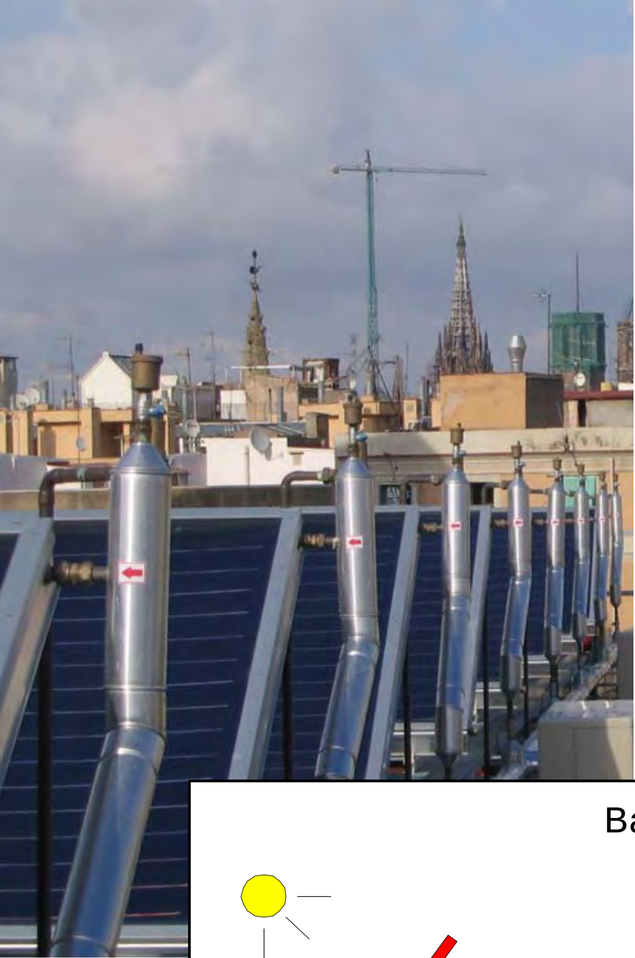

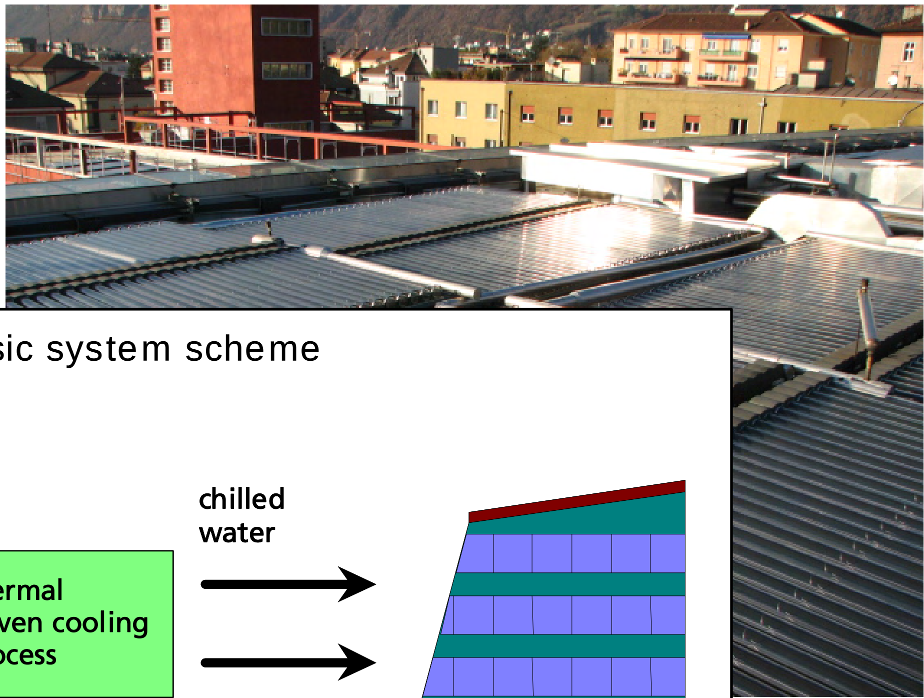

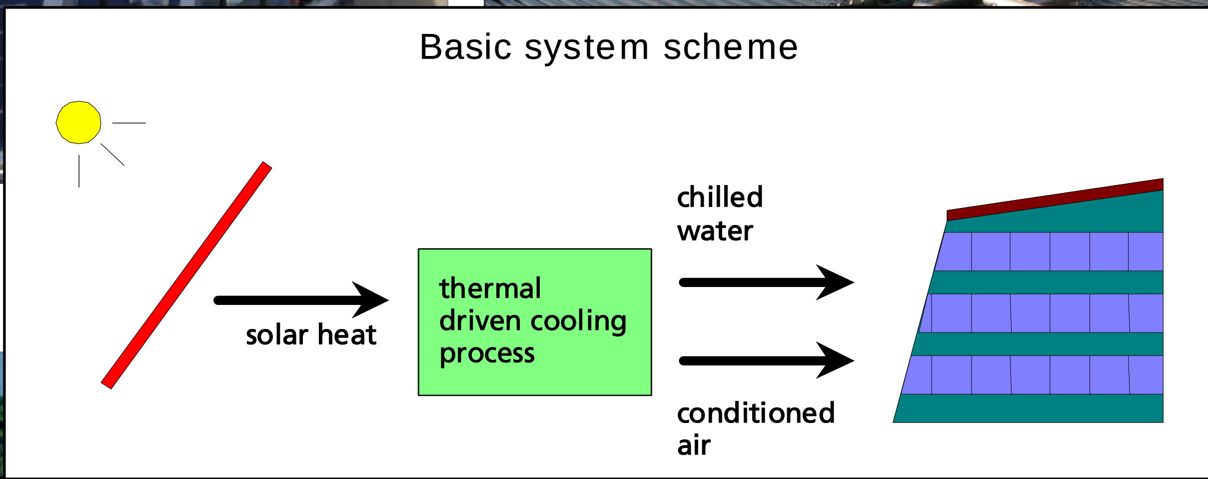

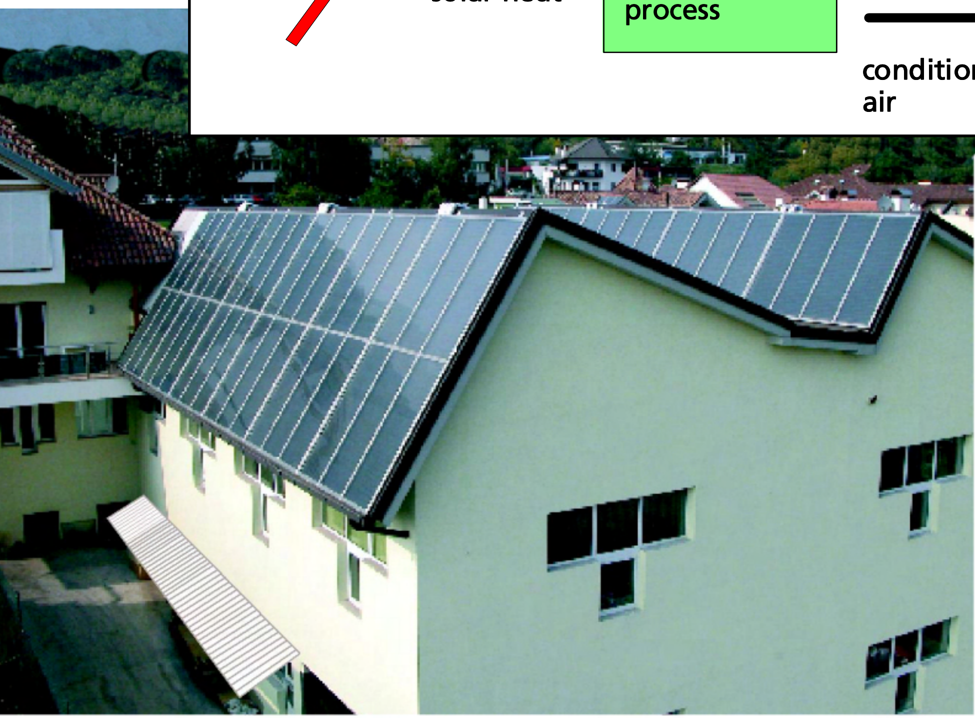

SOLAR HEATING & COOLING PROGRAMME
INTERNATIONAL ENERGY AGENCY

Task 38
Solar Air-Conditioning and Refrigeration

Industry Newsletter

First edition, 01-2009

IEA – SHC Task 38

Solar Air-Conditioning and Refrigeration

SOLAR HEATING & COOLING PROGRAMME
INTERNATIONAL ENERGY AGENCY

Task 38
Solar Air-Conditioning
and Refrigeration

Background

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The service for comfort air-conditioning requires a major part of the consumed energy in buildings in many countries. Especially electrically driven room air conditioners or chillers cause electricity peak loads in electricity grids although advanced systems reached a relatively high standard concerning energy consumption. This is becoming a growing problem with resulting electricity shortages at high grid loads in regions with cooling dominated climates. In recent years an increasing number of cases occurred in which summer electricity shortages were created due to air-conditioning appliances. In some regions or municipalities building regulations were set up in order to limit the application of active air conditioning systems, unless they are operated with renewable energies.

This underlines the necessity of new solutions with lower electricity consumption and in particular reduced consumption at electricity peak load conditions.

The use of solar thermal energy in combination with thermally driven cooling systems (chillers, open sorptive cycles) can be a possible solution among others.

The main objective of the international collaborative project Task 38 “Solar Air-Conditioning and Refrigeration” in the framework of the Solar Heating & Cooling Programme of the International Energy Agency (IEA) is the implementation of measures for an accelerated market introduction of solar air-conditioning and refrigeration with a major focus on improved components and system concepts.

The work in this Task wants to contribute to the process of rising acceptance of the technology and to overcome the main barriers on technical and information transfer levels.

It seems logical to apply solar energy for cooling purposes since in many applications, such as air-conditioning, cooling loads and solar gains occur at more or less the same time. The same holds not necessarily for refrigeration application e.g. in the food processing sector. However, also in these sectors a coincidence between solar gains and load occurs at least on a seasonal level. In general, solar assisted cooling can mean to produce electricity from solar radiation by photovoltaics and to drive electrically driven cooling systems or to produce heat from solar radiation by solar thermal collector systems and to use this heat in combination with thermally driven cooling processes. Thermally driven technology is of particular interest in case of applications where both cooling and heating is needed. In such cases a solar thermal collector can be used all year round for heating in winter and cooling in summer.

Task 38 "Solar Air-Conditioning and Refrigeration"
The main scopes of the Task are the technologies for production of cold water or conditioned air by means of solar heat. The main application covered by the project is cooling of buildings but also industrial refrigeration e.g. in the food sector is considered. Today solar assisted cooling has best chances for market introduction in cases of large buildings with central air conditioning systems. But there is also an increasing market seen for cooling equipment in the small residential and small commercial sector. Here new solutions are necessary in which the solar collector provides heat over the whole year, i.e. for heating in winter, for cooling in summer and for production of hot water in the entire year. So called pre-engineered systems are seen as a solution for this application range. Therefore Task 38 focuses on both custom-made systems with large capacities as well as pre-engineered systems with small capacities.

Task Objectives
The main objective of the Task is the implementation of measures for an accelerated market introduction of solar air conditioning and refrigeration with focus on improved components and system concepts.
This will be supported through

- Activities in development and testing of cooling equipment for the residential and small commercial sector;
- Development of pre-engineered system concepts for small and medium size systems and development of optimised and standardised schemes for custom made systems;
- Reports on the experiences with new pilot and demonstration plants and on the evaluation and performance assessment procedure;
- Provision of accompanying documents supporting the planning, installation and commissioning of solar cooling plants;
- Analysis of novel concepts and technologies with special emphasis on thermodynamic principles and a bibliographic review;
- Performance comparison of available simulation tools and applicability for planning and system analysis;
- Market transfer and market stimulation activities, which include information letters, workshops and training material as well as the 2nd edition of the Handbook for Solar Cooling for Planners.

Duration of Task 38: September 2006 to December 2010.

Subtasks

The work in this Task 38 is organised in four subtasks and each subtask consists of several work packages with specific focus and results.

Subtask A	Subtask B
Pre-engineered systems for residential and small commercial applications	**Custom-made systems for large non-residential buildings and industrial applications**

Subtask C

Modeling and fundamental analysis

Subtask D

Market transfer activities

Subtask A:
Pre-engineered systems for residential and small commercial applications

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The objective of Subtask A is to support measures for the development of small pre-engineered systems, defined as:

- Cooling capacity < 20 kW.
- A high degree of pre-fabrication of the entire system.
- No additional effort in planning is required for this type of systems.
- Pre-engineered systems, consisting in general of solar collector, storage tank, back-up system, chiller, heat rejection and control unit as the main components, can be connected directly to the room components by the installer.

The work in Subtask A comprises the following fields of activity:

- To get an overview, an investigation and description of the market available components and ongoing developments suitable for combined systems for heating and cooling with chilled water systems in the desired capacity range is carried out.
- Based on small-scale solar heating and cooling systems that are already on the market, generic system schemes are elaborated.
- The main part in Subtask A are monitoring activities of experimentally and commercially installed solar heating and cooling systems. So far 11 systems are being monitored, 8 other systems are planned for 2009
- Experiences from installed systems will be summarised in guidelines for installation and maintenance. In addition, a survey among end-users is carried out to collect their expectations regarding operation, installation and maintenance of pre-engineered systems.

Examples of realised small systems:

Fig. 1:
Installation at the office building of the Company SOLID in Graz, Austria (17.5 kW absorption chiller Yazaki WFC-SC5). Photo: SOLID

Fig. 2:
Two chillii® Cooling Kit PSC10 are installed at a bank in Miesbach, Germany, to produce 20 kW of cooling capacity. 99.8 m² flat plate collectors generate the required heat which is stored in 7,500 l hot buffer storage. The solar cooling system also has a 1,000 l cold buffer storage and a wet cooling tower to reject the heat of the chiller. Photos: SolarNext

Fig. 3:

The office building in St. Schörfling, Austria, has 162 m² facade collectors as a second envelope for the building. Two chillii® Cooling Kits STC8 are used to generate 15 kW of cold. The System consist of two water/silica gel adsorption chillers chillii® SCT8 and a hot as well as a cold buffer storage with 15,000 l and 1,500 l, respectively. The heat rejection is realised with dry cooling towers with a water spraying system. Photos: SolarNext

Fig. 4:

At the building of a retired people residence in Maclas, in the Rhône Alpes region of France, a solar cooling installation consisting of an absorption chiller (Sonnenklima Suninverse, Germany) with a capacity of 10 kW coupled with a collector field of 24 m² evacuated tube collectors is used for air-conditioning of the leisure space and the restaurant. Photos: TECSOL

Subtask B: Custom-made systems for large non-residential buildings and industrial applications

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The objective of Subtask B is to overcome the main technology related barriers for a wider implementation of medium and large scale systems for solar assisted cooling, characterised by:

- Cooling capacity > 20 kW.
- Individually planned systems for the particular application with involvement of planning engineers.
- Call for tender typically for single components and not for the system as a whole.

The target markets will be large air-conditioning and refrigeration end-users (large office and other non-residential buildings, hotels, industry etc.).

The work in Subtask B comprises the following fields of activity:

- A report to give an overview on large solar cooling systems using absorption and adsorption technologies as well as DEC-systems (Desiccant Evaporative Cooling) will be carried out.
- As support for future installations the previous experiences on system design and control strategies are compiled.
- A main part in Subtask B is the monitoring of overall 12 demo projects of large solar cooling installations. The elaboration and application of generally accepted evaluation procedures will guarantee the comparability of the monitoring results.
- With the expert-knowledge a method for the fast pre design assessment has been developed. With this tool a pre-selection of the technical and the hydraulic scheme according to the building and the meteorological boundary conditions is possible as well as draft sizing of the main components of the system.
- As one result of the work in Subtask B guidelines for installation and commissioning as well as for call for tender will be elaborated.

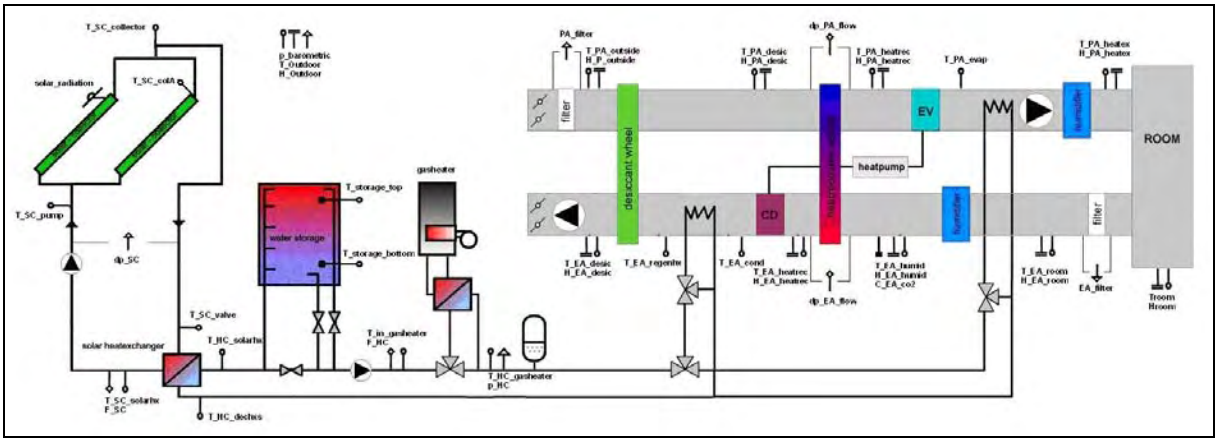
Examples of realised large systems:

Fig. 5:
Installation of solar assisted air-conditioning at the FESTO technology center in Esslingen, Germany, with 1218 m² evacuated tube collectors and 3 adsorption chillers (Mayekawa ADR-100). Photos: FESTO


Fig. 6:
Installation of solar assisted air-conditioning at EURAC research building in Bolzano, Italy, with 615 m² vacuum tube collectors and 300 kW absorption chiller (THERMAX - THW LT 14). Photos: EURAC

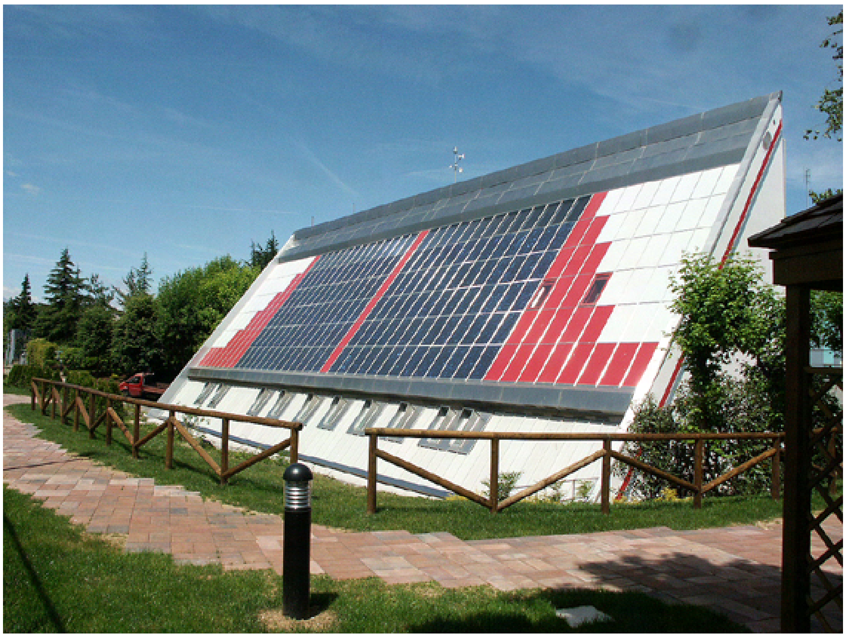
a)

b)



c)

Fig. 8:
Installation of solar assisted air-handling unit at the building of the Renewable Energy Department of INETI in Lisbon, Portugal. The driving heat for the system operation is provided by a combination of a heat pump and 24 CPC type solar collectors (44 m^2 aperture). The DEC-system has a maximum capacity of 5.000 m^3/h and provides conditioned air to 12 office rooms. Photos: INETI



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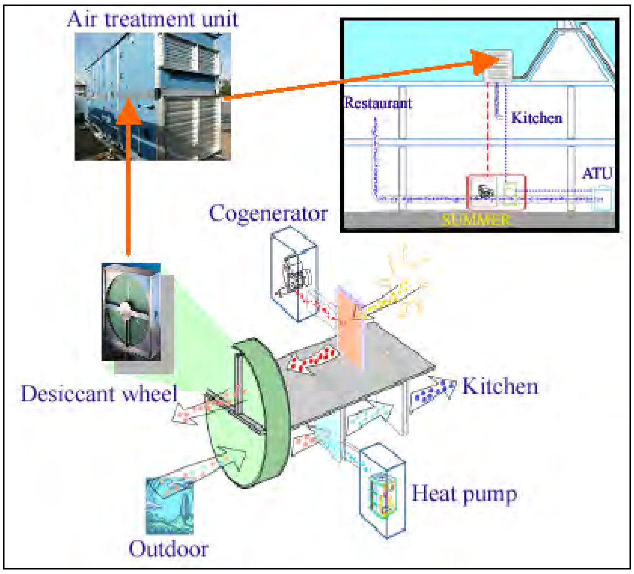

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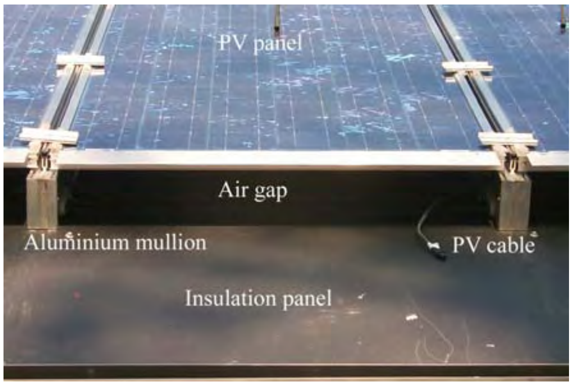

c)

Fig. 9:

Installation of a Hybrid Photovoltaic/Thermal Solar Desiccant Cooling Plant at the Fiat Research Centre in Turin, Italy. The system consists of a combination of 163 m^2 Hybrid Photovoltaic-Thermal Collectors with 32 m^2 solar thermal collectors (booster function) providing the driving heat for the DEC-system with a nominal air-volume flow capacity of 15.000 m^3/h. Beside the air-conditioning function the PV-system with a nominal capacity of 19.5 kWp has a yearly yield of about 100 MWh. Photos: POLIMI-BEST

Fig. 10:

Solar air-conditioning installation at Technology University Institute, Saint Pierre (La Réunion island), France. The installation cools classrooms (total: 180 m²) and is constituted of 90 m² double glazed SCHUCO collectors, 30 kW SCHUCO LiBr absorption chiller and a wet cooling tower. Specificity: tropical climate, no back-up. Photo: TECSOL / LPBS

Subtask C:
Modelling and fundamental analysis

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The main objectives of Subtask C are:

- Further development and examination of new and already existing component models and simulation tools with special regards to their applicability to different stages of the layout process
- Evaluation of novel and advanced solar cooling concepts which are still in a state of R&D and not yet ready for installation and market introduction.

The work in Subtask C comprises the following fields of activity:

- One result will be the survey on new solar cooling developments, comprising all relevant technologies:
  - Closed liquid sorption cycles
  - Closed solid sorption cycles
  - Liquid desiccant technology
  - Solid desiccant technology
  - Steam jet technology
- Different work has been done concerning modelling solid DEC as well as liquid DEC technologies using different software tools. The final report will also contain comparative simulation results with available experimental data.
- Another important area is the exergy analysis of solar cooling and also the evaluation of the performance of installed systems. Appropriate performance criteria has been elaborated and allow a comparative assessment.
- Because the question of heat rejection is of high interest for proper operation results of solar cooling systems a working group is occupied by this topic.

Subtask D:
Market transfer activities

Subtask Leader:

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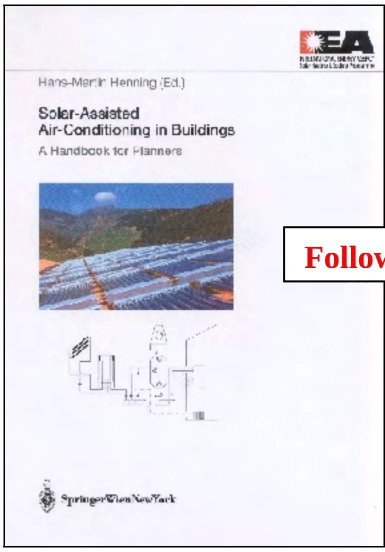
The main objectives of Subtask D are:

- To identify promising markets for solar air-conditioning and refrigeration technology and
- To ensure that the findings of the Task work are transferred to the important target audiences.

One of the major results with input from work of the entire Task will be a 2nd edition of the Handbook for Solar Cooling for Planners.



Follow up version

- Beside a report on life cycle analysis of conventional and solar driven cooling systems also a report on overall performance and cost assessment methodology will be elaborated. This work is basing on the results of Subtask A and B.
- Dissemination activities in Subtask D are the provision of training materials for installers and planners of solar cooling systems and the organisation of national industry workshops, where the results of the Task 38 will be presented.

List of small systems to be monitored in Subtask A

Systems in operation

Country	City	Name of installation / project	Nominal cooling power	Type of cooling / chiller
Austria	Sattledt	Office building; Headquarter of SOLution	15 kW	Absorption - H_2O/LiBr; EAW WEGRACAL SE15
Austria	Vienna	Municipal building MA 34	7.5 kW	Adsorption – H20/LiBr; Sortech ACS08
France	Maclas	Résidence du Lac / SIEL	10 kW	Absorption - H_2O/LiBr; Suninverse Sonnenklima
France	Perpignan	SOLACLIM	7.5 kW	Adsorption – H20/LiBr; Sortech ACS08
Germany	Berlin	Radiological Practice	10 kW	Absorption – H20/LiBr; Sonnenklima
Germany	Freiburg	Canteen; Fraunhofer Institute FhG-ISE	5.5 kW	Adsorption - Silacagel/Water; SorTech (prototype)
Germany	Garching	ZAE Bayern	10 kW	Absorption - H_2O/LiBr; Sonnenklima
Germany	Moosburg	Office building; Headquarter of CitrinSolar	5.5 kW	Adsorption - H_2O/Silicagel; chillii® STC6
Germany	Rimsting	Office building; Company SolarNext	15 kW	Absorption - H_2O/LiBr; chillii® ESC15
Italy	Milan	ISSA	4.5 kW	Absorption - H_2O/LiBr; Rotartica Solar v45
Italy	Milan	Kindergarten Politecnico di Milano	7.5 kW	Adsorption – H20/LiBr; Sortech ACS08

List of small systems to be monitored in Subtask A

Start of monitoring planned for 2009

Country	City	Name of installation / project	Nominal cooling power	Type of cooling / chiller
Austria	Graz	Office building; Company SOLID	17.5 kW	Absorption – H_2O/LiBr; Yazaki WFC-SC5
Austria	Gröbming	Training centre and office building Bachler	10 kW	Absorption - NH_3/H_20; chillii® PSC10
Denmark		AC-Sun ApS	10 kW	Ideal Rankin / Carnot cycle with overheating; AC-Sun
Germany	Miesbach	Raiffeisenbank Miesbach	2x 10 kW	Absorption - NH_3/H_20; chillii® PSC10
Germany	Stuttgart	ITW, University Stuttgart	10 kW	Absorption - NH_3/H_20; Prototype
Malta	Kordin	Headquarter of Eco Group	10 kW	Absorption - NH_3/H_20; chillii® PSC10
Malta	Kalkhara	Retirement home	10 kW	Absorption - NH_3/H_20; chillii® PSC10
Portugal	Lisbon	AoSol	8 kW	Absorption – NH_3/H_2O; AoSol

List of large systems to be monitored in Subtask B

Country	City	Name of installation / project	Nominal cooling power (volume flow for open cycle systems)	Type of cooling / chiller
Australia	Ipswich	Ipswich Hospital	300 kW	Absorption – BROAD BZH 25 (double effect)
Austria	Rohrbach	BH Rohrbach	30 kW	Absorption – EAW
Austria	Gleisdorf	Town hall	6250 m³/h 35 kW	DEC system Absorption – Yazaki WFC 10
Belgium	Brussels	Renewable Energy House	35 kW	Absorption – Yazaki WFC 10
Denmark	Skive	Municipal administration building of Skive	70 kW	Absorption
France	La Réunion Island	RAFSOL	30 kW	LiBr - Absorption chiller – SCHÜCO
Germany	Ingolstadt	AUDI logistic center	8000 m³/h	DEC system
Germany	Esslingen	FESTO technology center	1.05 MW	Adsorption – 3x MAYEKAWA ADR-100
Italy	Bolzano	EURAC	300 kW	Absorption – THERMAX – THW LT 14
Italy	Turin	ECOMENSA, Fiat Research Center	15.000 m³/h	Adsorption – DEC system
Italy	Palermo	DREAM	1250 m³/h	DEC system
Portugal	Lisbon	Renewable Energy Department INETI	5.000 m³/h	DEC system
Spain	Valladolid	CARTIF, Boecillo Technology Park	35 kw	Absorption – Yazaki WFC 10
Spain	Barcelona	PERACAMPS	35 kW	Absorption – Yazaki WFC 10

General Task 38 related publications:

Sparber, W., Napolitano, A. and Schmitt, Y.: Solares Kühlen & Heizen - aktueller Stand installierter Systeme großer Leistung und ein Ausblick auf neue Gebäude. Energy Forum - Solararchitektur & Solares Bauen. Brixen (I): December 2007.

Sparber, W., Napolitano, A.: Solar cooling, il condizionamento alternativo e pulito. Indagine sugli impianti di raffrescamento solare installati in Europa, in Ilsoleatrecentosessantagradi / Ilsolea360gradi, Newsletter mensile di ISES, Anno XV – n°8 settembre 2008

Sparber, W., Napolitano, A. and Melograno, P.: Overview in world wide installed solar cooling systems. 2nd International Conference Solar Air Conditioning, Tarragona – Spain, October 2007

Presentations at the EUROSUN 2008:

(Published in the proceedings of the EUROSUN 2008, the 1st International Conference on Solar Heating, Cooling and Buildings, Lisbon, Portugal, October 7 to 10)

Aprile, M., Ayadi, O. and Motta, M.: The application of a novel solar refrigeration concept in the Tunisian food and agro-industry: Simulations and first experimental results.

Ayadi, O. Doell, J.Aprile, M. Motta, M. and Núñez, T.: Solar energy cools milk.

Beccali, M., Finocchiaro, P., Luna, M. and Nocke, B.: Monitoring of a solar desiccant cooling system in Palermo, (Italy). First results and test planning.

Besana, F., Franchini, G., Perdichizzi, A., Rodriguez, J., Sparber, W. and Witte, K.: Heat rejection as a control strategy for Solar Combi^{+} systems.

Bongs, C., Morgenstern, A. and Henning, H.-M.: Modelling and first experimental characterization of a sorptive heat exchanger prototype for application in a novel desiccant evaporative cooling cycle.

Bourdoukan, P., Wurtz, E., Joubert, P. and Spérandio M.: A sensitivity analysis of a desiccant wheel.

Jakob, U. and Saulich, S.: Development and Investigation of solar cooling systems based on small-scale sorption heat pumps.

Jones, B. M. and Harrison, S. J.: First results of a solar-thermal liquid desiccant air conditioning concept.

Koller, T., Zetzsche, M., Brendel, T. and Müller-Steinhagen, H.: Operation of a small scale ice store.

Kühn, A., Corrales Ciganda, J. L. and Ziegler, F.: Comparison of control strategies of solar absorption chillers.

Marletta, L., Evola, G. and Sicurella, F.: Energy and exergy analysis of advanced cycles for solar cooling.

Mehling, H., Hiebler, S., Schweigler, C., Keil, C. and Helm, M.: Test results from a latent heat storage developed for a solar heating and cooling system.

Minds, S. and Ellehauge, K.: The AC-Sun, a new concept for air conditioning.

Mugnier, D. and Le Denn, A.: Fast pre-design method for the selection and the pre-design of solar cooling systems in buildings.

Napolitano, A.: Coupling solar collectors and co-generation units in solar assisted heating and cooling systems.

Núñez, T., Nienborg, B. and Tiedtke, Y.: Heating and cooling with a small scale solar driven adsorption chiller combined with a borehole system.

Pietruschka, D., Jakob, U., Hanby, V. and Eicker, U.: Simulation Based Optimisation of a Newly Developed System Controller for Solar Cooling and Heating Systems

Sparber, W., Thuer, A., Besana, F., Streicher, W. and Henning, H.-M.: Unified monitoring procedure and performance assessment for solar assisted heating and cooling systems

Wiemken, E.: Solar cooling in the German funding program SOLARTHERMIE 2000plus.

Witte, K. T., Albers, J., Krause, M., Safarik, M., Besana, F. and Sparber, W.: Absorption chiller modelling with TRNSYS - requirements and adaptation to the machine EAW Wegracal SE 15.

Zetzsche, M., Koller, T. and Müller-Steinhagen, H.: Solar cooling with an ammonia/water absorption chiller

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