage:
http://www.energylabnordhavn.com/

ability of the system to support real control applications was demonstrated.

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