Project ECOTEST **Deliverables** **D8.4 Analysis of the results and report** **D8.5 Proposal to CEN and communication**	ECOTEST ECO_WP8_XXX_WP8-ExecutiveSummaryAndProposals

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1 Introduction

In the WP8 of the ECOTEST project, the relevant standards for solar thermal appliances for the ErP were investigated. The solar thermal standards can be split into three categories: Components testing (Solar collector EN 12975 and EN ISO 9806, Store EN 12977-3 and EN 12977-4), "system testing" (Factory made systems EN 12976 and ISO 9459-5) and "system calculations" (SOLCAL, SOLTHERM and EN 12977-2). The SOLCAL method is not developed under the CEN/TC 312 but is proposed in the transitional methods (2014/C 207/03). The SOLTHERM method is not mentioned in the standards. It was developed in other projects as valid method for the calculations of the EN 12977-2. The RRTs were therefore separated into the following six subtasks

- RRT1: Solar Thermal Collector (EN 12975, EN ISO 9806)
  Determination of the relevant thermal performance parameters for ErP
- RRT2: Solar water heater store (EN 12977-3)
  Determination of the relevant thermal performance parameters for ErP
- RRT3: Solar combi store (EN 12977-3)
  Determination of the relevant thermal performance parameters for ErP
- RRT4: Factory made solar thermal system (EN 12976, DST)
  Determination of Q_{nonsol}
- RRT5: Solar water heater system (EN 12977, SOLCAL, SOTHERM)
  Determination of Q_{nonsol} based on results from RRT1, RRT2
- RRT6: Solar combi systems (EN 12977, SOLTHERM)
  Determination of Q_{nonsol} based on results from RRT1, RRT3

The testing programs, individual results and all the specific findings such as recommendations for revisions of standards are found in the corresponding final reports ECOTEST WP8-RRT1 to WP8-RRT6.

These standards for solar thermal systems and components cover a vast range of different products. In the RRTs of the ECOTEST project, only a few typical products were analysed. The standard EN ISO 9806 for collectors covers standard flat plate collectors as investigated in ECOTEST, but also Evacuated Tube Collectors (ETCs), Wind and Infrared Sensitive Collectors (WISCs - formerly known as unglazed or uncovered collectors), PVTs (Thermal collector and PV module in one), self-protecting collectors (such as parabolic trough collectors). Furthermore, the heat transfer medium can be any liquid but also air. The same applies for the standard EN 12976 that includes of course the ECOTEST system consisting of flat plate collectors and a conventional storage tank. Other system types such as thermosiphon systems using flat plate or evacuated tube collectors, but also integrated storage collectors (ICS) are falling under the same standard. These system types are very important for the south European market and contribute on a very substantial amount to the domestic heat demand.

Other hybrid systems of emerging interest were not considered at all. PVT systems are good examples with booming European markets. PVT collectors alone are not covering the DHW profiles and heating loads. Therefore, PVT collectors are usually part of a system including at least the PVT collector, geothermal power and a heat pump. Home batteries may be added as well. As a whole system, this can contribute in an important way to seasonal storage, hence to solve one of the main problems of decarbonizing the heating sector. It is therefore important to focus much more on interacting systems and provide solutions going far beyond the rating of an isolated individual product.

Other horizontal issues, general conclusions and recommendations related with the whole group of solar thermal standards and the methods used for the rating of solar thermal systems are summarised below.

2 General conclusions and recommendations

The test methods used in the solar thermal standards were developed in view of simulating the dynamic behaviour of individual and complete systems. They are also based on the knowing that in many cases, the solar thermal systems are interacting with other technologies that are needed as supplementary heat sources to cover the user demands during the whole year. The annual yield of solar thermal systems is highly depending on the geographic location and on the seasonal climatic and environmental conditions. The performance of a solar thermal system can therefore not be rated with simple generalised figures, as it is probably possible for other technologies. To provide such simplified performance-ratings, as required for regulations and subsidy schemes, it is essential to use clearly defined reference conditions such as the load profiles in ErP for domestic hot water and precise climate data for simulation. Average climate data such monthly or annual averages are not appropriate enough. Heating systems which are depending on external conditions and which are interacting with other appliances must be considered as non-linear systems: An increase of the heat demand of x-% cannot be directly linked to an increased supply of y-% of solar energy. Such simplified computations must fail to deliver reliable data and it is undoubted that detailed simulation tools would needed. Furthermore, the behaviour of the supplementary heating appliance delivering the Q_{nonsol} (i.e. the energy not supplied by the solar thermal appliance) must be known. This supplementary heating appliance and the solar thermal system are interacting systems that cannot be considered as completely separated appliances. Individual ratings of interacting appliances are therefore not appropriate.

For reliable performance-ratings detailed simulations tools are therefore necessary, as well as a very good knowledge of the dynamic behaviour of the individual appliances. For solar thermal systems, this detailed information is available for the collectors and it is partly available for the stores. It is well known that the system performance of real systems can be simulated with very good precision using simulations tools like TRNSYS. Such simulations tools require however experts to operate and are not yet suited for regulatory purposes. With simplified tools such as the SOLTHERM (RRT5 and 6) very good results can be achieved already. However, even the experts in the RRT8 were struggling hard before getting the good results.

These simulation tools are either complex and/or limited to single appliances such as solar thermal applications. As outlined above and in view of the decarbonisation aims, it is however very important to consider in an appropriate manner the simulation of combinations of different appliances. Similar problems are faced by other technologies as well. The different approaches from different technologies are not yet compatible. As an example, the bin-methods used for rating heat pumps and the ScenoCalc calculations for solar thermal collectors were both developed (amongst others) to consider seasonal variations. Yet, the two methods are not compatible and are of no help when combining a heat pump with solar thermal collectors.

It can be expected that more interacting or hybrid technologies will enter the heating market, which are not covered yet by any standard. Together with other new technologies, they may become important as supplementary sources for solar thermal systems. This further hybridization is evident as some individual decarbonized technologies are not always able to meet the required loads throughout the whole year. There will be however also economic reasons which are driven by and adapted to the temporal variations of the availability and cost of heat and power.

On a long term, it is therefore considered essential by the WP8 to develop a new set of hybrid standards for heating appliances. These standards must be driven by a centralized hybridization concept on how to consider the interaction between different appliances, including supplementary appliances such as stores, pumps and controllers of course. In line with this new concept, the individual standards and test procedures for the different appliances may have to be revised and/or amended to provide the required information for simulating the dynamic behaviour of a complete hybrid system. New appliances and new or advent technologies (PVT hybrid collectors, ground heat, PV heating, district heating, chemical stores, etc.) could be integrated already in an early stage, which is utterly important for their market development. A very important advantage of such a harmonized approach would be the possibility to establish also standardised databases where the tested appliances are parametrised in an unambiguous and harmonized way, thus allowing for simplified computations of the energy (and carbon) performance of a specific hybrid heating system. In combination with the energy rating of buildings, this approach would later also allow to deliver individualized energy labels for heating systems in new buildings but also for retrofitting heating systems in existing buildings.
Such as centralized hybrid concept would also be the right place to manage the horizontal information required by different appliances such as annual and geographical profiles for weather, heating loads, cold-water temperatures and primary energy factors. These basic data require proper management, as they need regular updates and adaptations.
The members of the WP8 are fully aware of the time line and the cost for such a new concept. It is however considered important to outline the difficulties arising when the performance rating of heating appliances is simplified, but also to propose on future solutions. These improvements will for sure result in complex computations. Apart from the technical aspects, it is therefore mandatory to consider also the communicability of these results. It must be possible to break down the results of these complex simulations to rather simple figures that are suitable for regulatory purposes such as Energy labelling in ErP or for subsidy schemes.

Solar thermal appliances are currently rated based on Q_{nonsol}, i.e. by the energy (or primary energy equivalent) NOT delivered by the system. This is in contrast with other appliances, which are rated based on the energy (or primary energy equivalent) delivered by the appliance. With this basic concept, solar thermal systems are usually considered as a technology that is "added to" an existing system. However, once a solar thermal system is installed and when it can deliver useful heating energy, it never makes sense to operate any other appliance using primary energy equivalents for heating. In view of decarbonizing the heating sector, it therefore seems mandatory to consider the solar thermal heater as first appliance and the non-solar appliances as supplementary heaters. A simple thermosiphon system - as it is common in southern Europe and in many other parts of the world – usually has a water heating efficiency of several thousands of percentages. This must be considered in an appropriate way.

The WP8-RRTs have shown that the performance figures for solar thermal collectors (RRT1) are very reliable and that the ScenoCalc calculations provide very reliable figures for comparing different collectors. The uncertainty is in the range of a few percentage only.
The standards for solar stores EN 12977-3 and -4 provide good results as it can be seen from the results of RRT2 and RRT3. A main drawback of the current standards is that the stratification is not yet considered in an appropriate manner. The main problem is however that there are competing standards from other TCs, which are providing the same parameters (Standing losses and store volume) but with known deviating results.

It was also found that testing whole systems (RRT4) is possible with very good results; however, there are two general problems with this standard:

- It is based on the standard ISO9459-5 that should be urgently revised. This standard is requiring a software that is completely outdated and is not able to handle complex tapping profiles.
- It is mandatory to respect very narrow limits for the testing conditions (radiation sums and ambient temperature).

The SOLCIS method that is based on this method can be considered as a reliable method, but a lot of work should be done on the two above-mentioned points.

The SOLCAL method (RRT5 and RRT6) is based on combining separately determined collector and store parameters. The formulas to calculate the Q_{nonsol} are given in the transitional methods and can be used to provide results. The technical background or even the derivation of this method are not known for the members of the WP8. The differences between the two available versions (see RRT5) are however in a range that allow raising general doubts about the method. The results of the SOLCAL method as defined in the transition methods are also not in line with observations from real systems. The results obtained with the new SOLCAL version 2017 are much closer to the expectations. As a whole, the SOLCAL method is therefore considered as a reliable rating tool and further modifications and validations would be necessary, at least to the new EN 12975 / ISO 9086 standards.

In view of the necessary simplifications for the revision of Lot 1 and Lot 2, the WP8 recommends - for the time being - to base all classification of solar thermal systems on collectors only and not on whole system considerations. As outlined above, this approach should be revised as soon as better tools are available. Supplementary energy use such as for controllers or pumps are virtually negligible and do not need any further consideration as they are well below all uncertainties arising from other system simplifications. The thermal store however should still be considered. The most appropriate approach seems to be to require a certain store volume with respect to the delivered energy of the thermal collector and of course a certain energy classification.
If the rating were based on collectors only, it would be disastrously wrong to base it on the collector area only. To illustrate the difference between different collectors in Figure 1 the monthly net yields of five different collectors (Flat plate, WISC, Evacuated tube collectors) was computed for the climates Strasbourg and Athens when operating at 25°C and 50°C. Same colours are the same collectors.

The total annual yield is indicated in the legend. All collectors fall under the EN 12975 / EN ISO 9806 and should be treated in exactly the same way. The standard EN ISO 9806:2017 was revised with the clear aim to allow a reliable collector performance rating independent of the type of collector. The collectors in Strasbourg were simulated with an inclination of 45° where for Athens 60° was selected. Other climates and other operating conditions would result in different results of course. It is important to note from Figure 1 that annual yields under the same operating conditions can vary by several 100%s between the different collectors. Furthermore, the operating temperatures and the locations have a very strong impact on the yields. The results are indicated based on gross area as this is the only area used in the EN ISO 9806:2017, the results would look similar when using aperture area or absorber area as in previous standards: A reliable relation between collector area and usable energy cannot be established.

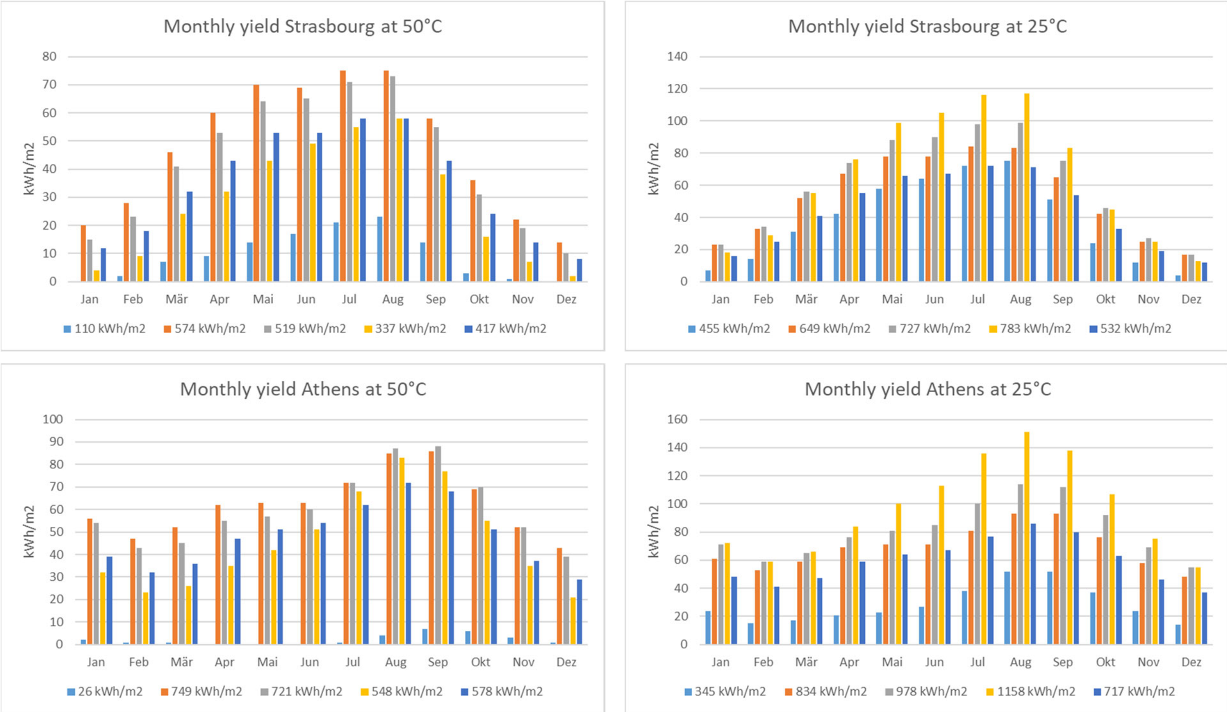

Figure 1: Comparison of monthly yields of different collector types in Strasbourg and Athens under different operating temperatures

The WP8 is therefore urgently proposing - at least until better standards are available - to base all performance ratings of solar thermal systems on thermal performance figures of solar thermal collectors only. The procedures are not yet implemented in the standard and not readily available. In view of the Lot 1 and Lot 2 revision the European solar thermal association ETSIF/SHE is however working hard on such proposals intended to bridge the gap between scientific precision and the necessary simplification of the procedures.

3 ANNEXES

The results of the individual RRTs are summarize in separate reports
WP8-RRT1
WP8-RRT2
WP8-RRT3
WP8-RRT4
WP8-RRT5
WP8-RRT6