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. On 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 investigations 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 shows the demand of further intensive training programs.

Keywords: Solar Combisystem, Solar Space Heating, Practical Experience, Installation Quality

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 by a specially developed questionnaire, which also can be downloaded from the project webpage. This form consists of 113 points, which is divided in parts of the plant, to evaluate all necessary information about the components as shown in Fig. 1.

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.

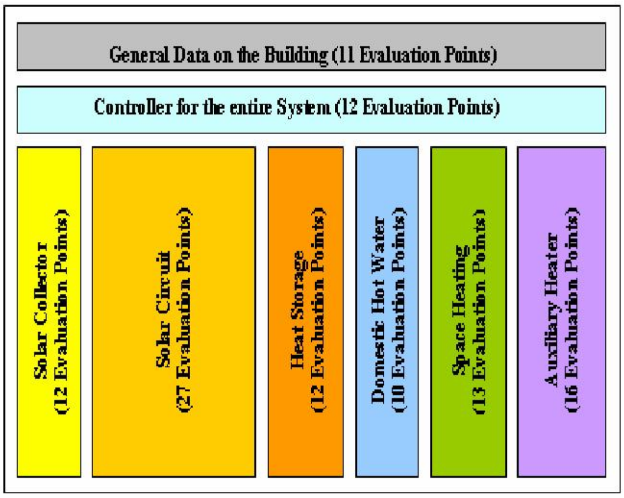

Fig. 1. Structure of the Evaluation Procedure

In Fig. 2 an example of a 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 project.

Fig. 2. Example of a one family house in Austria with a $18m^2$ collector on the roof.

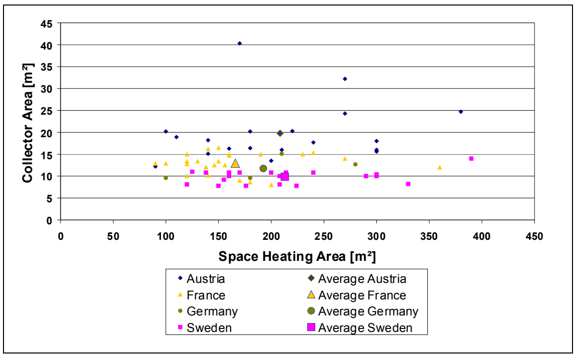

Fig. 3. Collector area versus space heating area of the 70 evaluated systems in Austria, France, Germany and Sweden.

2. INSPECTION SCOPE AND PROCEDURE IN AUSTRIA

Twenty plants were inspected in Austria. The dimensions of the evaluated plants are as follows: collector area: 12 to 40 m²; storage tank volume: 800 to 3,000 l (see Fig. 4). During the inspection the specifically developed questionnaire was completed. The collected data allows the systems to be described in sufficient detail. Ten of the 20 combisystems evaluated have then 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.

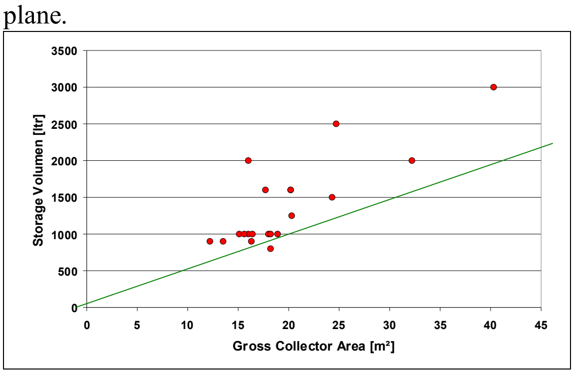

Fig. 4. Storage volume versus gross collector area of the 20 Austrian evaluated systems (green line = 50 ltr/m^2).

3. IN-SITU INSPECTION RESULTS

Plant inspections in Austria as well as in all other participating countries have revealed errors in the installation and workmanship of heat insulation that may lead to an inefficient operation of the entire heating system. Systems were documented properly only in very few cases for example, through maintenance logs, plant logs, documentation on control parameters, maintenance contracts and an in-situ hydraulic scheme. The results of the in-situ evaluation show significant deficiencies in some of the evaluated items and indicate that further intensive training is required. The essential outcomes of the inspection of the solar combisystems at single-family houses are described below.

Pipe Insulation

Pipe insulation is often neglected in thermal plants. Inspections showed that this insulation was inadequate in most cases in terms of heat losses but also in terms of protection against UV-radiation and animal bites. The examples in Fig. 5, 6 and 7 illustrate the high potential for improvement in this area.

Fig.5. Partially missing pipe insulation, no protection against animal bites and UV radiation

Fig. 6. Pipe insulation missing from solar circuit external pipes

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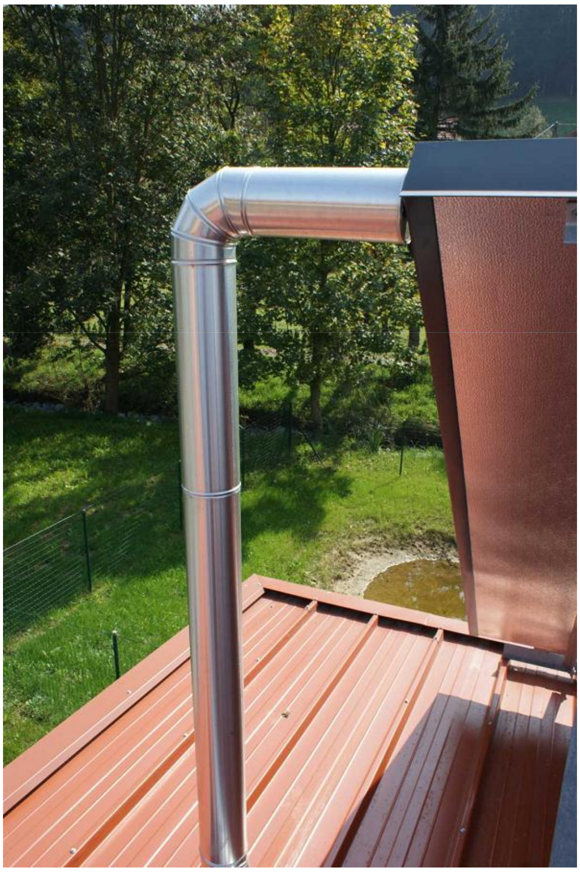

Fig. 7. Example of good pipe insulation including UV- and animal bite protection.

Safety Devices

Safety devices such as membrane expansion vessels, pressure control valves and their pressure-release pipes as well as collection vessels for the glycol mix must be fully functional at all times. If, for example, a ball valve is installed in between a safety device and the hydraulic circuit, the functionality of the safety device may be impaired due to unintended blocking. This may cause severe damage to the system. At least the lever should be taken away in order to avoid unauthorized closing of the ball valves in such situations.

The lack of a collection vessel after the safety valve may cause damage to the building due to spilt glycol mix if the valve were triggered. Over 50% of the plants inspected lacked a proper vessel. Where vessels existed, they were not temperature resistant. Fig. 8 and 9 illustrate a few examples of safety device deficiencies.

Fig. 8. Pressure control valve (left) and membrane expansion vessel (right): may both be blocked

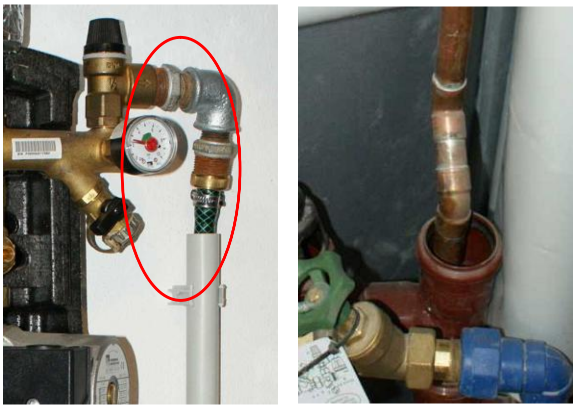

Fig. 9. Incorrect components/materials for pressure-release pipe installed after collector loop safety valve

Components close to Collectors

Temperatures of more than 150°C (steam) can be produced near collectors during stagnation. Therefore, all components installed near collectors must be temperature resistant. Air vents installed in close proximity to the steam (during possible stagnation) must not open automatically. Such devices cannot distinguish between air and steam and may drain the plant during stagnation. Fig. 10 and 11 illustrate inappropriate components found near collectors during in-situ inspections, in Fig. 12 a good example is shown.

Fig. 10. Inappropriate components (automatic air vent) for venting the primary collector loop

Fig. 11. Balancing valve near collector does not resist high temperatures

Fig. 12. Example of correct chosen manual maintained air vents which are insulated and withstand also high temperatures; perfect rock wool insulation of the pipes.

Storage Tank Insulation and Connections

The storage tank is one of the most important components in a solar combisystem. It can only comply with low-loss heat storage if attention is paid to loading (stratification, connection height, etc.) and storage insulation (quality of workmanship, insulation dimensions, insulation of hydraulic connections to the tank, etc.). The inspection showed that most plants lack proper storage insulation as Fig. 13, 14 and 15 show.

It is not only the in-situ installation workers, but also the solar system manufactures who are responsible for these deficiencies. Companies frequently deliver badly prefabricated storage insulation that is very difficult to mount correctly, i.e. insulation quality is already impaired as a result of the product itself.

Fig. 13. Very poor heat storage insulation at the top of the tank, which is the hottest place.

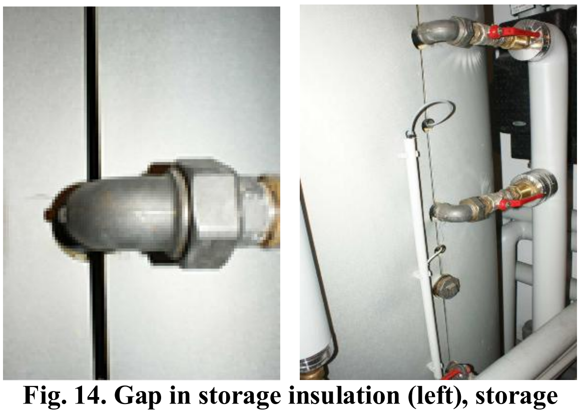

Fig. 14. Gap in storage insulation (left), storage connections not insulated (right)

Fig. 15. Inappropriate insulation material which did not survive the high temperatures which were reached in the heat storage.

One installation element that avoids heat loss due to leakage is a so-called thermosiphon heat trap. Installation of a thermosiphon heat trap at hydraulic connections in 'hot' areas of the storage tank is especially recommended. Fig. 16 and 17 illustrate two positive examples of storage tank insulations.

Fig. 16. Storage tank with exemplary good thermosiphon heat trap installation of the pipe connections.

Fig. 17. Additional insulation on top of the standard insulation, connections insulated up to storage tank insulation

Sensor Position and Sensor Mounting

The positions and mounting of the system's sensors were also inspected in the course of qualitative evaluation. Inspection of 20 solar combisystems found frequent errors in the positioning of the sensor responsible for the functionality of the solar heating system, in the bottom of the tank. In these cases the so called dead volume – the volume the solar heating system cannot use – is increased. The position of the sensor for auxiliary heating on the storage tank was also seen to be frequently ill-placed (Fig. 18, 19).

Fig. 18. Flow pipe connection for DHW preparation from the tank on the left side, but sensor for auxiliary heating of the tanks on the tank on the right side leads to long delay in reaction of auxiliary heating.

Sometimes the switching volume for the auxiliary heater is over sized, i.e. the storage volume only the solar heating system can use is limited which reduces the potential of solar energy input and a large part of the tank is kept at high temperature leading to higher heat losses than necessary. Since integration of auxiliary heating is often not clearly regulated by the solar heating system manufacturer (from a control technology and hydraulic point of view), some deficiencies in this respect have been noted.

Fig. 19. Deficient sensor mounting (left) position of 'storage-bottom' sensor too high (right)

Deficiencies in mounting the sensor on the storage tank were frequently noted. On the one hand sensors are not protected properly from the risk of slipping and on the other, sensors often fail to reach all the way to the end of the immersion sleeve and therefore cannot measure internal tank temperature correctly (see Fig. 19).

4. CONCLUSIONS

The investigations 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 shows the demand of further intensive training programs.

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.

REFERENCES

[1]. CombiSol project homepage: www.combisol.eu

[2]. Albaric, M., 2008, Eurosun 2008, 057 - Solar CombiSystems Promotion and Standardisation

[3]. (COMBISOL project), Lisbon, Portugal, 2008