IEA HPP ANNEX 38 : SOLAR AND HEAT PUMP SYSTEMS

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Abstract: A new Annex 38 in the Heat Pump Programme of the International Energy Agency started in 2010 and will last until end of 2013. “Solar and heat pump systems” Annex aims at understanding the best combinations of a heat pump and solar collectors for a one family house. The heat pump can be of any type. Several countries participate in this Annex and bring their experience and projects together to get the most of the international collaborative work.

Key Words: heat pumps, solar, combination, optimization, COP, SPF

1 INTRODUCTION

The solar thermal market is expanding since 2000 due to two factors: the near cost effectiveness of solar hot water preparation and the incentives and promotions in place in many European countries.

However reaching 100% solar is still a cost challenge. A good passive house in mid Europe can be almost 100% solar with about 30 m2 of collectors and 10 to 20 m3 of storage. The initial cost can reach 60 to 70’000 € for such a solution and it also needs some space inside the house.

In most cases an auxiliary heating system will be needed.

It has become very popular to heat a house with a heat pump solution due to the promotion undertaken by electrical utilities since a few years and the willingness of consumers not to dependant upon fossil fuels. In some countries electricity is however produced by fossil fuels. More and more customers are thus attracted by a heat pump solution combined with a solar installation at least for domestic hot water preparation.

Manufacturers have started to offer since a couple of years solution combining a heat pump and solar not only for hot water but also for heating purposes. Of course such combinations are more complex and need more control strategies and electronics. Therefore the optimization of the combination is more complex and the cost effectiveness of the combined technologies is not obvious.

Types of heat pumps can be all kinds but the market is clearly oriented towards brine to water in ground coupled heat pumps and comes slowly more and more to air to water heat pumps since their performance, reliability and noise protection have improved over past years.

2 IEA SOLAR HEATING and COOLING and HEAT PUMP PROGRAMME

The International Energy Agency has started the Solar Heating and Cooling programme (SHC) since 1977. It has followed or has lead the development of solar thermal market through a number of cooperative tasks that have confronted many new ideas within international groups of experts. The SHC programme started its 44th Task at the beginning of 2010. The task is called “Solar and heat pump systems”.

The IEA Heat pump programme has decided to jointly initiate the Task with the SHC programme. This gives the Task 44 group an ”annex” status too and a great opportunity to share solar knowledge with Heat pump experts and vice versa.

The group is then called: SHC Task 44 – HPP Annex 38 or T44+A38

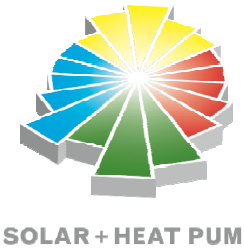

Figure 1: The Annex logo

3 ANNEX 38 SCOPE AND OBJECTIVES

3.1 Scope

The scope of Annex 38, which has begun in 2010, is on the following items:

- Small-scale residential heating and hot water systems that use heat pumps and any type of solar thermal collectors as the main components.
- Systems offered as one product from a system supplier/manufacturer and that are installed by an installer.
- Electrically driven heat pumps, but during the development of performance assessment methods thermally driven heat pumps will not be excluded.
- Market available solutions and advanced solutions (produced during the course of the Task).
- Cooling of buildings is an important topic for south European countries and might be investigated with reversible heat pumps.

To better focus on the current market demand, large scale systems i.e. systems using any type of district network or systems for large buildings are not directly included. They are studied in IEA SHC Task 45 initiated in early 2011.

3.2 Annex 38 organization

Annex 38 is divided into four Subtasks:

- Subtask A: Overview of solutions (existing, new) and generic systems, lead by Sebastian Herkel from Fraunhofer ISE of Stuttgart, Germany

- Subtask B: Performance assessment, lead by Ivan Malenkovic from the Austrian institute of technology (AIT), Vienna
- Subtask C: Modeling and simulation, lead by Michel Haller from the SPF center in Rapperswil Switzerland,
- Subtask D: Dissemination and market support, lead by Wolfram Sparber form the EURAC research center in Bolzano, Italy.

Like all Annexes, Annex 38 meets twice a year during two days where experts report the status and progress of their work and discuss new methods or tools for assessing and optimizing combinations of solar collectors and heat pumps.

3.3 Participants

The following countries have expressed interests in participating in the common work about solar and heat pump systems:
From the SHC committee: Austria, Belgium, Canada, Denmark, France, Germany, Ireland, Italy, Spain, Sweden, Switzerland The Netherlands, USA.
From the HPP committee: Finland, Germany, Switzerland, United Kingdom.

4 SEVEN GENERIC SYSTEMS

They are basically two kinds of systems that can be designed when dealing with two heat producers such as solar collectors and a heat pump, which are depicted in figure 1.

A non integrated solution: basically the heat pump does the heating and also serves as the auxiliary source for the domestic hot water which is mainly provided by the solar loop. The solar energy part can typically deliver 60 to 70% of the hot water needs. The two producers interact only at the level of the hot water tank, the heat pump working with solar just as a gas or fuel boiler would ie as a back up.

A fully integrated system: the heart of the system is still the heat pump but solar energy provides energy to the evaporator side of the heat pump, either through a storage tank or directly, and when possible to the domestic hot water tank and/or to the heating distribution system. It is hoped that on one hand the solar collectors can deliver more energy to the load in this type of combination and on the other hand that the efficiency (the coefficient of performance COP) of the heat pump can be enhanced. The seasonal performance factor (SPF) of the combination would then be greater than just the sum of the two producers if independent.

Annex 38 is working on a map of systems that represents the possible ways of combining solar collectors and a heat pump (figure 2). Theses combinations have pros and cons that will be analyzed by the group. They will also be compared with a common framework that the Annex will issue based on previous work in IEA projects such as SHC Task 26 in solar combisystems and Task 32 on heat storage.

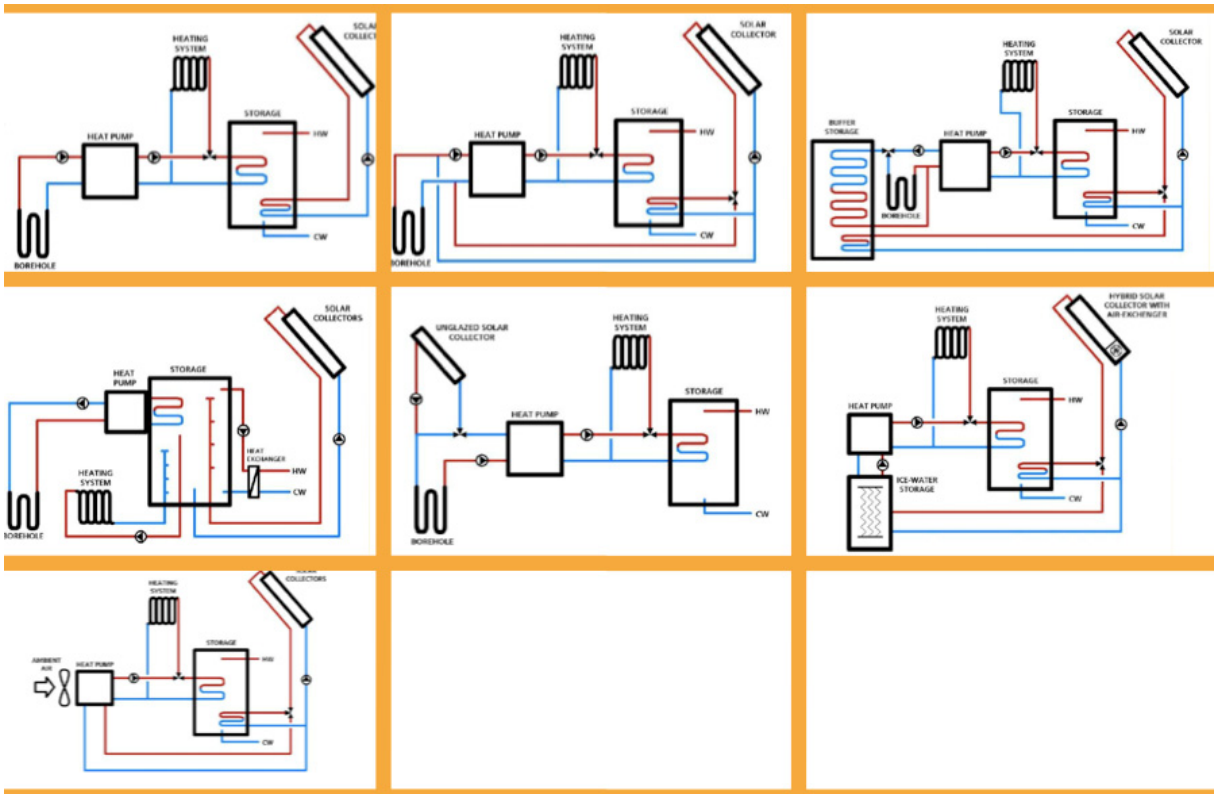

Figure 2: the seven generic systems identified by Task 44 – Annex 38 (source: Herkel 2010)

There are probably more combinations than those seven, but they will bring slight differences that can bring very little energy performances according to our current knowledge. Annex 38 will bring more insight on this question.

5 THE "SQUARE LAYOUT": A NEW WAY TO DESCRIBE A SYSTEM

Subtask A of T44+A38 has developed in the course of 2010 a new way to describe a project. The goal was to simplify the access to the understanding of a configuration of solar collectors with a heat pump and eventually a storage or several storage tanks.

This new way can be called the "square layout" and allows to rapidly understand the scope of a combination Solar + heat pump, without having to dive into the details of a schematics (figure 3).

A letter convention has also been derived and adopted during 2010 (figure 4). Describing a system becomes then possible in a non verbose but compact way.

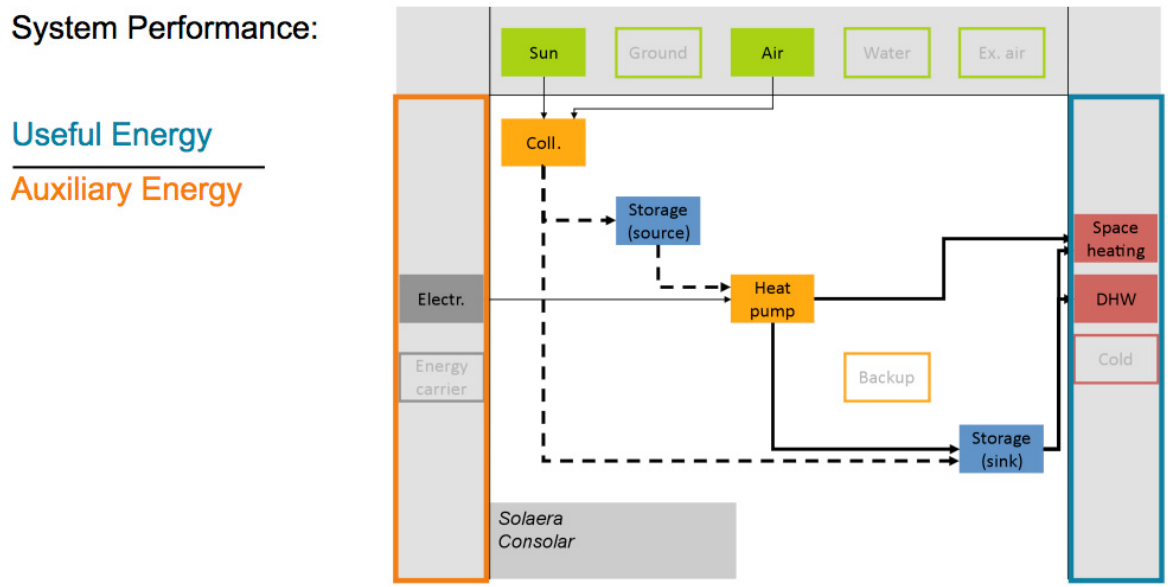

Figure 3: New square layout of a system (the links between boxes can be proportional to the fluxes providing a meaningful Sankey diagram of the system)

Sol, Air srS

srS, skS **SHP** skS, SH

S solar collector	*Air air*	*srS source storage (usually cold)*
HP heat pump	*G ground*	*skS sink storage (usually hot)*
Sol solar irradiation	*W ground water*	*SH space heat (directly)*

Figure 4: Conventional naming of a system. The method gives the clue to both the sources and the sinks of a solar + heat pump system.

6 PROJECTS IN SUBSTASK A

There are about 20 projects in Subtask A that are monitored by each participating teams. The reporting will be done with a common format and using the square layout so that comparison can be eased.

Most of the installations followed will be also simulated with Subtask C framework so that validation of models can be done in a first step and then in a second step sensitivity analysis can be performed to find out the optimal combination, layout or control strategy.

7 COP and SPF IN SUBSTASK B

The objective of this subtask is to reach a common definition on what should be the figures of merits of solar + heat pump systems and how to assess them. This work can lead to prenormative definition on how to test and report the performances of a combined solar and heat pump system.

Subtask B is trying to reach a consensus on definition of COP and SPF when a combined system is considered. The discussion is mainly about setting the boundaries of the system and eventually the primary energy conversion factors. Thee is also some discussion on how to measure key parameters such as the temperature change coefficient for an air heat pump. HPP Annex 28 work is the foundation to go further.

Subtask B gathers five laboratories form Austria, Germany, Italy, Spain, Switzerland to work on laboratory testing and definition of standards.

Common lab testing procedure is also being discussed. Important questions such as how many days should be considered as a representative sequence for a year (12 days such as in solar combisystems or more ?). This needs real testing that will be done over the course of the work (2010-2013).

8 MODELS IN SUBTASK C

Modeling is an important part of the work if we want to generalize the findings on both the field testing and the lab testing. It is the only way to understand if the system under consideration has been designed close to an optimum.

A survey of models for each component of a solar and heat pump systems was done in 2010. Most of the pieces of a system exist but some needs to be assembled together to get to a common tool.

The choice of the platform is also a controversial question. Several systems have been simulated with different packages (matlab/simulink or TRNSYS) but these were done for national or specific project purposes. Annex 38 aims at a common package that will be an international tool for the future as SHC Task 26 did for solar combisystems and Task 32 fpr advanced storage solutions.
Working groups on components have been set up (collector modelling, ground modelling, heat pump dynamic modelling, storage models, boundary conditions, platform independence) and will report on the best component model to pick up. For example, a model of solar collectors that can handle condensation on the surface of the absorber as well as freezing if the heat pump generates it in special winter conditions has to be integrated in the simulation package if we want to understand how important is this energy gain in a solar and heat pump combination.
This question of how much energy comes from solar radiation, air temperature, air humidity and moisture freezing when the collectors are on the evaporator side of the heat pump is not yet adequately addressed in current literature and practice.

9 COMMUNICATION IN SUBTASK D

Subtask D has the task of disseminating the findings. Although most of them will come at the end of the work period (2013), IEA recommends to communicate all along the work so that industry can take out the most of the progresses to incorporate the new information into their designs and products.

During 2010, the website of the Annex was developed within the iea-shc framework. Educational material will be put progressively on the web site. It is foreseen to present some 10 to 20 schematic of existing systems and their translation into the square framework developed within subtask A so that professors can teach the topic at ease.

10 CONCLUSIONS

The combination of a heat pump and solar collectors will represent a large market share of the house heating segment in future decades. In some regions of Europe, combined systems are already installed in 70 to 80% of new homes being encouraged by laws. Task 44 + Annex 38 will contribute to select best solutions either economically or in terms of best seasonal performance factor (SPF).

A common international definition of a SPF is currently lacking. Annex 38 accomplishes prenormative work to produce background for a shared definition of a SPF factor for combined systems. Annex will also recommend how to measure and assess performances of combined systems.

An IEA framework provides a unique opportunity to meet and share with the experts from universities and industries working on thermal solar and heat pumps to exchange new ideas and to test them. We have at present 50 experts from more than 10 countries part of the group. Annex 38 attracts top engineers and manufacturers of solutions with solar and/or heat pump for family houses. It is a unique platform to discuss optimal configurations of both world solar and heat pump.

Models to simulate such any type of combination of solar and heat pumps will be available and the most common ones will probably appear in commercial tools like Polysun for a worls availability.

Future systems will be sketched and new ideas will emerge from the exchange of practice, knowledge and experience, as past IEA SHC Tasks and HPP Annexes did.

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