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INCREASING FLEXIBILITY IN DISTRICT HEATING SYSTEMS – ELEMENTS AND SOLUTIONS FROM THE THERMAFLEX PROJECT

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SUMMARY

Flexibility in operation and heat sources is an important element of sustainable district heating. Within the demonstration project ThermaFLEX, flexibility concepts were developed. The research and testing focused on the interaction of various components within real district heating networks. We considered and implemented a combination of technical, non-technical, and systemic measures across eight Austrian district heating networks on a large scale. Our efforts led to the development of a diverse range of individual technologies and system solutions aimed at enhancing flexibility and decarbonizing district heating systems. Key elements included heat storage, integration across energy sectors and infrastructures, innovative smart control concepts, widespread adoption of heat pumps, utilization of solar thermal energy, and tapping into locally available heat and waste heat sources. These implemented elements and solutions demonstrate effective utilization and expansion of existing district heat infrastructure.

INTRODUCTION

Currently, district heating (DH) relies heavily on centralized generation, frequently by a limited number of heat-generating plants. Approximately half of this relies on fossil fuels like oil, gas, or coal, with biomass contributing significantly to renewable energy sources. However, for Austria's heat supply infrastructure to transition towards greater reliance on renewable heat, there must be a concerted effort to integrate locally available renewable energy carriers and heat sources. This shift necessitates a move towards increased decentralization within the entire DH sector. As a result, there will be a greater number of generation plants, coupled with the challenge of limited temporal availability and fluctuations in renewable energy sources. This complexity underscores the need for careful planning and management in transitioning towards a more sustainable DH system.

THE FLAGSHIP PROJECT THERMAFLEX

DH systems allow for the integration of renewable energy sources and are highly suitable for measures to increase flexibility and sustainability in terms of renewable supply sources, sector coupling with other infrastructures and local value creation. While DH already plays a large role in the current heat supply in Austria with more than 3,000 operational systems and a share of about 20% of the total heat supply, the share of renewables is only 50% here. Thus, further action is needed to increase this share and to utilize the described benefits, especially with the necessary extension of district heating systems and the phase-out of fossil fuels. To enable the steps for these benefits to be used, system-wide and holistic approaches, as well as scientific methods such as simulation and optimization during conceptualization, implementation and operation, next to innovative technical solutions need to be applied. ThermaFLEX explicitly had the ambitions to tackle the challenges for the implementation of flexible and sustainable DH systems and integration thereof in larger energy supply concepts together with in total 28 partners from research and industry in different demonstration cases and model solutions respectively. A methodology with three different pillars was applied including a) technical measures, b) systemic approaches and c) non-technical measures. Through this intelligent combination and holistic approach, it was possible to a) adapt and further develop existing district heating networks to meet future requirements (e.g., decentralized generation

and storage, load changes, different temperature levels, low summer load with increased heat losses, necessary enlargement, etc.), b) achieve corresponding climate goals, c) establish far-reaching user and stakeholder integration and d) strengthen economic benefits along the value chain.

IMPLEMENTED ELEMENTS AND SOLUTIONS IN REAL-LIFE DISTRICT HEATING SYSTEMS

ThermaFLEX used the linked model solutions to showcase, validate and optimize the developed concepts and used the results and experiences from the implementation and operation to derive Best Practices, highlight promising concepts and pathways and show quantitatively the technical, economic and ecological benefits and impacts of the model solutions and a potential further roll-out. A wide range of different heat sources and flexibility elements were used. The model solutions differ largely in scale, type of challenges addressed and solutions demonstrated. Overall, these experiences are widely applicable for DH systems and can be used as blueprints all over Austria and Europe. In the following, we give a brief overview of these model solutions and highlight their innovative elements:

- High-temperature heat pump: Waste heat utilization from the flue gas condensation of the waste incineration plant as a heat source for a high-temperature heat pump.
- Low-carbon district heating: Use of fluctuating industrial waste heat through bidirectional coupling of two heating networks and development of a high-level predictive control of network and heat generation units.
- Virtual heating plant: Coupling of district heating with the sewage treatment plant in Gleisdorf for heat supply from wastewater and implementation of a novel "virtual heating plant" control system.
- Innovative waste heat utilization at three different demonstration sites: a) Waste heat utilization Therme Wien: utilization of the waste heat available in the thermal water using a heat pump concept and integration into the Vienna district heating system, b) Renewable heat and cooling from wastewater - Wien Kanal: Energy recovery from wastewater for heating and cooling with innovative heat exchanger and heat pump system and c) industrial waste heat utilization: Implementation of an absorption heat pump to increase waste heat utilization at the AustroCel site in Hallein to be fed into the district heating network of Salzburg.
- Modernizing of DH networks: Development of a two-stage modernization concept in Saalfelden. Technical modernization (stage 1) was implemented. A heat pump integration (stage 2) was developed for future integration.
- Large-scale solar thermal integration: Integration of a solar thermal plant of around 5,000 square metres in combination with a 180 cubic metre storage tank into the DH network in Mürzzuschlag.

CONTRIBUTION TO AUSTRIA'S BUSINESS LOCATION

ThermaFLEX utilized a wide range of heat sources and flexibility elements (e.g., heat storage, smart control concepts, large-scale heat pumps). In parallel, highly integrated planning, implementation and operational management processes were applied (e.g. spatial energy planning, life cycle analyses). The measures led to a significant increase in the share of renewable energy as well as to decarbonization and diversification of the respective district heating system. Implementations were realized within the linked model solutions and showcased the great potential of the developed elements and solutions for the decarbonized heat infrastructure in different Austrian cities and regions. Based on monitoring and simulation data climate-neutral heat will be generated in the range between 180 and 200 GWh in future with the realized implementations leading to a substitution of around 45,000 tons of CO_2. Overall, the ThermaFLEX project demonstrated concrete solutions for efficiently using and expanding existing district heating infrastructures. The successful demonstration projects in Styria, Salzburg, and Vienna proved the feasibility of large-scale implementations within relatively short timeframes.

ThermaFLEX is part of the Green Energy Lab, a research initiative for sustainable energy solutions and part of the Austrian innovation programme "Vorzeigeregion Energie" of the Austrian Climate and Energy Fund