WP1.E3b / THEORETICAL EVALUATION OF PROMISING SYSTEM: Drainback Solar Water Heating System

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New Generation of Solar Thermal Systems

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SUMMARY

The evaluation of the new drainback solar water heating system **is based on a comparison of the system features with a simple thermosiphon system**. Thermosipon systems are widely used in Southern European countries. The primary market for the new system is Southern European countries.
During operation, the fluid in the collector loop is driven by a circulating pump, during stand-still periods the collector is emptied through gravity and the entire collector fluid is stored in the upper part of the heat exchanger pipes. The pump, situated in the lowest position of the collector loop, is able to refill the collector with fluid after the stand-still period.

The functionality of the evaluated solar thermal system complies mostly the functionality of a drainback system. The main advantages compared to thermosiphon systems are that

- the storage is not located on the roof on top of the collector. This has advantages in terms of aesthetic, security and stability.
- a higher solar fraction is expected,
- it has a high durability with little maintenance needs,
- installation expenditure is low,
- the system is safe against stagnation and is frost-resistant,
- therefore it can be used not only in Southern Countries

Compared to the reference, this drainback-pump solar heating system satisfies more aesthetic demands, but is also far more expensive and complex and needs electrical energy to work properly.

As a conclusion, the evaluated system can technically and economically be located between the market dominating thermosiphon system and a conventional state-of-the-art drainback system. Therefore, the evaluated system is compared in this report to a thermosiphon system. A comparison to a drain-back system is described in a separate evaluation report.

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Reference system

In this report, the system evaluated is compared to a typical thermosiphon as reference system. The reference system matches the highest market penetration of system technology used for solar water heating in some Southern European countries, especially Greece. Table 1 shows estimated market shares of thermosiphon systems in some South European Countries.

Table 1: Market shares and prices of thermosiphon systems in Southern Europe /Negst05/

Country	Typical collector area in m²	Market Share in %	System price excl. vat in €	Installation costs in €
Italy	3,0	85	1200	300
Greece	2,4	99	700	50
Spain	4,0	80	1800	400
Portugal	4,0	90	2500	500

The reference represents an inexpensive, simple and in Southern European countries widely used system. The evaluated system has to compete with it, so all statements in the *evaluation* section below are relative to (or in comparison with) the properties of the reference system if not stated differently.

Description of the reference system

Application: Solar domestic hot water system
Collector loop: thermosiphon system
Description: A thermosiphon system is based on of the natural convection of water. Therefore, no mechanical pumps, thermostats or any moving parts are required.
Cold water from the net flows directly into the tank on the roof. Solar heated domestic hot water flows from the rooftop tank to ground level whenever water is used within the building.
This fact drastically simplifies the system and leads to very few components. Figure 1 shows a schematic of a thermosiphon system. It is not recommended to use thermosiphon systems in cold climates, even if the collector loop is supplied with antifreeze fluid and thermally driven valves to drain the system. A drawback of the non-use of a pump is that no possibility is given to control the system.
Costs: About 700 € (retail sales price without installation and VAT, depending on the collector and storage size). Installation costs: 50 €
Collector area: 2.4 m²
Store volume: about 150l
Solar fraction: about 50…60% in Southern European countries (domestic hot water only)
Country: The system represents the state of the market in Greece (99% market share, see Table 1).

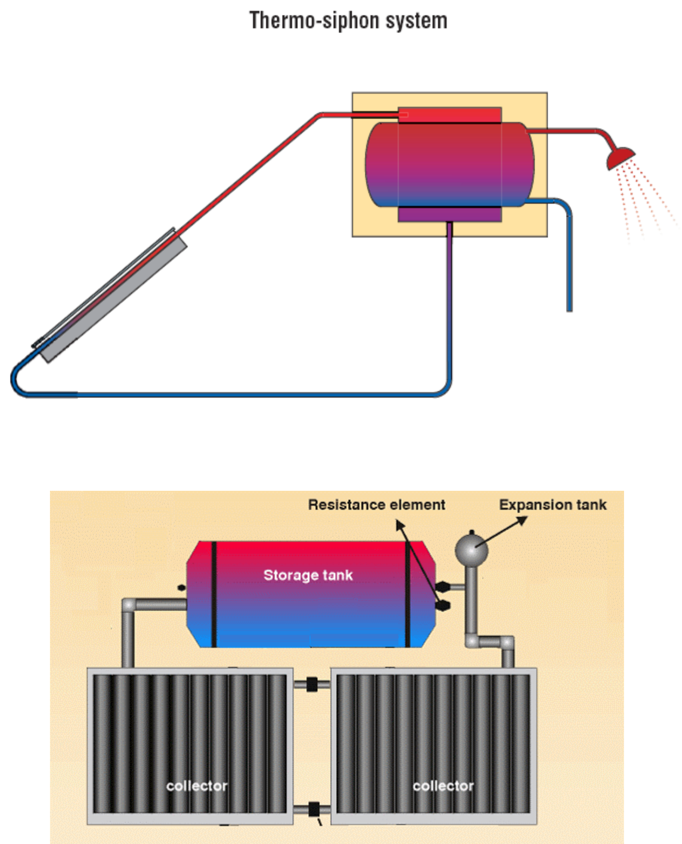

Figure 1: Reference system /Gree03/

Evaluation

Description of the evaluated system

Application: Solar domestic hot water system
Collector loop: Pumped, combined with drain-back Description: The functionality of the solar thermal system evaluated complies the functionality of a drainback system. The evaluated system is not equipped with a return and expansion vessel. The upper part of the internal pipe coil heat exchanger (see Fig. 2) is designed large enough to fully incorporate the liquid of the collector and part of the collector loop /Sch03/.
A conventional circulation pump that is providing the pressure head is used.
The control unit, circulation pump, security devices and the solar storage are integrated in one module. Additional devices like a collector loop control unit are not needed. This leads to a compact construction and only two components plus tubings: the storage unit and the collector /Wag05/.
Costs: The system cost is about 1900 € gross end-user price (retail sales price without installation and VAT) with a store volume of 160 l and a collector area of 2.4 m^2; about 2100 € gross end-user price (retail sales price without installation and VAT) with a store volume of 260 l and a collector area of 2.4 m^2.
Installation costs: 300 € (according to oral information from manufacturer)
Collector area:2.4 m^2
Store volume: 160l or 260l
Solar fraction: about 65% in Southern European countries (domestic hot water only).

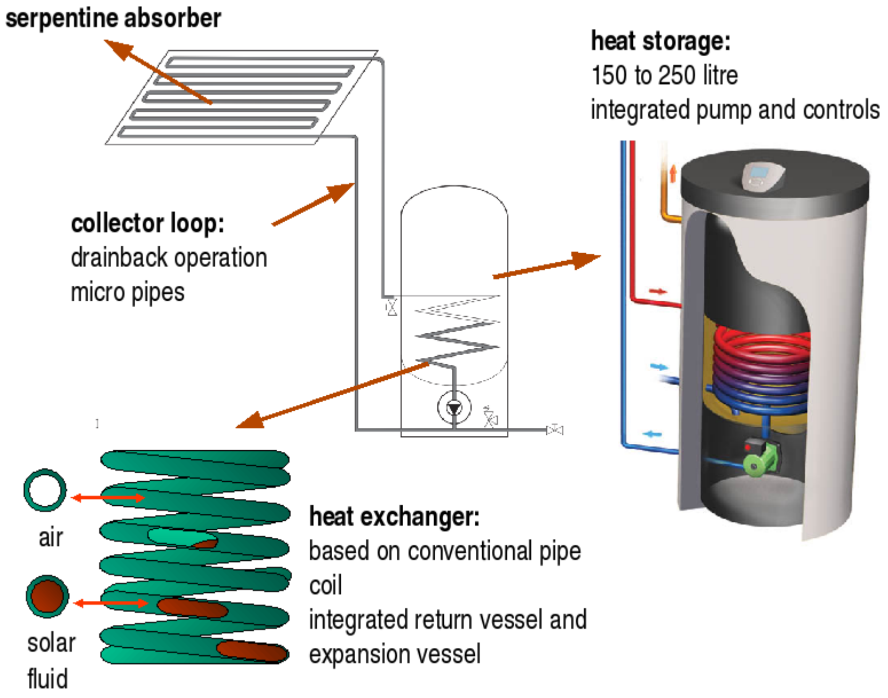

Figure 2: Solar thermal system evaluated

Cost and savings

Material and manufacturing:

Compared to the reference, the evaluated system is more material and manufacturing intensive. The distance of the heat store to the collectors leads to a longer collector loop and therefore more piping material and antifreeze fluid is required.
Nevertheless, material is used efficiently by the utilization of compact (combined sotrage, pump and controls) and integrated (advanced use of conventional pipe coil heat exchanger) components.

Installation:

The installation is more time-consuming because the store has to be installed in a separate place. On the other hand, fewer components have to be set up on the roof. The standardized transport dimensions (norm pallet) allow an efficient transport and storage of the components.

Maintenance:

Disadvantages of the evaluated drain-back system:

The access to the components is more difficult for the evaluated system compared to the reference system because of the integrated system design and an overall more complex system. Moreover the use of water-glycol fluid instead of plain water makes it necessary to check the fluid periodically.
Furthermore, moving parts (circulating pump) are installed. The reduced lifetime of such components leads to a higher maintenance effort.

Advantages of the evaluated drain-back system:

The filling and refilling process of antifreeze fluid is improved by the easier access to the collector loop and the drainback principle of the system /Sch03/.
Furthermore, all components except the collector are accessible more easily

No material and manufacturing cost reduction can be expected, compared to the reference.

Performance and energy savings:

The performance of the evaluated drain-back system is expected to be similar to or slightly better than the reference system because of lesser energy losses of the storage. On the other hand, auxiliary electrical energy is needed for proper operation of the solar thermal system. For an average operating time of 2000 hours per year (according to EN 12976) the electrical energy consumption is about 100 kWh.

Cost performance ratio :

The cost/performance ratio is expected to be worse than the reference system. Comparing the prices, the evaluated system is more expensive by a factor of 2,7.

Additional benefits

Aesthetics, building integration and space requirement:

In contrast to a thermosiphon system, the storage is not located on the roof on top of the collector. This has advantages in terms of aesthetic, security and stability. In the evaluated system, only a flat collector can be seen from within the outside of the building. Overall, there are low space requirements due to the small number of components. Also the hot water stores are relatively small (160 / 250l) which fit well in most buildings.

Technical integration:

Unlike in Central Europe, most buildings in Southern Europe do not have a cellar with a central room for the heating system of the house. This can lead to problems to integrate the separate storage with all its pipings and other connections in the house.

Environmental friendliness:

A better energetic amortisation compared to the reference is not achieved due to the higher number of components and the electrical energy consumption.

Markets and marketing considerations

Opening-up of new and niche markets:

Primarily designed for countries in Southern Europe, the evaluated drain-back system can also be used in most climates of the world. The protection from stagnation through emptying the collector loop and the use of water-glycol as an antifreeze enables the installation of the system not only in Southern European countries.
The evaluated system fits aesthetically well into buildings because of the absence of a roof-mounted heat store. Thus, the market acceptance of solar thermal systems can be improved.

Expansion of existing market:

The easy installation and the relatively low price of the evaluated system can lead to more installations of solar thermal systems in Southern Europe.

Special considerations and limitations

This type of system is marketed by Wagner & Co Solartechnik under the product name SECUSOL. Its specialized heat exchanger is patented since 2003.

Acknowledgements

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References

/Wag05/ Wagner & Co. Solartechnik, SECUSOL-Solarkomplettsystem – Technische Information und Montageanleitung, 2005

/Sch03/ Schabbach, T., Wagner, A., patent application EP1363081 „solar installation“, European Patent Office, 2003

/Gree03/ Greek Solar Energy Association, information provided for Sun in Action II –A Solar Thermal Strategy for Europe, Volume 2, The Solar Thermal Sector Country by Country, 21 National Reports, ESTIF, April 2003

/Negst05/ New Generation of Solar Thermal Systems – Work Package 1, Market survey of today’s systems technology, 2005