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Utilization of Waste Heat from Waste Water in Vienna

Tabea Gruber-Heusequin[a*], Christoph Segalla[a], Lisa Sophie Weginger[a], Mario Wallner[a], Rusbeh Rezania[a]

[a]Wien Energie GmbH, Thomas-Klestil-Platz 14, 1030 Vienna, Austria

Abstract

Austria's goal of full decarbonization by 2040 necessitates a fundamental transformation of its heating sector, which currently consumes approximately 105 TWh of fossil-based energy annually. In Vienna, the shift from individual gas boilers to sustainable heating solutions is central to this strategy, with district heating expected to cover 56% of total heat demand by 2040. To achieve climate neutrality, Wien Energie is diversifying heat sources and integrating innovative technologies, notably large-scale heat pumps and geothermal energy. A flagship initiative is the deployment of one of Europe's most powerful heat pump systems at Vienna's central wastewater treatment plant, the Wien Energie Wastewater Heat Pump (WE WWHP). This facility treats around 200 billion liters of water annually, offering a stable and abundant low-temperature heat source. The heat pump system, powered by renewable electricity from the nearby Freudenau hydroelectric plant, extracts thermal energy from treated wastewater and feeds it into the district heating network. The project's first phase, completed in 2023, supplies climate-neutral heat to 56,000 households, with full capacity expected by 2030 to serve up to 112,000 households and save up to 300,000 tons of CO_2 annually. The initial operational results show that the WE WWHP reliably delivers around 60 MWth of thermal output with a stable COP of 2.9, demonstrating efficient and robust wastewater-based heat production for district heating. This initiative not only advances Vienna's climate goals but also serves as a scalable model for urban heat recovery, demonstrating the feasibility and replicability of wastewater-based district heating systems in metropolitan areas worldwide.

Keywords: large-scale heat pumps; waste water; waste heat; decarbonisation; district heating; renewable energy;

1. Introduction

Austria's commitment to full decarbonization by 2040 requires a radical transformation of the heating sector, which currently accounts for the largest share of fossil-based energy consumption—approximately 105 TWh annually. In Vienna, the transition from individual gas boilers to sustainable heating solutions is a cornerstone of this strategy. District heating will play a central role, with its share expected to rise to 56% of total heat demand by 2040. However, achieving climate neutrality demands a diversification of heat sources and the integration of innovative technologies. Currently, combined heat and power (CHP) plants account for around 52% of district heating production; however, their share is expected to drop to around 13% by 2040. Starting in the 2030s, these plants will increasingly operate on green gas, thereby achieving net-zero emissions by 2040. The share of conventional heating plants will decline significantly, while the share from waste incineration plants will remain constant. To replace the heat generated by CHP and heating plants, geothermal energy and large-scale heat pump technology will play a key role. With these two technologies combined, Wien Energie will be able to produce more than half of Vienna's district heating [1].

Large-scale heat pumps allow the recovery of low-temperature waste heat from sources such as industrial processes, commercial facilities, and municipal infrastructure. Among these, treated wastewater stands out as an exceptionally stable and abundant source. Vienna's single wastewater treatment plant, *ebswien* in

* Corresponding author. Tel.: +43 (664) 88483593
E-mail address: tabea.gruber@wienenergie.at

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Simmering, treats the entire city's wastewater, as well as that of surrounding municipalities and industrial sites. Due to Vienna's combined sewer system, a substantial portion of rainwater also flows into the plant, resulting in the purification of around 200 billion liters of water per year—equivalent to over 21.6 million liters per hour or 144,000 full bathtubs. The *ebswien* was therefore identified as an attractive source for implementation of one of Europe's most powerful large-scale heat pump systems, the Wien Energie Wastewater Heat Pump (WE WWHP).

2. Approach

Implementing a project of this scale requires a combination of technical, infrastructural, and regulatory prerequisites, that can be grouped into three main categories: the heat source, peripheral infrastructure and the regulatory and economic framework.

The foundation of any heat pump system is a reliable and accessible heat source. For the WE WWHP project, treated wastewater provides an ideal solution. Its temperature remains stable between 12°C and 25°C throughout the year, ensuring predictable and efficient performance. In addition to temperature stability, the continuous flow of wastewater guarantees year-round availability, which is essential for consistent heat extraction. Furthermore, the proximity of the wastewater treatment plant to Vienna's district heating network minimizes transmission losses and reduces infrastructure costs, making the source both technically and economically viable.

Beyond the heat source itself, several peripheral components are critical to the success of such projects. First and foremost, heat pumps require significant electrical input. To maintain climate neutrality, Wien Energie sources this electricity from the nearby Freudenau hydroelectric plant, ensuring that the system operates entirely on renewable energy. Another key element is the integration into the existing district heating network, which enables efficient distribution of the upgraded heat to end users. Finally, sufficient land and construction space must be available for the installation of heat pump units, piping systems, and auxiliary equipment. At Simmering, a dedicated building was constructed specifically to house the heat pump facility, highlighting the importance of spatial planning in project execution.

The third pillar of project implementation involves regulatory compliance and financial planning. Wien Energie secured critical agreements and permits, including land lease contracts, energy supply arrangements with the nearby Freudenau hydroelectric plant, and building permits covering both construction and industrial regulations. These steps established the legal and economic framework necessary for project approval and ensured alignment with environmental and safety standards. From an economic perspective, Wien Energie invested approximately €70 million in the first phase of the WE WWHP project, supported by funding from the Federal Ministry for Climate Action, Environment, Energy, Mobility, Innovation and Technology. Comprehensive feasibility studies and environmental assessments provided the basis for project approval, ensuring that technical, financial, and sustainability criteria were met. Given the complexity of the undertaking, Wien Energie adopted a multi-lot approach rather than relying on a single general contractor. This strategy allowed project management to stay within Wien Energie and specialized contractors to manage distinct work packages, including: Heat Pumps, Plant Construction, Electrical Engineering, Construction (BoQ), HVAC (BoQ), General Planner for construction and HVAC, Various individual Trades (Crane, 110kv Transformer, etc.).

3. Results

Upon completion, the heat pump facility will consist of six heat pumps, each with a thermal output of around 18 megawatts per each heat pump. The three units already installed in Simmering were transported from France and each measure roughly 12 meters in length, 9 meters in width, and 7 meters in height, weighing approximately 205 tons. During the major installation phase in 2023, the heat pumps were brought in within 14 days and individual components weighing up to 47 tons were stacked and precisely positioned at their final location. Afterward, the source- and sink-side piping systems, electrical installations, and control system integration were completed at the site. Additionally, a photovoltaic system was installed on the roof of the building constructed specifically for the large-scale heat pump facility. The newly built structure also required the installation of several auxiliary systems, including an emergency refrigerant extraction system, fire detection systems, ventilation systems, overhead cranes, and lighting.

The heat pumps extract approximately 6°C from the treated water. This extracted waste heat is passed through evaporators (heat exchangers), where it is cooled further. A compressor then raises the temperature to the required level for producing hot water. The heat is then transferred to the district heating water via condensers (heat exchangers) (Fig.1).

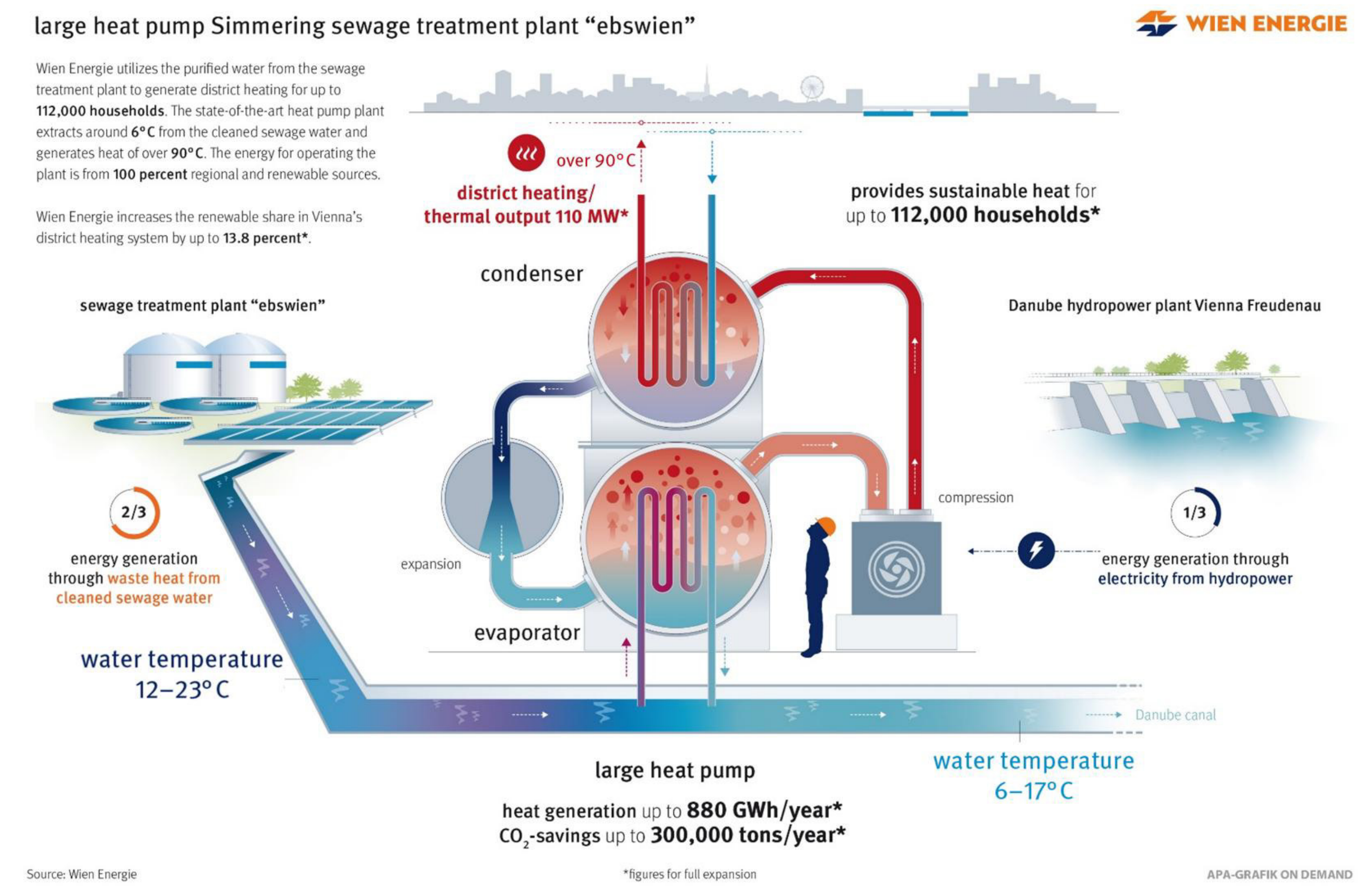

Figure 1. Systemic overview of waste heat recovery through large-scale heat pumps at the *ebswien* sewage treatment plant.

Since the end of 2023, the system supplies climate-neutral district heating to up to 56,000 Viennese households. Once fully operational by 2030, it will be able to serve up to 112,000 households, resulting in CO_2 savings of 150,000 tons per year during the partial operation phase and up to 300,000 tons annually after full completion. The first expansion stage increased the share of renewable district heating in Wien Energie's generation portfolio by approximately 7%, with another 7% expected upon completion of the second expansion stage.

First operational results demonstrate that combining large-scale heat pumps with cleaned sewage water as a heat source provides a reliable and highly efficient solution for district heating production. As can be seen in Figure 2, the three heat pump units collectively supply a stable thermal output of approximately 60 MWth, with individual units reaching up to 20 MWth, thus exceeding the specified capacity. Throughout the observed three-hour period, the system maintains consistent performance. The coefficient of performance (COP), shown by the red curve, is stable at 2,9, confirming that the sewage-water-based heat supply enables efficient heat production.

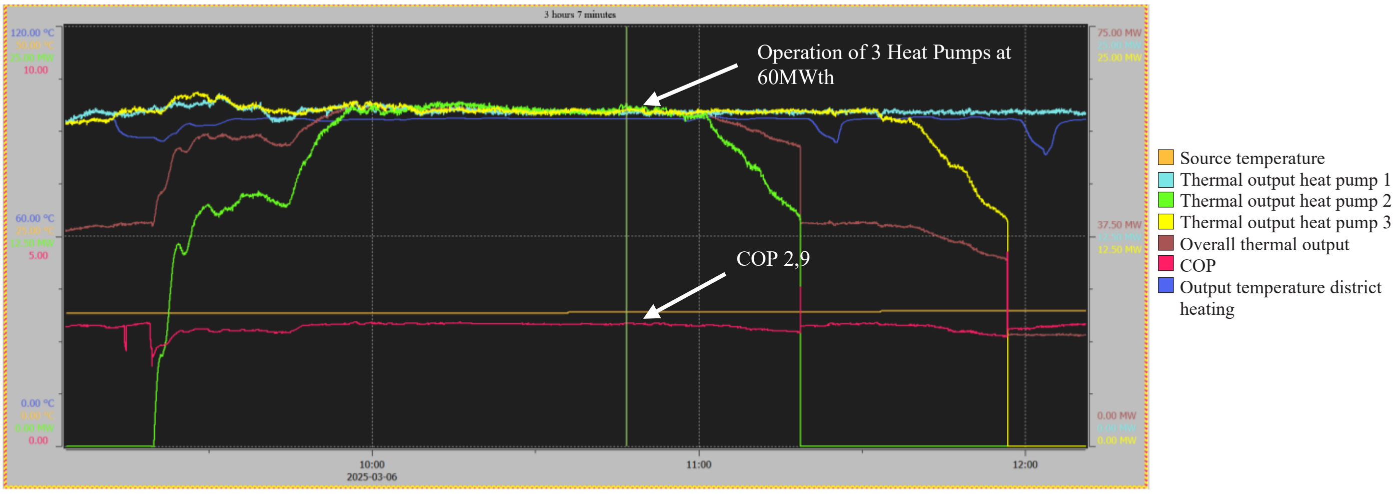

Figure 2. Operational time-series data of the WE WWHP over a period of approximately three hours. The green, light blue and yellow lines represent the thermal output of each unit. The red line represents the overall coefficient of performance (COP).

4. Conclusion

The realization of this project underscores Vienna's commitment to achieving its decarbonization targets by 2040 and sets a clear path toward a climate-neutral future. By leveraging innovative technologies such as large-scale heat pumps, the city ensures that it remains one of the most livable urban environments worldwide. Wien Energie demonstrates that wastewater heat recovery is not only technically feasible but also scalable and replicable. Its success provides a blueprint for other metropolitan areas with centralized wastewater treatment and district heating infrastructure. Adopting similar strategies can accelerate the global transition to climate-neutral energy systems, delivering substantial environmental benefits while supporting sustainable urban development.

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