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IEA SHC - TASK 26

Solar Combisystems

(Source: Wagner &Co, Germany)

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Edited by
Jean-Marc Suter and Irene Bergmann

http://www.iea-shc.org

Task 26 is completed

By Operating Agent Werner Weiss, AEE INTEC, Arbeitsgemeinschaft ERNEUERBARE ENERGIE, Institute for Sustainable Technologies, Feldgasse 19, 8200 Gleisdorf, Austria,
e-mail: w.weiss@aee.at, http://www.aee.at

Since the beginning of the eighties, the rate of growth in the use of solar collectors for domestic hot water preparation has shown that solar heating systems are both mature and technically reliable. But for several years solar thermal systems have seemed to be essentially restricted to this application.

From 1990 and further, the industry offered more and more solar combisystems, but basic scientific knowledge was missing in certain areas and methods. The designs resulted mainly from field experiences and they had not been carefully optimised. A first international survey in 1997 revealed more than 20 different designs that did not necessarily reflect local climate and local practice only. Collaborative work in analysing and optimising combisystems was seen as a proactive action that could favour good systems on a more global market than the national one.

Common definitions of terms were also missing and standardised test procedures were not available for this type of system. This means that it was difficult to determine a meaningful performance rating and even more difficult to compare the systems.

For domestic hot water systems, a great effort has been made in IEA SH&C Task 14 to assess and compare performances of different designs. For solar combisystems, the question of finding a "best" solution in a given situation had no answer in 1997.

Therefore, international co-operation was needed to analyse and review more designs and ideas than one sole country could cover. It was felt that an IEA activity was the best way to deal with solar combisystems in a scientific and co-ordinated way. Considering that, the Solar Heating and Cooling Programme of the International Energy Agency (IEA) launched in 1998 Task 26 called “Solar Combisystems”.

From autumn 1998 to December 2002, 35 experts from nine European countries and the USA and 16 solar industries have been working together to further develop and optimise solar combisystems for detached single-family houses, groups of single-family houses and multi-family houses. Furthermore, standardised classification and evaluation processes and design tools were developed for these systems. Proposals for the international standardisation of combisystem test procedures were another major outcome of Task 26.

To achieve the objectives of the Task, the participants carried out the research and development in the framework of the following three Subtasks:

Subtask A: Solar Combisystems Survey and Dissemination of Task Results. Lead Country : Switzerland, represented by Jean-Marc Suter, Suter Consulting, Berne

Subtask B: Development of Performance Test Methods and Numerical Models for Combisystems and their Components. Lead Country: The Netherlands, represented by Huib Visser, TNO, Delft

Subtask C: Optimisation of Combisystems for the Market. Lead Country: Austria, represented by Wolfgang Streicher, Graz University of Technology, Graz

The further development and optimisation of systems and their designs by the Task 26’s participants resulted in innovative systems with better performance-cost ratings. Besides, architectural integration of the collector arrays together with durability and reliability of solar combisystems were investigated. This should lead to greater confidence of the end user in this technology.

Solar industry and builders were involved in all activities in order to accelerate dissemination of results as broad as possible.

Fig. 1: Solar Combisystem with facade-integrated collector array (Source: Wagner & Co, Germany)

Task 26 Results

The results of Task 26 are besides a design handbook, several technical reports, design tools and proceedings of six industry workshops which can be downloaded from the web site of the IEA Solar Heating and Cooling Programme http://www.iea-shc.org/task26/.

Technical reports

Technical reports document some specific results and findings of Task 26 and provide details and background information on the topic presented.

The following technical reports will be available by end of June 2003 from the IEA SH&C web site http://www.iea-shc.org/task26/:

Comparison of solar combisystems, architectural and reliability/durability aspects

- Validation and background information on the FSC procedure
- Stagnation behaviour of collectors and systems
- Detailed results on the architectural integration of collectors
- One particular approach for the analysis of failure modes
- Changes noticed on the solar combisystem market since 1999 in the participating countries

Performance test of solar combisystems

- Description of test facilities
- Hot water performance of solar combistores
- Description of the DC test method
- Background of the DC test approach

- Investigation of test conditions for the DC test method
- Investigation of the twelve days CCT approach
- Validation of CTSS testing by *in situ* measurements
- Performance testing of solar combisystems - Comparison of the CTSS with the ACDC procedure
- Development of a collector emulator
- Research into average meteorological conditions

Optimisation of solar combisystems

- Reference conditions
- Optimisation procedure
- Non-standard TRNSYS models used in Task 26
- Description and analysis of systems and their optimisation, including FSC-calculations and results
- Elements of dream systems
- Material demand of systems

Proceedings of Industry Workshops

Oslo, Norway, April 8, 2002

(5.034 kb)

- Solar combisystems for a sustainable energy future
- Solar energy - a political issue?
- Solar energy in the Norwegian energy policy
- Combination of solar and natural gas in Dutch products
- Solar heating with a storage-integrated condensing gas burner
- Influence of different combistore concepts on the overall system performance
- Facade-integrated collectors - constructions, building physics and the results of two monitored systems
- Architectural integration of solar energy
- The Norwegian solar energy industry

Rapperswil, Switzerland, October 10, 2001

(2.313 kb)

- European market on thermal solar energy with a special focus on solar combisystems
- Solar combisystems - a system overview
- Dimensioning of solar combisystems

- Architectural integration of solar collectors, visual aspects
- Roof-integrated collectors, S.E.T. Solar-Roof, a single finished compact unit
- Integration of solar collectors into facades
- Facade-integrated collectors - constructions, building physics and results of two monitored systems
- Stagnation behaviour: the influence of the hydraulics on thermal stress of the components including the heat transfer fluid
- Long-term stability of heat transfer fluids, experience of the producers
- Use of glycol-water mixtures in solar systems from the point of view of the manufacturer

Delft, the Netherlands, April 2, 2001

(2.263 kb)

- European market on thermal solar energy with a special focus on solar combisystems
- Solar combisystems - a system overview
- A new generation of solar combisystems ATAG S-HR Solargascombi II
- Daalderop solar systems for domestic appliance: monosolar and multisolar
- Thermera® heat transfer fluid - a natural solution for heat transfer in building technology
- Drainback in small systems
- Recent experiences with large solar thermal systems in the Netherlands
- Legionella in hot water preparation
- Legionella and solar domestic hot water systems
- Roof integration of large collector areas - experiences from Norway
- Facade integration - a new and promising opportunity for thermal solar collectors

Espoo, Finland, October 9, 2000

(2.532 kb)

- The solar thermal market in Finland and future plans
- Solar combisystems - scope and goals of Task 26
- Durability and reliability of solar combisystems
- The Ekoviikki-large scale solar project: project overview and general system design
- Multi-family houses with solar system and district heating connection
- Multi-family houses with solar and geothermal heating system
- Monitoring results of a Swiss 30 m² system with 11 m³ storage tank
- Solar combisystem for a multi-apartment building - the Klosterenga project in Oslo
- System design and monitoring results of Austrian large scale solar combisystems for multiple family houses and office buildings

- Wagner office building: first experiences and measurements
- Performance of an air-based solar thermal system after twenty years of operation
- Space heating and DHW system with standard tank
- Modular heat exchange module for solar heating systems
- Solus II storage tanks

Borlänge, Sweden, April 3, 2000

(685 kb)

- Tests on the stagnation behaviour of solar combisystems
- The behaviour of heat transfer media in solar active thermal systems in view of the stagnation conditions
- Emissions from small biomass boilers
- Solar combisystem with integrated pellet burner in store
- Study of combined solar and biomass heating systems in Denmark
- Solar heating system for a new single-family house

Stuttgart, Germany, October 4, 1999

(375 kb)

- The Austrian solar thermal market
- Market development in Denmark since 1990
- Finnish solar collector market development 1995-1998
- Solar market in France
- Current status in Sweden (1999)
- Solar market in Switzerland 1990-1998
- Thermal solar energy in the Netherlands in 1999
- Solar market in the USA - 1998
- European product standards for solar domestic hot water systems reaching maturity
- Future solar thermal pump strategy
- Innovative pump developments in Switzerland
- Field tests of high efficiency small circulation pump
- Life cycle analyses of solar heating systems

Design Handbook – Solar Heating Systems for Houses

The book "Solar Heating Systems for Houses – A Design Handbook for Solar Combisystems" summarises all results of Task 26. In 13 chapters, it focuses on heat demand of buildings, different system designs and built examples, building-related aspects like space requirements of the systems and architectural integration of collector arrays, performance as well as durability and reliability of solar combisystems, and last but not least, dimensioning and testing of solar combisystems.

The book will be published in June 2003 by James and James (Science Publishers) Ltd., 8-12 Camden High Street, London NW1 0JH, UK

Design Tool – CombiSun

In the area of combisystem characterisation, the scheme named FSC Procedure, introduced by the French participant, has turned up to become a major powerful tool for solar combisystems. The FSC scheme has similarities with f-chart, the well-known design tool for solar water heaters. Data from Subtask C has been used to characterise some 10 generic systems. The characteristic functions obtained for each of them are the main background information for a simple design tool – called „CombiSun" – for architects and engineers. With this tool, solar combisystems can be compared and properly sized according to specific requirements from the practice.

CombiSun will also be available for downloading by end of June 2003 from the IEA SH&C web site http://www.iea-shc.org/task26/

The Altener Combisystems Project

By Klaus Ellehauge, ELLEHAUGE, Vestergade 48 H, 8000 Aarhus C, Denmark,
e-mail: klaus.ellehauge@elle-kilde.dk, http://www.elle-kilde.dk

The Altener Combisystems project is related to the IEA SH&C Task 26 co-operation, and one of the aims is to convert the findings of the IEA SH&C Task 26 to information usable for the public. Another aim is to collect practical information on real installed combisystems. The aims have been achieved by the realisation of 15-23 good examples of combisystems in each participating country. The participating countries are Austria, Denmark, France, Germany, Italy, Sweden and the Netherlands.

The project started in April 2001 and is going well on its way. It will end in March 2003. In October 2002, most of the planned systems were installed. Furthermore, monitoring on at least 3 of the installed systems in each country started.

Further outcomes of the project are:

- Dissemination activities: all participants have been arranging workshops from the beginning to the end of the project. Please find separate information on these in the article "Dissemination Activities within the ALTENER Project *Solar Combisystems*". Through this project, documents and materials were elaborated for the workshops. Among those is a document summarising experiences about what to be aware of when planning and performing the installation of the systems.
- Another major delivery will be a common PC tool for performance estimation of a number of the different combisystem types. A prototype has been elaborated on the basis of the work carried out in IEA SH&C Task 26 and will be finished before the end of the project.
- The costs of the systems are being analysed together with the performance and the savings. This will provide useful information on the cost efficiency of the systems.

The installed systems cover 10-11 different system types of which 9 are generic systems included in the IEA SH&C Task 26's work. Some of the represented systems are system types #1, #2, #3, # 9, #10, #15, and #19 (numbers are referring to the Task 26 generic systems).

There have been some delays regarding the original timetable mostly because of delays in the financing, but also because the process of involving industry and realisation of systems in most countries has needed more time than estimated. This means that in order to obtain yearly performance results, extrapolations will be tested to get yearly energy balances from the real monitoring period.

Website and contacts

Contact information can be found on the projects web site at the address: http://www.elle-kilde.dk/altener-combi.

Dissemination activities within the ALTENER Project „Solar Combisystems“

By Alexander Thür, AEE INTEC, Arbeitsgemeinschaft ERNEUERBARE ENERGIE, Institute for Sustainable Technologies, Feldgasse 19, 8200 Gleisdorf, Austria,
e-mail: a.thuer@aee.at, http://www.aee.at

The dissemination activities started in April 2001 with a common Kick-Off-Workshop in Delft/Netherlands and afterwards with national Kick-Off-Workshops in the following participating countries: France, Sweden, Denmark, Netherlands, Germany, Italy and Austria.

The first objective of these national workshops was to inform about IEA SH&C Task 26's activities and to disseminate its interim results. The content of the coloured booklet was mainly presented which showed a good overview of solar combisystems on the market in 2000 among IEA SH&C Task 26's countries. A second goal was to find industry partners to realise the demonstration combisystems.

Now, in December 2002, most of the demonstration systems are built and documented. Also, in each country, measurement devices have been installed in three solar combisystems and are running since several months.

In the final stage of this ALTENER project which will be completed in March 2003, experience and know-how in designing, building, operating and monitoring these demonstration projects shall be disseminated to a large number of interested persons in the professional fields of technical designer, installer, solar companies and architects, as well.

For this reason, in each country, a final seminar/workshop will be organised in February/March 2003. Table 1 shows the main data about the workshops and where to get further information.

Table 1: Main data about the final workshops and where to get further information

Country	Date	Place	Institute	Name	Contact
Austria	13.3.03	Hotel Europa, Graz	AEE INTEC Feldgasse 19 A-8200 Gleisdorf	Alexander Thür	Tel.: +43 – 3112 – 5886 – 12 Fax: +43 – 3112 – 5886 – 18 E-mail: a.thuer@aee.at http://www.aee.at
Denmark	6.3.03	Not known yet	ELLEHAUGE Vestergade 48 H DK-8000 Aarhus C	Klaus Elle-hauge	Tel. +45 – 40 – 386643 E-mail: klaus.ellehauge@elle-kilde.dk http://www.elle-kilde.dk
France	??.3.03	Not known yet	ASDER P.O. Box 45 299, rue du Granier F-73230 Saint Alban-Leysse	Thomas Letz	Tel.: +33 – 479 8588 50 Fax: +33 – 479 3324 64 E-mail: thomas.letz@asder.asso.fr http://www.asder.asso.fr/
Germany	19.3.03	ITW Stuttgart	Stuttgart University ITW Pfaffenwaldring 6 D-70550 Stuttgart	Harald Drück	Tel.: +49 – 711 – 685 3553 Fax: +49 – 711 – 685 3503 E-mail: drueck@itw.uni-stuttgart.de http://www.itw.uni-stuttgart.de/
Italy	20.3.03	Solarexpo, Verona	Ambiente Italia srl via Carlo Poerio 39 I-20129 Milano	Thomas Pauschinger	Tel.: +39 – 02 – 27744-230 Fax: +39 – 02 – 27744-222 E-mail: thomas.pauschinger@ambienteitalia.it
Sweden	19.3.03	Dalarna University in Borlänge	Högskolan Dalarna Solar Energy Research Center - SERC EKOS S-78188 Borlänge	Bengt Perers	Tel. +46 - 23 - 7787 29 Fax +46 – 23 - 7787 01 E-mail bpr@du.se http://www.du.se/ekos/serc/serc.html
The Netherlands	20.2.03	NOVEM, Utrecht	TNO Building and Construction Research Division Building & Systems P.O. Box 49 NL-2600 AA Delft	Huib Visser	Tel.: +31 – 15 – 2695246 Fax. +31 – 15 – 2695299 E-mail: h.visser@bouw.tno.nl http://www.bouw.tno.nl

Drainback technology

A success story with significant advantages for the future of solar heating systems

By Subtask B Leader Huib Visser, TNO, Building and Construction Research, Division Building & Systems, P.O. Box 49, 2600 AA Delft, The Netherlands, e-mail: h.visser@bouw.tno.nl

and Markus Peter, University of Oslo, Department of Physics, P.O.Box 1048, Blindern, N-0316 Oslo, Norway, e-mail: markus.peter@dp-quadrat.de

Drainback technology provides an interesting alternative for overheating protection of the fluid in the solar collector loop and also prevents the heat transfer fluid from freezing. Thanks to drainback of the collector fluid when the collector circuit is not running, the circulation can operate using plain water without (antifreeze) additives. This system concept is based on draining the water from the tilted collector and outdoor collector pipes using gravitational force and replacing the liquid with air from the top (Fig. 1). By replacing water in the collector with air, ice cannot be formed and damage is, therefore, avoided. The water also drains back if the heat store is fully charged, thereby avoiding boiling of water and high pressures inside the system. When using polymer materials in the collector circuit, both stopping the pump in time and a permanent opening in the collector loop to the atmosphere are needed to avoid overpressure.

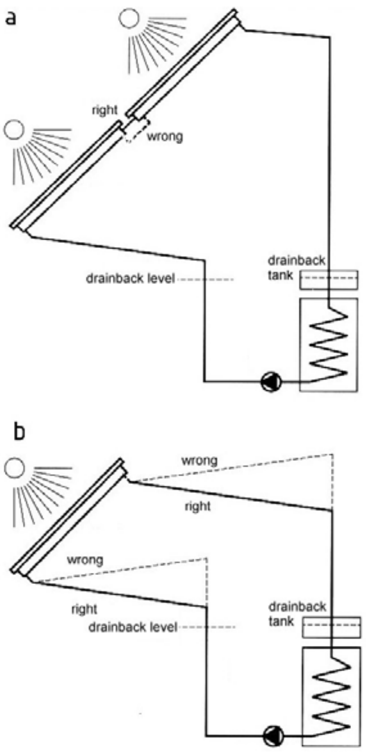

Fig. 1: Examples of correctly, respectively wrongly designed drainback collector loops showing the basic principle of this technology and some of its constraints.

In comparison with the use of heat transfer fluids, drainback technology using water features both advantages and disadvantages. Advantages are:

- water does not face the ageing drawbacks exhibited by collector fluids with additives, such as a change in material properties and possible corrosion of the collector loop;
- heat transfer properties of water, i.e. both heat capacity and viscosity are better than those of other heat transfer fluids;
- water is much cheaper than all other collector fluids and easily available;
- the collector loop generally does not face high overpressures, possibly leading to additional guarantee for safety;
- the level of maintenance for drainback systems is lower.

Disadvantages are:

- less flexibility in the choice of the solar collector;
- special attention for drainback collector loop design and installation (Fig. 1 and Fig. 2).

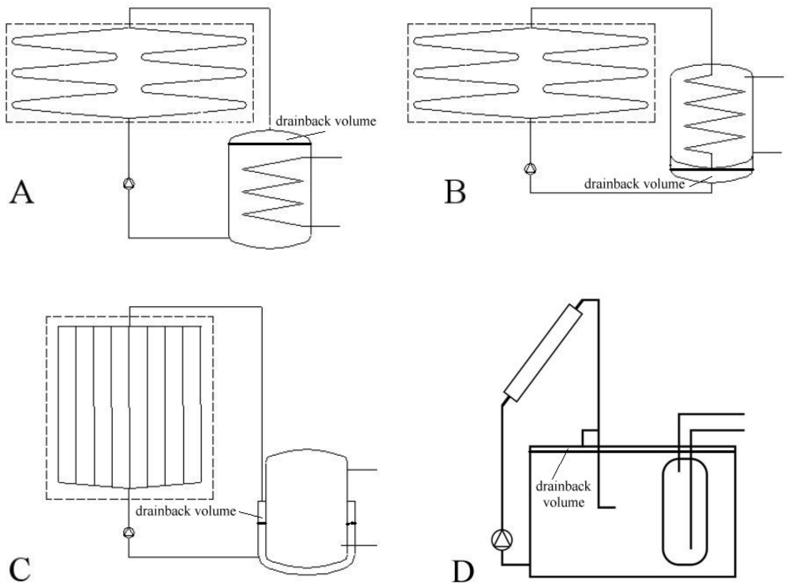

Fig. 2: Different implementations of the drainback concept.

In the Netherlands, drainback technology evolved from regulations in the eighties for quality of potable water. These regulations permitted additives in the collector fluid only if separated by a double-wall heat exchanger or by two series-connected heat exchangers from the potable water. In order to maintain good heat transfer, a single-wall heat exchanger was combined with plain water in the collector circuit. Manufacturers like ATAG Verwarming and ZEN Solar have developed this idea over a number of years into foolproof drain back systems. Nowadays, regulations in the Netherlands for double separation are not as strict as they were in the eighties. However, drainback systems are still used because of their advantages compared with the use of collector fluids with additives.

The application of polymer absorbers connected to rectangular heat stores, like in the SolarNor system originating from Norway, is another reason for applying the drainback concept. Significant overpressure must be avoided to protect the absorbers and the tank against mechanical stress that might harm the structure. This leads to a system that is permanently open to the atmosphere. Moreover, collector circuit, heat store and space heating distribution have been designed without any intermediate heat exchanger. Hence, the large volume of heat transfer and heat store fluid should be inexpensive and environment-friendly.

The drainback concept has been applied to systems with collector areas ranging from a few square meters to a few hundred square meters. Recently a drainback system with a few thousand square metres was successfully demonstrated.

The potential of drainback technology is high due to excellent thermal properties, inherent safety, low costs and easy maintenance. Over 80% of the Dutch solar energy systems and virtually all Norwegian solar combisystems include the drainback concept. Other Northern and Central European manufacturers have experienced drainback systems and have started commercial production. Often, only minor modifications are needed to change from a circuit with collector fluid containing additives into a drainback loop.

A major barrier for drainback technology in Europe is a lack of skilled workers when it comes to proper installation. The disadvantage of complex drainback collector loop designs and installation can be overcome by the manufacturer assembling in the factory as many drainback components as possible into the casing of the solar heating system. The manufacturer can also insure proper installation by providing accurate guidelines for mounting as well as directed education.

For open drainback systems, installers often exhibit scepticism regarding the corrosion problems, even though it is undeserved. The open technology is seen as a step back to the past. Even though drainback systems are inherently safe, e.g. if the electricity supply or pump fails, the system automatically drains and remains in a state where freezing or strong irradiance is not harmful, most of the installers cannot be convinced that drainback systems are safe and reliable. Today, education and training of installers focus on pressurised systems. Closed and pressurised systems filled with antifreeze determine the present state of the art in most countries.

An increased acceptance of drainback systems requires some investments in product development and the education of installers. Although the installation of drainback systems is increasing in Europe, the advantages of drainback do not seem to be attractive enough to launch the technology to a wide market. In some countries, the existing infrastructure is an obstacle for the introduction of new technologies.

Full details about the drainback technology will be published in the Design Handbook currently prepared by the Task 26 participants.

The FSC procedure, a powerful design tool

By Thomas Letz, ASDER, P.O. Box 45299, rue du Granier, 73230 Saint Alban-Leysse, France,
e-mail: thomas.letz@asder.asso.fr

In Task 26's framework, a new method has been elaborated to characterise solar combisystems[1] (SCS) in a simple way, enabling the comparison of systems built in different locations, with diverse collector areas and providing heat to different space heating and domestic hot water loads. The idea is to compare the present fractional energy savings of the system with the maximum theoretical fractional energy savings.

Two slightly different target functions have been defined by Task 26:

- the fractional thermal energy savings $f_{sav,\ th}$, which give fractional energy savings based on the saved fuel input of the solar combisystem compared to the reference heating system. This reference system includes a domestic hot water tank with annual heat losses equal to 644 kWh, and a boiler with an efficiency of 85%.
- the extended fractional energy savings $f_{sav,\ ext}$, which also take into account the parasitic electricity used by the system (pumps, valves, controller, burner, …)

FSC definition

Let us consider the example given in the following table: in the first line, we find the total heat demand of the house, including store and boiler losses (so-called "reference consumption"), and in the second line, the solar irradiation available on the collector area.

(kWh)	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Year
Reference consumption	2659	2131	1477	989	412	320	237	226	359	1230	1905	2494	14415
Solar irradiation available	716	991	1477	1740	1989	2017	2335	2183	1769	1230	663	558	17668
Usable solar energy	716	991	1477	989	412	320	237	226	359	1230	663	558	7943
												FSC	0.57

If the reference consumption and the solar irradiation available on the collector area are plotted in the same diagram, various zones appear (figure 1):

[1] SCS description can be found in : **SUTER J.-M., LETZ T., WEISS W., INÄBNIT J,** SOLAR COMBISYSTEMS in Austria, Denmark, Finland, France, Germany, Sweden, Switzerland, the Netherlands and the USA; Overview 2000 ; IEA SH&C – Task 26, 42 p. Available from the Task web site: http://www.iea-shc.org/task26/

①: energy consumption of the building which exceeds the solar potential

②: energy consumption of the building which could be saved by means of solar energy use. It is called 'usable solar energy' ($Q_{solar,usable}$)

③: solar energy in excess in summer time

Dividing the usable solar energy ② by the total reference consumption of the house ① + ②, a new parameter, called **Fractional Solar Consumption (FSC)** is defined.

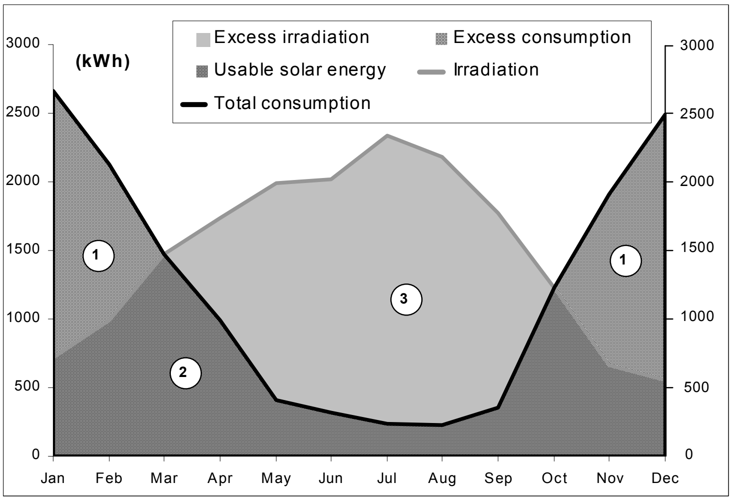

Fig. 1: Definition of FSC

FSC is a dimensionless quantity which simultaneously takes into account the climate, the building (space heating and domestic hot water loads) and the size of the collector area, in a way that does not depend on the studied SCS. FSC is calculated on a monthly basis in a simple way, using the solar collector area **A** (m^2), the monthly global irradiation in the collector plane **H** (kWh/m^2) and the monthly reference consumption without solar combisystem $\mathbf{Cons_{ref}}$ (kWh):

$$FSC = \sum_{1}^{12} \min(Cons_{ref}, A \,.\, H) \,/\, \sum_{1}^{12} Cons_{ref}$$

In the previous example, the calculated FSC is given at the bottom line of the table. We get FSC = 0,57.

Relation between f_{sav} and FSC

Simulations made in Task 26's framework have shown that the real fractional energy savings (thermal or extended) can be linked with FSC using a very simple parabolic relation:

$$f_{sav} = (a \cdot FSC^2 + b \cdot FSC + c)$$

Figure 2 gives an example of the relation between f_{sav} and FSC. Points have been calculated for the 3 reference climates and the 3 reference houses defined by Task 26, and for several collector sizes. It can be seen that the different points are closed to the mean parabola. Such diagrams have been drawn for 9 SCS simulated in Task 26's framework.

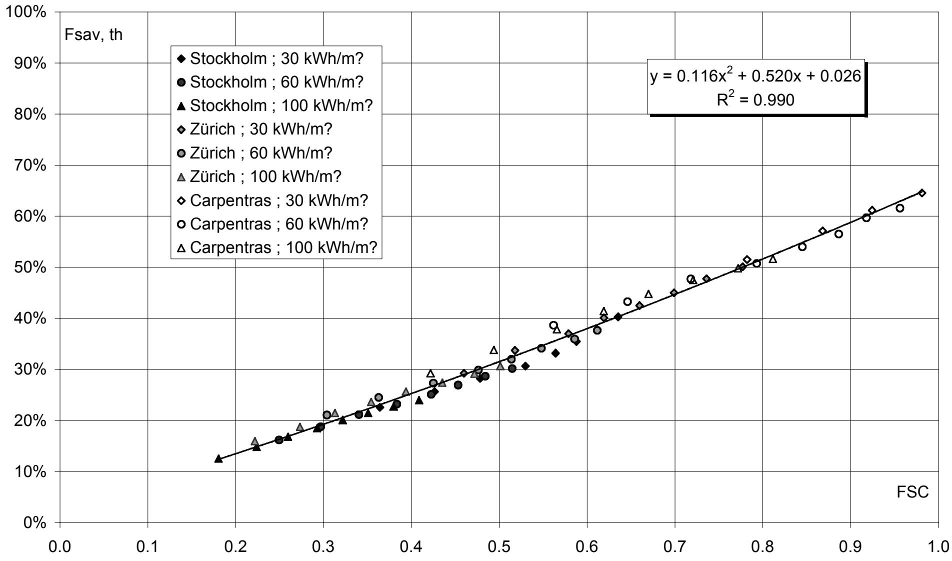

Fig. 2: f_{sav}. versus FSC

How to use the FSC concept ?

With the FSC approach, each SCS is characterised by its specific coefficient set (**a**, **b**, **c**) which describes the global behaviour of the system, taking into account, e.g., the quality of the solar collector, the efficiency of the auxiliary boiler, the insulation of the heat store and the behaviour of the controller.

As the **Fractional Solar Consumption** of a SCS can easily be calculated from the meteorological data and from the heat load of the house and the collector area, the present method gives a simple way to quickly obtain the yearly performance of a SCS, provided that the house is continuously occupied all over the year.

The FSC approach can also be used to quickly and graphically compare different SCS, with the diagrams presented in figures 3 and 4.

Figure 3 gives the ranges for collector areas and storage sizes allowed for the different combisystems simulated by Task 26.

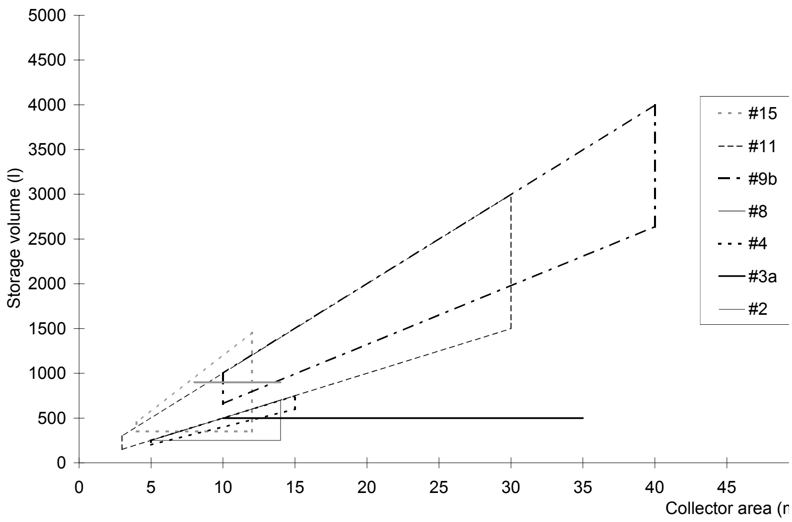

Fig. 3: Size of the simulated systems

Figure 4 gives the characteristic curves obtained for combisystems simulated in Task 26's framework. In order to get curves only related to the hydraulic scheme and the control strategy, a common reference solar collector has been defined and used for these simulations. In the same way, a common reference boiler has been taken for combisystems not including the auxiliary boiler. Therefore, combisystems from the market may have slightly different performances when compared to those presented in Figures 3 and 4.

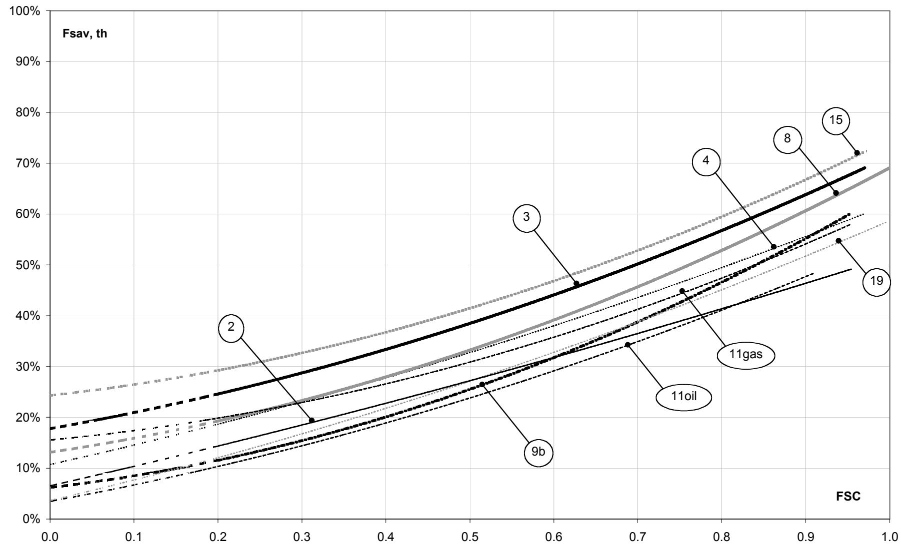

Fig. 4: Thermal performance (f_{sav} vs. FSC curves) of the simulated combisystems

A detailed analysis of these curves is given in the Design Handbook which will be published next year, when Task 26 is completed.

Conclusion

The FSC concept provides an easy tool to compare SCS, in order to have a quick idea of their performance according to main dimensioning parameters. A simplified design tool based on this approach will also be available in 2003, when Task 26 is completed.

Promising market development for solar combisystems

By Operating Agent Werner Weiss, AEE INTEC, Arbeitsgemeinschaft ERNEUERBARE ENERGIE, Institute for Sustainable Technologies, Feldgasse 19, 8200 Gleisdorf, Austria,
e-mail: w.weiss@aee.at, http://www.aee.at

Since the beginning of the nineties, the European solar market has experienced considerable development. As the figures from the IEA Solar Heating and Cooling Programme (Weiss, Faninger, 2002) and the German Solar Energy Association (Stryi-Hipp, 2001) confirm, sales of flat-plate collectors recorded an yearly average growth of 17% between 1994 and 2000. This means that while 480,000 m^2 of collector area were installed across Europe during 1994, the annual rate for installations was, in 2000, around 1.17 million m^2 collector area, meaning that the rate had more than doubled within a period of six years.

The installed collector area in Europe equalled to around 11.4 million square meters at the end of the year 2000. Out of this amount, 1.7 million square metres were accounted for by unglazed collectors which are used mainly to heat swimming pools and 9.7 million square metres by flat-plate and evacuated tube collectors used to prepare hot water and for space heating.

In the past, most flat-plate and evacuated tube collectors were installed for domestic hot water preparation. Since 1990 the demand for solar combisystems has been rapidly growing in several countries, too.

A first survey in 1997 showed that solar combisystems had already a considerable market share in Germany, Austria, Switzerland, Denmark and Sweden. Especially in Switzerland and Austria the collector area installed for combisystems was already approximately 50% of the total installed collector area.

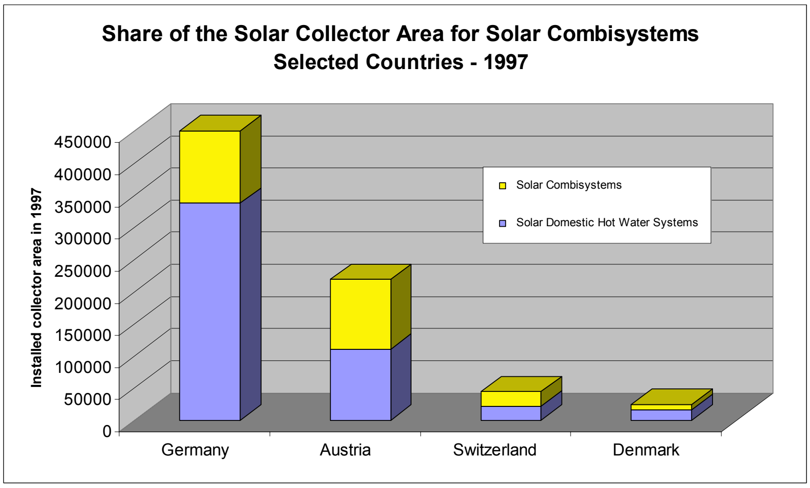

Fig. 1: Share of collector area used for solar domestic hot water systems and for solar combisystems in selected countries in 1997

In 2001 the total collector area installed for solar combisystems in the eight European countries, shown in figure 2, equalled to 340,000 m². Assuming that the average collector area for a combisystem is 15 m², this means that about 22,600 solar combisystems were installed in 2001.

In Sweden the share of the collector area installed for solar combisystems in 2001 was already significantly larger than the collector area installed for solar domestic hot water systems. In Austria, Switzerland, Denmark and Norway, the collector area installed for solar combisystems and for solar domestic hot water systems was almost the same. In Germany which installed a total of 900,000 m² collector area in 2001, the share of the collector area installed for combisystems was 25%.

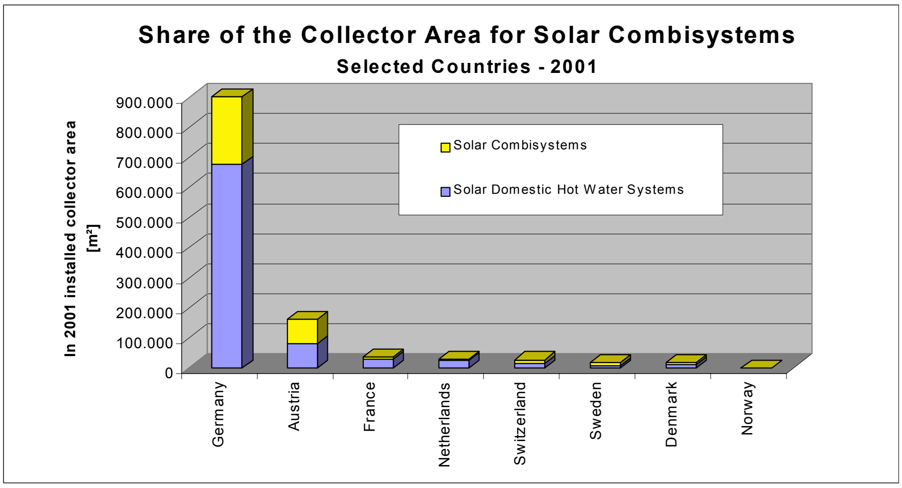

Fig. 2: Share of collector area used for solar domestic hot water systems and for solar combisystems in selected countries in 2001

Since the potential for solar combisystems in southern European countries is rather small, a realistic approach would be to assume that in the next eight years, a minimum of 20% of the total collector area yearly installed in Europe (EU 15 plus Switzerland and Norway) shall be used for solar combisystems. This means that in the countries of the European Union, around 120,000 solar combisystems with 1.9 million m^2 of collectors need to be yearly installed, if the goal set in the European Commission's "White Paper" - to install 100 million square meters of collectors up to 2010 – is to be met.

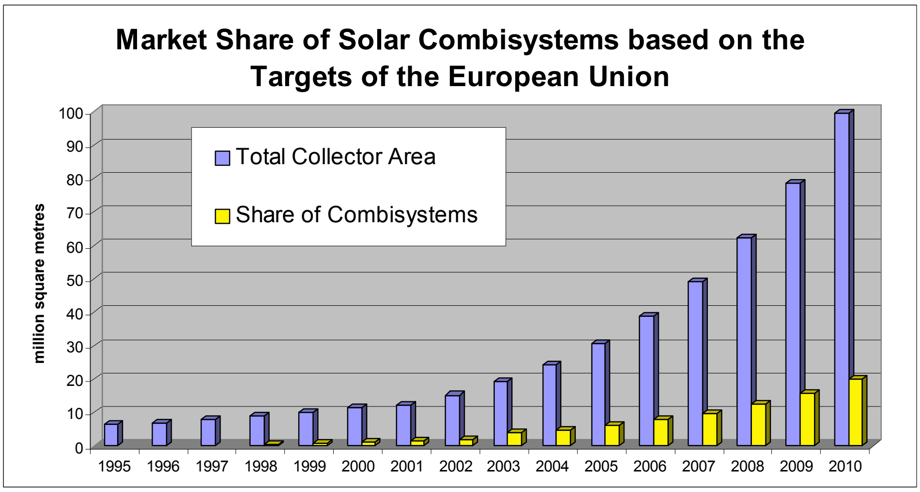

Fig. 3: Objectives for the installed collector area until 2010 in the European Union's member countries and the share of solar combisystems

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SHC-TASK 26 Participants

Country	Institute	Name	Contact
Austria	AEE INTEC, Arbeitsgemeinschaft ERNEUERBARE ENERGIE, Institute for Sustainable Technologies Feldgasse 19 A-8200 Gleisdorf	Werner Weiss*) Irene Bergmann Robert Hausner	Tel.: +43 – 3112 – 588617 Fax: +43 – 3112 – 588618 e-mail: w.weiss@aee.at e-mail: i.bergmann@aee.at e-mail: r.hausner@aee.at http://www.aee.at
	Graz University of Technology Institute of Thermal Engineering Inffeldgasse 25 A-8010 Graz	Wolfgang Streicher Richard Heimrath	Tel.: +43 – 316 – 873-7306 Fax: +43 – 316 – 873-7305 e-mail: streicher@iwt.tu-graz.ac.at e-mail: heimrath@iwt.tu-graz.ac.at http://wt.tu-graz.ac.at
Denmark	Solar Energy Center Denmark Technical University of Denmark Department of Buildings and Energy Build. 118 DK-2800 Lyngby	Simon Furbo	Tel.: +45 – 45 – 251857 Fax. +45 – 45 – 931755 E-mail: sf@byg.dtu.dk http://www.ibe.dtu.dk
		Louise Jivan Shah	Tel.: +45 – 45 – 251888 Fax. +45 – 45 – 931755 E-mail: ljs@byg.dtu.dk http://www.ibe.dtu.dk
		Elsa Andersen	Tel.: +45 – 45 – 251857 Fax. +45 – 45 – 931755 E-mail: ean@byg.dtu.dk http://www.ibe.dtu.dk
	ELLEHAUGE Vestergade 48 H DK-8000 Aarhus C	Klaus Ellehauge*)	Tel. +45 – 40 – 386643 E-mail: klaus.ellehauge@elle-kilde.dk http://www.elle-kilde.dk
Finland	Helsinki University of Technology Advanced Energy Systems P.O. Box 2200 FIN-02015 HUT	Petri Konttinen*)	Tel.: +358 – 9451 – 3212 Fax: +358 – 9451 – 3195 e-mail: petri.konttinen@hut.fi http://www.hut.fi/Units/AES/
France	ASDER	Thomas Letz*)	Tel.: +33 – 479 8588 50

	P.O. Box 45 299, rue du Granier F-73230 Saint Alban-Leysse		Fax: +33 – 479 3324 64 e-mail: thomas.letz@asder.asso.fr http://www.asder.asso.fr
	Clipsol-Recherche Z.I. F-73100 Trevignin	Philippe Papillon*)	Tel.: +33 – 479 34 35 39 Fax: +33 – 479 34 35 30 e-mail: philippe.papillon@clipsol.com http://www.clipsol.com
Germany	Stuttgart University ITW Pfaffenwaldring 6 D-70550 Stuttgart	Harald Drück*)	Tel.: +49 – 711 – 685 3553 Fax: +49 – 711 – 685 3503 e-mail: drueck@itw.uni-stuttgart.de http://www.itw.uni-stuttgart.de/
		Henner Kerskes	Tel.: +49 – 711 – 685 3215 Fax: +49 – 711 – 685 3242 e-mail: kerskes@itw.uni-stuttgart.de
	Kassel University Dpt. of Mech. Engineering Solar and System Technology D-34109 Kassel	Klaus Vajen	Tel.: +49 – 561-804-38 91 Fax: +49 – 561-804-39 93 e-mail: vajen@uni-kassel.de
		Ulrike Jordan	Tel.: +49 – 561-804 - 3813 Fax: +49 – 561-804-39 93 e-mail: jordan@ uni-kassel.de
Norway	University of Oslo Department of Physics P.O.BOX 1048, Blindern N-0316 Oslo	Michaela Meir*)	Tel.: +47- 22 85 64 69 Fax: +47- 22 85 64 22 e-mail: mmeir@fys.uio.no
		Markus Peter	Tel.: +30- 27 87 89 30 Fax: +30- 27 87 89 60 e-mail: markus.peter@dp-quadrat.de
		Bjørnar Sandnes	Tel.: +47- 22 85 64 59 Fax: +47- 22 85 64 22 e-mail: bsand@fys.uio.no http://www.fys.uio.no/kjerne/english/energy/index.html
Sweden	SP – Swedish National Testing and	Peter Kovács	Tel.: + 46 – 33 – 165662

	Research Institute P.O. Box 857 S-501 15 Boras		Fax: + 46 – 33 – 131979 e-mail: peter.kovacs@sp.se http://www.sp.se/energy/
	Högskolan Dalarna Solar Energy Research Center – SERC EKOS S-78188 Borlänge	Chris Bales*)	Tel.: +46 – 23 – 7787 11 Fax: +46 – 23 – 7787 01 e-mail: cba@du.se http://www.du.se/ekos/serc/serc.html
	Högskolan Dalarna Solar Energy Research Center – SERC EKOS S-78188 Borlänge	Bengt Perers	Tel.: +46 – 155 293125 Fax: +46 – 155 293060 e-mail: bpr@du.se
	Vattenfall Utveckling AB S-814 26 Älvkarleby	Stefan Larsson	Tel: +46 – 026-83801 Fax: +46 – 026-83810 e-mail: stefan.larsson@utveckling.vattenfall.se
Switzerland	Swiss Research Program CH-1035 Bournens	Jean-C. Hadorn*)	Tel.: +41 – 21 – 732 13 20 Mobile: +41 79 210 57 06 Fax: +41 – 21 – 732 13 20 e-mail: jchadorn@swissonline.ch
	Suter Consulting P.O. Box 130 CH-3000 Bern 16	Jean-Marc Suter	Tel.: +41 – 31 – 350 00 04 Fax: +41 – 31 – 3527756 e-mail: suter@suterconsulting.com http://www.suterconsulting.com
	SPF-HSR P.O. Box 1475 CH-8640 Rapperswil	Ueli Frei Peter Vogelsanger Beat Menzi	Tel.: + 41 – 55 – 222 4822 Fax: + 41 – 55 – 210 6131 e-mail: ueli.frei@solarenergy.ch peter.vogelsanger@solarenergy.ch beat.menzi@@solarenergy.ch http://www.solarenergy.ch
	School of Engineering (EIVD) Route de Cheseaux 1 CH-1400 Yverdon-les-Bains	Philippe Dind	Tel.: +41 24 423 23 59 Fax.: + 41 24 425 00 50 e-mail: Philippe.Dind@eivd.ch
	School of Engineering (EIVD)	Olivier Renoult	Tel.: +41 24 423 23 83 Fax.: + 41 24 425 00 50 e-mail: renoult@eivd.ch

	School of Engineering (EIVD)	Jacques Bony	Tel.: +41 24 423 23 83 Fax.: + 41 24 425 00 50 e-mail: bony@eivd.ch
	School of Engineering (EIVD)	Thierry Pittet	Tel.: +41 24 423 23 83 Fax.: + 41 24 425 00 50 e-mail: thierry.pittet@eivd.ch
The Netherlands	TNO Building and Construction Research Division Building & Systems P.O. Box 49 NL-2600 AA Delft Visiting address: Van Mourik Broekmanweg 6 NL-2628 XE Delft	Huib Visser*)	Tel.: +31 – 15-2763519 Fax. +31 – 15-2763022 e-mail: h.visser@bouw.tno.nl http://www.bouw.tno.nl
USA	University of Wisconsin Solar Energy Lab 1500 Engineering Dr. Madison, WI 53706	William A. Beckman*)	Tel.: 608 – 263 1590 Fax: 608 – 262 8464 e-mail: beckman@engr.wisc.edu http://www.sel.me.wisc.edu/

Observer

France	CSTB Energie, Environment Interieur et Automatisimes Route des Lucioles Boite postale 209 F-06904 Sophia Antipolis Cedex	Rodolphe Morlot	Tel.: 04 – 9395 6754 Fax: 04 – 9395 6431 e-mail: r.morlot@cstb.fr

*) National Contact Person

SHC-TASK 26
Industry Participants

Country	Company	Name	Level	Contact
Austria	SOLID Herrgottwiesgasse 188 A- 8055 Graz	Christian Holter	Level 2	Tel.: +43 - 316 - 292840-0 Fax: +43 - 316 - 292840-28 e-mail: solid@styria.com
	Solarteam GmbH Jörgmayrstraße 12 A-4111 Walding	Martin Bergmayr	Level 1	Tel.: +43 - 7234 - 83550 Fax: +43 - 7234 - 835509 e-mail:
	Sonnenkraft GmbH Resselstrasse 9 A-9065 Ebental	Peter Prasser	Level 1	Tel.: +43 - 463 - 740 958 Fax: +43 - 463 - 740 958 -17 e-mail: peter.prasser@sonnenkraft.com http://www.sonnenkraft.com
Denmark	Batec A/S Danmarksvej 8 DK 4681 Herfolge	E. Brender	Level 2	Tel.: +45 - 56 27 5050 Fax: +45 - 56 27 6787 e-mail: admin@batec.dk http://www.batec.dk
Finland	Fortum Power and Heat New Technology Business P.O. Box 20 00048 Fortum	Janne Jokinen	Level 1	Tel.: +358 10 4533306 Fax.: +358 10 4533310 e-mail: Janne.Jokinen@fortum.com http://www.fortum.com
France	Clipsol Zone Industrielle F-73100 Trevignin	Philippe Papillon	Level 2	Tel.: +33 - 479 34 35 39 Fax: +33 - 479 34 35 30 e-mail: clipsol@wanadoo.fr
Germany	SOLVIS- Solarsysteme GmbH Marienberger Straße 1 D-38122 Braunschweig	Thomas Krause	Level 2	Tel.: +49 - 531-28906-737 Fax: +49 - 531 - 28906-60 e-mail: tkrause@solvis-solar.de http://www.solvis-solar.de
		Dagmar Jaehnig		Tel.: +49 - 531-28906-47 Fax: +49 - 531 - 28906-60 e-mail: djaehnig@solvis-solar.de

	Consolar Energiespeicher- und Regelungssysteme GmbH Dreieichstrasse 48 D-60594 Frankfurt	Andreas Siegemund	Level 1	Tel.: +49 - 69 - 619911-44 Fax: +49 - 69 - 619911-28 e-mail: andreas.siegemund@consolar.de http://www.consolar.de
Norway	SolarNor AS Erling Skjalgssons gate 19 B N-0267 Oslo	John Rekstad	Level 1	Tel.: +47- 22 85 64 75 Fax: +47- 22 85 64 22 e-mail: john.rekstad@solarnor.com e-mail: john.rekstad@fys.uio.no
Sweden	Borö-Pannan AB Bangardsuagen 1 S-95231 Kalix	Bo Ronnkvist	Level 1	Tel.: +46 - 923 16680 Fax: +46 – 923 13797 e-mail: http://www.boroe.com
Switzerland	AGENA Le Grand Pré CH-1510 MOUDON	M.C. Jobin	Level 1	Tel.: +41-21 9052656 Fax: + 41-21 905 43 88 e-mail: agena.energies@span.ch
	SOLTOP Schuppisser AG St. Gallerstrasse 7 CH-8353 ELGG	Fritz Schuppisser	Level 1	Tel.: +41 - 52 364 00 77 Fax: + 41 - 52 364 00 78 e-mail: email@soltop.ch
	Jenni Energietechnik AG Lochbachstrasse 22 CH-3414 Oberburg	Josef Jenni	Level 1	Tel.: +41-34 422 37 77 Fax: +41-34 422 37 27 e-mail: info@jenni.ch
The Netherlands	ATAG Verwarming B.V. P.O. Box 105 NL-7130 AC Lichtenvoorde	Jos Luttikholt	Level 1	Tel.: +31 544 391777 Fax: +31 544 391703 e-mail: j.luttikholt@atagverwarming.com
	Daalderop B.V. P.O. Box 7 NL-4000 AA Tiel	Erwin Janssen	Level 1	Tel.: +31 344 636592 Fax: +31 344 636589 e-mail: development@daalderop.nl
	Zonne-Energie Nederland De Run 5421 NL-5504 DG Veldhoven	Paul Kratz	Level 1	Tel.: +31 40 2307203 Fax: +31 40 2307210 e-mail: P.Kratz@zen.nl

Level 1: Participation in 1 workshop per year and answer technical and marketing questions

Level 2: Participation in all Task meetings and provide feedback from the market