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Energy performance of decentralized solar thermal feed-in to district heating networks

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Abstract

Many papers have been written over the last years addressing the potential of decentralized solar thermal systems in District Heating Networks (DHN), assuming that the network can be used as a virtual storage so that prosumers can release excess solar energy into the network and use it later when it is needed.
When looking at the district heating systems in detail, many questions still remain unanswered. Is it possible to feed in all the surplus solar energy into the net? How does the solar input affect the network and the other prosumers? Is it sensible from the energy balance perspective? We have studied an existing DHN in an attempt to answer these questions.
A simulation model of the DHN in the Southern German city quarter Ludwigsburg-Sonnenberg was developed and extended to include decentralized feed-in of heat from solar thermal collectors to evaluate their potential contribution to network demands. It could be shown that prosumers supply during summer period significantly more heat than they demand, so that the thermal network could operate as an autonomous micro-grid.
By comparing the amount of electrical pumping energy that is needed to feed heat to the DHN with usable solar thermal energy, the benefit ratio of feeding heat into the DHN can be quantified.

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Keywords: District heating; distributed solar generation; solar thermal; prosumer; excess heat

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1. Introduction

The present paper forms part of a larger research project investigating the intelligent management of an existing heating network.

The main objective of this project is the simulation of the integration of distributed renewable heat sources in the existing district heating network of Ludwigsburg-Sonnenberg and its extensions.

Among other possibilities contemplated within the project, this paper studies the integration of distributed solar heat generation and local storage in the new branch of the DHN, which will be built to feed a planned extension of the district (shaded area in Fig. 1).

The new buildings to be constructed will become prosumers as they will be able to "consume" energy from the net as well as "produce" renewable energy for self-consumption or feeding into the net thanks to a solar thermal

Fig. 1. Urban structure planning Grünbühl/ Sonnenberg with a city extension to the South West (Source: City of Ludwigsburg)

system.

The term "prosumer" is already used in the power sector [1],[12], and in recent years, starts to be also used in the thermal energy sector [2],[3],[9],[10],[11],[16], although we do acknowledge that this terminology is incompatible with the first law of thermodynamics.

2. Background

Some papers have been written over the last years addressing the potential of decentralized energy systems in DHN as well as some of the possible technical problems that this connection could provoke.

Excess energy has first been discussed for the industrial sector in terms of the thermal energy contribution to DHN [13],[17].

More recently the concept has been extended to the residential sector.

An interesting overview of the state of the art includes distributed solar energy in DHN in combination with seasonal storage or using heat pumps [9]. The influence of excess heat production with seasonal storage has also been analysed [14].

Others investigate the benefits of local thermal storage for direct utilisation of heat from solar collectors in a dwelling connected to a DHN, but with no injection into the net [7]; or connected and using the net as a virtual storage system [2].

The impacts of feed-in to the net have also been studied, in particular how the temperatures, pressure or flow rates and velocities can be affected by the introduction of small scale prosumers into the DHN [9].

But these past studies tend to treat the network as an ideal storage facility without constrains on capacity or dynamics, so that prosumers can release excess solar energy into the network and use it later when it is needed [2],[3],[7],[14]. This idealisation may lead to optimistic results especially for the warm seasons.