# Task 33: SOLAR HEAT FOR INDUSTRIAL PROCESSES

Werner Weiss

AEE - Institute for Sustainable Technologies
Operating Agent for the Austrian Ministry of Transport, Innovation and Technology

Dairy, Trikala, Greece (source: CRES)

## TASK DESCRIPTION

Around 150 million square meters of solar thermal collectors, corresponding to an installed capacity of 105 $GW_{th}$, were installed by the year 2004 worldwide. Until now, the widespread use of solar thermal plants has focused almost exclusively on swimming pools, domestic hot water preparation and space heating in the residential sector.

The use of solar energy in commercial and industrial companies is currently insignificant compared to the use in swimming pools and the household sector. Most solar applications for industrial processes have been used on a relatively small scale and are mostly experimental in nature. Only a few large systems are in use worldwide. However, if one compares the energy consumption of the industrial, transportation, household and service sectors in OECD countries, the industrial sector has the highest energy consumption at approximately 30%, followed closely by the transportation and household sectors.

The major share of the energy, which is needed in commercial and industrial companies for production processes and for heating production halls, is below 250°C. The low temperature level (<80°C) complies with the temperature level that can easily be reached using solar thermal collectors already on the market. The principles of operation of the components and systems apply directly to industrial process heat applications. The unique features of these applications lie on the scale on which they are used, system configurations, controls needed to meet industrial requirements, and the integration of the solar energy supply system with the auxiliary energy source and the industrial process. For applications where temperatures up to 250°C are needed, the experiences are rather limited and suitable components and systems are missing. Therefore, for these applications the development of high performance solar collectors and system components is needed.

To be able to make use of the huge potential for solar heat in industry and to open a new market sector for the solar thermal industry, SHC Task 33 is going to carry out potential studies, it will investigate the most promising applications and industrial sectors for solar heat, and it will optimize, develop and test solar collectors for medium temperature applications (up

to approximately 250°C). The development of integral solutions for solar thermal energy applications for given industrial processes (based on the "PINCH-concept") is also one of the main topics of this Task. In additions, the development of design tools (based on TRNSYS simulations) and a software tool for fast feasibility assessment, economic analyses as well as the design and the erection of pilot plants in co-operation with industry are planned.

**Scope of the Task**
The scope of the Task is on solar thermal technologies for converting the solar radiation into heat, (i.e., starting with the solar radiation reaching the collector and ending with the hot air, water or steam transferred to the application.) The distribution system, the production process and/or the optimization of the production process are not the main topics of the Task. However, influences on the production process and the distribution system arising from the solar character of the heat source will be studied in the framework of the Task.

Applications, systems and technologies, which are included in the scope of this task, are:

- All industrial processes where heat up to a temperature level of approx. 250°C is needed.
- Space heating of production or other industry halls is addressed, but not space heating of dwellings.
- Solar thermal systems using air, water, low pressure steam or oil as a heat carrier, i.e. not limited to a certain heat transfer medium in the solar loop.
- All types of solar thermal collectors for an operating temperature level up to 250°C are addressed: uncovered collectors, flat-plate collectors, improved flat-plate collectors - for example hermetically sealed collectors with inert gas fillings, evacuated tube collectors with and without reflectors, CPC collectors, MaReCos (Maximum Reflector Collectors), parabolic trough collectors.

To accomplish the objectives of the Task, the Participants are carrying out research and development in the framework of the following four Subtasks:

- Subtask A: Solar Process Heat Survey and Dissemination of Task Results
  (Lead Country: Italy)
- Subtask B: Investigation of Industrial Energy Systems
  (Lead Country: Austria)
- Subtask C: Collectors and Components
  (Lead Country: Germany)
- Subtask D: System Integration and Demonstration
  (Lead Country: Germany)

**Collaboration with other IEA Programmes**
Due to the complementary background and know-how of the participants of the SHC and the SolarPACES Programmes, significant synergies were expected from collaboration. Therefore, it was agreed to co-operate with the SolarPACES Program on a "moderate level" according to the SHC "Guidelines for Co-ordination with other Programs."

**Duration**
The Task was initiated on November 1, 2003 and will be completed on October 31, 2007.

## ACTIVITIES DURING 2005

## Subtask A: Solar Process Heat Survey and Dissemination of Task Results

### Potential studies

Several potential studies carried out in different European Countries have highlighted the huge potential for the application of solar process heat in the industrial sector.

The potential studies for the three countries: Spain, Portugal and Austria have shown that the need for industrial heat at low temperatures, which could be met using solar heat, is around 26 PJ (technically achievable potential). Even if only 5% of this potential were to be achieved in the coming years, equal to only 0.6 % of the low-temperature heat requirement of these three countries, this would require the installation of one million square meters of collectors with a capacity of 700 $MW_{th}$ .
A first potential study has been carried out also for Italy, showing that about 1/3 of the industrial heat demand is in the temperature range below 250 °C. According to the study carried out by the University of Rome "La Sapienza", the potential for solar process heat is about 17.5 TWh/y, which corresponds to 19% of the Italian industrial heat demand below 250 °C, or 5,4% of the total industrial heat demand in Italy. Most of the application potential lies in the food sector (44%) and in the textile industry (25%).

In the framework of the Subtask A activities, a draft report summarizing the main results and outcomes of all potential studies has been prepared. The final summary document will be available in 2006.

Currently about 85 solar thermal plants for process heat are reported worldwide, with a total installed capacity of about 27 $MW_{th}$ (38,500 $m^2$).

### Classification of systems

The integration of solar heat into the industrial process is a key challenge. For using solar thermal energy, the temperature of the available heat and the variability of solar energy must be considered, as well as the heat profile required by the process.

To rise to these challenges, 23 generic system concepts were developed according to the requirements of the different energy carriers (air, water-glycol, pressurised water or steam), the temperature levels and the process to be supplied with heat. These concepts are currently being realised and tested in demonstration plants.

### Diffusion activities

*Industry workshos*

In 2005, two industry workshops were carried out. The first industry workshop was held in Madrid on February 25th, in the framework of the GENERA 2005, an international energy and environment trade fair. The workshop was attended by 70 persons.

The second industry workshop was organized at the University of Kassel (Germany) in parallel with the 5th Task 33/IV experts meeting. The workshop was attended by about 50 participants.

*Industry Newsletter*

The first annual Industry Newsletter of Task 33/IV was translated into 5 languages and distributed in electronic and paper versions in the participating countries.

## Subtask B: INVESTIGATION OF INDUSTRIAL ENERGY SYSTEMS

### Matrix of indicators

By analysing unit operations of industrial energy applications, it could be concluded that low temperature processes exist in nearly all industrial sectors that are suitable for using solar thermal energy in principle. Some industry sectors such as food, chemistry, plastic processing, textile industry, building materials industry and business establishments can be distinguished as very promising sectors. The investigation of these industrial energy systems has to focus on an integrated analysis of cooling and heating demands taking into account competitive technologies, when assessing the (economic) feasibility of solar thermal energy. Among those competing technologies are heat integration, co-generation, new technologies and heat pumps.
A matrix of indicators was developed in Subtask B as a decision support tool for solar experts. With this matrix the work with industry and the identification of suitable solar applications will be facilitated. With the matrix it should be possible to investigate and calculate the installation of solar heat in production processes without detailed knowledge of the relevant unit operations.
The research thus concludes promising technical and economical feasibility of solar thermal energy for industrial processes and identifies a seminal step to a sustainable zero emission production.

Within the scope of Subtask B also the possibilities for heat recovery and use of solar thermal energy in an Austrian dairy were examined within a feasibility study.

## Subtask C: Collectors and Components

In Subtask C a report was elaborated, which gives an overview of the different medium-temperature collector developments that are being investigated in connection with Task 33/IV. The different collector developments are described briefly in concise papers. The report was approved by the SHC executive committee and it is now publicly available for download under http://www.iea-ship.org/3_1.html.

The work on the different medium-temperature collectors was continued. Two activities may be mentioned here especially:

- A new medium temperature collector was introduced to the market: The company SCHÜCO presented a double glazed flat-plate collector at the ISH-fair in Frankfurt, Germany in March 2005. The anti-reflective double glazing of this collector is hermetically sealed and the gap between the glass panes is filled with an inert gas to reduce the heat losses of the collector cover.
- In Spain, the development of a concentrating collector is planned with a fixed reflector and a tracking receiver. This means, that within Subtask C now four different concepts for concentrating collectors are investigated:
  - tracked parabolic trough collectors - reflector and receiver are tracked together,
  - tracked parabolic trough collectors – with fixed receiver and tracking reflector
  - Fresnel collectors with tracking reflectors and fixed receiver,
  - and the new concept with a fixed reflector and a tracking receiver.

The collector developments are on-going and will be continued in 2006.

Figure 1: Improved flat plate collectors in a process heat application: double glazed anti-reflective flat plate collectors from ESE (Belgium) are used in this compact solar driven desalination system developed by Fraunhofer ISE, Germany.

**Collector Testing**

The general approach in the work on this topic is to base the considerations on the existing European collector testing standard EN12975. The aim is to investigate which changes or additional requirements are necessary in order to include the broad spectrum of medium-temperature collectors into the existing EN12975 standard: improved flat-plate collectors, stationary concentrating collectors, tracked parabolic trough collectors and other concentrating collectors. Most of the necessary points of discussions refer to concentrating and tracked collectors. A first test on a parabolic trough collector was carried out by DLR/ITW during summer 2005. In these tests a testing facility was used in which the tilt angle of the testing platform could be adjusted. Therefore the influence of end-loss effects could be eliminated in these tests. The work on collector testing will be intensified in the year 2006.

**Subtask D: System Integration and Demonstration**

In Spain the first demonstration project with a nominal capacity of 357 $kW_{th}$ was installed in Barcelona. It is used for cleaning of transport containers of the company CONTANK. It is expected that some 22% of the 1990 MWh/a heat demand of the company will be satisfied by the solar system. The total investment was about 270.000 €.

In Austria, a solar production hall heating system has been completed, and a warehouse with a solar supported heating system is under construction.
First monitoring results were obtained by AEE INTEC at the car wash plant “Sunwash” in Gratkorn. During the period May 2005 to August 2005, solar fractions between 72% and 82% were reached. The highest energy consumption occurred in March, and in absolute values, the solar field contributed almost as much energy as during a summer month. The monitoring of this installation will be continued.

Figure 2: The Sunwash plant in Gratkorn, Austria

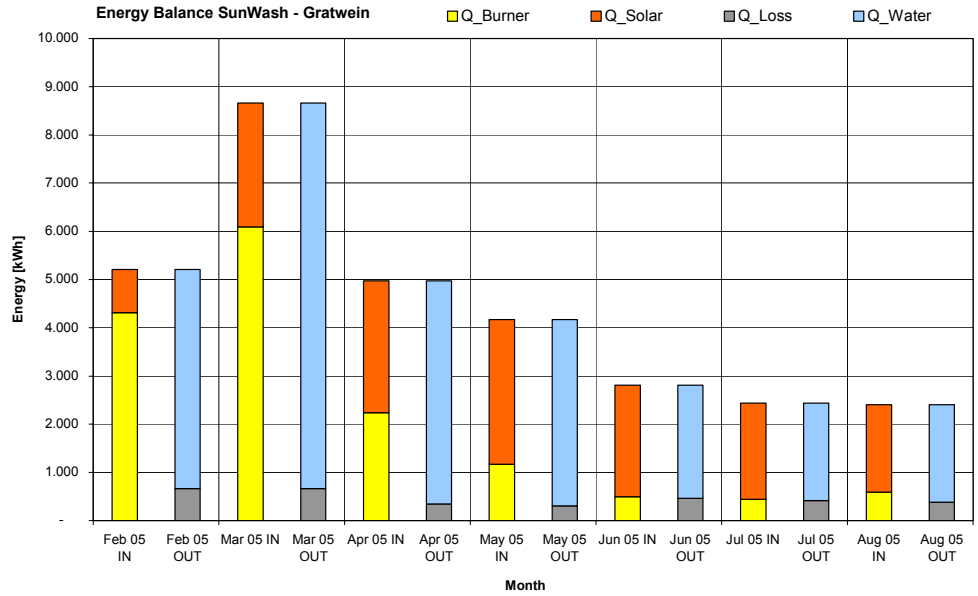


Figure 3: Monitoring results from the Sunwash plant in Gratkorn, Austria

## WORK PLANNED FOR 2006

### Subtask A: Solar Process Heat Survey and Dissemination of Task Results

The final version of the summary report of the potential studies will be finalized.

Regarding the plant survey, the inventory table summarizing the existing plants for solar process heat will be updated and furthermore the Power Point archive ("roadshow") of the existing plants will be finalized. A Subtask A report on existing plants will be finalized.

The next industry workshop will be organized in the framework of the 6$^{th}$ Task 33/IV Experts Meeting in Rome on 31/03/2006.

The second edition of the Industry Newsletter will be available by the end of January 2006 in English and in the languages of all participating countries.

### Subtask B: Investigation of Industrial Energy Systems

The focus of the work in Subtask B will be the extension of the matrix for mainly three industry sectors (food, textile, electroplating) and to fill in the matrix with data and information in a defined depth.
Further the methodology of the energy audit scheme and a road map will be worked out. The presented method and calculation scheme for total costs is tested during the whole project span and accommodated to the requirements. The data gained from these applications will be used for the outline of a road map. This road map shall be an instrument to visualize the differences, advantages and disadvantages of viable investment or operating options and the expected results in terms of either costs and energy use for the different approaches.
The intended purpose of the road map is to provide companies with a decision tool to find a tailor-made procedure for investments and / or operating options for consecutive projects protracting over a longer period with several investment phases or changes in operation.

**Subtask C: Collectors and Components**
The work on the development of medium temperature collectors will be continued in the different projects involved in the task.

Concerning testing of medium temperature collectors it is planned to start a round robin test in spring 2006. Different testing institutions are prepared to participate in the activity. Also the investigations on material tests will start in 2006. Performance parameters for material tests will be defined in the experts meeting in spring. Accelerated exposure tests are planned to start in autumn 2006

Regarding system aspects, first field test results will be discussed in the experts meeting in spring 2006. Also work on the stagnation behavior of large solar thermal systems for process heat will be carried out.

**Subtask D: System Integration and Demonstration**

In 2006 the first draft version of the design guidelines on how to integrate solar thermal heat into industrial processes will be prepared. The related documents and tools will be collected and maintained in a specific section on the Task Website. This site will contain a general description and procedure for the design of solar process heat systems and the use of the tools provided, the template/questionnaire for the collection of information for a specific site, the "pinch tool" under development at JOINTS, the GREENIUS fast assessment tool under development at DLR, as well as nomograms developed for specific applications.

Due to the size of the matrix developed by JOINTS, this tool will be made available to the participants via CD. All documents and tools are regarded as "working documents" to be updated and improved based on the experiences of the users. A first version shall be ready for discussion at the next Experts Meeting in Rome in March 2006.

Besides the design guidelines on the integration of solar heat into industrial processes also design guidelines for space heating of production halls are going to be finalized and published in 2006.

A main focus of the work in Subtask D will be on a number of case studies in order to initiate further pilot projects. Breweries, space heating of production halls and metal cleaning/surface treatment appear most promising, since several case studies or even ongoing projects already exist and contacts to further potential users in these sectors have been reported. To enhance the chances for identification and realization of pilot installations, dedicated workshops for

these sectors will be held at the next Expert meetings to intensify the exchange of experience and fully exploit potential synergies.

## LINKS WITH INDUSTRY

The Task defines two levels of participation for the solar industry:

- **Level 1.** An industrial participant at this level should expect to participate in an annual workshop organized by SHC Task 33 and to receive at least once during the Task duration a visit from a Task participant, and to answer technical and marketing questions on solar heat for industrial applications (this activity is part of the system survey and the dissemination activity of Subtask A).
- **Level 2**. An industrial participant at this level should expect Level 1 commitment and to participate in all Task meetings and to bring information and feedback from the market. Level 2 participation should be seen in close connection with the main participant of the country of origin of the industry.

A total of 15 companies from Austria, Italy, Spain, Portugal, Germany, Belgium, France and Brazil participate in the Task.

## REPORTS PUBLISHED IN 2005

- State-of-the-art report on medium temperature collectors
- Subtask B report

## REPORTS PLANNED FOR 2006

- Report on the potential of solar heat for industrial processes and the most promising industrial sectors
- Report and design guidelines for space heating of production halls
- Report on existing plants for solar process heat (draft)

**MEETINGS IN 2003**

First Experts Meeting
December 4 – 6
Gleisdorf, Austria

**MEETINGS IN 2004**

Second Experts Meeting
March 29 – 30
Brussels, Belgium

Third Experts Meeting
October 3 – 5
Oaxaca, Mexico

**MEETINGS IN 2005**

Fourth Experts Meeting
February 23 – 25
Madrid, Spain

Fifth Experts Meeting
October 3 – 8
Kassel, Germany

**Planned Meetings for 2006**

Sixth Experts Meeting
March 29 – 31
Rome, Italy

Seventh Experts Meeting
October 11 – 13
Lisbon, Portugal

## TASK 33 NATIONAL CONTACTS

**Australia**
Wes Stein
Lucas Heights Science & Technology Centre
New IllawarraRd, Lucas Heights NSW, PMB 7
Bangor NSW 2234

**Austria**
Werner Weiss, Dagmar Jähnig and
Thomas Müller
AEE INTEC
AEE - Institute for Sustainable Technologies
Feldgasse 19
A-8200 Gleisdorf

**Italy**
Riccardo Battisti, Annalisa Corrado
Claudia Vannoni, Serena Drigo
University of Rome "La Sapienza"
Department of Mechanical and Aeronautical
Engineering
Via Eudossiana
**18 00184 Rome**

Hans Schnitzer and Christoph Brunner
Joanneaum Research
Elisabethstrasse 16/1
A-8010 Graz

Gernot Gwehenberger
Technical University of Graz
RNS
Inffeldgasse 25c
A-8010 Graz

**Mexico**
Claudio Estrada
CIE-UNAM
Privada Xochicalco, S/N, Col. Centro
Cuernavaca, Mor., Mexico

**Portugal**
Maria Joao Carvalho
INETI
Edificio H, Estrada do Paço do Lumiar, 22
1649-038 Lisboa

**Spain**
Esther Rojas Bravo
CIEMAT-PSA
Avda. Complutense, 22, Edificio 42
28040 Madrid

Eduardo Zarza
CIEMAT-PSA
P.Box 22, Tabernas
04200-Almería

Hans Schweiger
AIGUASOL Engineering
Palau 4, 2o 2°
08 002 Barcelona

**Germany**
Klaus Vajen and Elimar Frank
Kassel University
Department of Mechanical Engineering
Solar and System Technology
D-34109 Kassel

Andreas Häberle
PSE GmbH
Christaweg 40
D-79114 Freiburg

Klaus Hennecke
DLR
Institut für Technische Thermodynamik
D-51170 Köln

Matthias Rommel
Fraunhofer ISE
Heidenhofstrasse 2
D-79110 Freiburg

Stephan Fischer
ITW, Stuttgart University
Pfaffenwaldring 6
D-70550 Stuttgart

Markus Peter
dp2 - Energienutzung mit Verstand
Michelsweg 29
D- 59494 Soest