SOLAR HEAT
FOR INDUSTRIAL PROCESSES

WORK PLAN

Solar Haeting & Cooling Programme Task 33

SolarPACES Programme Task 4

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Compiled by Werner Weiss, Austria

Solar Heat for Industrial Processes

1 Task description

Background

Around 60 million square meters of solar thermal collectors were installed by the year 2000 in the OECD countries. 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. Between 1994 and 2000 average growth rates of 18% were attained each year for these applications in Europe.

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 on a relatively small scale and are mostly experimental in nature. Only a few large systems are in use world-wide.
On the other hand, if one compares the energy consumption of the industrial, transportation, household and service sectors, then one can see that the industrial sector has the biggest energy consumption in the OECD countries at approximately 30%, followed closely by the transportation and household sectors.
Caused by the fact that energy is available at low cost and without limitations, industry did not care too much about energy efficiency and substitution of (fossil) fuels. The main activities in this field started in 1973 and 1979/80 following the two oil (price) crises. Later on, oil prices – and related to that the prices for natural gas and electricity – fell again. Today – even in the face of a possible critical political situation in the Middle East – energy prices are low.
On the other hand, it is obvious that fossil resources are finite and alternatives have to be found for any application, including the use in industrial and commercial applications.

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 which can easily be reached with solar thermal collectors already on the market. The principles of operation of 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 also 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, it is necessary to integrate solar thermal systems into the industrial processes in a suitable way especially when it is necessary to further develop the solar thermal components so that they fulfil the requirements stipulated.

How useful solar energy can be for industry is shown by the fact that fulfilling the goal of installing 2 million square meters of solar thermal collectors for industrial process heat and

solar cooling, as outlined in the “Campaign for Take-off” of the European Commission, alone would represent primary energy savings of about 2,000,000 MWh/year.
Therefore, solar thermal energy in industry can be an important contribution to a reliable, clean and safe supply based on renewable energy sources.

Why an IEA SHC project ?

The Solar Heating and Cooling Program of the International Energy Agency offers an ideal platform for international collaborative RD&D work. Several added values can be identified in a collaborative, international project compared to a national one.
Participating countries benefit from the specific know-how of each of the other participants. A study of the international state-of-the-art and their potential has only to be done once. Tools, such as design or simulation programs, may be similar for application in the participating countries. An international project may be capable of bringing together a supplier of technology in one country and an interesting market in another country.
In this new field of solar thermal application, international co-operation is needed to analyse the potential, to develop new high performance components and adapted system designs as well as for the dissemination of the results of the joint effort. Collaborative work in the framework of the Solar Heating and Cooling Program is a proactive action that can also favour good systems in a reasonable period of time on a more global market than the national one.

Furthermore 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.
At this level, the Task work is jointly defined, that is, the SolarPACES ExCo provides input to the Task Concept Paper and the Task Definition Phase. Once the Task is defined, the SHC ExCo will manage the Task.
In the course of such collaboration, both ExCos may find that they have differing views on the definition of work. If the two ExCos agree to collaborate at this level, it is assumed that they will make every effort to resolve their differences. Such resolution implies that the SHC ExCo is willing to make changes in the Task Work Plan proposed by the SolarPACES ExCo. However, as ExCos are independent and sovereign bodies, it is understood that such decisions remain the sole responsibility of the SHC ExCo.
To minimise the additional effort for the Operating Agent, the information exchange with the SolarPACES ExCo will be mainly through a representative participating in the Task and nominated by the SolarPACES ExCo.

Due to the complementary background and know-how of the participants of the two implementing agreements, significant synergies are expected from this collaboration. Whilst SHC is approaching the process heat sector from a range of lower temperatures and smaller plant sizes, SolarPACES has in the past, mainly focused on large scale, high temperature applications. On the other hand, markets for concentrating solar technologies developed in SolarPACES have only just started to be developed, whilst flat plate and vacuum tube collectors already have a significant commercial market, and standardisation and qualification issues have been comprehensively dealt with.

Joining both Implementing Agreement’s expertise will make it possible to select the most appropriate solar technology for specific applications from a comprehensive range of options (flat plate, vacuum tube, trough,..), and to avoid the re-invention of the wheel by the mutual exchange of know-how (high temperature solutions, standardisation issues,...). The broadened basis of manufacturers, scientists and potential customers will also increase the visibility of technology and applications. Since Task results will be disseminated through complementary contacts and communication channels, improved market opportunities for the technologies and methods developed in this Task can be expected.

Main activities to be undertaken

- Potential studies for all participating countries
- Investigation of the most promising applications and industrial sectors
- Development of integral solutions for solar thermal energy applications for given industrial processes (based on the “PINCH-concept”)
- Development and optimisation of collectors and all other components of the solar loop for medium temperature applications (up to approx. 250°C)
- Collector and component testing (medium temperature applications)
- Development of methods and test procedures for reliability assessment, especially the durability of materials and components
- Development of design tools (based on TRNSYS simulations) and a software tool for fast feasibility assessment.
- Economic analyses
- Feasibility studies
- Design and erection of pilot plants in co-operation with industry

1.1 Scope 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.

Specific process engineering technologies to which solar heat has to be supplied, such as the technologies for desalination of sea water, industrial cooling applications and electricity generation, are not the main focus of the Task. They may be considered to a certain extent if there is strong interest from industry.
For cooling applications, for instance, the work will be restricted to the adaptation of the results of SHC Task 25 to industrial applications.

Applications which are not addressed in this task are:

- The drying of agricultural goods
- greenhouses

- the detoxification of water

1.2 Objectives and subtasks' organisation

The main goals of the activity will be to:

1. Collect the resulting knowledge and experiences;
2. Provide methods and tools to analyse a wide range of solar applications for industry;
2. Help to co-ordinate research and development of solar thermal systems for industrial applications leading to improvements in both performance and costs;
3. Ensure the reliability of new materials and components;
4. Make sure that this knowledge is made available to those who can benefit from it;
5. Spread the awareness that solar thermal can be an integral part of industrial processes;
6. Demonstrate that systems providing solar heat for industrial applications are reliable and economical, as well as environmentally useful.

Several subtasks have been identified. They are presented in the following sections.

1.3 Participation from industry

There are several actors in the solar industry: engineering companies, manufacturers of solar components and the installers of systems.

The Task is designed to attract as many as possible from engineering companies, solar manufacturers and system sellers. The latter can contribute a lot to the quality of the Task and they can learn a lot from other's experiences and the Task work.

Due to the nature of the solar industry, being composed of very small to medium size companies, the Task defines two levels of participation for the solar industry:

- an industrial participant at level 1 should expect to participate in an annual workshop organised by Task 33 / Task 4 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).

- an industrial participant at level 2 should expect level 1 commitment and to participate in all Task meetings, bringing 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.

Task 33 / Task 4 will invite the solar industry organisations from all participating countries, as well as the international umbrella organisations such as ESTIF to participate.

The financial aspects of industry participation are left to the decision of each country: either the industry will have to make its own contribution or some support can come from public funding.

1.4 Subtask A

Solar Process Heat Survey and Dissemination of Task Results

Lead country: Spain (Aiguasol)

The objectives of this Subtask are:

- to provide a comprehensive description of the potential and the state-of-the-art of solar heat for industrial process. This includes the evaluation of completed research programs, of projects realised and the study of ongoing developments in this field, as well as carrying out economic analyses.

- to disseminate the knowledge to the four main target groups involved: solar manufacturers, process engineers, installers and potential buyers (industry).

The participants shall achieve these objectives by:

- carrying out a potential study and investigating the most promising industrial sectors for solar thermal systems

- documenting the state-of-the-art in the participating countries

- documenting the projects realised and monitoring results

- monitoring market developments

- documenting the solar collector and system technology available and the system costs

- carrying out economic analyses

- strenghtening collaboration with the solar industry during the Task and verifying that the industry gets valuable benefits and contributions from the Task throughout the work plan; and adapting the presentation of the results of all subtasks to the four target audiences: solar manufacturers, process engineers, installers and potential buyers (industry).

For the review work packages A1 to A5 as well as for the dissemination work packages A6 to A9 described below one partner from each participating country will be responsible for the sub-coordination, documentation of the state-of-the-art and dissemination of results.

Proposed activities in this subtask are the following:

A1. Potential study

Available data on industrial heat demand will be analysed with respect to the potential of application of solar thermal energy, classified by temperature ranges, industrial sectors and processes. For this, unified criteria will be used in order to compare the data, bringing together the experience from previous and ongoing projects in this field (The Austrian project PROMISE, EU-Projects POSHIP and PROCESOL).

Available data on industrial heat demand will be collected for each of the represented countries. Data for other selected countries not represented in the Task – but with high solar radiation and a high potential for solar industrial heat application - will be collected from data bases from the IEA (World Energy Outlook) and other international organisations.

A2. Documentation and Analysis of Case Studies found in the literature or carried out by participants regarding the integration of solar heat in production processes.

A3. Review of systems and applications in all participating countries
In order to get as much information as possible from projects carried out in the past an overview on realised and projected systems will be carried out. For this survey a form will be developed which makes the projects comparable and which reflects the main performance criteria in the energetic and economic area. In as far as this is available, monitoring results on solar process heat plants will be collected and analysed.
In order to organise the available information, materials such as questionnaires and lists of projects available from other projects (POSHIP, IEA-Task 25) will be updated and adapted. The collected information will be updated at every Task meeting throughout the period of execution of the present Task.

A4. Review solar collector and system technology available on the market
A review of the national solar market will be given by each participant in order to collect and distribute the information about the solar collectors and solar system technology available. This information will be maintained and updated throughout the period of execution of Task 33 / Task 4.

A5. Economic analysis
The economic analysis of solar thermal applications for industrial processes will be carried out. For this a review will be carried out on the fuel costs, return on investment, company internal added values and the possibilities for funding and tax reductions. The possibilities of CO2 trading as a financing scheme will also be investigated.
Economic parameters will be defined as a basis for the feasibility studies to be carried out in Subtask C & D.

A6. Organisation of industry workshops targeted at industries not directly involved in the Task and at other potential users of the Task results. Industrial participants at level 1 will be the primary target group, industrial participants at level 2 will be well informed within the Task. The "industry workshops" will be organised in conjunction with a Task 33 / Task 4 meeting or can be combined with international events, such as Eurosun conferences or trade fairs. They will last one afternoon or one evening. Interested manufacturers will be asked to present their products and developments and Task 33 /Task 4 researchers will report the current findings of the Task. The Operating Agent, the Subtask A leader, will be responsible for the organisation of these workshops and a participant from the hosting country.

A7. Publication of an annual Newsletter presenting Task 33 / Task 4 works and results, targeted at the solar industry. The contents of each newsletter will be agreed on at the task meetings and responsible persons for each contribution will be defined. The newsletter will be produced in English and can be translated into national languages. The Newsletter will be published on the Task web site and sent to industry via e-mail.

A8. Preparation of an information dossier for the dissemination of general information on the possibilities of solar process heat in industry. This dossier of about 30 pages will be edited in an early stage of the project in order to be used as a base material for the dissemination activities to be carried out. It is the intention to ask the solar industry from the participating countries to take over the printing cost of this brochure.

A9. Preparation of a handbook on solar process heat, summarising all Task information and results. The handbook will give an outline of the design process for solar process heat systems: assessment of feasibility, selection of appropriate processes and suitable points of coupling the solar thermal system with the existing heat supply, selection of system technology, performance prediction, economic analysis etc. Also some pilot plants will be described.

The final editing and distribution will be part of the Operating Agent's responsibilities.

Effort

The estimated effort is 2 to 6 person-months per participant and year during the 4 years, and 3 person-months per year for the subtask leader.

Deliverables

1. Potential study on solar heat for industrial processes in the participating countries and the most promising industrial sectors for solar thermal systems;

2. Report on the state-of-the-art of the solar collector technology, system concepts and system costs in the participating countries; review of existing and projected solar process heat systems.

3. A choice of interesting and promising designs to be further analysed by Subtask C and D, and for which a missing simulation component tool can be developed by Subtask C and D;

4. Guidelines for the economic analysis of solar plants for industrial applications;

5. Materials for dissemination of Task 33 / Task 4 results:

    - An annual industry Newsletter to deliver new information (paper version, and an Internet version on the IEA SHC and the SolarPaces Program site);
    - An information dossier
    - A handbook on solar process heat. This handbook will be published either as a printed handbook, on a CD or on a web site.

6. Proceedings of Task workshops on the status of solar heat for industrial processes.

7. A subtask report.

1.5 Subtask B

Investigation of industrial energy systems

Lead country: Austria (JOINTS)

The objectives of this Subtask are

a) to identify applications and the corresponding temperature levels of the processes and/or the energy utility system suitable for solar energy.
b) to investigate and develop integrated solutions considering solar thermal, waste heat recovery and improvements in the processes and energy utility systems.

The temperature at which energy is supplied in many industrial processes has not been limited by the characteristics of conventional energy systems. The partial or total replacement of conventional sources by solar energy in existing applications is usually limited to operations in the same temperature ranges as that of the sources replaced unless the energy supply system can be modified.
Solar energy can, therefore, be integrated into production

a) as a top-up to the existing energy supply system (steam, water,…)
b) as a new system (e.g. low pressure steam, luke water,…)
c) directly in the process avoiding supply systems

The following sectors appear important for solar thermal energy supply and will be investigated in detail, country specific priorities will result from Subtask A:

- chemicals
- food & beverage
- textiles
- timber
- galvanic and anodising industry
- consumer goods
- paper & pulp

Work in Subtask B will leave the production processes untouched but discuss the energy system in the companies. This mainly relates to the temperature levels in energy supply and the possibilities of heat integration.
The participants shall achieve this objective by:

- Integrating solar heat to the “PINCH-concept” (mainly for batch processes)
- Integrating industrial processes into design procedures of solar systems
- investigation, assessment and documentation of energy efficiency and other competing possibilities to save energy in production

The activities proposed for this subtask are the following:

B1. Identification of energy-relevant characteristics, parameters, indicators of energy supply processes to get the ability to document, classify and assess them. Industrial processes are usually supplied by a heating system with steam, thermo oils or hot water, powered by the incineration of fossil fuels. Most energy supply systems operate at varying temperatures and loads during the day, the week and the year.

Characteristics of load curves of industrial production processes with the potential to use solar heat will be documented and analysed regarding peak hours and stop times and compared with supply loads of solar thermal systems.

B2. Identification of typical temperature differences (second law losses) in industrial energy supply systems in order to get information about necessary levels of heat supply in selected industrial sectors.
In classical energy supply systems, high levels of temperature in the supply system (steam, hot water) lead to smaller and cheaper equipment for heat distribution (small volumes) and heat transfer (high ΔT), without increasing energy costs. This results in rather high "second law losses" that should not be accepted with solar heated production. As solar energy is used, higher temperatures become more expensive and larger equipment with smaller temperature differences becomes more economical. On the other hand, few industries will be ready to replace their existing heat delivery system as a whole and solar heat has to be supplied at the temperature level of the existing steam or hot water system.

B3. Expansion of existing heat integration models (e.g. PINCH-technology) to solar energy and/or expansion of design tools for solar heating systems to industrial processes. The minimum energy demand of a production system and the maximum potential for heat recovery can be found through heat integration models like the PINCH-theory. This theory will be adapted to the temperature and load curves of solar thermal systems in order to find the optimal integration for a time-dependent user.

B4. Judging solar energy with other ways to save fossil fuels like energy efficiency, heat pumps and heat integration. A number of technologies are suitable to save fossil fuels in production processes and to save energy costs in doing so.
It is of no use to supply an energetically inefficient production system with solar energy. Energy conservation, co-generation and heat pumping sometimes might offer a more sustainable and economic solution. Experience has shown that the integration of solar energy into production processes in general is pushed by the application of general efficiency measures.

B5. Development of a short-cut "Total Cost Analysis", including solar options. This activity aims to clarify all the parameters that influence the economic performance of the installation of a solar plant in an industrial process, besides the energy costs. Such costs are e.g. the chemicals for boiler feed water, service costs, efficiency losses and the maintenance of the conventional energy supply system.

Effort

The estimated effort is 4 to 6 person-months per participant and year during the 2 years, and 3 person-months per year for the subtask leader. The partners of subtask B will continue their work in subtask D after the B ends.

Duration: 2 years

Deliverables

1. **Matrix of indicators** that can be used to describe and classify industrial energy supply systems regarding the possibility to include solar thermal energy (temperature levels, temperature differences, load curves,…)

2. **Energy System - Analysis Tool** based on the matrix of indicators. A methodology on how to practically analyse an industrial energy system in order to work out the relevant indicators

3. **Description of improvement methodologies** for energy efficiency. Documentation of what alternatives to solar energy have to be regarded in order to avoid mislead investments in industrial energy systems.

4. **Process integration tool kit**. Methodology on the best way to integrate solar energy into an industrial energy supply and recovery system.

5. **"Total cost analysis"** methodology and tool kit

6. **Materials for dissemination** in Subtask A and design in Subtask D

7. **Subtask report**

1.6 Subtask C

Collectors and Components

Lead country: Germany (Fraunhofer-ISE)

The objective of this Subtask is to develop, improve and optimise collectors, components and systems with a potential for integration in industrial processes with a temperature level up to 250°C.

For a given application the most suitable collector technology has to be selected. The Subtask deals with all collectors for process heat from uncovered collectors, (advanced) flat plate and vacuum-tube collectors to concentrating collectors. The development emphasis is placed on the temperature level from 80 to 200°C ('medium temperature collectors').

Methods for the assessment of the impact on the properties of materials and components on the performance of the collectors and systems with regard to improved and new medium temperature collectors, will be developed and optimised. Appropriate durability test tools will be applied to specific materials / components to allow the prediction of service life and to generate proposals for international standards.

The participants shall achieve these objectives by:

- developing new collectors, components and system designs for process heat applications in co-operation with the involved industry
- advanced collector developments (for example double glazed flat plate collectors with anti-reflection coated glazing, hermetically sealed collectors with inert gas fillings, CPC collectors, parabolic trough collectors,...)
- collector testing at temperatures of 100 -250°C, elaboration of recommendations for collector testing standards for the medium temperature level
- investigating the material problems for medium temperature collectors up to 250°C operating temperature and system components
- determining parameters for modelling collectors in simulation programs to reflect the realistic performance of medium temperature collectors in process heat systems
- measurements on the thermal performance of all other components (heat exchangers, storage pipes, etc) of solar thermal systems operating at high temperatures. If possible, these measurements will be carried out in existing systems and in laboratory measurements in order to be able to realistically model medium temperature systems.
- investigating the stagnation behaviour of large medium temperature collector fields. The influences and consequences on the collector loop fluids.
- involving the solar industry in the analysis of all working fields through industry-dedicated workshops

Proposed activities in this subtask are the following:

C1. Medium temperature collector developments

Some of the available collectors are suitable for application in systems with medium operating temperatures. But there are development possibilities to improve collectors so that they can be operated at medium temperatures. New collector developments and improvements are necessary to achieve a better cost/performance ratio as is presently achieved for medium temperature systems. The collectors to be investigated may be, for example, double glazed flat plate collectors with anti-reflection coated glazing, hermetically sealed collectors with inert gas fillings, CPC collectors, MaReCos (Maximum Reflector Collectors), vacuum tube collectors with and without reflectors, parabolic trough collectors, etc...). In these activities, investigations on materials suitable for medium temperature collectors will play an important role.

The aim is to achieve improvements with respect to the thermal performance and, even more so, with respect to collector costs for the medium temperature range form 80 to 250°C.

C2. Medium temperature collector testing

There is a broad range of experience in collector testing for operating temperatures below 100°C. Most of the testing laboratories carry out the tests with water as the fluid and up to a maximum temperature of 100°C. Therefore, only very few test results are available for higher operating temperatures. In simulation programs, an extrapolation of the collector performance determined at low temperature measurements (up to 100°C) is made to describe the collector performance at higher temperatures. Definitively, these extrapolations often have a high uncertainty. This results in system design calculations with uncertain component dimensioning results. The present situation is undoubtedly a major obstacle in designing medium temperature process heat systems with the needed accuracy for successful pilot systems.

Therefore the testing of suitable collectors at medium temperatures and the exchange of experiences amongst different testing laboratories is very important. It is suggested to carry out a round-robin test on a medium temperature collector with efficiency measurements at 160°C or higher. The results will be discussed with respect to improving the testing procedures in the ISO 9806 and EN12975 standards. A comparison of outdoor and indoor measurements (using solar simulators) will be carried out.

C3. Test and Qualification Standards for medium temperature collectors up to 250°C

An important task for the wide spread commercial application of solar collectors in industrial processes will be the development of some Test and Qualification Standards allowing to assess such different technologies as flat plate collectors (stationary, using global radiation) and parabolic troughs (tracking, using direct radiation) with a view to their respective suitability for a particular application (in terms of the degree of compliance with specific requirements). Whilst comprehensive standards and procedures already exist for the non- or low-concentrating collectors, the methods used for concentrating systems are not yet described in standards. The envisioned aim of some kind of "unified" standard would be a major added value for the co-operation between IEA, SHC, and SolarPACES, relieving potential customers and manufacturers alike of much doubt and uncertainty. Due to the inherent differences of the technologies to be characterised, this will be a challenging task.

The aim is to contribute to a unified standard for medium temperature collectors.

C4. Reliability of collectors for industrial processes

In order to achieve an improved performance / cost ratio for collectors for industrial processes, the reliability of collectors and their service life time is important. Moreover, in the development of medium temperature collectors, new materials and components will be used. This concerns the full width of collector technologies from flat-plate collectors to vacuum tube collectors and parabolic trough collectors. Reflectors (including their mechanical support), glazing and absorbers are especially addressed.
Representative and realistic test samples will be identified and prepared. Relevant performance parameters will be defined and characterisation procedures will be established. The durability methodology test procedures developed in Task 27 will be applied. Accelerated exposure tests in laboratories and on outdoor test facilities will be carried out.

The aim is to improve the reliability of 'medium temperature' collectors (80 to 250°C) for industrial process heat and their service lifetime.

C5. Realistic medium temperature component parameters for simulation models
In order to carry out simulation calculations, the parameters are needed which describe the performance of all system components with the required accuracy. Measurements on the thermal performance of all system components -besides the collector- (i.e. heat exchangers, storage, pipes, etc) of solar systems will be carried out and the available information will be collected. If possible, these measurements will be carried out on existing systems or in laboratory measurements in order to be able to realistically model medium temperature systems.

The aim is to elaborate validated parameters, to be able to simulate complete medium temperature systems with the required accuracy, in order to design pilot systems operating successfully..

C6. Investigation of the stagnation behaviour of large medium temperature systems
The aim of the Task is to integrate solar heat into industrial processes. To achieve this aim it is very important that the systems operate very reliably in all the operation modes that may occur. In this respect, special emphasis has to be put on the aim that the solar thermal systems can handle stagnation situations without any danger of failure and without the need for additional maintenance works. This is also an experience from the development of solar combisystems (see SHC TASK 26 and other projects). Stagnation has to be regarded as a normal operation mode of solar thermal systems. In industrial process heat systems stagnation may occur due to times without industrial production because of weekends or vacation times. Particularly when it comes to large collector fields for industrial process heat, the stagnation behaviour has to be investigated.

The aim is to develop techniques to handle stagnation situations in large medium temperature collector fields.

Effort

3 to 8 person-months per year is expected from each participant in this Subtask and 3 person-months per year for the subtask leader.

Deliverables

1. New performance and cost-improved collectors suitable for medium temperature solar process heat systems. The documentation of available and newly designed collectors for medium temperature solar process heat systems.

2. Recommendations on the testing of medium temperature collectors and on the elaboration of standards for medium temperature collectors. Results from round robin collector test.

3. Documentation on realistic component parameters needed for simulation calculations on medium temperature solar process heat systems.

4. Recommendations on service life time test procedures for collector components of medium temperature collectors.

5. Subtask report.

1.7 Subtask D

System Integration and Demonstration

Lead country: Germany (DLR)

The main objective of this Subtask is to initiate pilot projects covering a broad variety of technologies in suitable applications representing a significant part of industrial process heat consumers (in terms of size, temperature levels, heat transfer media, load patterns, etc.). These pilot plants endeavour to become a "best practice" reference, encouraging other potential users to employ these technologies. Pre-feasibility studies will be performed in each participating country, to provide a basis for the identification of the most promising applications and to bring together partners for the design, funding and implementation of selected pilot projects. It is endeavoured to initiate at least one pilot project per participating country. The operation of these plants shall be monitored for a representative period to provide feedback on the design and operation concept as a basis for future development and improvements.

The Participants shall achieve this objective by the following major activities:

- developing design guidelines for solar process heat integration in industrial energy supply systems
- developing numerical simulation tools for fast feasibility assessment and system optimisation
- carrying out case (feasibility) studies
- organising roadshows and workshops targeted at selected industry sectors to congregate suitable partners and motivate the formation of consortia for the realisation of pilot plants
- monitoring solar industrial process heat systems in operation

Proposed activities in this Subtask are the following:

D1. Design Guidelines
Development of a structured design approach, giving guidance with respect to the criteria and sequence of decisions during the system design process. The result will be a kind of roadmap, leading from the analysis of the intended application (with methods developed in Subtask B) and evaluation of different technological solutions (e.g.: direct coupling of a solar system to a particular process versus integration of solar heat into the overall "conventional" energy system, heat storage or fossil back-up, etc.) to the definition of basic system design parameters (e.g.: size and temperature level of the solar contribution) and the selection of appropriate components.

D2. Numerical Simulation Tools
Based on the results from Subtasks A, B and C, the TRNSYS model library will be extended to include standard industrial consumer models and appropriate collector models (if not yet available). This is a very effective way to allow rather detailed system modelling (e.g. for feasibility studies) with a "standard tool" understood and accepted by a large user community. Nevertheless, such detailed simulations require some experience and the implementation of specific information about the system to be investigated, which generally is not easily available.

Therefore, a simple to use model for "quick and dirty" first assessments and/or support for the dissemination task will also be developed. This tool will include some "standard" configurations, weather and load profiles to allow even non-experienced users to get a "feeling" for the different technological options offered. The "Greenius" tool developed at DLR for the easy assessment of different renewable electricity generation options is seen as a good basis for this endeavour.

D3. Case Studies

In parallel to and using interim results of the work packages D1 and D2, case studies for promising applications identified in Subtasks A and B will be carried out in close co-operation with interested industries. Lessons learned from these case studies will provide feedback for further developments in work packages D1 and D2, as well as, the identification of R&D requirements for component improvements or the identification and proposal of candidate sectors for the realisation of pilot projects. A series of workshops is intended to intensify the exchange of knowledge and experiences of the different Subtask working groups, which is required to achieve the objective of this Subtask.

D4. Pilot Projects

As early as possible during the task, activities will be started to promote the demonstration of promising technologies and applications. This will include the identification of suitable candidates from work package D3, the preparation of targeted roadshows and workshops for selected industry sectors, providing support for the formation of qualified consortia, assisting in the definition of detailed project plans and the acquisition of funds, as well as providing consulting services for the detailed design, procurement and implementation of the selected systems and components. The aim is to initiate “best practice” reference installations for a wide range of applications and technologies. Whilst it is endeavoured to initiate at least one suitable consortium per participating country within the project period, an extension of the current Task time frame may be required for the realisation of the actual pilot projects.

D5. Monitoring

This work package relates to both systems under construction or already operating, and newly installed systems initiated in work package D4. The operation will be monitored to validate and improve the methods and models developed in work packages D1 and D2 to verify design assumptions and component performance, and to obtain reliable information for the promotion of further solar industrial process heat systems. Guidelines for the monitoring of industrial process heat installations will be developed to ensure the consistency of the results obtained by different teams and for different technologies and applications. This Subtask may be extended beyond the current Task time frame. A decision on this will be made after the second year.

Effort

A total of 3 to 8 person-months per participant is seen to be required for this activity during each year over the 4 years duration of the Task (excluding the pilot projects and monitoring activities), and 3 person-months per year for the subtask leader. The effort related to the pilot plants and monitoring will largely depend on the complexity of the project, and can only be estimated on the basis of the related feasibility study.

Deliverables

1. Design guidelines for solar industrial process heat systems
2. TRNSYS model library for solar industrial process heat components
3. Software tool for fast feasibility assessment
4. A series of case study reports
5. Detailed proposals for at least one pilot plant in each participating country
6. Monitoring reports for each pilot plant
7. Subtask report

2 Information plan

The following documents are planned during the Task work:

1. "*Solar systems for industrial applications – realised projects and case studies* ", a colour brochure (information dossier) to be published by Subtask A by the end of Year 1.

2. *Industry workshops,* during the Task duration, in conjunction with every Task meeting, will be organised in the host country of the meeting. The system manufacturers and the target user groups will be invited.

3. *National industry workshops* can also be organised by Task participants using the information gathered during Task workshops and the material produced by the Task.

4. A *Newsletter* targeted at the solar industry and buyers will be produced at the end of Year 2, 3 and 4. The Newsletter will be distributed through national channels (for instance, included in a solar industry or solar association or HVAC journal)

5. A *design handbook on solar systems for process heat* will be a major effort of Task 33 / Task 4 and published by the Operating Agent on a CD-ROM, a Web-site or as a printed version.

6. Part of the information produced by Task 33 / Task 4 can be made available through the Internet, at a marginal cost, on the Web site of one of the national laboratories participating in the Task.

7. In general - the dissemination of results will take place at a national level.

3 Time table

The time schedule for the Task definition phase is given in table 1.
The time schedule for the activities foreseen during the Task is given in table 2

Table 1: Time schedule for the Task definition phase

10-02	11-02	12-02	01-03	02-03	03-03	04-03	05-03	06-03	07-03	08-03	
TDW 1	SHC-ExCo			TDW 2	SP-ExCo			SHC-ExCo			
											November 2003 to October 2007

TDW: Task definition workshop

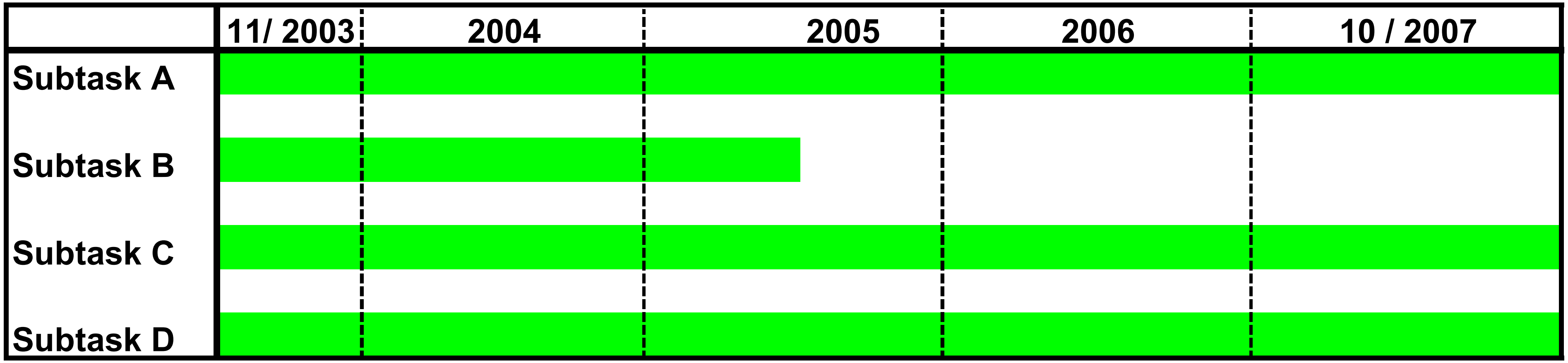

Table 2: Level of efforts for the participants.

Totals are based on a number of 8 countries participating in the Task and a minimum of 7 participants in each Subtask.

Level of efforts for participants		2003 PM	2004 PM	2005 PM	2006 PM	2007 PM	Σ PM	# of Part.	Total PM	Total PY
Subtask A participant	Min.	1	2	2	2	2	9	7	63	5.25
	Rec.	3	6	6	6	4	25	7	175	14.6
Subtask B participant	Min.	1	4	4	---	---	9	7	63	5.25
	Rec.	3	6	6	---	---	15	7	105	8.75
Subtask C participant	Min.	1	3	3	3	3	13	7	91	7.6
	Rec.	3	8	8	8	8	35	7	245	20.4
Subtask D participant	Min.	1	3	3	3	3	13	7	91	7.6
	Rec.	3	8	8	8	8	35	7	245	20.4
Total	Min.								308	25.7
	Rec.								770	64.2
Average participation per country	Min.									2.5
	Rec.									6.4

Min. = Minimum effort required PM = Person Month
Rec. = Recommended effort PY = Person Year

Table 3: Level of efforts for the Subtask Leaders and the Operating Agent.

Level of efforts for subtask leaders and operating agent	2003 PM	2004 PM	2005 PM	2006 PM	2007 PM	2008 PM	Total PM	Total PY
Subtask A Leader	1	3	3	3	3	0	13	1.1
Subtask B Leader	1	3	3	3	3	0	13	1.1
Subtask C Leader	1	3	3	3	3	0	13	1.1
Subtask D Leader	1	3	3	3	3	0	13	1.1
Operating Agent								
Task administration	1	4	4	4	4	2	19	1.6
Edition: design handbook					2		2	0.2

4 General information

4.1 State-of-the-art review

A first state-of-the-art review on solar heat for industrial applications has been made with participants of the Gleisdorf (Austria) meeting. A preliminary document gathering material presented during the meeting was edited in March 2002 by Austria.

4.2 Agenda

June 2002:	Preliminary proposal at the IEA SHC ExCo
October 2002:	First Task Definition Workshop in Madrid, Spain
November 2002:	Presentation of the Task concept paper at the IEA SHC Executive Committee meeting
February 2003:	Second Task Definition Workshop in Freiburg, Germany
March 2003	Presentation of the Draft Workplan and Annex at the IEA SolarPaces Executive Committee meeting
June 2003:	Presentation of the Final Draft Workplan and Annex at the IEA SHC Executive Committee meeting
November 2003	First Task meeting
October 2007	End of Activity

5 Contributors

The following people have contributed to the proposal:

1. Uwe Begander, JOINTS, Graz, Austria
2. Ismaël Daoud, Institut Wallon, Namur, Belgium
3. Maria-Luisa Delgado, CIEMAT, Madrid, Spain
4. Claudio Estrada, CIE-UNAM, Cuernavaca, Mor., Mexico
5. João A Farinha Mendes, INETI, Lisbon, Portugal
6. Stephan Fischer, ITW, Universität Stuttgart, Stuttgart, Germany
7. Klaus Hennecke, DLR, Köln, Germany
8. Michaelis Karagiorgas, Centre for Renewable Energy Sources (CRES), Pikermi, Greece
9. Michael Köhl, Fraunhofer ISE, Freiburg, Germany
10. Christopher Koroneos, University of Thessaloniki, Greece
11. Eva Kudrnova, Technology Centre AS CR, Prague, Czech Republic
12. Angel Morales, CIEMAT, Madrid, Spain
13. Thomas Müller, AEE INTEC, Gleisdorf, Austria
14. Svante Nordlander, SERC, Borlänge, Sweden
15. Henrik Quicklund, SP, Swedish National Testing and Research Institute, Sweden
16. Esther Rojas, CIEMAT-PSA, Madrid, Spain
17. Manuel Romero, CIEMAT-PSA, Almeria, Spain
18. Matthias Rommel, Fraunhofer ISE, Freiburg, Germany

19. Marcelino Sancuez, CIEMAT, Madrid, Spain
20. Hans Schweiger, AIGUASOL Engineering, Barcelona, Spain
21. Hans Schnitzer, JOINTS, Graz, Austria
22. Lars Staudacher, ZAE Bayern, Germany
23. Werner Weiss, AEE INTEC, Gleisdorf, Austria
24. Eduardo Zarza, CIEMAT – PSA, Spain

List of participants: 1st Task Definition Meeting, Madrid

21 October 2002

	Surname	First Name	Institute / Company	Address	E-mail	Country
1	Begander	Uwe	JOINTS		uwe.begander@joanneum.at	Austria
2	Delgado	Maria-Luisa	CIEMAT	Avda. Complutense, 22, Edificio 42, 28040 Madrid	luisa.delgado@ciemat.es	Spain
3	Estrada	Claudio	CIE-UNAM	Privada Xochicalco, S/N, Col. Centro, Cuernavaca, Mor., Mexico	claudio.estrada@ciemat.es	Mexico
4	Farinha Mendes	João A	INETI	DER/INETI, Edificio G, Estrada do Paço do Lumiar, 22, 1649-038 Lisboa	Farinha.Mendes@ineti.pt	Portugal
5	Fischer	Stephan	ITW, Universität Stuttgart	Pfaffenwaldring 6, D-70550 Stuttgart	fischer@itw.uni-stuttgart.de	Germany
6	Hennecke	Klaus	DLR, Institut für Technische Thermodynamik	D-51170 Köln	klaus.hennecke@dlr.de	Germany
7	Morales	Angel	CIEMAT	Avda. Complutense, 22, Edificio 42, 28040 Madrid	angel.morales@ciemat.es	Spain
8	Müller	Thomas	AEE INTEC	Feldgasse 19, A-8200 Gleisdorf	t.mueller@aee.at	Austria
9	Rojas	Esther	CIEMAT-PSA	Avda. Complutense, 22, Edificio 42, 28040 Madrid	esther.rojas@ciemat.es	Spain
10	Romero	Manuel	CIEMAT-PSA	Plataforma Solar de Almeria, 04200-Tabernas, Almeria, Spain	manuel.romero@ciemat.es	Spain
11	Rommel	Matthias	Fraunhofer ISE	Heidenhofstr. 2, D-79110 Freiburg	rommel@ise.fhg.de	Germany
12	Sancuez	Marcelino	CIEMAT	Avda. Complutense, 22, Edificio 42, 28040 Madrid	marcelino.sancues@ciemat.es	Spain
13	Schweiger	Hans	AIGUASOL Engineering	Palau 4, 2o 2a, 08 002 Barcelona, Spain	hans@aiguasol.com	Spain
14	Weiss	Werner	AEE INTEC	Feldgasse 19, A-8200 Gleisdorf	w.weiss@aee.at	Austria

List of participants: 2nd Task Definition Meeting, Freiburg

February 3 – 4, 2003

	Surame	First Name	Institute / Company	Address	E-mail	Country
1	Begander	Uwe	Joanneum Research, JOINTS	Elisabethstrasse 16/1, A-8010 Graz	uwe.begander@joanneum.at	Austria
2	Lerchenmüller	Hansjörg	Fraunhofer ISE	Heidenhofstr. 2, D-79110 Freiburg	lerch@ise.fhg.de	Germany
3	Estrada	Claudio	CIE-UNAM	Privada Xochicalco, S/N, Col. Centro, Cuernavaca, Mor., Mexico	claudio.estrada@ciemat.es	Mexico
4	Nordlander	Svante	SERC, Högskolan Dalarna	S-781 88 Borlänge	snr@du.se	Sweden
5	Fischer	Stephan	ITW, Universität Stuttgart	Pfaffenwaldring 6, D-70550 Stuttgart	fischer@itw.uni-stuttgart.de	Germany
6	Hennecke	Klaus	DLR, Institut für Technische Thermodynamik	D-51170 Köln	klaus.hennecke@dlr.de	Germany
7	Müller	Thomas	AEE INTEC	Feldgasse 19, A-8200 Gleisdorf	t.mueller@aee.at	Austria
8	Rommel	Matthias	Fraunhofer ISE	Heidenhofstr. 2, D-79110 Freiburg	rommel@ise.fhg.de	Germany
9	Schweiger	Hans	AIGUASOL Engineering	Palau 4, 2o 2a, 08 002 Barcelona, Spain	hans@aiguasol.com	Spain
10	Weiss	Werner	AEE INTEC	Feldgasse 19, A-8200 Gleisdorf	w.weiss@aee.at	Austria
11	Schnitzer	Hans	Joanneum Research, JOINTS	Elisabethstrasse 16/1, A-8010 Graz	hans.schnitzer@joanneum.ac.at	Austria
12	Staudacher	Lars	ZAE Bayern	Walther Meißner Str. 6 D-85748 Garching	staudacher@muc.zae-bayern.de	Germany
13	Köhl	Michael	Fraunhofer ISE	Heidenhofstr. 2, D-79110 Freiburg	mike@ise.fhg.de	Germany
14	Häberle	Andreas	PSE GmbH	Christaweg 40, D-79114 Freiburg	ah@pse.de	Germany
15	Quicklund	Henrik	SP, Swedish National Testing and Research Inst.	Industrig. 4, Box 857 S-501 15 BORÅS	henrik.quicklund@sp.se	Sweden
16	Kudrnova	Eva	Technology Centre AS CR	Rozvojova 135, 165 02 Praque 6	kudrnova@tc.cas.cz	Czech Rep.
17	Zarza	Eduardo	CIEMAT - PSA	P.Box 22, Tabernas, 04200-Almería	eduardo.zarza@psa.es	Spain
18	Suter	Jean-Marc	Suter Consulting	P.O. Box 130, CH-3000 Bern 16	suter@suterconsulting.com	Switzerland
19	Koroneos	Christopher	University of Thessaloniki	Box 483, 54124 Thessaloniki	koroneos@aix.meng.auth.gr	Greece
20	Farinha Mendes	João A	INETI	DER/INETI, Edificio G, Estrada do Paço do Lumiar, 22, 1649-038 Lisboa	Farinha.Mendes@ineti.pt	Portugal
21	Brakmann	Georg	Fichtner Solar GmbH	Sarweystrasse 3, D-70191 Stuttgart	brakmanng@fichtnersolar.com	Germany