Intelligent Energy Europe

SolarKeymark-II –
Large open EU market for solar thermal products

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www.estif.org/solarkeymark/skii.php and www.solarkeymark.org

Large open EU market for solar thermal products - Solar Keymark II

Project period: 01-01-2006 to 31-12-2007

Budget: 785,000 € – supported by Intelligent Energy–Europe

Partners

- European Solar Thermal Industry Federation (coordinator), ESTIF (BE)
- SolarKey International, SolarKey (DK)
- University of Stuttgart, Institut für Thermodynamik und Wärmetechnik, ITW (DE)
- Centre Scientifique et Technique du Bâtiment, CSTB (FR)
- Technical Research Institute of Sweden, SP (SE)
- GREENoneTEC Solarindustrie GmbH GREENoneTEC (AT)
- Solahart industries Pty Ltd Solahart (NL)
- THERMOMAX LTD., Thermomax (UK)
- Österreichisches Forschungs- und Prüfzentrum Arsenal, arsenal research (AT)
- National Center for Scientific Research “DEMOKRITOS”, Demokritos (GR)
- Instituto Nacional de Engenharia, Tecnologia e Inovação, I.P., INETI (PT)
- Canary Island Institute of Technology, ITC (ES)

Purpose

- Open EU market with harmonised national requirements; once testing and certified according to Solar Keymark a product can be sold all over EU (no extra special national requirements should be set)

Key Results

- Solar Keymark recognised by authorities all over Europe
- Solar Keymark accepted by the industry (more than two thirds of the collectors sold today have Solar Keymark)
- The way is paved for a large open European market for solar thermal quality products

Editors: ESTIF and SolarKey Int., Brussels, February 2008.

Executive summary: The project has successfully assisted in implementing one set of pan-European requirements (Solar Keymark) for solar thermal products. Now more than two thirds of the collectors on the market are Solar Keymark certified – with a growing trend. Tools assisting the national implementations of the

Energy performance of Buildings Directive are made available. Improved standards and test procedures have been proposed.

Recommendations for the attention of key decision makers:

- National/regional authorities: Solar Keymark certified products should be accepted/recognised in national/regional support schemes and regulations.
- Manufacturers/distributors: Have your solar thermal products Solar Keymark certified if you want to access more countries in EU.
- Installers/engineers/planners: Use / require use of Solar Keymark certified product to assure product quality.

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Disclaimer

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Background

Although the European (EN) Standards for solar thermal products and the CEN Solar Keymark existed already for a few years before the project, the inter-European trade of solar thermal products was still often hampered by differing national regulations and requirements in national/regional subsidy schemes, which were not fully compatible with the EN standards.

Manufacturers who wanted to sell their products in several countries/regions often had to have them tested/certified repeatedly depending on the local requirements, in order to compete in the market. This was a de facto trade barrier, requiring additional resources to be spent by the manufacturers operating in more than one national market, both in terms of costs and time.

Because of the lack of acceptance of the Solar Keymark by public authorities, manufacturers did see only limited benefit in having their products Keymark certified. This was a classical "chicken-and-egg problem": As long as only a few products had the Solar Keymark, this label was not perceived as relevant by national authorities. And as long as the Keymark did not give direct access to national/regional markets, manufacturers did not apply for the Solar Keymark.

Furthermore it was feared that different national ways of implementing the EC Directive on the Energy Performance of Buildings (EPBD) would lead to new trade barriers if different calculation procedures were used and locally tested/certified solar thermal products were treated differently from others.

Objectives

The general purpose of the project was to pave the way for a large open EU market for quality solar thermal products.

The specific objectives were:

- Promoting the European Solar Keymark towards (national) authorities to make it accepted in all national building regulations and solar thermal support schemes
- Updating the Solar Keymark scheme rules and underlying EN standards to make them more flexible and thus more attractive to solar thermal manufacturers – and promoting in general the mark to the industry
- Implementing the European standard for calculating solar thermal systems in buildings and other relevant actions for co-ordinated national implementations of Council Directive 2002/91/EC on the energy performance of buildings

The big challenge of the project was to transfer the bad circle:
Few certified products -> no recognition -> no motivation for certification -> still few certified products -> ...

into the positive circle:
Many certified products -> recognition -> motivation for certification -> more certified products -> ...

As seen in the next chapter this positive circle has now indeed been established. The project participants and the European solar thermal industry are grateful to the European Commission and the Intelligent Energy Europe programme that it thanks to this project was possible to make this very important step forward towards a large open EU market for quality solar thermal products.

Achievements and interesting results

The overall success of the project can be illustrated by the dramatic development in the number of Solar Keymark products – see fig. 1.

- The original goal was: 15-20% of the annual European solar collector market Keymark'ed at the end of the project.
- The result by the end of the project is: More than 66% of solar collectors sold by the end of 2007 were Keymark'ed.

➔ "Success factor": Approximately 400%

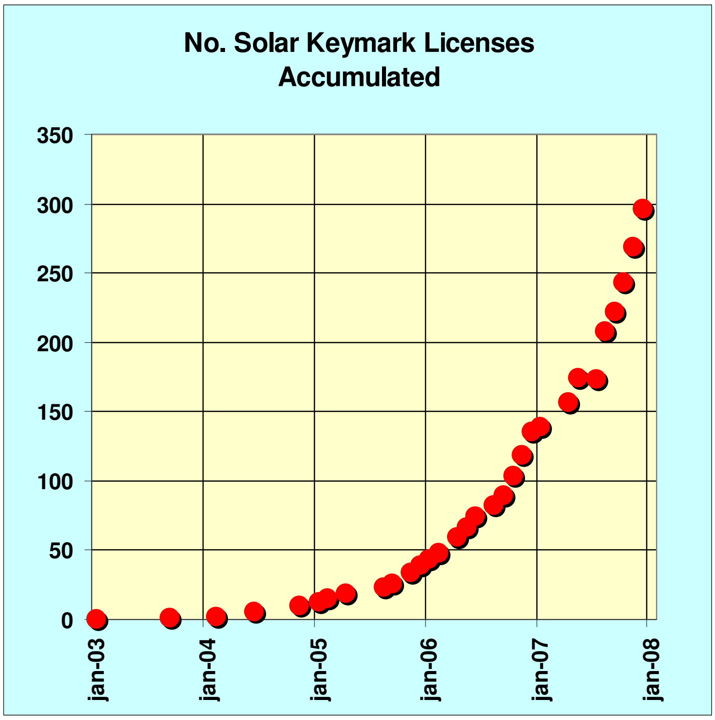

Figure 1: Historical development of number of Solar Keymark licenses

Main achievements

The main achievements reached by the action:

- **General recognition by national authorities of ONE set of quality requirements** for solar thermal products valid for the whole EU: Solar Keymark certification. Solar Keymark is now recognised by national authorities all over Europe - apart from some (minor) deviations:
    - Spain: ISO 9001 certification required on top of testing according to EN standards
    - Germany: Minimum performance level criterion for collector, declaration of fulfilment of requirements in "Blauer Engel"
    - UK: Extra national requirements for roof integrated collectors
    - And in France some insurance companies still require national CSTBat certification

- **Very high and general acceptance by the European industry of Solar Keymark certification.** The number of Solar Keymark licenses has "exploded" during the project period - see fig. 1. **Now more than 2/3 of the collectors sold on the European market show Solar Keymark.** Increase in numbers of Solar Keymark licenses during the project period: From 40 in January 2006 to 300 in January 2008; an **increase of 650% !**

- **The Solar Keymark Network.** A framework for continuing the future maintenance of the Solar Keymark has been established. The network consists of industrial representatives and Solar Keymark operators (certifiers, test labs and inspectors). The tasks are:
    - Exchange of experience
    - Secure harmonised inspection procedures and result presentation
    - Organise comparison of test results from different labs (Round Robin)
    - List certified products, accredited test labs and empowered certification bodies
    - Suggest future improvement of the certification scheme

- **New draft Solar Keymark certification scheme rules.** The scheme rules have been improved and updated – now with harmonised result presentation sheets and harmonised inspection check lists and procedures. Scheme rules prepared for taking in also solar thermal hot water storages when the standard EN 12977-3 is approved and published - expected during 2008.

- **Tools now available for use in connection with national implementations of the Energy Performance in Buildings Directive (EPBD) with respect to solar thermal:**
    - Input from the project to the **new European Standard for calculating the influence of solar thermal system on the energy performance of buildings:** EN 15316-4-3 Heating systems in buildings — Method for calculation of system energy requirements and system efficiencies — Part 4-3: Heat generation systems, thermal solar systems
    - A **software tool for calculating savings due to solar thermal systems** in building - based on the above EN 15316-4-3 was developed in the project
    - A collection of more than 40 national guidelines and other material for decision makers HVAC experts and installers is made available.

- **Improved standards & test methods proposed & recommended to CEN TC312.**
    - Improved test methods, especially concerning evacuated tube collectors have been developed.
    - **A new general and simple method estimating the annual performance of a collector based purely on the collector test results has been developed** – a simple software tool is made available for this purpose. It is proposed to include in the next version of the collector standard EN 12975 a requirement to present also this estimated annual collector output as a result of the collector test.

Other interesting results

Very large export activities in the solar thermal sector

From the analysis made of the trans-national trade it is rather clear why the major part of the solar thermal industry welcomes ONE set of requirements. It showed up that half of the solar collectors produced in Europe are exported from one country to another – with increasing trend. See fig. 2. The analysis was made based on data from 90% of the European collector market.

Figure 2: Exported collectors / collector market. Red line: Trend

Solar Keymark for complete systems is - so far - not very popular

Solar Keymark is now by far the most popular for solar collectors. Keymarking is also possible for complete solar systems ("kit-systems" for domestic hot water) - but so far only a rather small number of solar systems show the Keymark - see fig.3.

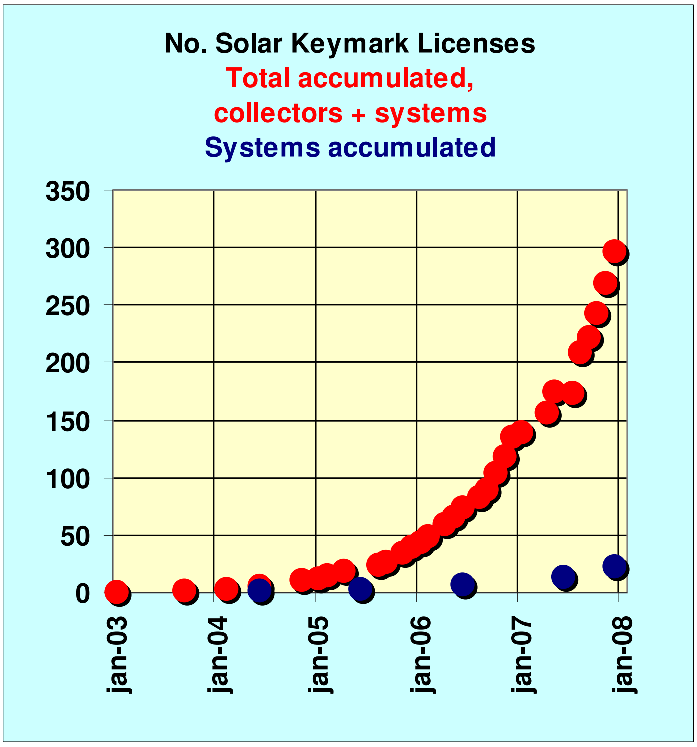

Figure 3: Historical development of number of Solar Keymark licenses
- *red dots indicate the total number*
- *blue dots the system Keymarks alone*

The reasons for this are:

- The number of complete system sold are much less than the number of collectors sold
- **Keymarking of systems is rather costly as each system configuration has to be tested and certified**

In the project a new draft of Solar Keymark scheme rules has been developed including a much more flexible certification (certification of a whole system family can be done based on only one system test). These new scheme rules will be proposed to CEN Certification Board in 2008 - approval is expected, and this will most probably cause a new Solar Keymark explosion with respect of "numbers of system Keymarks". This is important as France and Spain plan - in the near future - to require not only Keymark on collectors but also on the complete system.

The importance of the Solar Keymark Network

The fact that the Solar Keymark Network is now established is not very surprising; this was done as originally planned. The interesting thing is that **it was realised how important such a network is**, now when the Solar Keymark has become the de facto all-European set of requirements.

The participants of the Solar Keymark Network meetings are considering the Solar Keymark Network of a very important and valuable instrument. They strongly expressed their wish to continue to meet beyond the duration of the Solar Keymark II project. Since the activities of the Network were financed by the project the continued success of Solar Keymark and the Solar Keymark Network relies heavily on a sustainable organisation and funding of the Network.

The members of the Network are at moment trying to raise funding for the continuation of the work.

Performed tasks

Analysis of trade and barriers to trade

It was found that there is a considerable trade between member states of solar collectors: Between on third and one half of all collectors sold in EU cross national borders!

Country reports telling the national situation - country by country in 12 countries - with respect to: regulations, subsidies, testing, certification, insurance and other factors – are made available. Valuable information for manufacturers considering entering a national market.

The only major remaining problems/barriers observed are in France, where still some regional subsidy schemes and some insurance companies requires national certification.

Trans-national trade of collectors

The trade of solar collectors between Member States was analysed. The main conclusions are:

- There is a considerable trans-national trade of collectors across the borders in Europe – between 1/3 and 1/2 of all glazed collectors are crossing the national borders!
- The cross border trade is increasing also in relative numbers
- Due to this large trade across the national borders it is very important to avoid trade barriers

The analysis was based on input from the following countries:

- Austria
- Denmark
- Germany
- Greece
- Portugal
- Sweden
- Switzerland
- France
- Italy

representing approximately 90% of the European collector market, see fig.4.

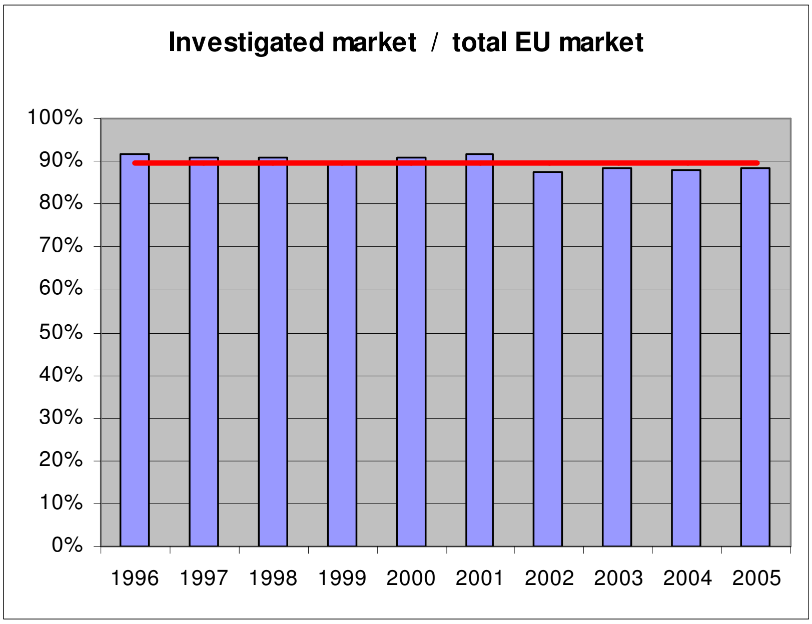

Figure 4: Share of the market included in the analysis.
Red line: Average %.

The general trends and outcome from the analysis are shown in fig. 5 & 6:

- The general trend is that the markets, the exports and the imports are all increasing
- Export is growing very fast also in relative numbers (from 10% to 45% the last 10 years)
- Approx. 1/3 of all collectors in the investigated countries are imported. This relative figure is almost constant the last 10 years when looking overall on Europe.

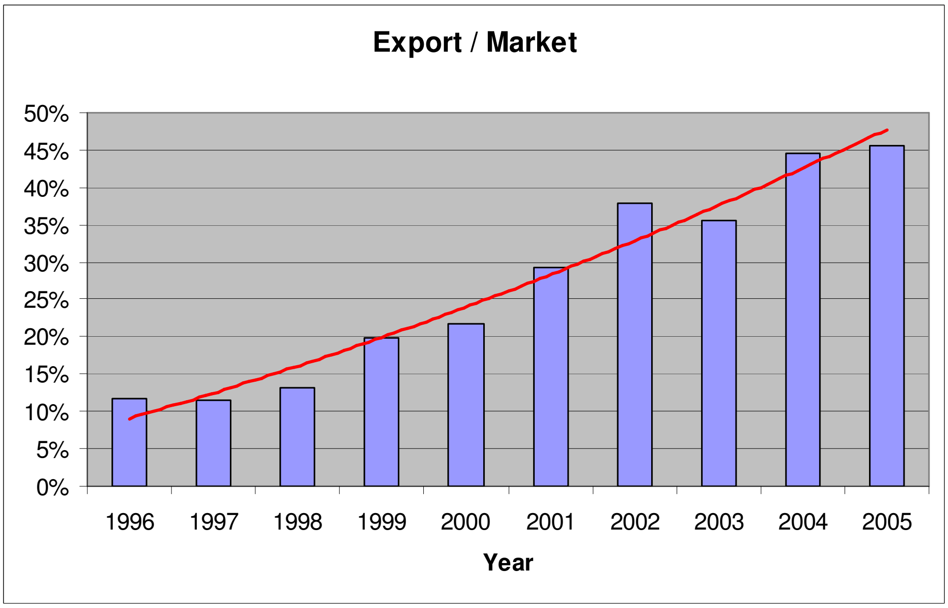

Figure 5: Exported collectors / collector market.
Red line: Trend

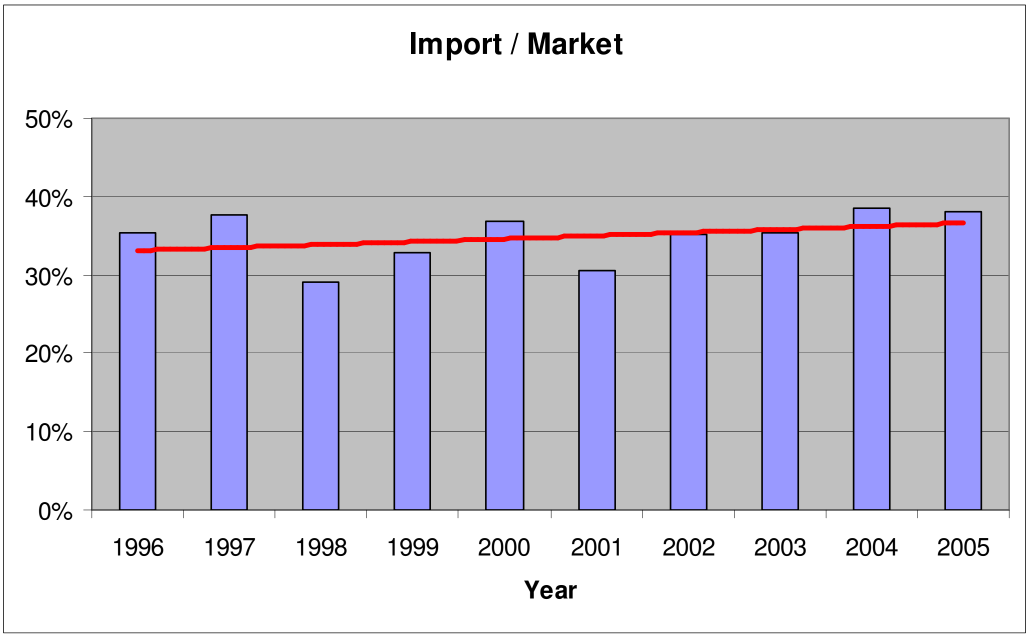

Figure 6: Imported collectors / collector market.
Red line: Average (34%)

Analysing the national figures tells the following:

- Austria has a very good position on the European market – exporting 300 MW in 2005 (almost double of the Austrian home market) – Austria is the "big exporter"
- Germany is the biggest market in Europe – and now the German industry is also gaining a good position on the European market exporting almost 100 MW in 2005 – but Germany is still the "big importer" (250 MW)
- The "new fast growing markets" in Europe: France, Spain and Italy are importing most of their collectors
- Despite the small home market, the Swiss industry has managed to establish a substantial export (larger than the home market)
- The Danish market is only one with a decreasing trend in the period (it seems that the Danish collector manufacturers has missed their chance in the mid 90'ties to develop the export markets)

Detailed results are reported in "European trade of solar thermal products" available from the Solar Keymark web: http://www.estif.org/solarkeymark/skii-crossborder.php

Country details

In the project "country reports" were made in the beginning of the project and again close to the end of the project. These "initial" and "final" country report tell the national situation – country by country – with respect to:

- Regulations
- Subsidies
- Testing
- Certification
- Insurance
- Others

In the final reports:

- actions taken in the project period and
- remaining trade barriers at the end of the project
- action needed to overcome remaining trade barriers

are given.

These reports are good tools for manufacturers considering entering markets in the countries described. Final reports are available for:

- Austria
- Denmark
- France
- Germany
- Greece
- Ireland
- Italy
- Northern Ireland (UK)
- Poland
- Portugal
- Spain
- Sweden

Country reports are available from the Solar Keymark web: http://www.estif.org/solarkeymark/skii-countryreports.php

Remaining barriers to trade

The only major remaining problems observed are in France, where still some regional subsidy schemes and some insurance companies requires national certification. Behind this problem is the situation that in the national French certification CSTBat a whole year exposure test is still required. This is much more than required in the European Standard EN 12975, which only requires 30 days exposure with some specific conditions fulfilled. Here we have on the one side: The French authorities / test labs / experts not convinced that the period of 30 (special) days is long enough to unveil potential weaknesses of all collectors; and on the other side: The other test labs represented in the project trusting that the method given in the European Standard will discover far most potential weaknesses – and on the same side the European industry not accepting a test period of one year. It has not been possible to solve this problem with the time limits of the project, although this issue has been treated and discussed.

One way forward to solve this problem is via the CEN Technical Committee TC312. The European Standard for solar thermal collectors has just been opened again for revision (due to request from the participants in this project). Discussion will now take place in TC312 based also on the resource documents produced and made available from this project. However revising a European Standard takes some time, typically 3-4 years. So in parallel the French solar association ENERPLAN is working on the insurance companies and the authorities to improve the situation.

The Solar Keymark Network

The Solar Keymark Network acts as a platform for improving and maintaining the Solar Keymark certification. Participants in the Solar Keymark Network are representatives from certification bodies, test labs, inspectors and manufacturers.
The Solar Keymark Network was established on Feb. 14th, 2006 at Brussels during the first Solar Keymark project meeting. In the meanwhile the following Solar Keymark Network meetings took place:

- June 21st, 2006 at Freiburg, Germany
- February 15th, 2007 at Lyon, France
- October 2nd, 2007, at Vienna, France

The meetings were chaired by Mr. Harald Drück, ITW, University of Stuttgart.

The meetings were attended by approximately 15 to 25 representatives from solar thermal test laboratories, certifiers and solar industry. During the meetings aspects related to testing procedures, the use of uniform weather data for performance prediction, the maintenance of the Solar Keymark scheme rules, harmonised inspection procedures and result formats, inter-comparison tests etc. were discussed and corresponding decisions were made.

The minutes of the meetings are available via:
http://www.estif.org/solarkeymark/skii-network.php (Please note that a password is required in order to access the minutes)

Within the Solar Keymark II project two major activities were directly linked to the Solar Keymark Network. These activities were related to quality assurance measures and minimising testing effort by maximising testing flexibility and are described in the following sub-chapters in more detail.

Quality assurance measures

In order to ensure that tests and inspections are performed have a uniform quality level, common quality assurance measures were carried out within the test labs and inspection bodies involved in the project. The main measures were a solar collector inter-comparison performance test and the elaboration of harmonised procedure and check list described in a document named "factory inspection report"

Collector inter-comparison performance test

The collector inter-comparison performance test was performed on three collectors. Two flat plate collectors of the type GREENoneTEC SK500N and one evacuated tubular collector of the type Thermomax DF100. The required collectors were provided by the project partners Thermomax and GREENoneTEC. Participants of the collector inter-comparison test have been the following test laboratories:

- Österreichisches Forschungs- und Prüfzentrum Arsenal
- Centre Scientifique et Technique du Bâtiment
- National Centre for Scientific Research "DEMOKRITOS"
- Instituto Nacional de Engenharia, Tecnologia e Inovação, I.P.
- Canary Island Institute of Technology
- University of Stuttgart, Institut für Thermodynamik und Wärmetechnik
- Swedish National Testing and Research Institute

The results, namely the conversion factor η_0, and the heat loss coefficients a_1 und a_2 as well as the power output of the tested collectors were sent to Mr. Jan Erik Nielsen of SolarKey Int.. He evaluated the results and prepared a report which includes all results in an anonymous form.
The evaluation of the results showed in some cases deviations between the participating test laboratories that exceeded the standard uncertainties reported to such an extent that additional investigations are desirable in the future.

Factory inspection report

A harmonised factory inspection report was elaborated within the project. The first drafts, based on the existing factory inspection reports of the certification bodies CERTIF, CSTB, DINCERTCO and ELOT were finalised during the last project meeting in Vienna with the help and input of all participants.
The structure and content of the report is shown below.

1. General
2. Quality system
3. Incoming goods
4. Production control and routine tests
5. Production during visit
6. Calibration of measuring equipment
7. Control of measuring equipment
8. Preservation of product
9. Complaints
10. Records
11. Corrective actions
12. Changes to certified product
13. Inspectors evaluation
14. General remarks

The harmonised factory inspection report is intended to be used by all independent inspectors assigned by the certification bodies during the factory inspections carried out in the frame work of the Solar Keymark certification.

The final version can be downloaded from the Solar Keymark web site: http://www.estif.org/solarkeymark/skii-network.php

Minimising testing effort by maximising testing flexibility

At present a full test of each system configuration or system family respectively for factory made systems according to EN 12976 is necessary for Solar Keymark certification. To reduce testing effort, a extrapolation procedure was developed that allows for factory made systems with different sizes of collector area and store volume a performance determination based on a test of only one system.
In order to develop such a procedure nine system configurations of a thermosiphon solar domestic hot water system that can be composed on the basis of three stores with different volumes and three different collector areas were tested. The required system components were provided by the project partner Solahart and were carried out at ITW (Germany), CSTB (France) and INETI (Portugal). Each lab performed three complete system tests so that in total all nine configurations will be tested.

System testing

At **ITW** the three system configurations tested were composed of a store with a volume of 300 litres in combination with 1, 2 and 3 collector modules corresponding to 1.86, 3.72 and 5.58 m^2 collector area. During the summer of 2006 the tests of the configurations with 1 and 2 collector modules were performed. The test of the configuration with 3 collector modules was partly carried out during the year 2007. Due to bad weather condition the measurements could not be finished in 2006 and therefore remaining measurements were carried out in the year 2007.

At **CSTB** three different system configurations of the thermosiphon system from Solahart were tested according to EN 12976-2 from May 2006 to August 2006. The three system configurations have different solar collector areas (1.74, 3.48 and 5.22 m²) and different store volumes (150, 180 and 300 litres).

INETI was also testing three system configurations of the thermosiphon system from Solahart. The configurations are composed of the same collector area and stores with different volumes (300, 180 and 150 litres).

In September 2006 the first system configuration was installed and tests were carried out. For one configuration complete test results according the CSTG test method were obtained. All other test sequences for the three system configurations according to the DST method were carried out during the year 2007.

The results of the tests described above formed the basis for the validation of the developed extrapolation procedure (see next chapter). Based on the performance parameters of the DST-Test the solar fraction ($f_{sol,DST}$) for the location of Athens and a hot water demand of 200 l/d were determined for the systems consisting of different collector areas (A_c) and store volumes (V_{sto}). The results are shown in Table 1 Since for one system configuration (collector area: 1.74 m², store volume: 0.15 m³) the solar fraction f_{sol} is not available for a hot water demand of 200 l/d only f_{sol} of eight system configurations is listed in Table 1.

Number	A_c [m²]	V_{sto} [m³]	$f_{sol,DST}$ [%]
1	3.48	0.18	**0.74**
2	5.22	0.30	**0.82**
3	3.96	0.18	**0.70**
4	3.96	0.15	**0.68**
5	3.96	0.30	**0.73**
6	1.86	0.30	**0.61**
7	3.72	0.30	**0.77**
8	5.58	0.3	**0.82**

Table 1: DST-results ($f_{sol, DST}$) obtained by the three laboratories CSTB, INETI and ITW for the location of Athens and a hot water demand of 200 l/d

Extrapolation procedure

The overall goal of the activities related to minimising testing effort by maximising testing flexibility was the development of a procedure of extrapolating performance test results of one solar domestic hot water system tested to systems o the same type but differing in size.

The basic idea is to set up an equation that establishes a relationship between the solar fraction f_{sol} of a solar domestic hot water system and the collector area (A_c) and the store volume (V_{sto}).

$$f_{sol} = f(A_c, V_{Sto}) \quad (1)$$

The function has to fulfil two criteria: it has to be a good approximation to the real behaviour of the system and it has to be a function that can be solved directly.

In a first step the simulation software TRNSYS was used to identify the influence of the collector size and the storage volume on the solar fraction. A thermosiphon system with the store on the roof and without auxiliary heating was examined with TRNSYS. For different collector sizes (2... 6 m²), different store volumes (0.2 … 0.6 m³) and different daily hot water demands (110 l, 200 l, 300 l) the simulation was carried out at the location of Athens and the solar fraction f_{sol} obtained was listed. Figure 7 displays the solar fraction in dependency of collector size and store volume. It can be seen that these values build a surface in the three dimensional space. The surface can be described by a polynomial of second order where the values of a1....a8 can be determined by a regression analysis.

$$\begin{aligned} f_{sol}(A_c, V_{Sto}) = {} & a1 + a2 \cdot A_c + a3 \cdot A_c^{\ 2} + a4 \cdot V_{Sto} + a5 \cdot A_c \cdot V_{Sto} \\ & + a6 \cdot Ac^2 \cdot V_{Sto} + a7 \cdot A_c \cdot V_{Sto}^{\ 2} + a8 \cdot V_{Sto}^{\ 2} \end{aligned} \quad (2)$$

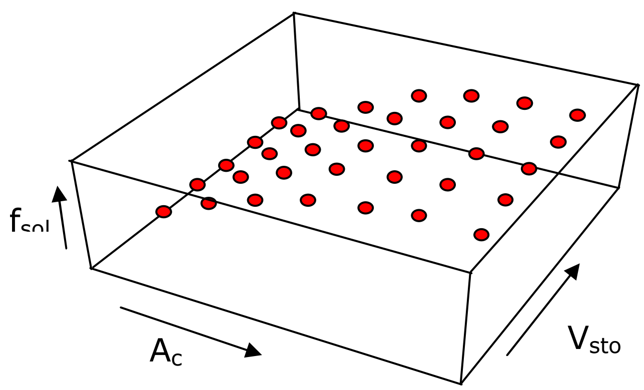

Figure 7: Calculated solar fraction f_{sol} in dependency of the collector aperture area A_c and the storage tank volume V_{sto}

In order to verify the accuracy of the results of equation (2) the computed values of f_{sol} are compared to the results of the TRNSYS simulation. The relative discrepancy resulting from this comparison is calculated according to equation (3),

$$\varepsilon_{rel} = \left| \frac{f_{sol\_TRNSYS} - f_{sol\_calc}}{f_{sol\_TRNSYS}} \right| \cdot 100\% \qquad (3)$$

For the system modelled up to now the relative discrepancy reaches values up to $\varepsilon_{rel} = 5.5\%$.

So far, for each product line of different design a new function $f_{sol} = f(A_c, V_{Sto})$ has to be determined. As the simulations necessary to derive the function are pretty complex and time-intensive it is not reasonable to carry out this calculation for every product line of hot water systems available on the market. Hence a different approach was used where the effects of collector size and storage tank volumes can be estimated more easily.

A classification of physical properties influencing the solar fraction of a thermosiphon system has been developed. The following influence parameters have been taken into account:

- Geographic position
- Performance o the thermal collector (e.g. collector efficiency)
- Performance of the storage tank (e.g. heat losses)

Characteristic values of these parameters representative for the European solar thermal market have been chosen e.g. different types of collectors and different values of the heat loss rate of the store. Thermosiphon systems with all possible combinations of the influence parameters have been modelled with TRNSYS and for each configuration the equations (2) has been set up. Altogether, 12 equations for each hot water draw have been determined for the location of Athens. It will be assumed that these equations cover a wide range of thermosiphon systems (without auxiliary heating) on the market.

In the next step a method had to be found to assign a product line to one specific surface described by equation (2). For each product line at least one system has been tested according to the DST-method and the solar fraction has been obtained by the long term performance prediction. The aim is to find the surface where the discrepancy between the values of f_{sol} obtained by the DST-method and obtained with equation (2) is minimal. The discrepancy is defined with,

$$\Delta f_{sol,j} = f_{sol,DST} - f_{sol,calc,j} \qquad (4)$$

j = 1... 12: equation number

If more than one system test has been performed, the summation over the discrepancies has to be determined:

$$\Delta F_{sol,j} = \sum_i \left|\Delta f_{sol,i,j}\right| \qquad (5)$$

i : system number
j: equation number

It is presumed that the equation where the value of ΔFsol is minimal describes the system behaviour in the best way. In this case the function is used to extrapolate the test results to system of the same type but differing in size.

For the validation of the mathematical model the results of the DST tests of the thermo-siphon system product line described in section above on system testing are used. The collector area and store volume with the corresponding value of the solar fraction of one system configuration have been entered in the DHWScale program developed within the project. For the remaining systems the results of the solar fraction were obtained by the extrapolation procedure. The comparison of the results achieved with the DHWScale program and with the DST-test showed good agreement. The uncertainty of the program lies in the range of 11 %. The error can be further reduced if more than one system of the product line is tested with the DST-method. With two system tests the uncertainty lies in the range of 6 %.

The mathematical model has been integrated into the computer program "Microsoft Excel" which allows the user to extra- or interpolate test results easily. The software, called "DHWScale" (Screenshot see Figure 8) as well as a manual describing the program is available as one deliverable of the project. The paper "Development of a procedure for extrapolating test results of one solar domestic hot water (DHW) system tested to systems of the same type but different in size" presents the mathematical model and the results in detailed. This paper is also available as deliverable of the project.

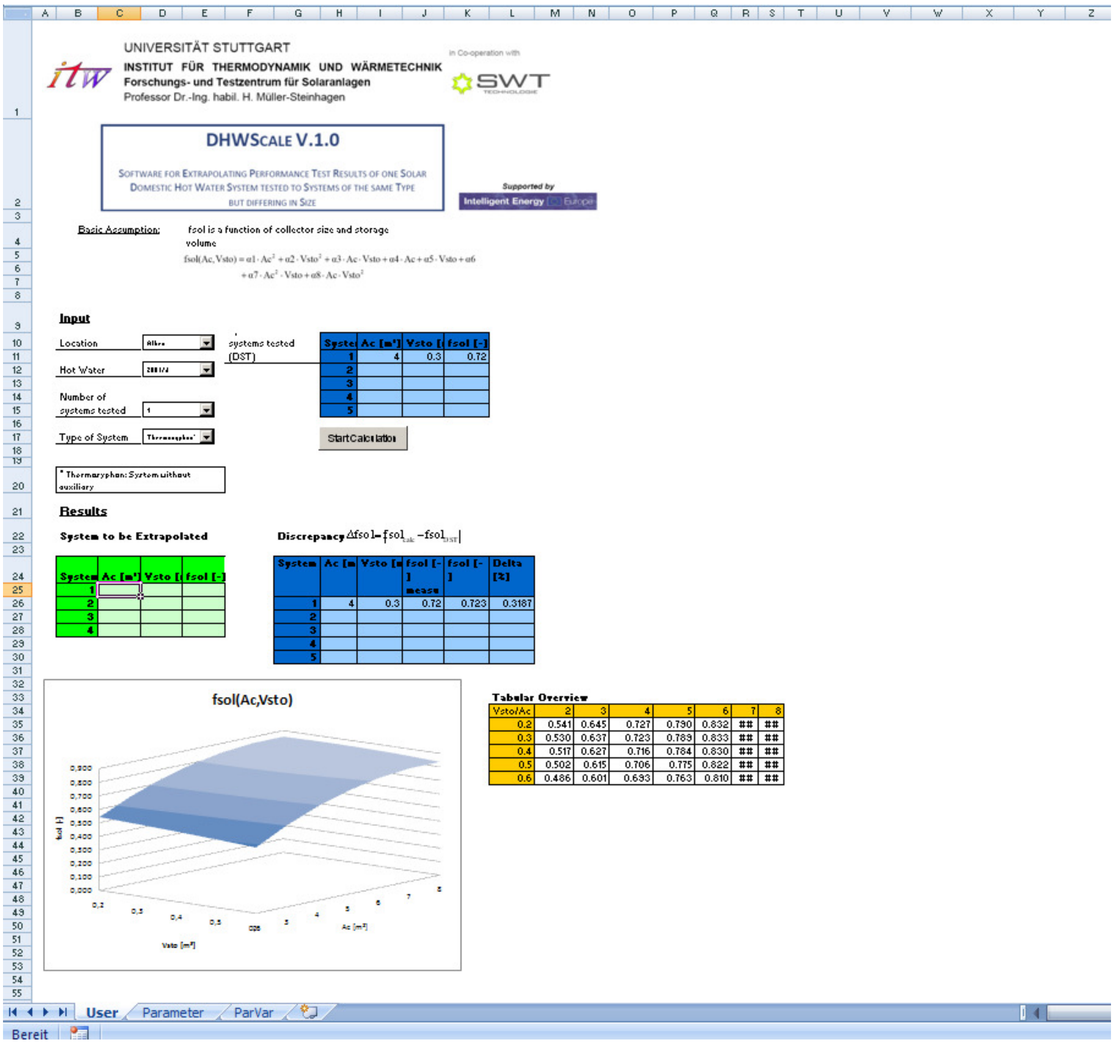

Figure 8: Screenshot of the DHWScale –Program

Solar Thermal and the Energy Performance of buildings Directive

In the framework of the Kyoto Protocol, the European Union (EU) has agreed to a total reduction of greenhouse gas emissions by 8% below 1990 levels during the first commitment period (2008-2012). Accordingly, the European Commission has launched the European Climate Change Programme (ECCP) in 2000, in order to establish a community strategy for the implementation of the Kyoto protocol.

Within the first ECCP report, cost effective measures for the reduction of green house gas emissions were identified and a list of priority actions on community level was given. Within these actions, promotion of energy performance of buildings took an important part, and a new directive on energy performance of buildings was recommended. The Directive 2002/91/EC on the energy performance of buildings (EPBD) was adopted finally in late 2002 and builds up an overall framework to promote energy efficiency for both new and existing buildings. This Directive allows for:

- The implementation of calculation methods (standards) of energy performance of buildings
- The implementation of thermal regulations for new buildings revisable every 5 years.
- The application of thermal regulations to major renovations of buildings greater than 1000 m2
- The obligatory supply of energy performance certificates during sales and rentals and the display of such certificates in public buildings
- An obligation of regular inspection of the boilers and air conditioning systems.

New buildings

The European Commission has mandated CEN (M343) to produce a set of standards to support Member States for the national implementation of the EPBD.

Under the mandate M343 about 28 standards (43 with parts) are being produced, covering the different elements of the calculation procedures, system inspection procedures and other relevant procedures. The main relations between different (clusters of) CEN standards are shown in figure 9.

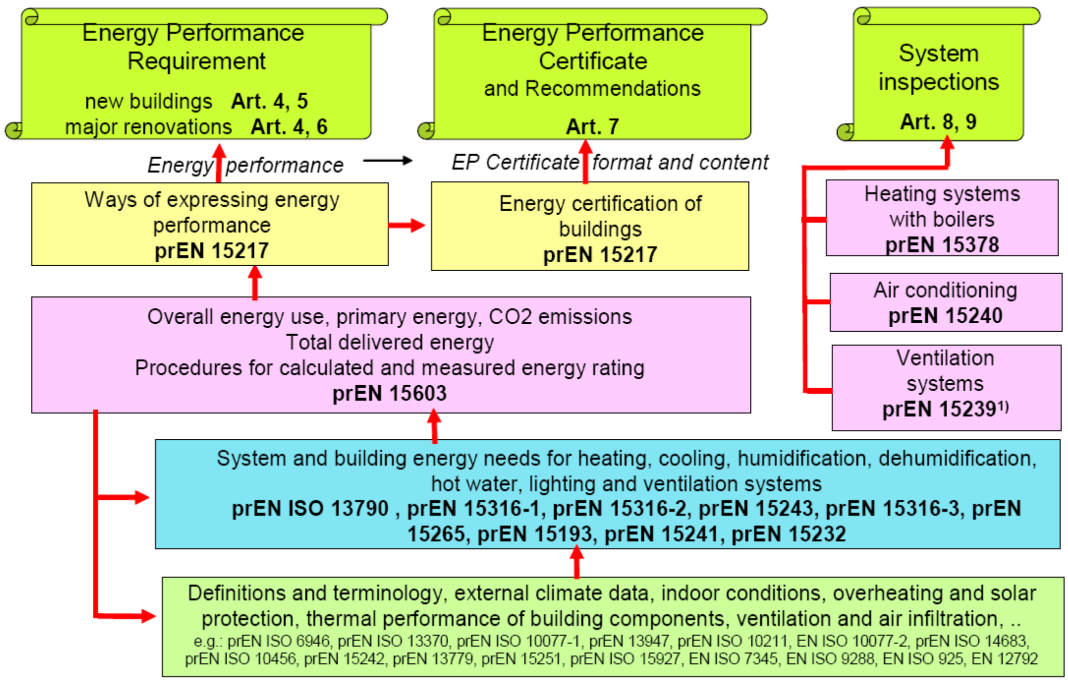

Figure 9 – Basic scheme of CEN standards

The EN 15316-4.3 European standard: Heating systems in buildings — Method for calculation of system energy requirements and system efficiencies — Part 4-3: Heat generation systems, thermal solar systems is one of the 43 standards used to assess the overall energy performance of a building. **This standard was adopted in June 2007.**

This European Standard gives methods for calculation of the thermal solar system input for space heating and/or domestic hot water requirements and the thermal losses and auxiliary energy consumption of the thermal solar system. The calculation is based on the performance characteristics of the products given in product standards and on other characteristics required to evaluate the performance of the products as included in the system.

From September to December 2007, a survey of national implementation of EPBD was performed over 18 EU countries. From this survey, it comes up that Member States, in the preparation of EPBD transcription into national legislation, have had to refer to either existing or new national procedures. This is the reason why EN 15316-4-3, which has only been approved in 2007, has not been implemented in any of the Member State building codes so far.

There are few existing calculation methods in Europe enabling to predict the energy performance of thermal solar systems. As far as possible, Members States who don't have such national methods should use EN 15316-4-3 for that purpose. For countries that already have such calculation methods, EN 15316-4-3 can be implemented in further revision of national regulations, assuming there is an understanding for further harmonisation between the Members States.

A software called SOLEN has been developed in the framework of this project on the basis of this calculation method. This software allows calculating the monthly and annual thermal performance of a thermal solar system as well as the energy savings and the quantity of CO2 avoided compared with a conventional system. This software can be downloaded at ftp://ftp.cstb.fr/SOLARKEYMARK II , free of charge.

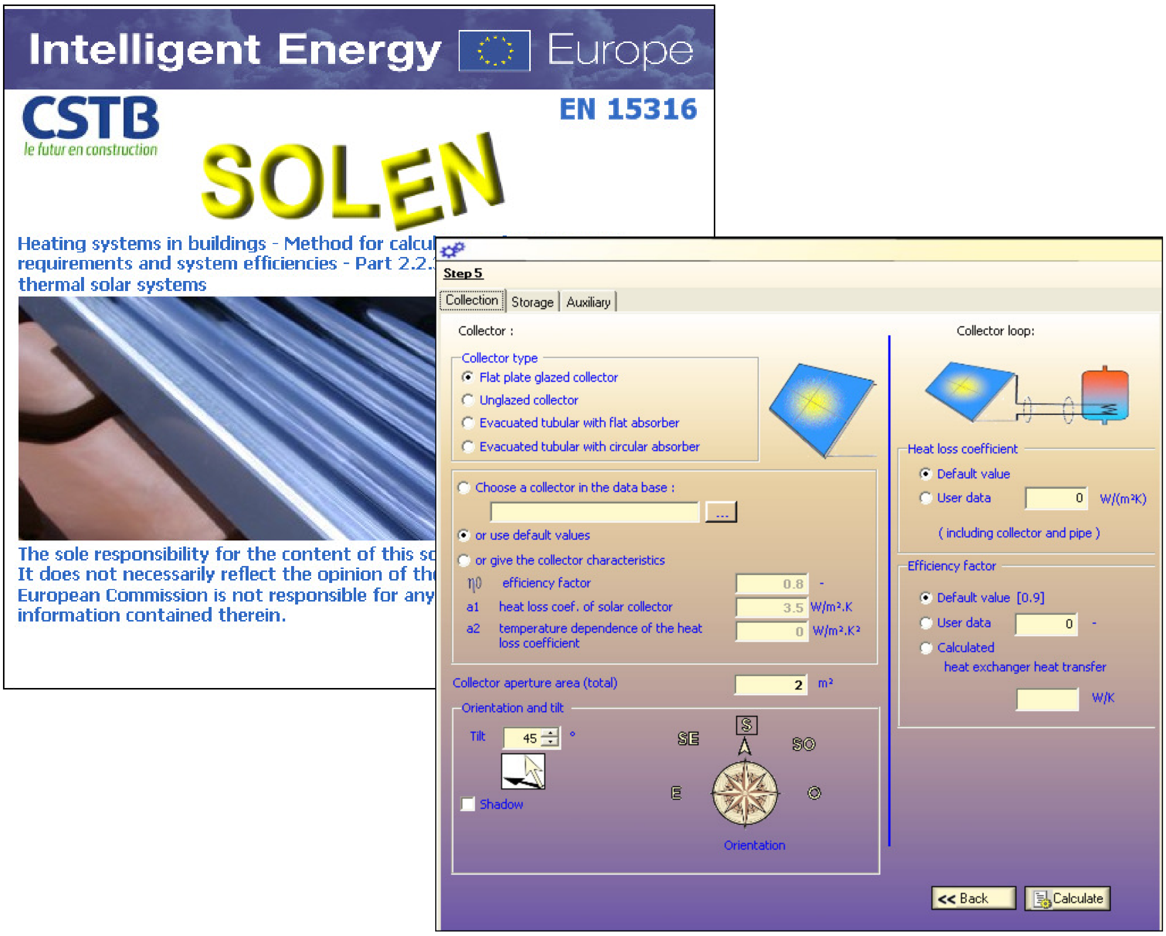

Figure 10 – SOLEN software

A study was carried out in order to compare the results produced by this software with the experimental data from test cases listed by the CSTB. These test cases are representative of those that can be found in Europe in the domain of individual and collective solar hot water production.

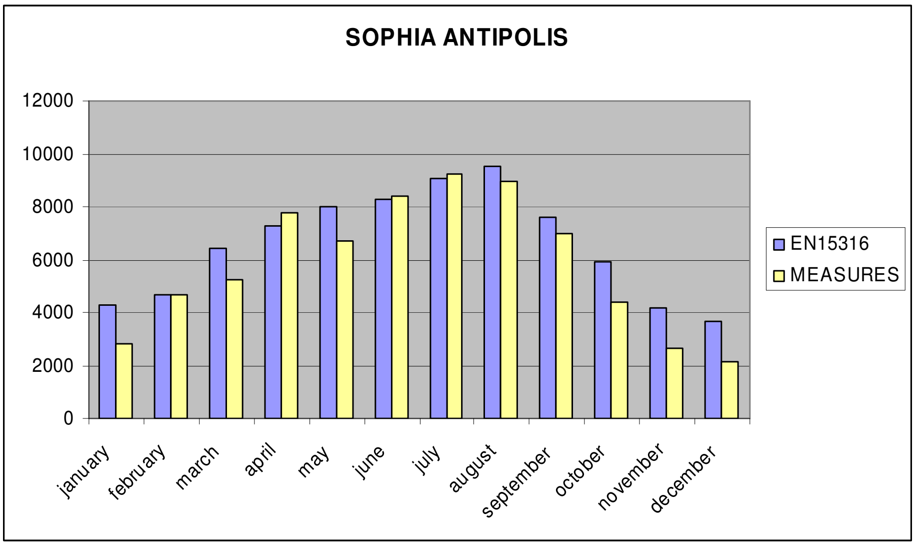

Figure 11 - Comparison of the solar production (in kWh) between EN 15316 and measurements – Hotel building

The results vary depending on the case, but overall SOLEN reproduces in a correct way the behaviour of thermal solar systems understanding that the experimental data are also subject to caution and that is concerns a very simplified calculation method.

This software can therefore be used as a calculation tool in order to promote in Europe the development of thermal solar systems.

Existing buildings

The Energy Performance Building Directive (EPBD) prescribes the use of an Energy Performance Certificate (EPC). This EPC displays the energy performance of a building and cost-effective measures to enhance energy performance are advised. Detailed implementation is left to the Member States, thus allowing each MS to choose the regime that corresponds best to its particular situation.
From 2006, when a dwelling is built, sold or rented out, an Energy Performance Certificate should be supplied mandatory.

The energy performance of buildings should be calculated on the basis of a methodology, which may be differentiated at regional level. The methodology should include aspects concerning:

- thermal characteristics
- installation (heating, hot water supply, air conditioning)
- application of renewable energy sources
- natural ventilation
- passive solar systems and solar protection
- indoor climatic conditions.

A small-scale survey in participating countries was performed to investigate how energy certificates are or will be implemented. Conclusions from this analysis are: i) Most EU countries have one, sometimes more, energy performance calculation methods but only few of them have methods or software adapted to existing buildings, ii) In most EU countries no official method (at a national or regional level) exists but sometimes a specific method is advised, iii) RES are rarely implemented in energy performance calculation methods or software.

The EN 15316-4.3 standard allows to calculate the contribution of thermal solar system to space heating and/or domestic hot water needs and the thermal losses and auxiliary energy consumption of the thermal solar system. Because this standard was only adopted in June 2007, it has not been implemented in any existing software enabling to assess the energy performance of a building.

A study was performed to demonstrate how software based on EN 15316-4-3 standard can be used in conjunction with energy performance calculation methods and how Energy Performance Certificate can be positively influenced by solar thermal systems. This study has shown that the installation of solar thermal systems in existing buildings (both dwelling and flat) can have a rather strong impact on the ranking of building energy performance in terms of energy-efficient class.

Heating system	**Heating**	**DHW**	**Solar fraction**	**Total**	**Energy efficiency class**
	kWh(PE)	**kWh(PE)**	**%**	**kWh (PE)/m²**	
Reference system	11269	2505	0%	138	D
Solar[1] Combi system	8378		41%	84	B
Gain				**-39%**	

Table 2 – One storey detached house - Gas heating

Standards

The work on standards mainly focused on:

- New standard method for determination/estimation of annual output of collectors based on collector test results only.
- Collector exposure test - general acceptance of a common procedure
- Improving test method for evacuated tubes

The work done is quite comprehensive and the description quite a long story – so the issues/results are briefly summarized here and then described in more detail in the following sub chapters.

Standard procedure for collector annual output:
Up till now test results from EN12975 test did show collector efficiency curves and power curves. Such curves make it possible to compare collectors for equal momentary operation conditions (irradiation, ambient air temperature and collector mean temperature). In figure 12 and 13 below two collectors:

A. Evacuated tubular collector of 1.7 m²
B. Flat plate collector of 2.0 m²

are compared using efficiency curves and power curves.

[1] The backup system for the Solar Combi system uses the same energy as the reference system.

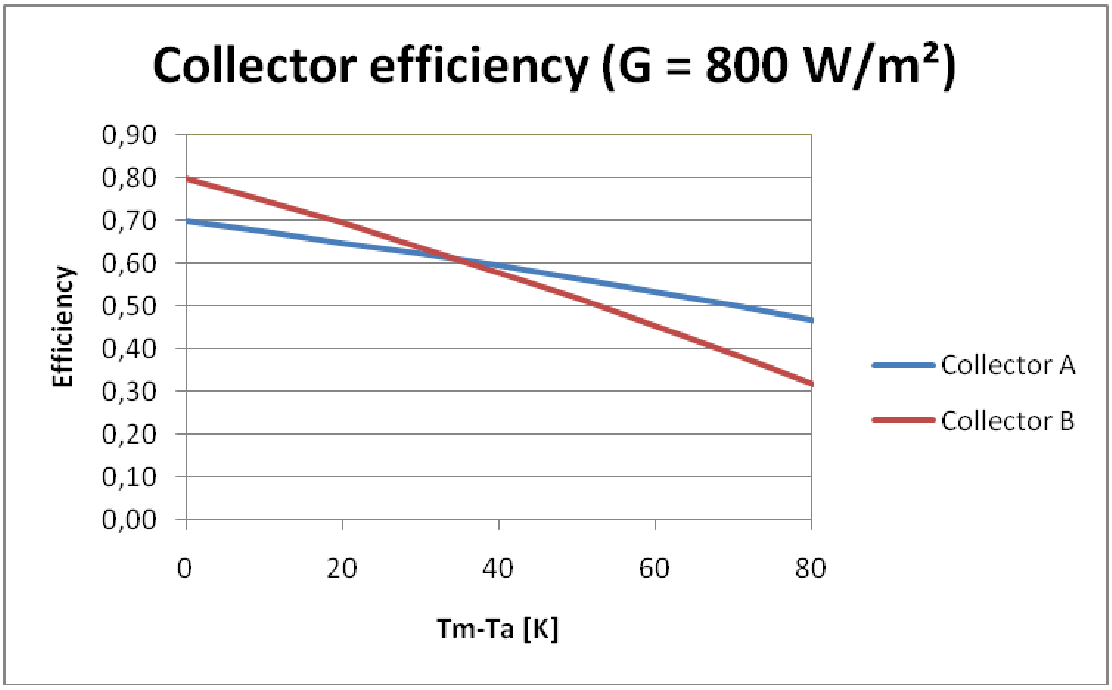

Figure 12. Collector efficiency curves of a typical evacuated tubular collector (A) and a typical flat plate collector (B). Presentation of results according to standards of the past.

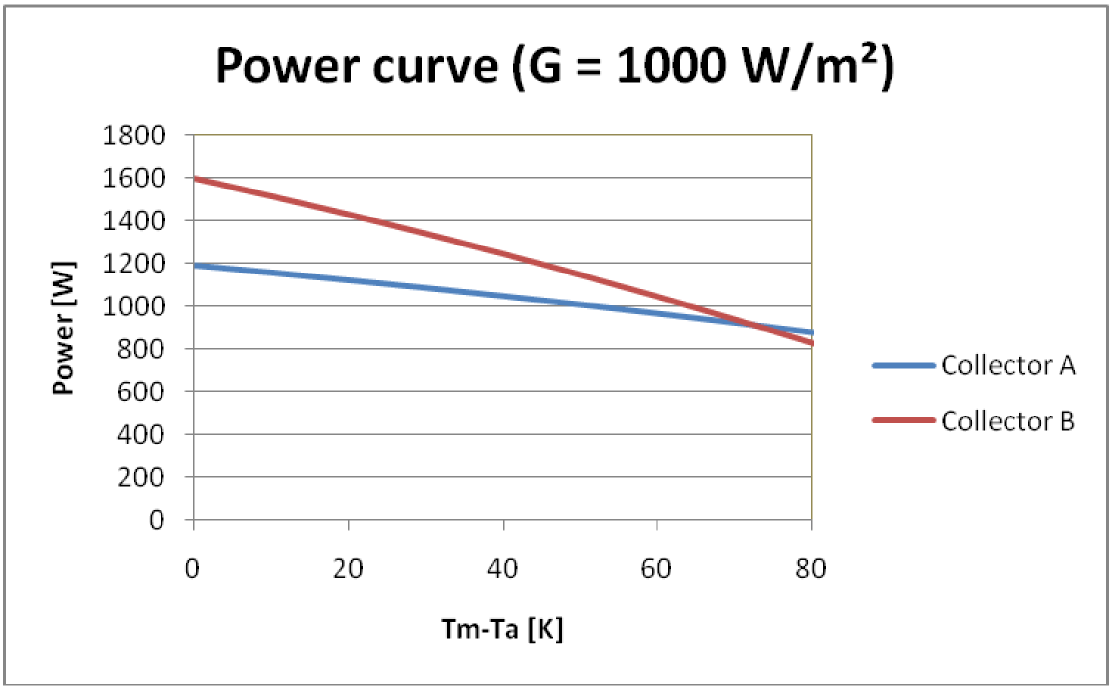

Figure 13. Collector power curves of a typical evacuated tubular collector (A) and a typical flat plate collector (B). Presentation of results according to present standards.

But the interesting thing is of course annual output of the collectors – so in the project a simple method for estimating the annual output of a collector has been developed.

The method assumes a constant inlet temperature to the collector all year round, and the – for a given climate – the annual output is the calculated hour by hour throughout the year. This makes it possible to compare collectors on an annual performance basis – taking into account the climate and typical operating temperature. In fig. 14the same two collectors are compared for two different climates (Stockholm and Athens).

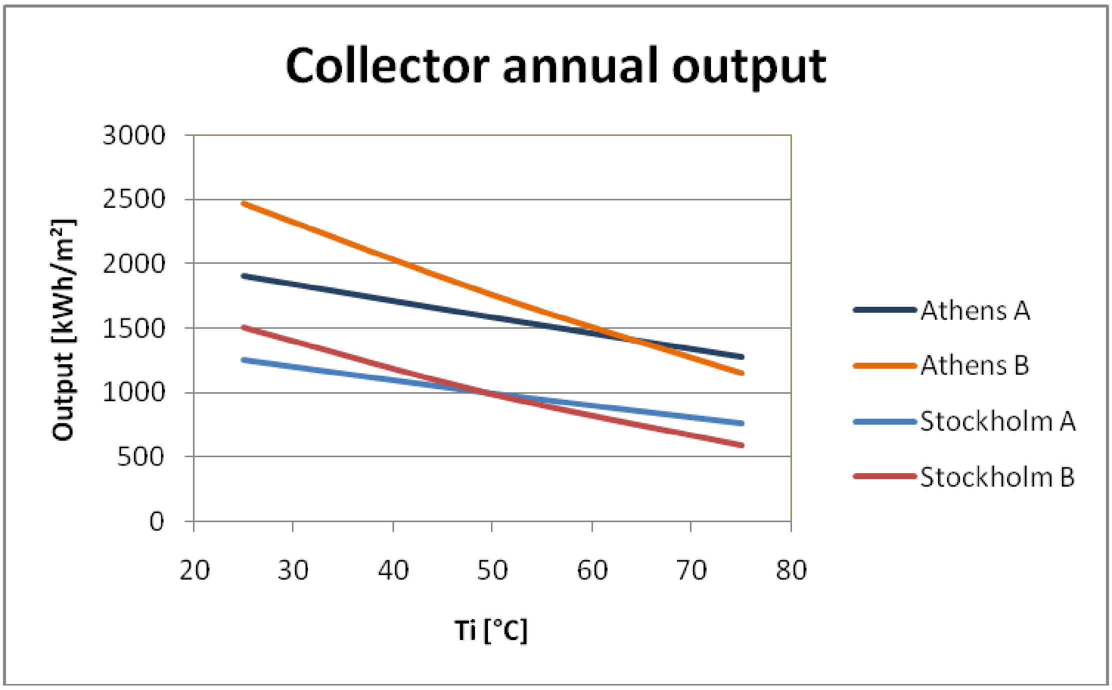

Figure 14. Collector annual output. Comparison of a typical evacuated tubular collector (A) and a typical flat plate collector (B) according to the method developed in the project. This will most probably be added to the result presentation required by standards of the future.

The method will be proposed to CEN/TC312 for inclusion in the next version of the EN12975 collector standard. The method is described more in detail below.

General acceptance of collector exposure test

It was not possible within the time frame of the project to reach unanimity with respect to the collector exposure test. However some interesting/promising proposals have been brought forward for further discussion and processing in CEN TC312.

Improvements of qualification test procedures for evacuated tube collectors

For historical reasons the qualification test procedures for collectors were developed with a focus on flat plate collector and were left with potential for improvements with respect to the special conditions related to evacuated tube collectors.

Annual Energy output

Background

The most important function of a solar collector is its energy performance, the energy output during one year. Based on results from testing according to EN 12975-2:2006 it is possible to calculate an annual energy output. However, the energy output might differ depending on which test laboratories that performs the calculations due to different calculation procedures. Furthermore the energy output will be dependent on where the solar collector will be located and used in practice, i.e. the outdoor climate, the tilt angle and the collector mean temperature. In order to be able compare different kinds of solar collectors from test results, independent of which test laboratory that has performed the test and where the collector finally will be located, it is important to have a standard procedure on how to calculate a comparable energy output.

A common procedure to calculate the yearly energy output is able to replace, for example, the present methods in Germany and Sweden or other special national methods.

A standardised procedure for calculation of the annual collector energy output based on the performance parameters resulting from efficiency tests according to EN 12975 and reference climates has been developed in the Solar Keymark II project. The procedure is programmed into an Excel spread sheet that will be available for all test laboratories and is meant to be an informative annex to EN 12975 in the future. The aim is that it should be easy to perform the calculations while still giving enough sophisticated results that can consider specific features of the most common collectors in the market, it will mainly facilitate performance comparisons for potential buyers.

The Excel spread sheet is based on hour by hour calculation with the input of performance parameters resulting from an efficiency test to calculate the incident angel modifier. Other predefined inputs that should be chosen are the collector inlet temperature (25, 50 or 75 ºC), location (Athens, Davos, Stockholm and Würtsburg) and tilt angels (0, 30, 45, 60 and 90 degrees). An example of results with the Excel spread sheet is given in Fig. 15.

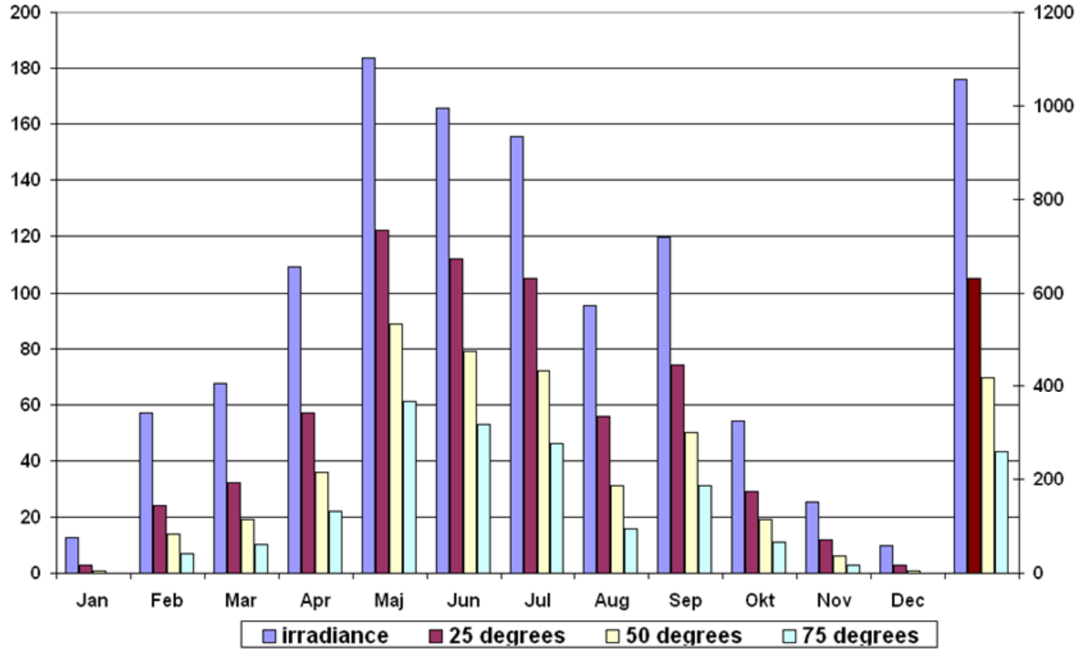

Fig.15. Example of results for monthly and annual energy output for different inlet temperatures calculated with a developed Excel spreadsheet. The left y-axis has the unit kWh per m^2 and month and right kWh per m^2 and year.

Based on the need for a common procedure on calculation of the energy output from collectors on the basis of performance test data, it has been decided to develop such a procedure. An inquiry among the participating countries has been carried out and the test laboratories have agreed on the basics of the calculation.
It is assumed that a common procedure for collector output calculations will increase the competition on the market and contribute to an open market for collectors and systems either such figures are used as a base for subsidies, for rating or as a pure consumer information

The outcome from the inquiry led to the following decision about the calculation:

- Hour by hour calculation with constant collector mean temperature and different climates.
- IAM effects should be included and later on even thermal capacitance.
- 4 climates (Stockholm, Wurzburg, Davos and Athens, preferably from Meteonorm)
- 3 collector mean temperatures (25, 50, 75ºC), of which 50ºC is chosen as the reference temperature.
- To be implemented in Excel.

It was decided that SP should prepare a draft proposal for such a calculation. The aim was:

- Should be a part of standard (EN 12975) as an informative annex when ready
- Easy to perform but enough sophisticated to take account specific features of most common collectors in the market.
- Based on weather data from 4 reference locations in Europe
- Relating to the standard for EPBD calculations prEN15316-4-3
- Relating to the procedure for m2 to kWh conversion and IEA world statistics

Short description
Below a brief description of the calculation procedure is given - a complete description can be found in reference [2].

Inputs
The calculation is based on the following inputs:

- Collector location (there is possible for the user to add more weather data from more locations): Stockholm, Wurzburg, Davos and Athens
- Collector performance data (based on aperture): η_0 (weighted as 85% beam (at θ=15º) and 15% diffuse), a_1, a_2 and $K_{\theta d}$
- Collector tilt angle (the azimuth is fixed to south): 0, 30, 45, 60 and 90 degrees
- Collector mean temperature, variable (25, 50 and 75 is default)
- IAM type:
  - Simple, one direction (e.g. flat plate collector)
  - Simple, two directions (e.g. flat plate collector with dependence in to directions or some collectors with reflectors)
  - User defined Incidence dependency for every 10 degrees between 0 and 90 both transversally and longitudinally. (e.g. vacuum tubes and collectors with reflectors)

Calculations
The calculation is based on equation 32 in EN 12975-2:2006 but without dependency of wind, thermal capacitance and sky temperature (and therefore only valid for glazed collectors). The heat delivered to the distribution system (kWh/m^2) is then calculated according to the following equation (see reference [2] or EN 12975-2:2006 for symbols and units):

$$Q/A_a = \eta_0 * K_{\theta b}(\theta) * G_b + \eta_0 * K_{\theta d} * G_d - a_1(t_m - t_a) - a_2(t_m - t_a)^2$$

Where: $\eta_0 = F'(\tau\alpha)_{en} * K_{\theta b}(\theta=15) * 0.85 + F'(\tau\alpha)_{en} * K_{\theta d} * 0.15$

The weather data is taken from Meteonorm 6.0 and hour by hour. No calculations of weather data is made by the program they are all taken from Meteonorm at each tilt and location.

Outputs
The output-sheet is displaying the following data and calculations:

- A diagram and a table that shows the monthly and yearly calculated energy output for the collector together with global irradiance.
- Location, longitude, latitude, tilt angle and time period of the climate data for the chosen location
- The collector information, η_0, a_1, a_2, $K_{\theta d}$ together with incidence angle modifier (IAM)

The calculations are not as precise as calculations made in for example TRNSYS or Polysun. The advantages are that the method has a fully transparency. Due to the few parameters it is also easy to use.

Validation and accuracy
The Excel-sheet has been compared against two types of commercial software. A TRNSYS model with a solar collector Type 1 and Mode 1 (Presim No. 301) and the "Gross Heat Gain" in Polysun 3.3.

TRNSYS
SP has used the actual model for the annual energy output for calculation regarding the Swedish subsidy since 2003. The inputs for the model have been a reference year (Stockholm 1986 with 1057 kWh/m2 for a tilt of 45 degrees in south and mean ambient temperature of 6.1 ºC) together with η0, a1, a2 and a table of incidence angle modifier (IAM). For the validation the same climate (Meteonorm) has been used for both TRNSYS and the Excel-sheet.

Polysun
The Polysun is develop by SPF in Rapperswil and is also including specific heat capacity. The input for IAM is restricted 50 degrees longitudinally and transversally. There is however possible to choose a model for a flat plate collector or an ETC. The climate for Stockholm has a global irradiance of 1214 kWh/m2 and a mean ambient temperature of 6.6 ºC. The diffuse irradiance is in Polysun 6.6 % higher than in Meteonorm data.

Result of the validation

The comparison is performed for four types of collectors; one flat plate collector and three types of ETC. The calculations are all done for Stockholm, south, a tilt of 45 degrees, and at the temperatures 25, 50 and 75 ºC. The output has been corrected regarding differences in global irradiance and ambient temperature.

Excel versus Polysun
A positive difference means that the annual energy output is higher for the calculations done with Excel and vice versa. The specific heat capacity is in Polysun put to 1 kJ/m^{2}K. For collectors in the Polysun database

Type of collector / Temperature	**25 ºC**	**50 ºC**	**75 ºC**
Flat plate. Excel with IAM type: Simple, one direction	**0 %**	**1 %**	**-1 %**
ETC double glass, cylindrical absorber and direct connection. Excel with IAM type: Simple, two directions Polysun: Special IAM: No	-4 %	-4 %	-2 %
ETC double glass, cylindrical absorber and heat pipe. Excel with IAM Type: User defined Polysun: Special IAM: No	0 %	4 %	9 %
ETC double glass, cylindrical absorber, flooded. Excel with IAM Type: User defined Polysun: Special IAM: Yes (see Polysun manual)	4 %	6 %	10 %

Excel versus TRNSYS
A positive difference means that the annual energy output is higher for the calculations done with Excel and vice versa.

Type of collector / Temperature	**25 ºC**	**50 ºC**	**75 ºC**
Flat plate. Excel with IAM type: Simple, one direction	-6 %	4 %	1 %
ETC double glass, cylindrical absorber and direct connection. Excel with IAM type: Simple, two directions	-11 %	-11 %	-11 %
ETC double glass, cylindrical absorber and heat pipe. Excel with IAM Type: User defined	**-7 %**	**-3 %**	**2 %**
ETC double glass, cylindrical absorber,	**-3 %**	**-1 %**	**3 %**

flooded. Excel with IAM Type: User defined			

Conclusions of the validation
For flat plate collectors the model is nearly equivalent to the calculations in Polysun and also quite good compared to the TRNSYS model. In calculation with ETC it is recommended to not use the Excel-sheet with "IAM type: Simple, two directions". Excel with IAM Type: User defined and the TRNSYS model gives also a very high conformably in calculations of ETC.

Conclusions
It is recommended to CEN/TC 312 to consider this calculation be a part of standard (EN 12975) as an informative annex.

Further improvements
Add thermal capacitance as an input. Add more locations. It is possible for the user to add more locations but there is maybe desirable to have more locations as normative.

Improved exposure test – accelerated ageing test of collectors

Background
The present European exposure test has been under a lot of debate, mainly due to its inability to maintain uniform test conditions when applied in different parts of Europe. Furthermore it is not considered to reveal the weaknesses of ETCs. Some countries have since long had stricter exposure tests than what is required by EN 12975, and one of the main objectives in the Solar Keymark II project is to eliminate such barriers. Two different methods are now evaluated within the Solar Keymark II project as new candidates for exposure test, but it is not yet clear if any of them will be sufficient enough. The test needs to have the following requirements:

- Main objective is to agree on a standard so that we all do the same test.
- Solve the basic problem of irreproducible test conditions in different locations
- The tests should not be unnecessarily long lasting since it will take too long time to come out with new products and it will give expensive testing.

The present outdoor exposure test was discussed due to the fact that it a) requires a long time to carry out and b) is not proven to give the same results wherever it is applied. Two French and one Australian alternative method have been briefly investigated and the latter is judged as promising. Here, the collector is connected to a heating circuit by which the collector is heated to its stagnation temperature. The collector is then maintained at this temperature for 12 hours per day in 10 days. After that a thermal performance test is carried out at a single test point. A major advantage with this method compared to the CSTB proposal is that the reproducibility of the tests are assured in the way that different national climatic conditions will not at all affect the outcome of the results. The Australian approach is also less time consuming, even compared to the outdoor exposure presently described in EN 12975-2:2006. A drawback of the Australian method is that the cumulative impact of a number of different climate variables such as rain, UV and wind is not assessed.

The Australian method is checked theoretically with the following results:

- Questioned if it will give the result that we expects
- Practical carrying out
  - Difficult to make outdoor in Sweden
  - Expensive in inside in solar simulator
- Australian test works well for flat plate collectors and vacuum tubes without heat pipes. It can also be used for heat pipes if it is done in solar simulator or with hot oil within the piping. It will be more expensive for heat pipes but possible to use.
- The Australian method also requires a retest of thermal performance at one temperature.
- Suggestion that a third method need to be developed
- Check that additional conditions in exposure test will be equivalent with the Australian method.
- When the standard is revised we suggest that more work is needed to agree on a test procedure for this test. The Australian method is a recognized standard that is faster and more repeatable. Solar Keymark therefore believe that all test laboratories will be willing to stand behind one method if a new method is developed with inspiration from the Australian method
- For collectors with an integrated overheating protection the calculation method to get the stagnation is not appropriate

A general acceptance of either the today's method of exposure test in EN 12975, the French's methods or the Australian is not possible to reach within the timeframe of the project.

Conclusions

- Further work on theory and validation needed for a prolonged outdoor exposure test. Idea of accelerated test on small scale collector was abandoned and FMEA approach not intended for the standard

- ”Australian method” (short term heat cycling) should be more appealing to industry and ”more reproducible”. A proposal based on this method should be developed and discussed in CEN/TC 312 WG 1 as an alternative to the present outdoor exposure.

Performance and quality tests for collectors with evacuated tubes

Most of the work related to development of test methods and quality criteria for solar collectors has been done mainly by considering plate collectors. Only to a minor extent has evacuated tubular collector (ETC) and its specific properties been addressed. ETC collectors today have a remarkable development of the Chinese solar thermal market. In ten years their market shares have grown from 35 to 85 %. The total annual sales of collectors are around 15 million m2 and growing by an annual 30%. In Europe ETCs have not been the same success so far but their shares are increasing and they have a significantly potential to contribute to a large scale introduction of solar thermal products. In order to meet this market development it is necessary that testing of performance and quality should also take the specific characteristics of ETCs into account. This is considered in the Solar Keymark II project that is developing procedures for quality and performance testing of ETCs.

Items relevant to ETCs with heat pipes:

The heat pipe construction is sensitive in several ways:

- The amount and composition of the evaporating liquid
- The vacuum inside the metal pipe
- The material quality in the pipe and the design of the pipe and the bulb.
- Improper dry connection resulting in low heat transfer capacity.
- Dry out effects during testing under high irradiance
- Risk for freezing, damage due to high temperatures (reflectors), air pockets inside the bulb as a result of improper filling or material...

These possible failure modes together with the ones resulting from the “metal fin inside double wall glass tube” construction and from the absorber itself makes variable quality and/ or energy performance much more likely for these collectors than for e.g. ordinary flat plate collectors.

The work is based on a questionnaire about ETC testing performed in 2005 among 15 test laboratories, a few manufacturers and importers (Kovács et al., 2007). The purpose of the inquiry was to give a background to an assessment of the need for revised test procedures regarding performance- and quality testing of ETCs. The questionnaire turned out to raise a number of new questions and the ongoing work is based on some of the proposals that were addressed:

- ETCs have comparatively low heat losses which results in higher stagnation- and maximum operation temperatures than compared to flat plate collectors. This means a higher probability for fault to occur during the high temperature- and exposure test that might affect the collector's efficiency. In order to reveal low quality products it is recommended to introduce a test cycle for these collectors. First the collector is measured for efficiency, then to a high temperature- and exposure test and finally for efficiency once again. In order to save costs one of the efficiency tests could be limited to zero loss efficiency, but preferably also the eventual increase in heat losses should be assessed. In order to get knowledge about the effect of introducing a test cycle measurements are ongoing with the test cycle for two types of ETCs.

- Damaging of heatpipes due to freezing can result from improper composition of the working media in the heatpipe or from bad design of the metal tube (material quality, thickness, shape of lower end) and has been reported by several sources (Kovács et al., 2007). As breakage of the metal tube in the case of bad design often doesn't occur until after several freeze cycles, a new procedure for freeze testing has been proposed and will be tested and evaluated within the Solar Keymark II project.

- The EN 12975 standard has today weaknesses of not describing in detail where the stagnation temperature should be measured and with higher stagnation temperatures it will be difficult to determine unambiguous stagnation temperature. Special attention is also required in order to avoid thermal stress on the heat transfer fluid. These problems will be more obvious for ETCs and an investigation is ongoing in the Solar Keymark II project where the stagnation temperatures are measured at different places of the ETC.

- The EN 12975 standard has today weaknesses of difficulties to determine efficiency at high temperatures with good accuracy which will be more obvious for ETCs since they have high operation temperatures. Several laboratories have reported that dry out effects can occur during testing of ETCs with heat pipes during high irradiance conditions and that the present collector model used in the standard was not able to accurately model the thermal capacitance and time constants of the collector. The method available for calculating the thermal capacity of the collector has been reported to underestimate the figures for double glass ETCs. These are also important subject for further research that is needed in near future.

New test cycle for vacuum tubes

Background
In order to reveal low quality products, in particular among ETCs with double glazing's and heat pipes, it was recommended in NEGST to introduce a test cycle for these collectors where the same collector is first measured for efficiency, then subjected to a (possibly revised, tougher) high temperature- and exposure test and then measured for efficiency once again.

A test performed by SP on typical Chinese ETC with heat-pipe did not uncover any difference in performance after a cycle of high temperature test and exposure test with internal and external shock. The industry says in order to show any differences cycles with freezing must be added.

Conclusions
More work is needed before it can be recommended to implement at test cycle for ETCs.

Mechanical load of vacuum tubes:

Background
The mechanical load test in EN 12975-2:2006 is in practice not suitable for tests on vacuum tubes. Due to the round shape of the tubes and the distance between them it is not easy to make a load on the tubes that is corresponding to the reality. The negative pressure test is intended to access the extent to which the fittings between the collector cover and collector box are able to resist uplift forces caused by the wind. This is not relevant for tubular collectors.

The positive pressure of the collector is possible to perform with a plastic folio, but the load on the tube surface is overrated when using 1000 Pa. The negative load is not possible to perform with neither of the procedures described in EN 12975-2:2006 chapter 5.9.2.2.

Today's test at SP
SP is today performing both the negative and the positive load by putting a plastic folio under or on top of the collector. A fan placed under the collector is creating a negative or positive pressure. To make a test better is corresponding to the reality and be able to test the negative load SP are using the plastic folio and a downscaled load. The folio is able to put between the tubes and the foundation or reflectors. The downscaled load is calculated as:

(Area of header + outer tube diameter * length of tubes) / (Gross area of the collector)

This is often resulting in a pressure between 600 and 800 Pa. SP has tested more than 15 vacuum tubes collector with more than 300 tubes for positive and negative load and no one has failed. This is of course not guaranteed that all tubes are resisting this test.

Today's test at INETI
INETI uses the suction cups for the mechanical load test, and in the case of ETC they could perform the negative load using an iron plate where the suction cups were applied. The iron plate is then fixed to the base structure of the collectors. This has only been applied to a collector with reflector.

With this methodology they could only test the fixing of the collector and reflector to the roof and not the collector itself (the tubes and header), which seems to be a problem when there is no reflector behind. They consider that a test should be done if the collector has a reflector and in this case positive and negative pressure would be needed but the form to apply the positive pressure has to be decided.

Conclusion
It is decided to skip the negative pressure test within Solar Keymark right now and wait for any decisions about reversion of EN 12975. It is at the same time recommended to CEN/TC 312 to skip the negative pressure tests in EN 12975 for vacuum tubes. An alternative is to perform the test with plastic folio both for positive and negative load. A third alternative is to only carry out the test for vacuum tubes with reflectors.

Measurements on stagnation temperature on vacuum tubes

Background
According to EN 12975-2:2006 the stagnation temperature shall be measured at two-thirds of the absorber height and half the absorber

width (5.3.2). This is not suitable for vacuum tubes. In two notes there are given an opportunity to choose an alternative location and an alternative method of the measurement. The location or method should then be clearly described with the test results.

There is in many ways helpful to straighten out where the highest temperature is expected. For example, this could unveil uneven quality in the performance of the tubes or the whole collector.

Measurements on double-glass vacuum tubes reveal that is likely to find the highest temperature in the top of the bulb at vacuum tubes with heat pipe and near the header in vacuum tubes with U-pipe.

On single glass it is not possible to get access to the absorber and therefore the above location of the temperature sensor is not applicable. A measurement inside the header or riser does not seem to differ much from the temperature inside the actual tubes.

Conclusion
It is recommended to CEN/TC312 to more precise define where the temperature should be measured for vacuum tubes (According to Note 1 in chapter 5.3.2). A suggestion is given below:

Type of collector	Position of measurement	Comments
Flat plate collector	Backside of the Two-thirds of the absorber height and half width	As stated in EN 12975 today
Double-glass vacuum tubes with heat pipe	Just below the top bulb inside the tubes - in at least 3 tubes	E.g. thermocouple attached to the copper tube
Double-glass vacuum tubes with U-pipe	Near the header – in at least 3 tubes	E.g. thermocouple attached to the copper tube
Single glass vacuum tubes	Inside the header	E.g. thermocouple attached to the copper tube or a surface sensor
Concentrating collectors (not vacuum tubes)	On the absorber - on a spot in the middle of the absorber with assumed highest concentrating factor	E.g. thermocouple attached to the absorber

Collector components - requirements and test methods

Introduction

Durability testing of solar absorber coatings, anti reflective coatings, reflector materials and polymer components of solar collectors were early addressed as important subjects for improvement of standards and they have already been accepted as part of upcoming revisions of EN 12975 by the CEN/TC 312 meeting in Canary Islands in April 2006.

The absorber itself, in the collector, is directly or indirectly subjected to a number of tests in the present standard for collector testing EN 12975. Requirements for reliability are also defined. However, for the long term durability of the absorber or more specifically, the absorber coating, there are no requirements. Considering the rapid and continuously ongoing development of new materials, coatings etc. and the increasing specialization among manufacturers, it is assumed that manufacturers of absorbers could benefit from methods that can ”predict” a long service life. Standardised methods and requirements would also benefit their clients, the collector manufacturers, who would then be able to strengthen quality requirements on their suppliers. A new document: “Recommended qualification test procedure for absorber surface durability” (Carlsson, 2004) describes tests applicable to organic and inorganic coatings can more or less be considered ready for inclusion in the standard.

Polymer materials have so far only been used to a limited extent in solar thermal applications. In low temperature applications such as pool heating the introduction has been very successful and in general without problems related to the materials. On the contrary, in medium and high temperature applications where polymers were tried to replace inorganic materials, it has in general failed. As polymers definitely have many potential advantages to offer in solar thermal applications compared to traditional materials, it will be useful to researchers and manufacturers to have a set of common tools and methods to assess their properties and suitability for more demanding applications. The work to include these considerations into the standard is still within the starting phase but there are some methods that can provide an extensive input to this field.

Another subject for improvements of standards is the increasing use of reflectors and anti reflective coatings of cover materials as a cost efficient way of improving the performance. It is a highly exposed component having a high influence on the performance, but is not assessed in the present standard. For example it is a need to be able to assess the long term effects on the collector output. At present no standardised methods are available for this purpose.

Background
With regard to requirements and test methods for collector components (absorber surfaces, polymer absorbers etc.) it has been decided to develop a proposal for revision of EN 12975 mainly based on existing documents from ISO and IEA.

Description
- Absorber coating surface
- Polymer materials
- Reflector and anti reflective coatings of cover materials

Testing solar collectors´ ageing and corrosion characteristics
The test method includes [4]:
- Cover of plastic
- Absorber surfaces in solar collectors with and without cover sheets

Requirements
Measure the absorption α (weighted with the solar spectrum, air mass 2) and the emissivity ε (at 100 °C) before and after testing. Neither the absorption nor the emissivity may have been reduced or increased respectively by more than 5 percentage points after testing. The samples must not either exhibit any traces of crazing, flaking or cracking, or show changes in colour.

However, colour change can be accepted if the absorption or emissivity has not reduced or increased respectively by more than 5 percentage points after testing.

Dissemination of results

The approaches and issues were discussed openly throughout the project and non-project-partners were invited to give input as well. The results were disseminated widely – through the website, brochures, presentations at conferences, articles, face-to-face talks etc.

When the project was conceived, it was expected that promotion of the Solar Keymark to the industry would be a major task of the dissemination strategy (by then, only 13 products carried the Solar Keymark!). But when the project finally started, it became quickly clear that interest in the Solar Keymark had dramatically increased already and manufacturers/importers were now interested in getting to know the details of how the certification process works, how OEM products are treated etc. Therefore dissemination was adapted from mostly raising awareness through push-measures (newsletters, press releases) to mostly providing more detailed answers using pull-measures (constantly updated website, translation of the Solar Keymark brochure into further languages, additional workshops at industry events). The website www.solarkeymark.org already draws a lot of interest and the provision of up-to-date material from the project proved most important throughout the duration of SolarKeymark-II.

The promotion of the Solar Keymark towards national authorities was achieved through personal communication between project partners and public authorities as well as in some cases by letters of ESTIF to national governments.

The establishment of the Solar Keymark network, bringing together test institutes and certifiers was another measure which helped to spread information beyond the project partners themselves. The network has proven very successful and the next meetings are already planned for June and October 2008.

Conclusions

The Solar Keymark has dramatically gained in recognition – both, by industry and by national authorities. On both sides, understanding of this certification scheme has been improved through this project, leading to a fantastic adoption rate by the industry: 2/3 of solar collectors traded in Europe today are Solar Keymark certified (the consortium had originally hoped to reach 15-20% by the end of the project). With Spain, Germany and the UK now accepting or even requiring the Solar Keymark – albeit with some additional requirements – the acceptance by public authorities has also increased very well during the project. Industry hopes that acceptance in national support schemes will pave the way also for general acceptance of Solar Keymark'ed products in regional or local support schemes and building codes.

Lessons learned

- The Solar Keymark has proven to be a very successful tool to open national markets for solar thermal products.
- The SolarKeymark-II project has laid the grounds for further improvements of the certification scheme (e.g. by proposing a methodology for up- and down-scaling of test results).
- With longer-term projects such as SolarKeymark-II, one has to take into account changed timings compared with the planned schedule: In the case of the SolarKeymark-II project, adoption of the Solar Keymark by the industry happened faster than expected, while the formal adoption of standards

lasted longer than foreseen. The project consortium should be able to deal with such variations.

Recommendations for further work / similar actions

The solar thermal sector is developing rapidly. This makes updates to EN standards and the revision of the Solar Keymark scheme rules necessary from time to time. Otherwise, the standards or the certification scheme itself could become an obstacle for product development. The adaptation of standards to the state of the art in products and the market is essential for the success of solar thermal. Future projects can build on the work of the Solar Keymark I and the Solar Keymark II project in order to continuously improve/adapt standards and certification schemes.

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