COMPREHENSIVE EVALUATION AND MONITORING OF SOLAR THERMAL COMBISYSTEMS FOR DETACHED HOUSES

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Abstract

In the course of the IEE-project "CombiSol – Standardisation & Promotion of Solar Combisystems", in Germany, France, Sweden and Austria, 70 recently built plants were analyzed by experts from the respective countries. The focus was a qualitative evaluation of the solar thermal systems. For 45 of these evaluated solar combisystems based on a detailed monitoring campaign an energy balance about the whole thermal energy supply and -distribution is going to be drawn in order to get quantitative evaluation results. A further part of the project is to get basic data for a comparison between laboratory tests and in situ monitoring. The result should be modified standard concepts for testing of solar thermal combisystem units.

In Austria, 20 plants were subjected to the qualitative evaluation, 10 of them in meantime are equipped with measurement devices, in which the data will be recorded for a whole year. This will be achieved by heat meters in all hydraulic circuits, measuring the demands of electricity, oil and natural gas of the entire heating system and the installation of a pyranometer close to the solar thermal collector.

The investigation of the plants in Austria and all other participating countries have shown that mistakes often occur in the quality of installing the insulation, which can lead to an inefficient operation of the complete heating system. Since the integration of the auxiliary heating by the solar manufacturers is often not clearly defined, in several cases mistakes were detected. Issues relating to operation management such as maintenance documentations, plant logbooks, documentations of the settings of the controllers, maintenance contracts and on site located hydraulic schemes were available only in few cases. The result of the on-site evaluation is, unfortunately, that significant shortcomings in various evaluation points exists and it also shows the demand of further intensive training programs.

1. Introduction

In the framework of the IEE-Project CombiSol – Standardisation & Promotion of Solar Combisystems, experts performed a qualitative inspection on 70 recently commissioned plants in Germany, France, Sweden and Austria. A detailed energy balance of the total thermal energy supply and contribution of 45 of these combisystems will be carried out over a 12-month period ending on December 31st, 2010. One of the project's objectives is to obtain basic data about the systems in order to compare laboratory test outcomes with in-situ monitoring results to develop new and/or modified standard procedural instructions for testing solar combisystems.

The qualitative evaluation was made based on a specially developed evaluation form, which also can be downloaded from the project homepage (www.combisol.eu). This form consists of 113 points, which are divided in parts of the plant, to evaluate all necessary information about the components as shown in Fig. 1.

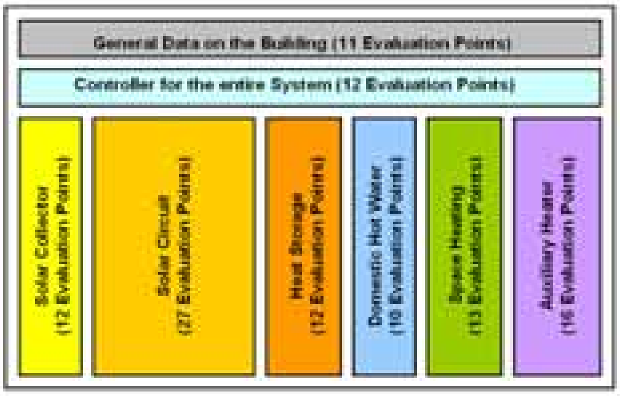

Fig. 1. Structure of the developed questionnaire

The evaluation of the plants, which takes a time of about 2 hours per unit, includes the annual energy demand of the building, the type of domestic hot water preparation, the quality of the installation of the insulation and the hydraulic system, the positions of the sensors, the heights of the tank connections, the dimensions of all components of the system and some more. On the basis of this information, it is possible to describe and evaluate these systems with a sufficient detailing.

In Fig. 2 an example of an one family house in Austria is shown with integrated flat plate collectors in the roof how it is typically installed in Austria. Fig. 3 gives an overview on the typical sizes of the collector areas versus space heating area of the 70 one family houses which were evaluated within the entire CombiSol project.

Fig 2. Example of a detached house in Austria with 16 m^2 collector area

In Fig. 3 the distribution of the evaluated plants in the four participating countries is shown. The French, the German and the Swedish plants have a collector area in a range between 8 and 17 m^2, especially the Austrian plants have a range of collector area between 12 and 40 m². The range of space heating area starts at 90 m² and ends at 390 m².

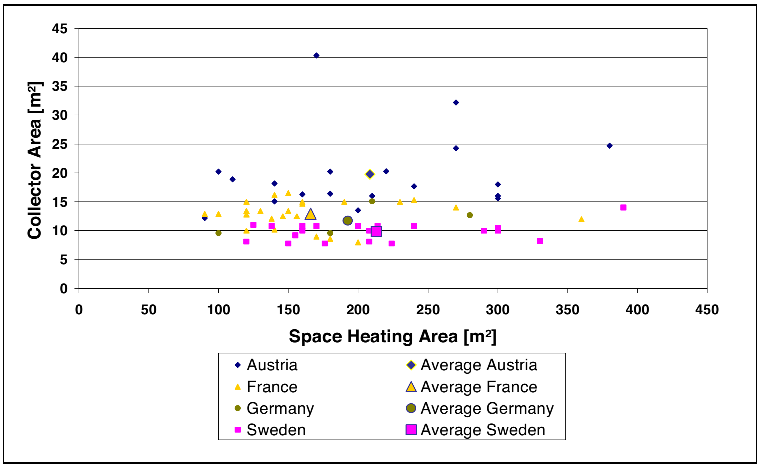

Fig. 3. Collector area versus space heating area of the evaluated solar thermal combisystems

2. Evaluation Scope and Procedure

In Austria, 20 plants were inspected. In Fig. 4 the main dimensions of the solar thermal combisystems in the four participating countries are shown. The dimensions of the Austrian plants are between 12 and 40 m² collector area and between 800 and 3000 litres heat storage volume. During the inspection the specifically developed evaluation form had to be completed. The collected data allow the systems to be described in sufficient detail. Ten of the 20 evaluated combisystems have been equipped with measuring systems that record the measured data during a whole year, ending on December 31st, 2010. This was carried out by installing a heat meter in all hydraulic circuits, measuring the electricity consumption and oil and/or natural gas consumption of the entire heating system, as well as installing a pyranometer in collector plane.

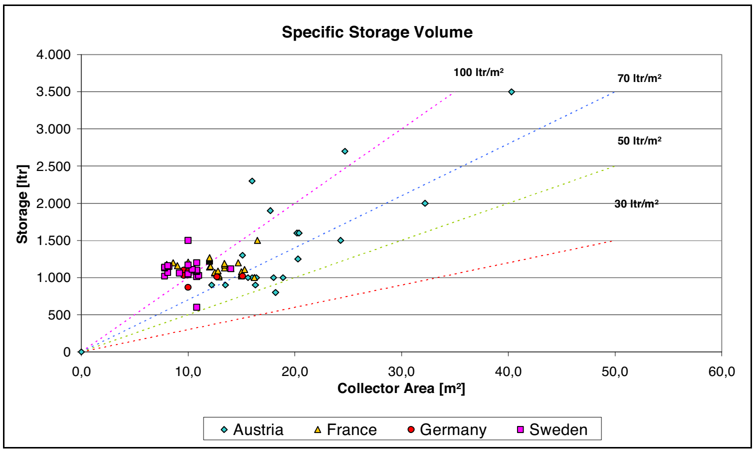

Fig. 4. Heat storage volume versus gross collector area of the 70 evaluated plants

3. Results of the In-Situ Inspection

The investigations of the plants in Austria and all other participating countries showed that still serious mistakes occur in the hydraulic installation and the workmanship of the insulation, which can lead to an inefficient operation of the whole heating system. Documents for the operational management such as maintenance logs, plant documentations, documentation of control values, maintenance contracts and an on-site located hydraulic scheme were only available in very few cases. The results of the in-situ evaluation show significant deficiencies in some of the evaluated items and indicate that further intensive trainings and improvement of some components of the system are required. The essential outcomes of the inspection of the solar combisystems at detached houses are described below.

3.1. Tank Insulation and Tank Connections

The heat store in a solar thermal combisystem is one of the most important components. It can be a low heat loss storage only if the charging strategies (solar thermal and auxiliary energy) and a high quality tank insulation is assured. The inspections showed that several plants have shortcomings, in the following points:

- Not or bad insulated areas and pipe connections in the hot part of the tank (Fig. 5 and Fig. 6)
- Not or bad insulated connections between two heat storage tanks
- No thermosiphon traps installed
- Generally bad workmanship of the heat store insulation
- Vertical gap between the hard foam shells
- Air gap between the insulation and the tank

Fig. 5. Very poor heat storage insulation at the top of a tank (left),
good alternative of heat storage insulation, on site build box filled with cellulose insulation material (right)

Fig. 6. Heat storage tank connections are not insulated (left),
storage tank with exemplary good thermosiphon heat trap installation of the pipe connection (right)

3.2. Sensor Position and Sensor Mounting

Among others, the correct sensor positions and mountings are govern for an efficient and reliable operation of the entire heating system. Also in this category at the in-situ evaluation improvement potentials were registered:

- Reference temperature sensor for the solar thermal system on the tank was positioned too high
- Sensor positions of the auxiliary heater on the tank were chosen suboptimal
- Sensors are not fixed against slip out or reaches not till the end of the immersion sleeve
- The diameter of the immersion sleeve was too wide compared to the sensor dimension

Fig. 7. The diameter of the immersion sleeve is too wide and sensor is fixed just with some textile pressed into the immersion sleeve (left), good sensor mounting with fixed sensor and correct dimensions of sensor and immersion sleeve (right)

3.3. Components for Pressure Consistency and Safety Device

Components such as membrane expansion vessels, pressure relief valves with their drain pipe as well as the collection vessel for the anti freeze fluid must be functional at all times. If this is not the case, the solar thermal system could suffer some damages. Following the most established cases:

- Isolation valve between pressure relief valve or expansion vessel and hydraulic circuit which easily can be closed by anybody (e.g. children)
- Drain pipe and/or collection vessel not available
- Dimension of collection vessel too small
- Material of drain pipe and/or collection vessel was not temperature resistant (>>100°C!)

Fig. 8. Drain pipe not temperature resistant (left), temperature resistant collection vessel, made of metal (right)

3.4. Components near to the Collector

For components in close proximity to the collector in the case of stagnation temperatures up to 200°C (superheated steam) may occur. For components which are more distant from the collector, temperatures up to 160°C (saturated steam) must be expected. Consequently, when selecting components that are installed near the collector if is necessary to pay attention to their temperature resistance. In this category following mistakes were found:

- Automatic deaeration valves close to the collector (which allows steam to exhaust)
- Not temperature resistant flow regulation valves within high temperature critical parts of the collector loop

Fig. 9. Not temperature resistant flow regulation valve within high temperature critical parts of the collector loop (left), correct manual deaeration valves within high quality insulation (right)

3.5. Pipe Insulation

The pipe insulation is often neglected in heating systems in the domain of detached houses. In the quality investigation had to be found deficits in most cases. Some significant errors are listed below:

- Fittings are not insulated
- Bad workmanship of the pipe insulation respectively the pipes are only partly insulated
- The pipes in the whole heating system are not insulated
- No protection of the external insulation against UV-rays and animal bites
- Wrong dimension of the insulation (gap between pipe and insulation)
- Not temperature or water resistant insulation material in the solar circuit

Fig. 10. External pipes insulated only partly (left), correct protection against UV-rays and animal bites (right)

4. Conclusions

The evaluation of the plants in Austria and all other participating countries have shown that mistakes often occur in the quality of installing the insulation, which can lead to an inefficient operation of the complete heating system. Since the integration of the auxiliary heating by the solar manufacturers is often not clearly defined, in several cases mistakes were detected. Issues relating to operation management such as maintenance documentations, plant logbooks, documentations of the settings of the controllers, maintenance contracts and on site located hydraulic schemes were available only in few cases. The result of the on-site evaluation is, unfortunately, that significant shortcomings in various evaluation points exist and shows the demand of further intensive training programs.

At the qualitative evaluation, many small and generally easy avoidable shortcomings that affect the efficiency and the reliability of the entire heating system, were found. If the solar thermal system suppliers raise the rate of prefabrication on one hand and if the installers mind the few main aspects of good installation quality on the other hand, long-lasting and energy efficient solar combisystems would be able to built without much extra effort.

5. Prospects to Further Actions

Since January 2010, 10 of the 20 evaluated solar combisystems are equipped with measuring systems in order to register the overall energy balance of the heating systems. Plant monitoring is scheduled for at least 12 months. At the end of the monitoring period the results will reveal whether the results of the qualitative evaluation have been validated.

Further detailed information on the project and upcoming results will continuously be uploaded at the project homepage: www.combisol.eu.

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