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A statistical analysis on market-available solar thermal heat pump systems

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Abstract

During the last years, most various combined solar thermal heat pump systems have entered the market for residential heating and/or domestic hot water generation. In order to determine the suitability of currently developed methods for testing or assessing such systems for present-day solutions, a thorough review and analysis of market-available systems are essential. The basis of the presented analysis is formed by 135 combined solar thermal heat pump systems that were researched and documented from October 2011 till September 2012. They were provided by 88 companies from 11 countries.

The characteristics of solar collectors and heat pumps are broken down at the component level. At the system level, the characterisation is centred on the interaction between solar collectors and heat pump. Here, numerous reviewed systems follow concepts using solar thermal energy as a low-temperature energy source for the heat pump, either additionally or exclusively. It is shown by cross analysis that this feature applies especially to systems incorporating unglazed collectors or photovoltaic-thermal collectors. More findings specific to the combination between collectors and heat pump, to climates or countries are presented as well. This research indicates that many solar thermal heat pump systems differ from standard concepts in various ways. The outcome motivates a holistic approach regarding testing and assessing of such systems.

Keywords: Hybrid system; Heat pump; Solar heat pump; PVT collector

1. Introduction

Numerous combinations of heat pumps and solar thermal collectors, henceforward referred to as *solar thermal heat pump* (STHP) systems, became market-ready over the last few years. It is evident, as shown in Section 3.1, that some systems entered the market even earlier, obviously motivated by the oil crisis around 1979. An explicit and enduring trend developed just in the current century, though. All this background is mirrored by the non-solar heat pump market in Europe (cf. Nowak and Murphy, 2011). It can therefore be said that, qualitatively, STHP combinations were realised as were heat pumps per se.

Regarding testing and assessing STHP systems, existing methods and standards are limited (cf. Section 4). The use of solar thermal energy as a source for heat pumps, for example, is ignored by today's national and international standards. The idea, in contrast, has already been discussed for decades within the scientific community. The first scientific work on this topic – as far as the authors are aware – was presented by Threlkeld in 1953, who tellingly stated:

> Although the developing of solar collector temperatures below normal room temperature would provide a heat source not directly utilizable, it could provide a relatively high-temperature source for the heat pump as compared to some of the usual heat pump sources such as outdoor air and the earth.

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Following this idea, substantial research work was carried out, among others by Freeman et al. (1979), Trinkl (2006), Citherlet et al. (2008) and Kjellson (2009). Since 2010, Task 44 of the *Solar Heating and Cooling Programme* (SHC) of the *International Energy Agency* (IEA) has been organised,[1] simultaneously as Annex 38 of the IEA *Heat Pump Programme* (HPP). The objectives comprise, among other topics, the definition of performance figures and test methods for STHP systems. The precondition for any such work is a review of the market-available systems, investigating the relevance of non-standard components and configurations. Accordingly, the review is required to be:

- conducted on the international, preferably even global level, as there might be regional particularities in design aspects, e.g. caused by climate, tradition or politics,
- comprehensive as possible, i.e. not limited to selected and thus misleading samples, and
- followed by in-depth analyses regarding technical solutions on both component level and system level.

Earlier overviews on STHP systems were provided by Tepe and Rönnelid (2002), Müller et al. (2008), Henning and Miara (2009) and Trojek and Augsten (2009), identifying 5, 13, 19 or 25 systems, respectively. Most recently, the work of Trojek and Augsten was updated and confined to 19 systems by Berner (2011). Due to the fact that neither of these compilations features all of the aspects described above, a new approach was launched within Task 44/Annex 38. The methods and the results are presented in the following sections.

2. Methods

The presented and analysed systems were surveyed between October 2011 and September 2012 by members of 10 research institutions participating in Task 44/Annex 38, listed in the acknowledgements. This means that companies were preferably searched and contacted by native speakers being at the same time proven experts in the field of modern heating technology. Like all activities of Task 44/Annex 38, the market survey and the subsequent analyses are limited to STHP systems that are equipped with electrical-driven compression heat pumps and designed for *domestic hot water* (DHW) preparation and/or residential space heating. Cooling functions are documented as supplementary information only.

In principle, any heat pump can be combined with any solar thermal collector. Therefore, only those companies were taken account of which genuinely provide at least one of the main components, i.e. solar collector, heat pump, storage(s) and/or controller. Research projects were also ignored; gigantic numbers of individual STHP systems would accumulate otherwise.

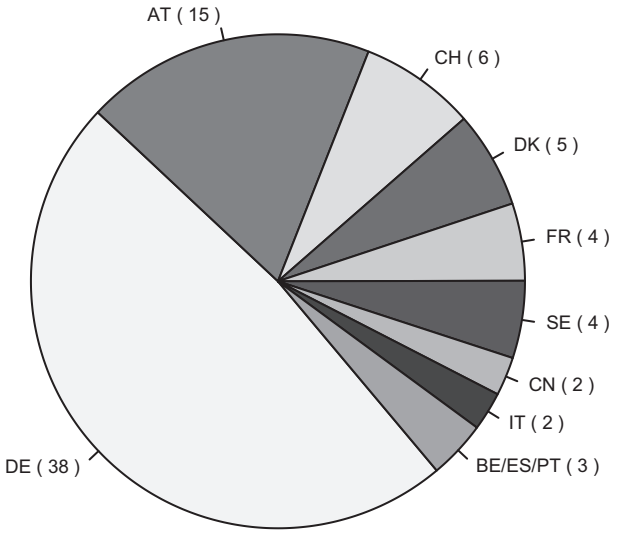

Fig. 1. Surveyed companies by country (country-code labelling according to ISO 3166-1).

To ensure comparability, the characteristics of each STHP system were documented in a harmonised way on two-sided fact sheets, including data on the overall concept, hydraulics, dimensioning and system control, as well as technical specifications mainly of the collector, heat pump and storage(s). Most data were derived from online or print sources, though personal contact to representatives of the companies could be established in most of the cases, enabling interviews. Anyhow, it is clear that the correctness of the retrieved information cannot be checked systematically and independently. Moreover, completeness cannot be claimed. The fact that the majority of identified companies originates from countries[2] officially participating in Task 44/Annex 38 might possibly be explained by the barrier of language, resulting in certain countries erroneously being underrepresented or even unrepresented.

It has to be noted that in the following analyses, all systems are treated equally, i.e., without respecting the number of installations. Respecting the number of installations for each system would certainly lead to quite different results. The data base is incomplete here, but when it comes to market penetration, most conventional approaches – as can be expected – outnumber the less classical configurations. Finally, it is pointed out that, due to imperfect data collection, the sample size is not necessarily constant throughout this paper. From the 88 researched companies, for example, all appear in Fig. 1 but only 60 in Fig. 2. But as all figures are labelled with absolute numbers, the sample size can easily be calculated if desired.

The fact that, in the literature, various specifications are analysed to describe or compare STHP systems is clearly demonstrated by Frank et al. (2010). Depending on the respective interests, independent authors focus on parame-

[1] http://task44.iea-shc.org.

[2] Confer to Fig. 1; all presented countries except of Sweden and China officially participate in Task 44/Annex 38.