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Thermal activation of sewers and embedding in a heating-cooling network

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The energy district approach is a crucial aspect of the transition to a more sustainable energy system in heating. This approach views individual users not as separate entities for energy optimization, but as a network of users within a specific district to leverage synergies. This requires an energy generation system that both utilises and distributes the energy resources available in the district. In the future, as a result of climate change, residential buildings as well as workplaces in Central Europe will have to be cooled more frequently. The energy supply system must must have the capability to transfer thermal energy of different levels through the network.

For this purpose, the ´IWAES´ project aims to use the per se necessary infrastructure of urban wastewater management, which is supplemented by thermal absorbers as well as transport pipelines, to meet its objectives.

The overarching goal of the heating network is to make an urban district completely energy self-sufficient. To achieve this, waste heat from individual users is balanced out, thermal surpluses are stored using phase change storage and all available heat and cooling sources in the quarter (borehole heat exchangers, photovoltaics, thermally activated foundation elements) are integrated into the network. In the ´IWAES´ project, the primary thermal energy source and sink is the thermal activation of the wastewater system, which is also used as thermal infrastructure. The thermal utilisation of the sewage network has the advantage that the temperature level of the sewage and the surrounding soil can be used for both heating and cooling.

Figure 1: Hybrid channel with absorbers inside and outside the sewer.

Common geothermal energy sources (borehole heat exchangers etc.) use the thermal energy available in the ground, which is replenished by solar inputs and the deep geothermal flow. The energy sources can therefore only be utilised efficiently for a certain number of hours per year and must then be regenerated either by time-intensive natural heat flows or energy-intensively by extra energy sources (solar thermal, etc.).Wastewater thermal plants regenerate themselves by the constant outflow of wastewater as well

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as through the flowing duct air. Investigations carried out proofed that the air in the sewer flows independently of the direction of the wastewater flow and consequently induces a convective heat transfer between the inner wall of the sewer and the sewer air. The thermally activated sewer, called "hybrid sewer", as designed in the project consists of helical absorber pipes installed outside and optionally additional absorber pipes installed inside. Additional transport pipes attached above the sewer allows a transportation and distribution of heat energy enabling a thermal balance between heat supply and demand and therefore between the individual users of the district (Figure 1).

On the basis of real hybrid sewers installed and equipped with measurement technology, the performance of the hybrid sewers can be further investigated by means of three-dimensional hydrothermally coupled simulations and transferred into a simplified design approach. Furthermore, the material and operating parameters that have a decisive influence on the thermal performance of the activated sewer are investigated and the extent to which the geometry can be optimised with regard to performance and economic, manufacturing and ecological issues.In the ´IWAES´ project, the hybrid sewer is integrated into a specially developed multi-stage balancing concept, which is based on the principle of energetic subsidiarity and thus represents an innovative possibility for local heat and cold generation [1]. The concept represents a fifth-generation heat network [2], so that every consumer can also be a producer of thermal energy at the same time and is connected to the thermal network via a bidirectional acting house connection. The focus of this contribution is on the presentation of the developed technical components and the thermal activation of the sewers as well as their performance.

Initial studies showed that up to 15 % of the thermal energy demand of an urban district can be obtained from the thermal energy of the wastewater alone. Furthermore, it has been shown that the thermal energy generated by the hybrid canal can be used efficiently for both heating and cooling, and that higher extraction rates can be achieved over a longer time than with conventional geothermal extraction systems. It was also found that the efficiency of the heating network increases significantly with the number of different types of use (server rooms, swimming pools, etc.) and differential energy sources. Furthermore economic and ecological studies have also shown that the developed concept is clearly advantageous compared to conventional thermal supply concepts.

The research that is now pending represents the validation of the developed concept on the basis of real laid and measurement-equipped hybrid ducts. In addition, a functional, economic and legally permissible operating model will be investigated.

Data Availability Statement

The measured and used data are available from the authors on request.

Contributor statement

Conceptualisation: Till Kugler; Data Curation and Formal Analysis: Till Kugler; Investigation: Till Kugler; Supervision, Project Administration: Christian Moormann; Resources and Visualtisation: Till Kugler; Writing Original Draft: Till Kugler; Writind – Review & Editing: Christian Moormann, Till Kugler

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