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Optimal connection of heat pump and solar buffer storage under different boundary conditions

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Abstract

The paper presents the results of a simulation study, in which the connection of heat pumps and buffer storage tanks has been investigated. The simulations are carried out for a new type of a solar thermal combi system with a 32 m² collector field leading to a solar fraction of more than 50 %. In the first stage, the most influencing installation and operation parameters have been identified and optimized for typical boundary conditions of weather/climate, hot water demand, building and space heating system. Within further simulations these boundary conditions are varied to find generalized design rules for the connection of heat pumps and storage tanks. These results are presented and discussed.

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Keywords: Heat pump; buffer storage; boundary conditions; solar active house; system simulation; solar fraction

1. Introduction

Heat pumps have a significant and increasing share in the European heating market, e.g. in Germany 9 % of the heat generators in buildings installed in 2014 have been heat pumps [1]. In most applications, especially in space heating systems equipped with thermostatic valves, heat pumps are operated with a storage tank. The design of the storage and its connection to the heat pump has a significant influence on the performance of the heat pump and the whole system, see e.g. [2].

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Within a comprehensive investigation, system simulations in TRNSYS are used to identify the optimum design of the connection between a heat pump and a solar buffer storage including total storage volume, number and size of heated zones, sensor and in- and outlet positions. These parameters are investigated within a new developed heat supply concept for solar active houses with a solar thermal fraction of more than 50 %. The solar heat is either used in thermally activated concrete elements or within a buffer storage which distributes its heat to the space heating circuit and the domestic hot water preparation. In addition, a heat pump charges the buffer storage in order to cover the remaining heat demand. Within the present investigation the system serves as a back-ground for the analysis of the connection of heat pump and storage tank. Fig. 1 (left) shows a layout scheme of the concept while a detailed system description and an analysis with a focus on the solar thermal performance is published in [3].

It has to be noted that the investigation covers non-modulating heat pumps, that means the heat pump only operates in on-/off mode and is not able to heat the fluid to a set temperature. Especially in the case of air as heat source, several heat pumps on the market are modulating. This changes the operation characteristics of the heat pump drastically and also affects the connection to a buffer storage. Therefore, the investigation results presented here are only valid for non-modulating heat pumps. Nonetheless, non-modulating ground source heat pumps have a significant market at the moment with efficiencies usually higher than air-source heat pumps.

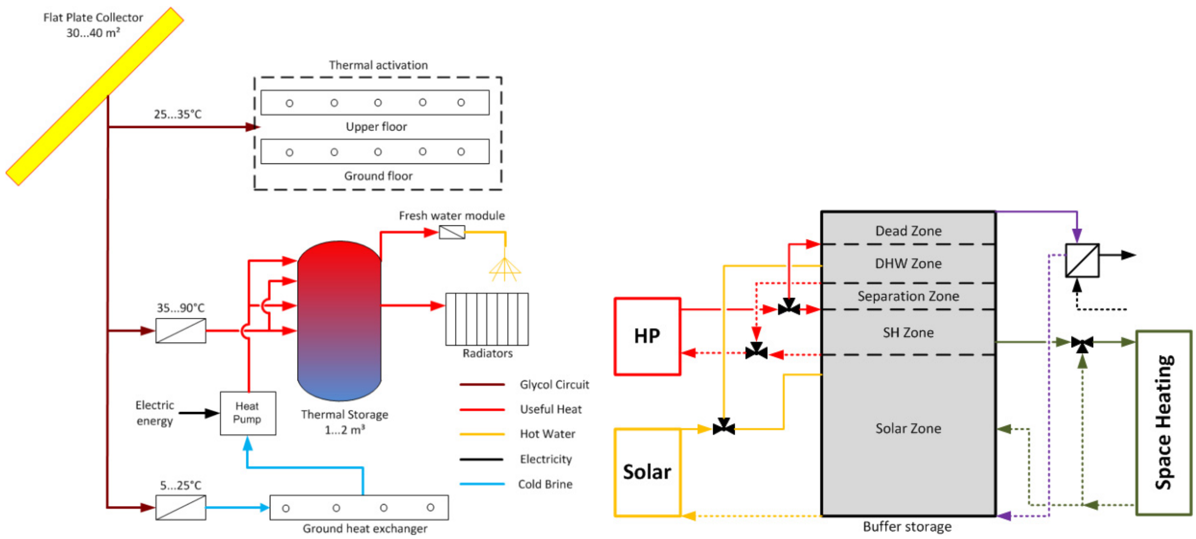

Fig. 1. Left: Scheme of the solar thermal heating system for the investigation (the lines indicate energy flows), right: Scheme of buffer storage with two heated zones and its connections to heat pump, solar thermal collectors and heat sinks

Nomenclature

BHE	Borehole heat exchanger
DHW	Domestic hot water
HP	Heat pump
Rad	Radiator
SH	Space heating
SPF	Seasonal performance factor