EuroSun2026

SOLAR DISTRICT HEATING NETWORK WITHOUT BIOMASS: SUPPLYING HEAT TO A RURAL VILLAGE

Summary

Decarbonizing the heat supply of existing residential buildings remains one of the key challenges of the energy transition in Germany and across Europe. In rural settlements with predominantly single-family homes, the transformation of individual heating systems is often very slow due to low renovation rates and high investment costs. Here, solar district heating networks with seasonal thermal energy storage offer a promising pathway for achieving high shares of renewable heat while maintaining economic feasibility. This paper presents the innovative solar district heating project under construction in Rüdigheim (Hesse, Germany), designed to supply around 100 households with 2.3 GWh/a climate-neutral heat via a approx. 5 km heating network. The system combines a large-scale solar thermal collector field (approx. 5.500 m²) with a seasonal storage (TTES 17,400 m³) and an internal heat pump to maximize storage capacity and system efficiency. The system aims to achieve an exceptionally high solar fraction of approximately 87 %, making it one of the highest solar shares implemented in a district heating system worldwide.

Keywords: solar district heating, seasonal thermal energy storage, rural heat transition, renewable heat

Field of application for the findings: Renewable district heating systems, rural energy systems

Addressed audience: Researchers, planners, municipalities, utilities, and policy makers

1. Introduction and current heat supply

Heating (and cooling) of buildings represent one of the largest sources of greenhouse gas emissions in Europe, causing millions of tons of CO_2 emissions per year in Germany alone with space heating accounting for the largest share. Despite increasing efforts to improve building efficiency, renovation rates in the existing building stock remain relatively low, in Germany actually about 0,7 %/a, making it unlikely that deep renovations alone will achieve climate neutrality in the required timeframe. This is especially true for rural areas, where the costs for renovations are high compared to the respective building values.

District heating systems based on renewable energy sources offer a promising alternative. By centralizing heat generation and integrating large-scale renewable heat sources, such systems can achieve high efficiencies and reduce overall system costs. In particular, solar district heating combined with seasonal thermal energy storage has proven capable of achieving very high renewable heat shares.

The village of Amöneburg-Rüdigheim in Hesse, Germany, represents a typical rural settlement with predominantly existing residential buildings currently heated by individual fossil fuel-based systems, see Figure 1. More than 90 % of the houses were built before 1980 and a large share of about 36 % are half-timbered houses, which are particularly difficult to renovate.

Rüdigheim aims to connect 100 buildings to the new DHN, achieving a connection rate of approximately 80 %. The overall demand for space heating and domestic hot water preparation is estimated at 2.3 GWh/a (without network distribution and seasonal storage losses).

The solar district heating network under construction aims to replace the decentral fossil systems with a largely solar-based heat supply, enabling a direct pathway toward climate-neutral heating for the majority of buildings in the village.

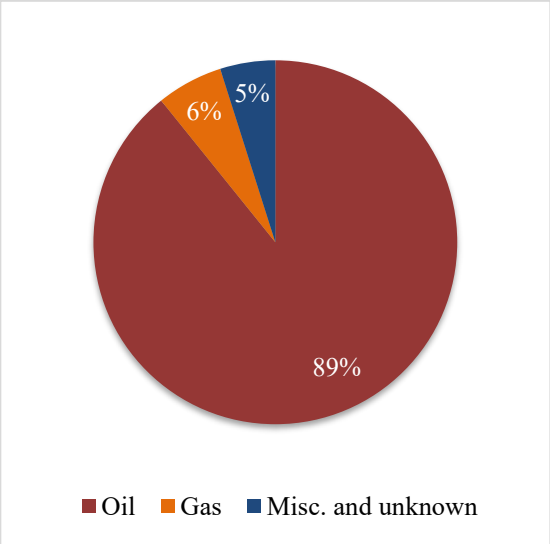

Fig. 1: Current structure of heat supply in Amöneburg-Rüdigheim

2. Innovative solar district heating network

2.1 Concept and solar fraction

The solar district heating concept in Rüdigheim is designed as a highly innovative, solar-based heat supply system combining three main components, see figure 2. The only heat source is a large solar thermal collector field with approximately 5.500 m² (gross collector area). Originally the collector field was planned to integrate both, flat plate collectors and evacuated tube collectors in order to maximize efficiency and achieve higher operating temperatures. However, the current planning status only consists of evacuated tube collectors. The generated solar heat is either directly used or stored in a large above-ground seasonal thermal energy storage steel tank with a volume of 17,400 m³. This seasonal storage allows excess heat produced during summer months to be stored and used during the heating season in autumn and winter, therewith enabling the high solar fraction of the system.

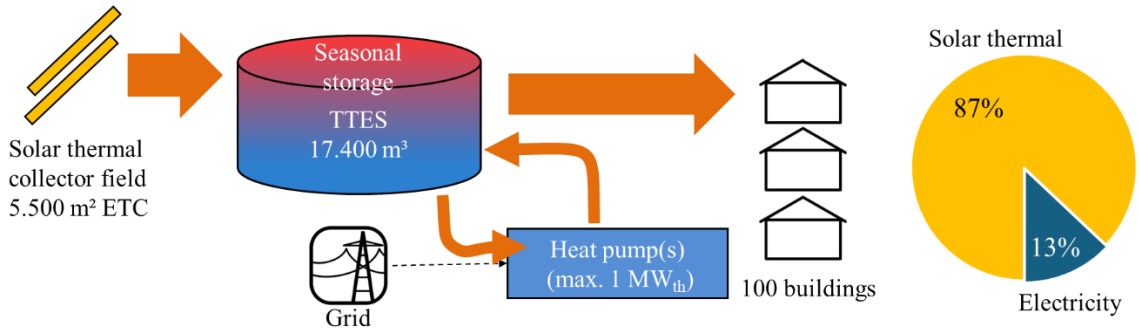

Fig. 2: Innovative solar district heating network planned for Amöneburg-Rüdigheim, fractions based on total energy production (incl. storage and distillation losses).

To further enhance system efficiency and storage capacity, an internal heat pump is integrated into the system. The heat pump uses the lower storage temperatures as a heat source and provides heat on the designed net flow temperature to the upper storage. This integration increases the storage capacity and improves overall system performance, since the solar thermal system also benefits from low return temperatures.

Heat is distributed to approximately 100 households through a district heating network with a length of roughly 5 km. The overall system is designed to supply around 87 % of the annual heat demand from solar energy, with the remaining share covered by grid electricity to operate the heat pump. This exceptionally high solar fraction makes the project probably the most ambitious solar district heating system in moderate latitudes.

2.2 Current status and next steps

The Rüdigheim solar district heating project is currently transitioning into the construction phase. Following detailed planning and feasibility studies, the project has received funding support within regional and European funding programs for energy transition. Construction of the district heating infrastructure and the central energy system components is planned in stages, starting with the seasonal storage, followed by the large collector field. The construction of the storage foundation started in 10/2025, currently the seasonal storage base plate is being built (03/2026), see figure 3.

Fig. 3: Current (March 2026) status of construction – storage base plate (top) and top cover (bottom) construction

3. Outlook and presentation

The contribution will present the technical concept, design considerations, and implementation status of the Rüdigheim solar district heating system. Particular emphasis will be placed on the innovative system configuration enabling the exceptionally high solar fraction in a rural district heating network.

Furthermore, the paper will discuss the expected operational performance of the system and its role as a potential blueprint for the decarbonization of rural settlements with similar building structures. Lessons learned from the planning and implementation phases will be highlighted to support the replication of comparable projects. The presentation will also compare the Rüdigheim project with other successful solar district heating initiatives, such as the system implemented in Bracht, illustrating how such projects can contribute to accelerating the heat transition in rural areas.

4. Declaration of Generative AI and AI-assisted technologies

During the preparation of this work the authors used “ChatGPT” and “DeepL-Write” for creating a first draft and in order to check grammar and improve readability of the text. After using these tools, the authors reviewed and edited the content as needed and take full responsibility for the content.