WP1.E9 / THEORETICAL EVALUATION OF PROMISING SYSTEM: Combisystem with pool heating in Southern European Climate

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New Generation of Solar Thermal Systems

CONTENTS

SUMMARY

The evaluation performed focused on systems that can provide hot water, space heating and swimming pool heating, and are designed for application in southern climates specifically for single-family houses. Due to the climate characteristics of southern Europe, space heating is required for a shorter period than in other European locations. In this evaluation it was considered a six month period for space heating and on the other six months, swimming pool heating.

This type of systems are applicable to a niche market of people who are building their houses as single-family house and want also take profit of the climate conditions for the use of solar energy. It is common that the construction of a swimming pool is also planned.

The evaluation is made considering as reference system the most common solar heating system for domestic water heating in Portugal – 4m^2 collector area and 300 l storage tank. The system in evaluation offers extra service - space heating and swimming pool heating.

The system in evaluation consists of a collector field and a combistore (see reference /1/) providing solar hot water preparation and space heating in winter period (considering that this period is from October to March) and providing also swimming pool heating in the summer period (April to September).

The evaluation made shows that in southern European climates a solar combi-system, which will not only be used for space heating but also for swimming pool heating will give extra service in comparison to the traditional solar heating systems used and can be economically interesting, provided that pool heating is equally appreciated as water heating and space heating.

This evaluation was based on simulations made using TSol program /2/ and the climatic data base used was also provided by TSol, for Lisboa and Porto. The heat load for space heating was fitted to the conditions expected to be imposed by new building regulations in Portugal.

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Reference system

Choice and use of the reference system

In this report, the system evaluation is based on a comparison with a reference system. The reference system matches the state of the art of system technology used for water heating in Portugal – thermosyphon or forced circulation systems. The system configuration is thought for a family of four persons and it will have 4 m^2 collector area and a 300 l storage tank.
The use of combisystems in Portugal is very limited. The reasons for this are related to the low economical interest of such systems taking into account the short heating season.

Description of the reference system

Application: Primary purpose: solar domestic water heating

Description: The most common solar domestic water heating systems in Portugal are thermosyphon systems with either flat plate or low concentration CPC collectors and a horizontal storage tank (see Fig. 1). Forced circulation systems can also be used but they are not so common for this type of applications - single-family houses, typically with four persons.

Cost (retail sales price of the reference system without installation): ≈2800 Euros

Collector area and store volume of the reference system: 4 m^2, 300 l

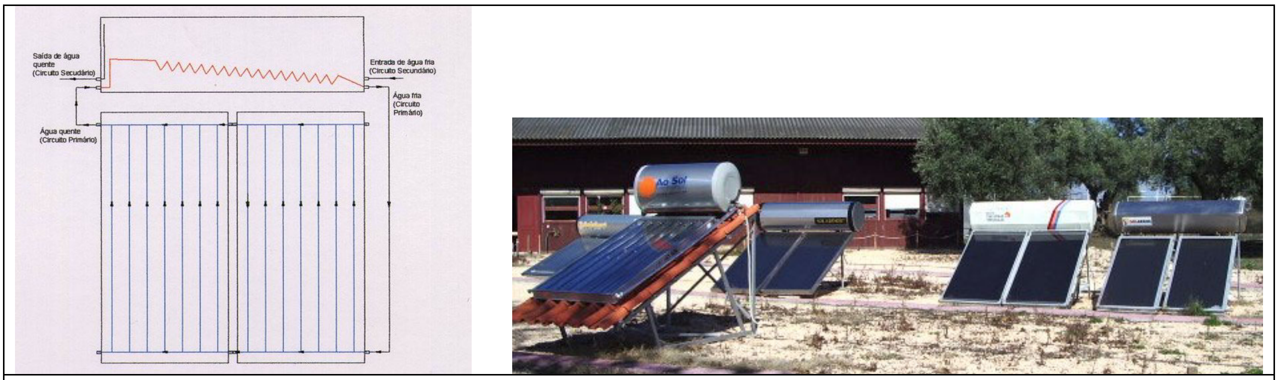


Figure 1: Hydraulic scheme of the reference system and picture of several systems commonly used in Portugal.

Market: The reference system represents the state of the technology in Portugal

Reference: The reference system is described in NEGST WP1.D1 / SURVEY ON THE STATE OF THE TECHNOLOGY OF SOLAR THERMAL SYSTEMS, Appendix (Portugal)

Evaluation

Description of the evaluated system

Application: Primary purpose: solar hot water preparation and space heating (solar combisystem) during winter season (six month – October to March)

Secondary purpose: Pool heating in summer period (six month – April to September)

Description: The system in evaluation is formed by a collector field and a combistore providing solar hot water preparation and space heating in winter period (considering that this period is of six month, from October to March) and providing also swimming pool heating in the summer period (six month – April to September). The backup system considered is a gas boiler using either natural gas or propane. The backup system is only considered for the hot water preparation and space heating. No backup is considered for swimming pool heating. The swimming pool heating is obtained using an extra heat exchanger in the collector loop.

A schematic representation of the system is given in Fig.2 and was extracted from the simulation program used for the theoretical evaluation – Tsol (See reference /2/).
The collector considered is a standard flat plate collector with the following efficiency parameters:
$\eta_0 = 0.78$; $a_1 = 3.8$ W/m^{2}K; $a_2 = 0.03$ W/m^{2}K^2
The collector area considered was of 10 m^2. Other collector areas were considered and the results are reported in /3/.
The combistore considered was selected from TSol data base (Combination Tank (1200 l)) (see Fig.2).
The combisystem considering just preparation of hot water and space heating is similar to system number 4 of reference /1/. An extra external heat exchanger is added for swimming pool heating.
The Space Heating (SH) system considered is a low temperature space heating loop - floor heating loop. This technology is well adapted to the use with solar systems due to the low return temperature when compared with space heating radiators that need higher temperatures and have also higher return temperatures.
The system considered introduces the possibility to use solar energy for space heating and also use of exceeding energy in summer for swimming pool heating (PH). It offers extra service when compared to the reference system and its cost analysis shows economical feasibility, provided that pool heating is equally appreciated as water heating and space heating.

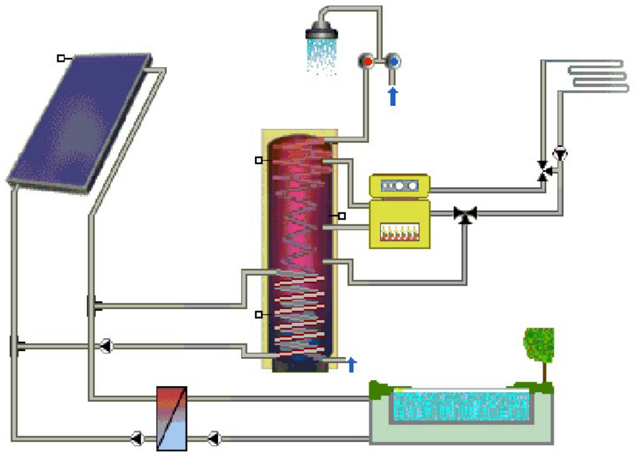


Figure 2: Solar thermal system evaluated (Hydraulic scheme – from TSol (see reference /2/)

Cost and savings

Material and manufacturing: The evaluated system uses more material (larger heat storage and larger collector area) then the reference system.

Installation: The system concept evaluated corresponds to a cost increase in installation since there will be a higher collector area, although only the collectors will need installation on the roof or terrace and the storage tank will be installed inside the house and not on de roof. The cost of installation will be lower when decision to install the system is made before construction of the house.

Maintenance: No additional cost increase is foreseen for the maintenance of the system in relation to the common thermosyphon system. A good control device with appropriate alarms can help the owner to detect and quickly contact maintenance offered by the installer in a maintenance contract.

Combined cost: From contacts made with companies that already installed similar systems in Portugal, it was possible to determine an average price for these systems of 700 €/m^2, if only the solar part is considered (collectors, storage tank and control system). This cost corresponds also to the specific cost of the reference system.

The system concept in evaluation will correspond to a higher investment since it will have a larger collector area and a larger storage tank.

Performance and energy savings, (including embodied energy[1]): A performance increase (or improved energy savings), compared to the reference is clear, since the system in evaluation will allow additional use of solar energy for space heating and swimming pool heating. There will be higher energy savings.

In Table 1 the energy savings for the reference system and for the system in evaluation is listed for two locations in Portugal – Porto and Lisboa.

Table 1- Energy Savings

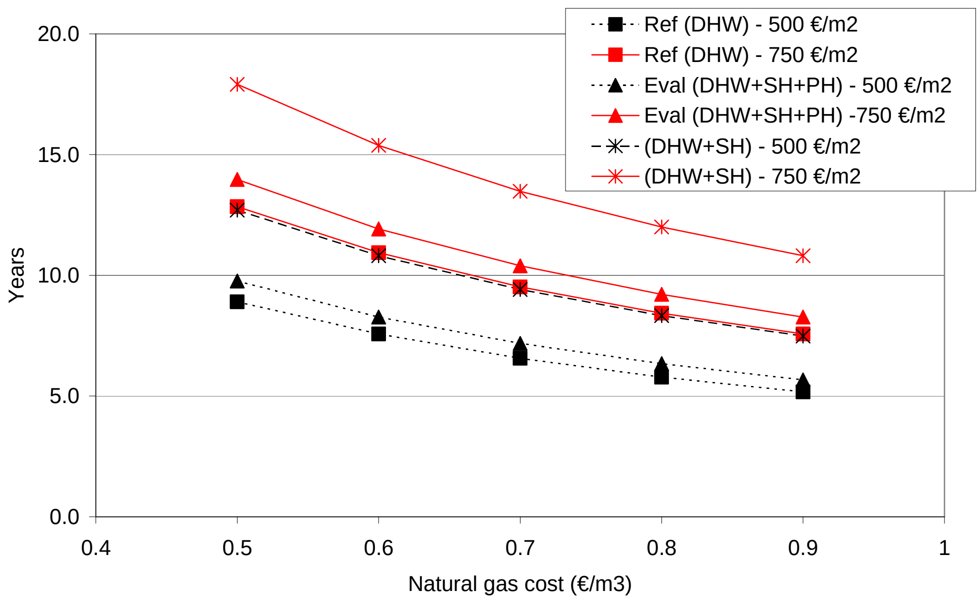
	Yearly Yield (kWh/year)			
	Reference System DWH ($4m^2$/300 l)	DWH+SH[2] ($10m^2$/1200l)	Evaluation system DWH+SH+PH[3] ($T_{Pool,max}$=32ºC) ($10m^2$/1200l)	Evaluation system DWH+SH+PH ($T_{Pool,max}$=26ºC) ($10m^2$/1200l)
Porto	2822	5013	6379	5661
Lisboa	2941	4966	6674	5080

The heat load for space heating was fitted to the conditions expected to be imposed by new building regulations in Portugal. The heated floor area considered is 150 m^2. The window area is 4.5% of floor area in the north façade and 10.4% in the south façade, according to /4/. A room temperature of 20ºC was considered without any decrease during the night. The design external temperature was considered 1ºC for Oporto and 4ºC for Lisboa. This corresponds to an annual space heating requirement of 9.38 MWh for Lisbon and 12.46 MWh for Oporto.
The swimming pool area is 32 m^2 and desired pool temperature was considered to be 24ºC, with a maximum pool temperature of 26ºC or 32ºC allowed. It was also considered the use of pool cover during night hours.

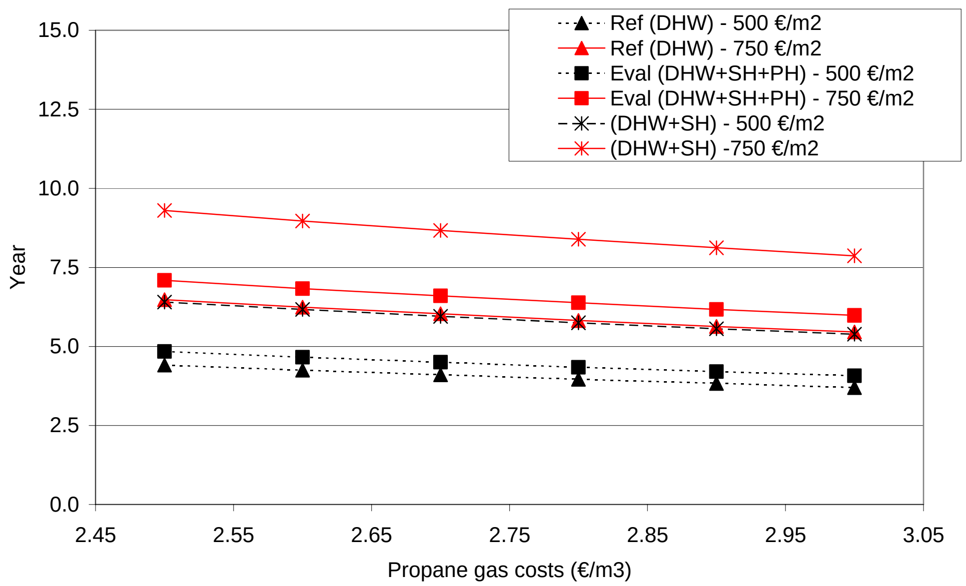
Cost performance ratio: An analysis of payback period for the reference system and for the system in evaluation was made considering the use of natural gas and propane gas. Two values were considered for system cost – 500 €/m^2 and 750 €/m^2. The lower value corresponds to a possible objective in lowering the system costs in a larger market.

Results for Lisboa are presented in Fig.3 and show that the payback period of the evaluation system is similar to that of the reference system, provided that pool heating is equally appreciated as water heating and space heating. In Fig. 3 the maximum pool temperature considered is 32ºC.
If a lower limit for the maximum pool heating temperature is considered, e.g., 26ºC, payback period is higher for the evaluation system then for the reference system, as can be seen in Fig.4. In this situation it is closer to a system providing only hot water and space heating.
In the case of Porto the limit in maximum pool temperature will not have such a strong influence in the payback period as it happens for Lisboa. Please compare Fig.3 b) and Fig.4b) for Lisboa with Fig. 5 a) and b) for Porto.

[1] Was not considered in the analysis made
[2] SH – Space Heating
[3] PH – Swimming Pool Heating

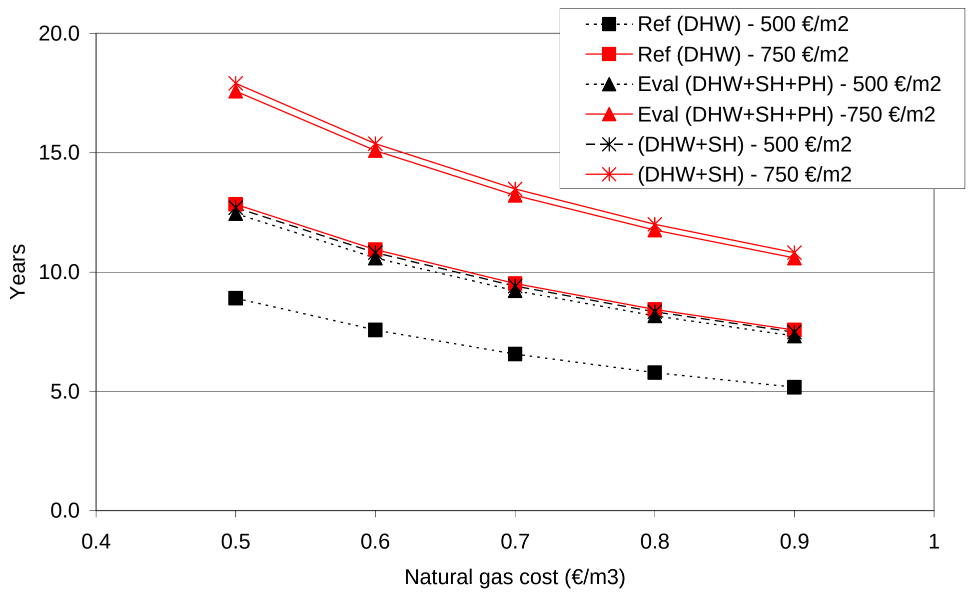


a) Natural gas

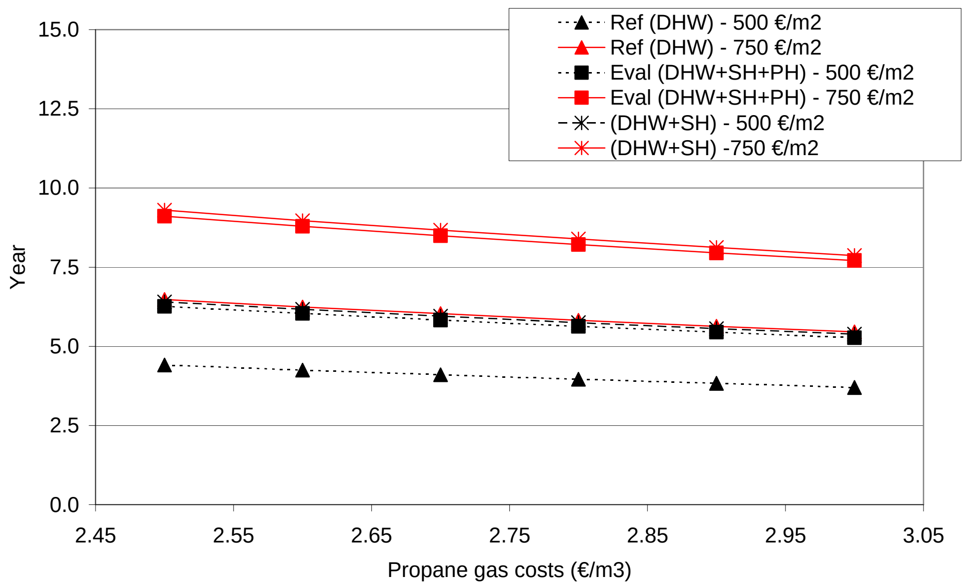


b) Propane gas

Fig. 3 - Simple Payback Period as a function of gas costs for reference (ref) and evaluation (eval) systems, considering $T_{Pool,max}$=32ºC. Calculation for Lisboa.

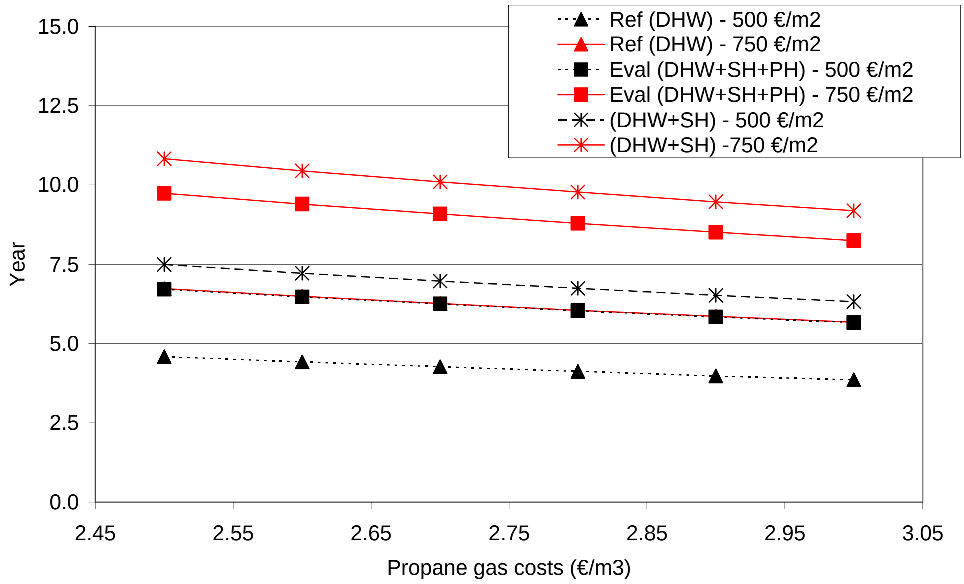


a) Natural gas

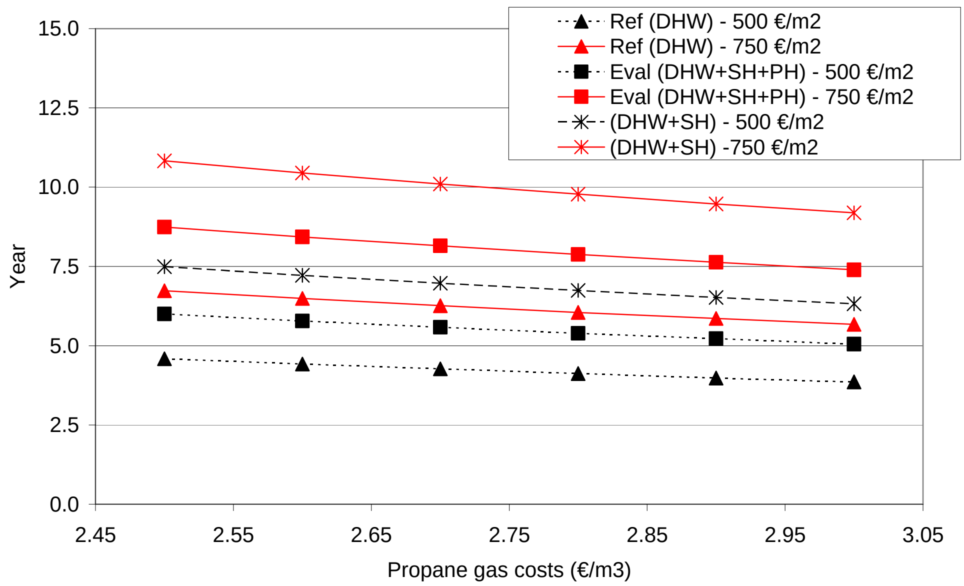


b) Propane gas

Fig. 4 - Simple Payback Period as a function of gas costs for reference (ref) and evaluation (eval) systems, considering $T_{Pool,max}$=26ºC. Calculation for Lisboa.



a) $T_{Pool,max}$=26ºC



b) $T_{Pool,max}$=32ºC

Fig. 5 - Simple Payback Period as a function of gas costs for reference (ref) and evaluation (eval) systems. Calculation for Porto considering propane gas.

Additional benefits

Safety and health: Not applicable

Range of application, extra service, extra comfort, extra function:

The system allows for extra service – space heating and swimming pool heating. Extra service is one important benefit of this system configuration in comparison with the reference system.

Environmental friendliness: The evaluation system uses more material but this is compensated by extra energy yielding.

Aesthetics, building integration and space requirement:

The system in evaluation will not have the storage tank in the top of the roof as the common thermosyphon systems. This can constitute an aesthetic advantage, especially if the decision of installation of this type of system is made before the phase of building construction and a good integration of the collectors is made.

Technical integration: Not applicable

Markets and marketing considerations

Opening-up of new and niche markets: The system in evaluation opens a niche market that corresponds mainly to single-family houses, especially if it corresponds to a new house in construction. It can also fit to secondary use house (holiday house) or touristy settlement houses. This system will contribute to the consideration of solar thermal systems for space heating, since it solves the problem of use of surplus energy in summer.

Expansion of existing market: It will contribute to the expansion of the existing solar energy market. This type of system, will also prepare the market for the use of solar assisted air conditioning systems that may be available in medium term in the market and that will cover an extra additional service – space cooling in summer.

Special considerations and limitations

Two aspects are mainly related to the uncertainty in the present evaluation.

One is the difficulty in determining the present market price of this type of solutions since only a few installers are offering this type of system.

The other is associated to the use of the simulation program TSol. The program uses tools for generation of climatic data - radiation data and ambient temperature data – that may not be completely adapted to southern climates. However this uncertainty will be within the year to year variability of climate data and will not impose differences in the comparison with the reference system which was also simulated using TSol.

Acknowledgements

The authors acknowledge the information on solar combi systems already installed in Portugal to Eng.º João Oliveira (Ao Sol) and Eng.º Rafael Ribas (Vajra). The authors also acknowledge MSc Susana Camelo for help in the definition of space heating load parameters.

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