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Simulation and evaluation of solar thermal combi systems with direct integration of solar heat into the space heating loop

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Abstract

Usually, solar heat in combi systems is used via a buffer storage. In contrast to that, the solar collectors may be connected directly to the space heating circuit in order to store the heat in the building itself. Such a direct solar integration is investigated within system simulations for different layouts and heating elements. The simulations show significant reductions in the final energy demand as well as an increasing solar yield due to less thermal losses of the storage tank compared to the usual solution with one buffer storage. A prototype of one of the investigated heating concepts within a single family house proofs the functionality of the system concept and the high solar yield, particularly at low radiation levels. Since only a few manufacturers provide such system solutions with a direct solar integration, the results may have an important impact on the future development of combi systems.

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Keywords: System simulation; solar thermal combi system; direct integration; heat pump; buffer storage; floor heating;thermal activation

1. Introduction

Within solar thermal combi systems the solar heat is usually utilized via a buffer storage, see e.g. [1]. Such a storage has the advantage that the solar heat may be stored for periods without or insufficient irradiation, respectively. However, the solar yield and its effect on the end energy savings is reduced due to the necessarily higher collector temperature and the thermal losses of the storage tank. Alternatively, the solar heat may be used directly within the space heating loop. In the context of an on-going project a system with such a direct integration was developed for a

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building with a solar fraction above 50 %, where the solar heat may be used directly within a thermal activation of the concrete floor slabs. System simulations according to [2] and measured results of a test house reveal the functionality and high performance of this system. Based on this concept advanced system layouts are developed differing in the type of solar integration and the heat distribution elements. All these concepts are investigated and evaluated within a comprehensive simulation study.

Nomenclature

C	Collector
FH	Floor heating
f_{Sol}	Solar fraction
HP	Heat pump
Q	Heat amount (kWh)
Rad	Radiator
TA	Thermal activation

2. System concepts

System simulations are carried out to analyze and evaluate several solar thermal combi systems. Within these concepts the solar heat is distributed via a buffer storage and/or directly to the heat distribution elements. Integrated into a full system layout such "direct systems" are analyzed within the simulation environment TRNSYS 17 [3]. As a reference, typical combisystems with only one buffer tank are considered (named "buffer system"). Both systems may be equipped with different heat distribution elements – radiators, floor heating or thermal activation of concrete elements. The investigation also includes the aforementioned solar active house concept with a combination of two types of heating elements, a thermal activation directly heated by the solar thermal collector and radiators solely heated by the auxiliary heater via the buffer storage (named Rad + TA). All systems are shown in Fig. 1.

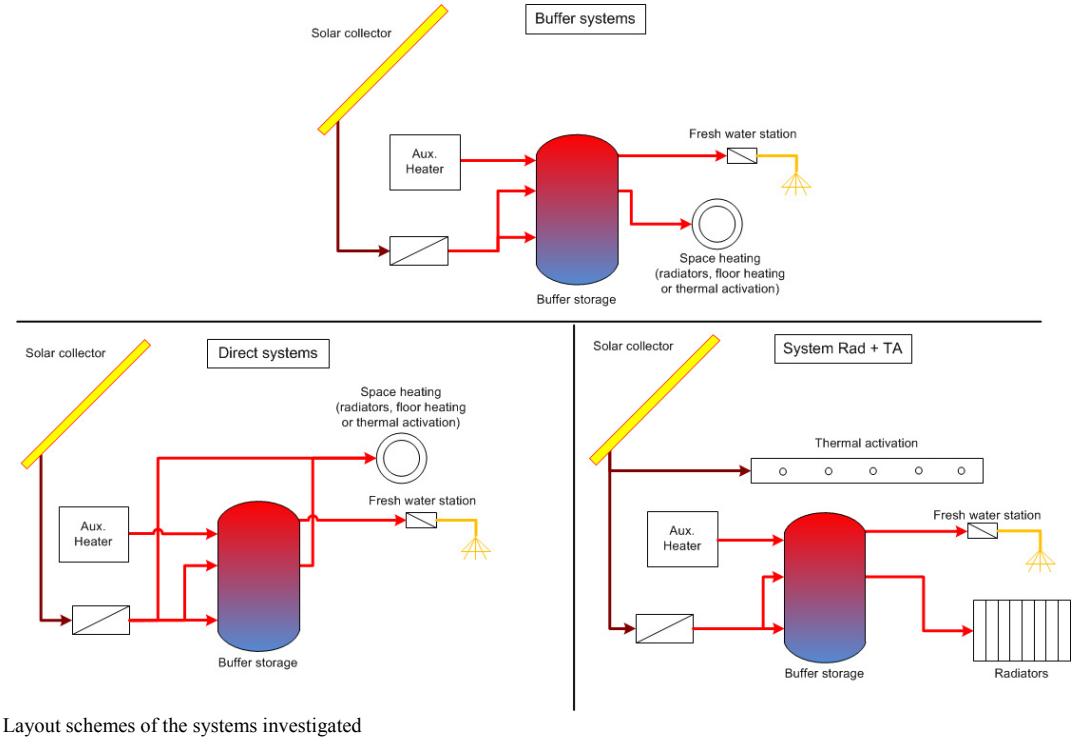

Fig. 1. Layout schemes of the systems investigated