INVESTIGATION ON SECTOR COUPLING POTENTIALS OF COLD DISTRICT HEATING & COOLING NETWORKS

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1 SUMMARY

In this paper the topic of sector coupling is discussed with a specific focus on utilising extra profits for the operation of cold district heating & cooling (CDHC) networks. In the course of the research project *DeStoSimKaFe*[1] it was investigated, how the heat energy production and the heat capacities of an existing CDHC system can provide flexibilities for power to heat applications. The intention is to take advantage of the benefits of the day ahead pricing of European electricity market or the electricity balancing market of the respective country. Therefor in a first step a previously developed co-simulation tool for large district heating systems was adapted to the specific environment of the existing CDHC system. In a second step the system flexibilities were systematically investigated with respect to heat capacity, response behaviour and electrical energy consumption as a function of thermal comfort in the buildings. So that quality and quantity of the flexibilities provided are known and subsequently can be used to optimise the heat energy retail price for customers in the investigated CDHC network in Zürich, Switzerland.

2 INTRODUCTION

The energy demand of cities worldwide is increasing rapidly hence climate protection in this field must be strongly promoted (United Nations, 2018). For meeting the Paris climate targets, the share of fossil-based energy production must be reduced significantly in combination with further strengthening of energy efficiency measures (United Nations, 2015). Therefor different sources of renewable energy production as well as low exergy waste heat have to become accessible at large numbers in a reasonable economic effort. With its possible synergy effects sector coupling is seen as a key concept to achieve these goals of the energy transition.

A large share of CO_2 emissions and thus potential for climate protection measures lies in the sector of energy supply for buildings (BMVIT, 2018). District heating systems therefor provide great opportunities for sustainable and flexible heat energy supply in the building sector with lowering system temperatures or integrating renewables, thermal storage, heat pumps and smart control.

Newly developed cold district heating & cooling (CDHC) networks provide great possibilities for integrating renewables as well as reusing waste heat sources of different kind (Werner, 2017) (Pellegrini & Bianchini, 2018). Through the smart application of industrial sized heat pumps in combination with the system storage capacities flexibilities are created which can make use of the advantages of the energy day ahead market.

Another important, already well-known contribution to the energy transition is the harvest of solar energy and wind. Yet integrating volatile renewable energy sources like these into the existing electrical power grid depicts a significant challenge to our energy systems. Therefor technical solutions have to be developed in order to provide the necessary system flexibilities. CDHC systems and its sector coupling of power to heat offer abilities to provide respective power grid stabilisation services (Terreros et al., 2019).

Therefor a previously developed co-simulation tool for large district heating systems (Nageler et al., 2019) was redesigned to fit the investigated CDHC network. Subsequently this tool was used to evaluate the flexibility options of the network in its quality and quantity. The goal was to optimise the heat energy retail price for customers in an existing CDHC network in Zürich, Switzerland.

[1] www.destosimkafe.aee-intec.at

3 METHODOLOGY

Adapting the co-simulation tool to the investigated CDHC network

With regard to the special requirements of a grid-bound heating and cooling supply, extensions and adaptations were carried out to fit the existing co-simulation framework to the investigated CDHC network. Different suitable transfer station models containing specific components were developed in IDA ICE, to cover the multiple supply concepts of the network. The concept presented in Figure 1 for example allows, through the use of a hydraulic separator, to feed each thermal zone of the simulated building separately with a heat pump for heating and a heat pump for cooling. The cold district heating network (8-22 °C) operates as source and sink. Also, a bypass possibility was integrated which enables freecooling directly from the CDHC network, if the source temperature allows it.

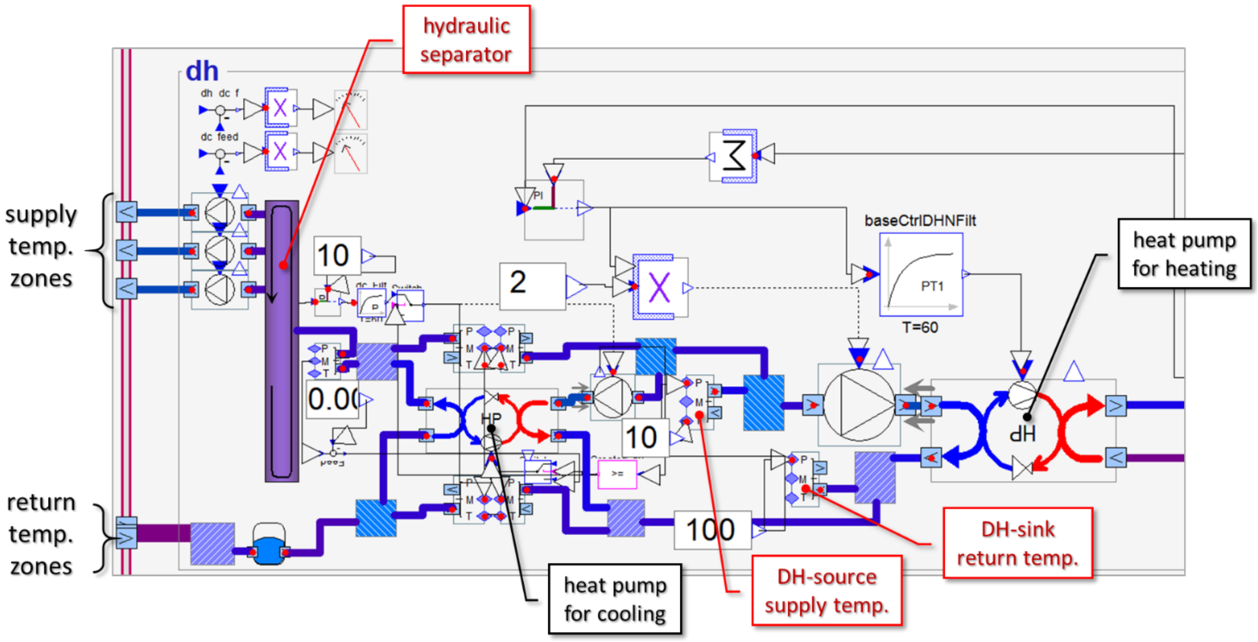

Figure 1: Automatable heating and cooling system for coupling multiple thermal zones with a CDHC supply network including decentralised heat pumps for heating and cooling

Investigating system flexibilities

In the following step the flexibilities of the CDHC network were systematically investigated with respect to heat capacity, response behaviour and electrical energy consumption as a function of thermal comfort in the buildings. So that quality and quantity of the flexibilities provided are known and subsequently can be used to optimise the heat energy retail price for customers in the network.

In the case of the investigated network, the CDHC network is divided in two sections which are linked though transfer station containing large industrial heat pumps. The primary side of the heat pump is connected to the low temperature network including large bore hole storage fields. The secondary side consists mainly of classical district heating networks in different size and shape including the customer buildings. This secondary side is used to determine the flexibilities and can be simplified to one single storage mass. In this mass all thermal capacities are included. Network piping, buildings masses and decentralised hot water storage tanks.

For the state of charge of the thermal mass, lower and upper boundaries of key performance indicators of the network are defined. They consist of the room air temperature and the fanger thermal comfort number and are calculated within the building simulation model of the co-simulation. In order to determine the total network heat capacity and the respective electrical energy consumption, the network is heated up from the discharged state (lower boundary) to the fully charged state (upper boundary). To investigate the network response on load steps through power variations of the heat pumps, different step response tests are carried out. The test will be carried out varying the system boundary conditions like outdoor air temperatures or CDHC system temperatures.

4 REFERENCES

BMVIT (2018). Austrian Climate and Energy Strategy. Mission 2030, Federal Ministry Republic of Austria Sustainability and Tourism, & Federal Ministry Republic of Austria Transport Innovation and Technology, 2018, 1–90. www.bmvit.gv.at

Nageler, P., Heimrath, R., Mach, T., & Hochenauer, C. (2019). Prototype of a simulation framework for georeferenced large-scale dynamic simulations of district energy systems. Applied Energy, 252(May), 113469. https://doi.org/10.1016/j.apenergy.2019.113469

Pellegrini, M., & Bianchini, A. (2018). The innovative concept of cold district heating networks: A literature review. Energies, 11(2), 236. https://doi.org/10.3390/en11010236

United Nations (2015). UN climate change conference Paris. 2015 [online], available on http://www.un.org/sustainabledevelopment/cop21/

United Nations. (2018). World Urbanization Prospects 2018. United Nations, Department of Economic and Social Affairs, Population Division.

Werner, S. (2017). International review of district heating and cooling. Energy, 137, 617–631. https://doi.org/10.1016/j.energy.2017.04.045

Terreros, O., Spreitzhofer, J., Basciotti, D., Esterl, T., Schmidt, R.-R., Natiesta, T., Haslinger, E., Geyer, R., Leoni, P., Leimgruber, F., Kerschbaumer, M., Pober, M., Huber, R., & Ziegler, M. (2019). Sondierung zur Realisierung des Wärmepumpenpooling für städtische Wärmenetze. Berichte Aus Energie- Und Umweltforschung, 50/2019.

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6 CONFERENCE TOPIC

This paper is addressing the topic of ‘Coupling of Energy Sectors’.