Task 38
Solar Air-Conditioning and Refrigeration
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.

<table>
<thead>
<tr>
<th>Subtask A</th>
<th>Subtask B</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pre-engineered systems for</td>
<td>Custom-made systems for</td>
</tr>
<tr>
<td>residential and small</td>
<td>large non-residential buildings</td>
</tr>
<tr>
<td>commercial applications</td>
<td>and industrial applications</td>
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<tr>
<td>Subtask C</td>
<td></td>
</tr>
<tr>
<td>Modeling and fundamental</td>
<td></td>
</tr>
<tr>
<td>analysis</td>
<td></td>
</tr>
<tr>
<td>Subtask D</td>
<td></td>
</tr>
<tr>
<td>Market transfer activities</td>
<td></td>
</tr>
</tbody>
</table>
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 consists 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
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 m² aperture). The DEC-system has a maximum capacity of 5,000 m³/h and provides conditioned air to 12 office rooms. Photos: INETI
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 m² Hybrid Photovoltaic-Thermal Collectors with 32 m² solar thermal collectors (booster function) providing the driving heat for the DEC-system with a nominal air-volume flow capacity of 15.000 m³/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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Politecnico di Milano, Dip. Energetica, Piazza Leonardo da Vinci 32, 20133, Milano ITALY
email: mario.motta@polimi.it

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.

- 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

<table>
<thead>
<tr>
<th>Country</th>
<th>City</th>
<th>Name of installation/project</th>
<th>Nominal cooling power</th>
<th>Type of cooling/chiller</th>
</tr>
</thead>
<tbody>
<tr>
<td>Austria</td>
<td>Sattledt</td>
<td>Office building; Headquarter of SOLution</td>
<td>15 kW</td>
<td>Absorption - H2O/LiBr; EAW WEGRACAL SE15</td>
</tr>
<tr>
<td>Austria</td>
<td>Vienna</td>
<td>Municipal building MA 34</td>
<td>7.5 kW</td>
<td>Adsorption – H2O/LiBr; Sortech ACS08</td>
</tr>
<tr>
<td>France</td>
<td>Maclas</td>
<td>Résidence du Lac / SIEL</td>
<td>10 kW</td>
<td>Absorption - H2O/LiBr; Suninverse Sonnenklima</td>
</tr>
<tr>
<td>France</td>
<td>Perpignan</td>
<td>SOLACLIM</td>
<td>7.5 kW</td>
<td>Adsorption – H2O/LiBr; Sortech ACS08</td>
</tr>
<tr>
<td>Germany</td>
<td>Berlin</td>
<td>Radiological Practice</td>
<td>10 kW</td>
<td>Absorption – H2O/LiBr; Sonnenklima</td>
</tr>
<tr>
<td>Germany</td>
<td>Freiburg</td>
<td>Canteen; Fraunhofer Institute FhG-ISE</td>
<td>5.5 kW</td>
<td>Adsorption - Silicagel/Water; SorTech (prototype)</td>
</tr>
<tr>
<td>Germany</td>
<td>Garching</td>
<td>ZAE Bayern</td>
<td>10 kW</td>
<td>Absorption - H2O/LiBr; Sonnenklima</td>
</tr>
<tr>
<td>Germany</td>
<td>Moosburg</td>
<td>Office building; Headquarter of CitrinSolar</td>
<td>5.5 kW</td>
<td>Adsorption - H2O/Silicagel; chillii® STC6</td>
</tr>
<tr>
<td>Germany</td>
<td>Rimsting</td>
<td>Office building; Company SolarNext</td>
<td>15 kW</td>
<td>Absorption - H2O/LiBr; chillii® ESC15</td>
</tr>
<tr>
<td>Italy</td>
<td>Milan</td>
<td>ISSA</td>
<td>4.5 kW</td>
<td>Adsorption - H2O/LiBr; Rotartica Solar v45</td>
</tr>
<tr>
<td>Italy</td>
<td>Milan</td>
<td>Kindergarten Politecnico di Milano</td>
<td>7.5 kW</td>
<td>Adsorption – H2O/LiBr; Sortech ACS08</td>
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List of small systems to be monitored in Subtask A

Start of monitoring planned for 2009

<table>
<thead>
<tr>
<th>Country</th>
<th>City</th>
<th>Name of installation/project</th>
<th>Nominal cooling power</th>
<th>Type of cooling/chiller</th>
</tr>
</thead>
<tbody>
<tr>
<td>Austria</td>
<td>Graz</td>
<td>Office building; Company SOLID</td>
<td>17.5 kW</td>
<td>Absorption – H2O/LiBr; Yazaki WFC-SC5</td>
</tr>
<tr>
<td>Austria</td>
<td>Gröbming</td>
<td>Training centre and office building Bachler</td>
<td>10 kW</td>
<td>Absorption - NH3/H20; chillii® PSC10</td>
</tr>
<tr>
<td>Denmark</td>
<td></td>
<td>AC-Sun ApS</td>
<td>10 kW</td>
<td>Ideal Rankin / Carnot cycle with overheating; AC-Sun</td>
</tr>
<tr>
<td>Germany</td>
<td>Miesbach</td>
<td>Raiffeisenbank Miesbach</td>
<td>2x 10 kW</td>
<td>Absorption - NH3/H20; chillii® PSC10</td>
</tr>
<tr>
<td>Germany</td>
<td>Stuttgart</td>
<td>ITW, University Stuttgart</td>
<td>10 kW</td>
<td>Absorption - NH3/H20; Prototype</td>
</tr>
<tr>
<td>Malta</td>
<td>Kordin</td>
<td>Headquarter of Eco Group</td>
<td>10 kW</td>
<td>Absorption - NH3/H20; chillii® PSC10</td>
</tr>
<tr>
<td>Malta</td>
<td>Kalkhara</td>
<td>Retirement home</td>
<td>10 kW</td>
<td>Absorption – NH3/H20; chillii® PSC10</td>
</tr>
<tr>
<td>Portugal</td>
<td>Lisbon</td>
<td>AoSol</td>
<td>8 kW</td>
<td>Absorption – NH3/H20; AoSol</td>
</tr>
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## List of large systems to be monitored in Subtask B

<table>
<thead>
<tr>
<th>Country</th>
<th>City</th>
<th>Name of installation/project</th>
<th>Nominal cooling power (volume flow for open cycle systems)</th>
<th>Type of cooling/chiller</th>
</tr>
</thead>
<tbody>
<tr>
<td>Australia</td>
<td>Ipswich</td>
<td>Ipswich Hospital</td>
<td>300 kW</td>
<td>Absorption – BROAD BZH 25 (double effect)</td>
</tr>
<tr>
<td>Austria</td>
<td>Rohrbach</td>
<td>BH Rohrbach</td>
<td>30 kW</td>
<td>Absorption – EAW</td>
</tr>
<tr>
<td>Austria</td>
<td>Gleisdorf</td>
<td>Town hall</td>
<td>6250 m³/h 35 kW</td>
<td>DEC system Absorption – Yazaki WFC 10</td>
</tr>
<tr>
<td>Belgium</td>
<td>Brussels</td>
<td>Renewable Energy House</td>
<td>35 kW</td>
<td>Absorption – Yazaki WFC 10</td>
</tr>
<tr>
<td>Denmark</td>
<td>Skive</td>
<td>Municipal administration building of Skive</td>
<td>70 kW</td>
<td>Absorption</td>
</tr>
<tr>
<td>France</td>
<td>La Réunion Island</td>
<td>RAFSOL</td>
<td>30 kW</td>
<td>LiBr - Absorption chiller – SCHÜCO</td>
</tr>
<tr>
<td>Germany</td>
<td>Ingolstadt</td>
<td>AUDI logistic center</td>
<td>8000 m³/h</td>
<td>DEC system</td>
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<tr>
<td>Germany</td>
<td>Esslingen</td>
<td>FESTO technology center</td>
<td>1.05 MW</td>
<td>Adsorption – 3x MAYE-KAWA ADR-100</td>
</tr>
<tr>
<td>Italy</td>
<td>Bolzano</td>
<td>EURAC</td>
<td>300 kW</td>
<td>Absorption – THERMAX – THW LT 14</td>
</tr>
<tr>
<td>Italy</td>
<td>Turin</td>
<td>ECOMENSA, Fiat Research Center</td>
<td>15.000 m³/h</td>
<td>Adsorption – DEC system</td>
</tr>
<tr>
<td>Italy</td>
<td>Palermo</td>
<td>DREAM</td>
<td>1250 m³/h</td>
<td>DEC system</td>
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<tr>
<td>Portugal</td>
<td>Lisbon</td>
<td>Renewable Energy Department INETI</td>
<td>5.000 m³/h</td>
<td>DEC system</td>
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<tr>
<td>Spain</td>
<td>Valladolid</td>
<td>CARTIF, Boecillo Technology Park</td>
<td>35 kw</td>
<td>Absorption – Yazaki WFC 10</td>
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<tr>
<td>Spain</td>
<td>Barcelona</td>
<td>PERACAMPS</td>
<td>35 kW</td>
<td>Absorption – Yazaki WFC 10</td>
</tr>
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</table>
General Task 38 related publications:


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)


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.

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.


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


## Task 38 - Participants

<table>
<thead>
<tr>
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<th>arsenal research</th>
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<tr>
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</thead>
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<th>CSIRO Division of Energy Technology</th>
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19009, Pikermi Attiki  
GREECE  
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<tr>
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<th>DER/INETI - Instituto Nacional de Engenharia, Tecnologia e Inovacao</th>
<th>EDF R&amp;D - Département Enerbat Centre des Renardières</th>
</tr>
</thead>
</table>
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PORTUGAL  
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77818 Moret-sur-Loing  
FRANCE  
www.edf.fr |
<table>
<thead>
<tr>
<th>Organization</th>
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<tbody>
<tr>
<td>Ellenhauge &amp; Kildemoes</td>
<td>Vesteregade 48H, 2.tv. 8000 Århus C DENMARK</td>
<td><a href="http://www.elle-kilde.dk">www.elle-kilde.dk</a></td>
</tr>
<tr>
<td>EURAC research</td>
<td>Viale Druso/Drususallee 1 39100 Bolzano/Bozen ITALY</td>
<td><a href="http://www.eurac.edu">www.eurac.edu</a></td>
</tr>
<tr>
<td>Fraunhofer-Institute for Environmental, Safety and Energy Technology UMSICHT</td>
<td>Osterfelder Str. 3 46047 Oberhausen GERMANY</td>
<td><a href="http://www.umsicht.fraunhofer.de">www.umsicht.fraunhofer.de</a></td>
</tr>
<tr>
<td>Fundación CARTIF</td>
<td>Energy Division, Renewable Energies Area</td>
<td><a href="http://www.cartif.es">www.cartif.es</a></td>
</tr>
<tr>
<td>HeIG-VD - School of Business and Engineering, Laboratory of Solar Energetic and Building Physics (LESBAT), Route de Cheseaux 1 CH - 1400 Yverdon-les-Bains SWITZERLAND</td>
<td><a href="http://www.heig-vg.ch">www.heig-vg.ch</a></td>
<td></td>
</tr>
<tr>
<td>IKERLAN - Centro de investigación tecnológicas</td>
<td>Parque Tecnológico de Álava Juan de la Cierva 1 01510 Miñao SPAIN</td>
<td><a href="http://www.ikerlan.es">www.ikerlan.es</a></td>
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<td>Institut für Luft- und Kältetechnik Gemeinnützige Gesellschaft mbH</td>
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<td><a href="http://www.ilkdresden.de">www.ilkdresden.de</a></td>
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<td>Joanneum Research</td>
<td>Institut für Energieforschung IEF Elisabethstraße 5/l A-8010 Graz AUSTRIA</td>
<td><a href="http://www.joanneum.at">www.joanneum.at</a></td>
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<td>Institut für Solartechnik SPF</td>
<td>Hochschule für Technik Rapperswil HSR</td>
<td><a href="http://www.solarenergy.ch">www.solarenergy.ch</a></td>
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