Available online at www.sciencedirect.com

ScienceDirect

Energy Procedia 48 (2014) 598 – 607

Energy Procedia

SHC 2013, International Conference on Solar Heating and Cooling for Buildings and Industry
September 23-25, 2013, Freiburg, Germany

Evaluation of combined solar thermal heat pump systems using dynamic system simulations

Werner Lerch[a], Andreas Heinz[a], Richard Heimrath[a]

[a]*Graz University of Technology, Institute of Thermal Engineering, Inffeldgasse 25/B, 8010 Graz, Austria*

Abstract

This paper presents results from the national Austrian project "Highly efficient combinations of solar thermal and heat pump systems (SolPumpEff)". In this project different combinations of solar energy and heat pump systems are considered through dynamic system simulations in TRNSYS [1]. In such systems solar thermal energy can be used on one hand directly to charge the buffer storage and on the other hand as heat source for the evaporator of the heat pump (HP). In this work systems, in which solar heat is only used directly (parallel operation of solar and HP) and systems using the collectors also as a heat source for the HP are analysed and compared to conventional air HP systems. With a combined parallel solar thermal HP system the system performance compared to a conventional HP system can be significantly increased. Unglazed selectively coated collectors as source for the HP have the advantage, that the collector can be used as an air heat exchanger. If solar radiation is available and the collector is used as source for the HP, higher temperatures at the evaporator of the HP can be achieved than with a conventional air HP system.

Selection and peer review by the scientific conference committee of SHC 2013 under responsibility of PSE AG

Keywords: solar heat pump; solar, heat pump; low energy buildings;

1. Introduction

In Austria and also in other European countries several companies have developed solar air HP systems. In most of these systems solar energy is not only used to charge a buffer storage (parallel system) but also as heat source for the evaporator of a HP. In some configurations unglazed collectors are used as a heat source [14]. In the IEA SHC Task44 (www.iea-shc.org/task44) the performance and relevance of combined systems using solar thermal and heat pumps are evaluated, a common definition of the performance of such systems and contributions to a successful market penetration of this new promising combination of renewable technologies is provided [6]. In the Task more than 100 systems from participating countries were surveyed during 2010 and 2011. The results of the survey

1876-6102
Selection and peer review by the scientific conference committee of SHC 2013 under responsibility of PSE AG
doi:10.1016/j.egypro.2014.02.070

showed that 70 % of systems were found to be parallel solutions, 7 % serial systems, 21 % complex systems and very few regenerative solutions. The number of air and ground source systems were about in the same range and some systems were operated only with solar collectors as source for the evaporator and many in several modes of operation [6].

2. Solar thermal and heat pump systems

In this paper different heating systems are analysed and compared through dynamic system simulations in TRNSYS. On the one hand a conventional air HP system with and without solar thermal system with covered selectively coated collectors (parallel system) is considered in the project, and on the other hand serial solar air HP systems with covered and uncovered selectively coated collectors have been defined and evaluated. Additionally a system with ice storage has been considered.

2.1. System A

Figure 1 shows the hydraulic layout of System A, which is an air HP system without any solar thermal system. The HP provides heat to the buffer storage but also directly to the heating system of the building. The buffer storage is divided into a domestic hot water (DHW) and a space heating (SH) volume. As backup an electrical heater is placed in the buffer storage (space heat volume), which provides heat at times when the performance of the HP is not sufficient to cover the heating demand. In this system without solar collectors the buffer storage has a volume of 0.3 m³. The domestic hot water (DHW) heating takes place through an external heat exchanger.

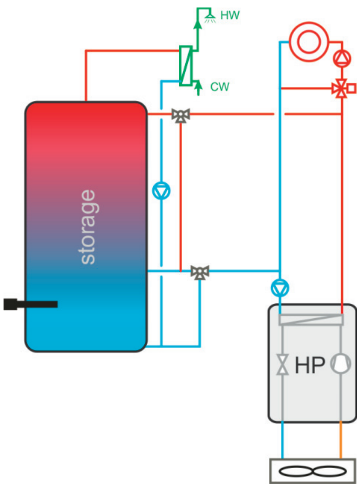

Fig. 1. System A

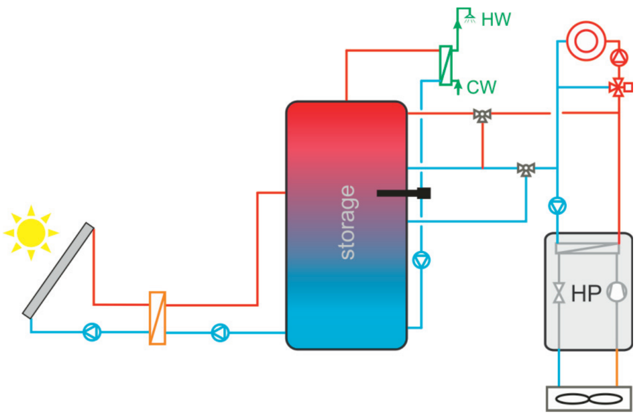

Fig. 2. System B

2.2. System B

The difference between System A and System B is that in System B a solar system is in-stalled in a parallel way. For the solar system covered selectively coated collectors are used. The buffer storage volume is increased to 1 m³. In Figure 2 the integration of the solar thermal system is shown. The solar loop is divided into a brine (solar side) and a water loop (buffer storage), whereby the heat transfer between them takes place via a plate heat exchanger (Figure 2). Solar energy is only used to charge the buffer storage. As a second energy source an air HP system is installed.