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Integration of solar thermal systems into existing district heating systems

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Abstract

Modern district heating (DH) networks are usually operated with a changing flow temperature to cover the heat load of the supply area, depending on the outside temperature. Due to the minimum temperature requirements of individual customers, DH networks also need to operate during the summer months. During this time, the load on the system is relatively low. This requires combustion facilities to operate on low load levels as well. These systems have a potential of improving the energy efficiency by utilizing other energy sources such as waste heat from industrial processes or solar thermal systems. The overall aim of the presented work is to provide a new methodology for the integration of solar heat into existing DH systems.
The feasibility of including solar thermal systems in existing DH networks will be analyzed, based on the state of the art of solar DH. The main focus will be on large DH systems that are mainly supplied by fossil fuel powered combined heat and power (CHP) plants considering how such plants can be operated in the future. In this paper, characteristic technical and ecological key performance indicators of a transformed DH system will be displayed.
The work was carried out based on real data of an example DH network in Germany. It was analyzed how a sub-network of a system can be supplied during the summer season by a solar thermal system as far as possible independently from the main-network without using a back-up boiler system. The favored solution in this article is to use a thermal storage that can be recharged once a day by a central CHP plant.

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Keywords: District heating; Solar district heating; Solar thermal systems; Distributed renewable system; Solar field

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1. Introduction

The integration of solar thermal systems in DH systems is a more and more common practice in some countries; however, few studies have been performed on methodologies and benefits of integrating solar thermal systems in DH systems that are mainly supplied by large scale CHP plants with low heat generation costs.

The general idea behind including solar collector fields in DH networks is to lower or even completely supply the low heat demand of a DH network during the summer months. Since the 1980s Denmark and Sweden have built many solar heating plants [1]. In some of these cases a seasonal storage is used to provide a solar fraction even above 50 % of the total system demand. The high taxation of primary energy sources supported the ambitions in Denmark that lead to seasonal storages which are only feasible in a very large scale [2]. In comparison to the Danish and Swedish developments solar DH systems in Germany started to be built later, at the beginning of the 1990s.

The large DH systems in Germany are generally supplied by large CHP plants. These plants are often operating as base load power producers and can supply heat and electricity at a cost-efficient level during summer and winter due to funding through the CHP production law (KWKG) [3]. In addition to the availability of low-cost heat, high and very high system temperatures in the DH systems also prevented solar heat generating systems [4]. In the case of the DH system Chemnitz, only a large change in the system structure in one district made a change feasible. Possibilities of including solar collector systems in existing DH networks that are not about to change radically and are using large scale CHP plants as a main heat source were rarely analyzed. Despite of the higher specific generation costs a solar collector field can also bring several advantages to systems of the mentioned kind.

This paper presents aspects where a solar collector field can be beneficial for a DH system based on a large-scale CHP plant and how such a collector field can be included. The work was carried out by evaluating the load pattern of a part of an existing DH system in Germany.

In the given case, the system analyze was based on the following conditions:

- A fixed supply temperature in a connected sub-network that is not needed in the whole system
- A long connection pipeline between the main network plant and the connected sub-network
- A reduction of the primary energy factor (PEF)
- A reduction in CO_2 emissions

Considering the interests of the network owner, different methodologies of including a solar collector field were developed. In the given case, a solution without a local backup boiler is preferred; instead a daily reheat of a storage from the large CHP plant was suggested.

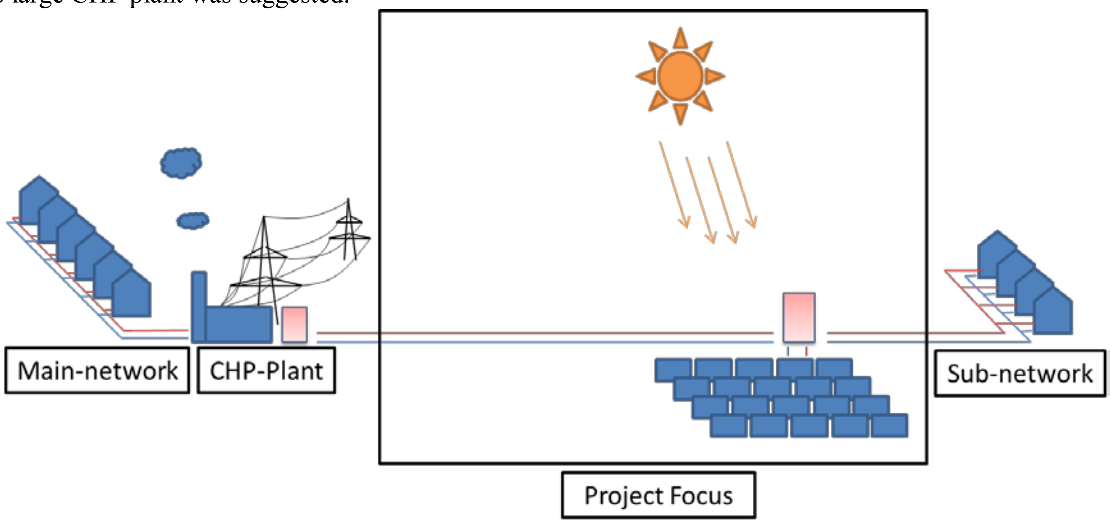

Figure 1. Project focus: The solar thermal field and the thermal storage are located between main-network and sub-network