

# **HANDOUT (1) session 1.2**

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# Examples of implemented installations (1)

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## „Absorption“:

- Germany, Wolfferts, Köln, office area, 70kW, collector ETC 176m<sup>2</sup>
- Germany, Ott & Spies, Langenau, office area, 35 kW, collector ETC 22m<sup>2</sup>
- Germany, Bundespresseamt Berlin, office area, 70 kW, collector ETC 244m<sup>2</sup>
- Germany, Fraunhofer-Institut, Umsicht / Oberhausen, office and lab, 58 kW, collector ETC 108m<sup>2</sup>
- Germany, Bundesverkehrsministerium Berlin, cooling net, 70 kW, collector FPC 209m<sup>2</sup>
- Germany, ZAE Bayern, Garching, office and lab, 7 kW, collector ETC 20m<sup>2</sup>
- Germany, M+W Zander, Stuttgart, office area, 143 kW, collector ETC 260m<sup>2</sup>
- Germany, Technologiezentrum Köthen, office area, 15 kW, collector ETC 79m<sup>2</sup>
- Greece, American College, Athens, School, 168 kW, collectors ETC 615 m<sup>2</sup>
- Greece, Solar Lab Demokritos, Athens, office and lab, 35 kW, collector FPC 160m<sup>2</sup>
- Greece, Rethymno Village Hotel, Rethymno, 105 kW, collector FPC 450 m<sup>2</sup>
- Greece, Lentzakis Crete, Rethymno, Hotel, 105kW, collector FPC 450 m<sup>2</sup>
- Spain, Social and Cultural Centre Clara Campoamor, Barakaldo, Auditorium and exhibition area, 292 kW, collector FPC 150m<sup>2</sup>
- Spain, Education Department Reg. Government, Toledo, office area, 252 kW, collector ETC 750 m<sup>2</sup>
- Spain, Fabrica de Sol Building, Barcelona, office area, 105 kW, collector ETC 120 m<sup>2</sup>
- Spain, Fondation Metropoli Building, Madrid, office area, 105 kW, collector ETC 72m<sup>2</sup>
- Spain, Daoiz y Velarde Sports Centre, Madrid, 170 kW, collector ETC 507 m<sup>2</sup>
- Spain, Head Offices of Inditex, Aretixo / La Coruna, office area, 170 kW, collector FPC 1500 m<sup>2</sup>
- Spain, Old People´s Home, Fustinana/Navarra, 105 kW, collector ETC 102 m<sup>2</sup>

## Examples of implemented installations (2)

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### „Absorption“: (cont'd)

- Spain, University Rovira I Virgili, Tarragona, office area, 35 kW, collector ETC 96 m<sup>2</sup>
- Spain, Head Offices of Viessman Spain, Pinto, Madrid, office area, 105 kW, collector ETC 6 m<sup>2</sup>
- Spain, Belroy Palace Hotel, Benidorm Alicante, 125 kW, collector ETC 345 m<sup>2</sup>
- Spain, University of Sevilla, Laboratory, 35 kW, collector FPC 151 m<sup>2</sup>
- Spain, University Carlos III, Leganes Madrid, Laboratory, 35 kW, collector FPC 50 m<sup>2</sup> and ETC 50 m<sup>2</sup>
- Spain, Laia Hotel, Derio, 105 kW, collector FPC 160 m<sup>2</sup>
- Spain, Cartif, Boecillo Technology Park, Valladolid, office and lab, 35 kW, collector FPC 37m<sup>2</sup> and ETC 40 m<sup>2</sup>
- Spain, Siemens Contromatic, Cornellia del Valles, office area, 105 kW, collector CPC 214m<sup>2</sup>
- Spain, National Institute of Aerospecial Techniques INTA, Huelva, Laboratory, 10 kW, collector FPC 25m<sup>2</sup> and ETC 18m<sup>2</sup>
- Spain, Fontedoso, El Oso, industry bldg, 105 kW, collector FPC 504 m<sup>2</sup>
- Spain, Stella Feuga Bldg, Santiago de Compostella, office area, 115 kW, collector FPC 60 m<sup>2</sup>
- Portugal, Traffic control unit, office area and control unit, 70 kW, collector CPC 663 m<sup>2</sup>
- Italy, Baxter, Trento, office and exhibition area, 108 kW, collector FPC 108 m<sup>2</sup>
- Austria, Winery Peitler, Styria, wine store, 10 kW, collector FPC 100m<sup>2</sup>
- France, CSTB- Building, Sophia Antipolis, Laboratory, 35 kW, collector ETC 63 m<sup>2</sup>
- France, DIREN- Building, Guadeloupe, office area, 35 kW, collector ETC 61 m<sup>2</sup>
- France, Wine basement, Banuyls, wine store, 52 kW, collector ETC 130 m<sup>2</sup>

## Examples of implemented installations (3)

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### „Adsorption“:

- Germany, University Hospital in Freiburg. GBU NAK 70, chilling capacity 70 kW, heat, vacuum tube collectors 170m<sup>2</sup>, storage tanks
- India, Storage of Agricultural Products in Haipur, CPC collectors 25m<sup>2</sup>, methanol/silica gel
- Germany, Hospital in Kamenz, Dresden. Mycom ADR 30, chilling capacity 105 kW, collector 115m<sup>2</sup>, water/silica gel
- Germany, Office Building Remscheid. Mycom ADR 30, chilling capacity 105 kW, collector 150m<sup>2</sup>, water/silica gel
- Germany, Office “An der Loge” Dresden. Nyshido NAK 70, chilling capacity 70 kW, flat plate collectors 156m<sup>2</sup>
- Germany, Office Building Bremen. Mycom ADR 15, chilling capacity 50 kW, collectors 120m<sup>2</sup>, water/silica gel
- Germany, University Dortmund. Mycom ADR 30, chilling capacity 105 kW, water/silicagel
- Germany, Office Building Augsburg. Nyshido NAK100, chilling capacity 350 kW, flat plate collectors 2000m<sup>2</sup>, water/silica gel
- Germany, Office Building Würzburg. Nyshido NAK 70, chilling capacity 70 kW, flat plate collectors 60 m<sup>2</sup>, water/silica gel
- Mexico, Cuernavaca. Mycom ADR 50, chilling capacity 176kW, water/silica gel
- Greece, Sarantis cosmetic Factory, Ahames

## Examples of implemented installations (4)

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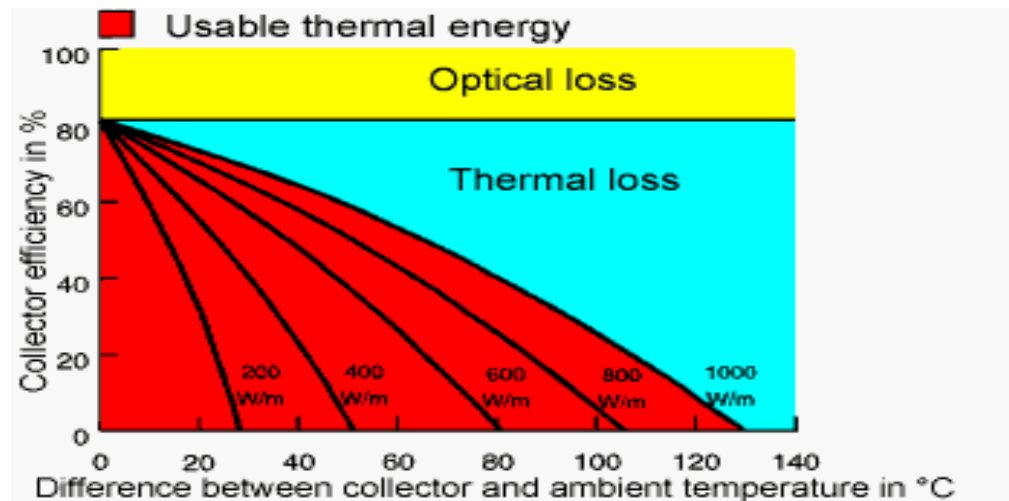
### „Dessicant Cooling“:

- Germany, Chamber of Trade and Commerce, Freiburg. Solar air collectors, energy consumption 18,162 kWh
- Austria, Office Building “Ökopark Hartberg”, cooling capacity 30 kW, Air flow 6000m<sup>3</sup>/h
- Spain, Public Library, Mataro. Energy consumption 70000kWh, Air flow 12000m<sup>3</sup>/h

# Information (1)

## How much energy does a solar collector provide?

The efficiency of a solar collector is defined as the quotient of usable thermal energy versus received solar energy. Besides thermal loss there always is optical loss as well. The conversion factor or optical efficiency  $\eta_0$  indicates the percentage of the solar rays penetrating the transparent cover of the collector (transmission) and the percentage being absorbed. Basically, it is the product of the rate of transmission of the cover and the absorption rate of the absorber.



Efficiency graph of solar collector performance

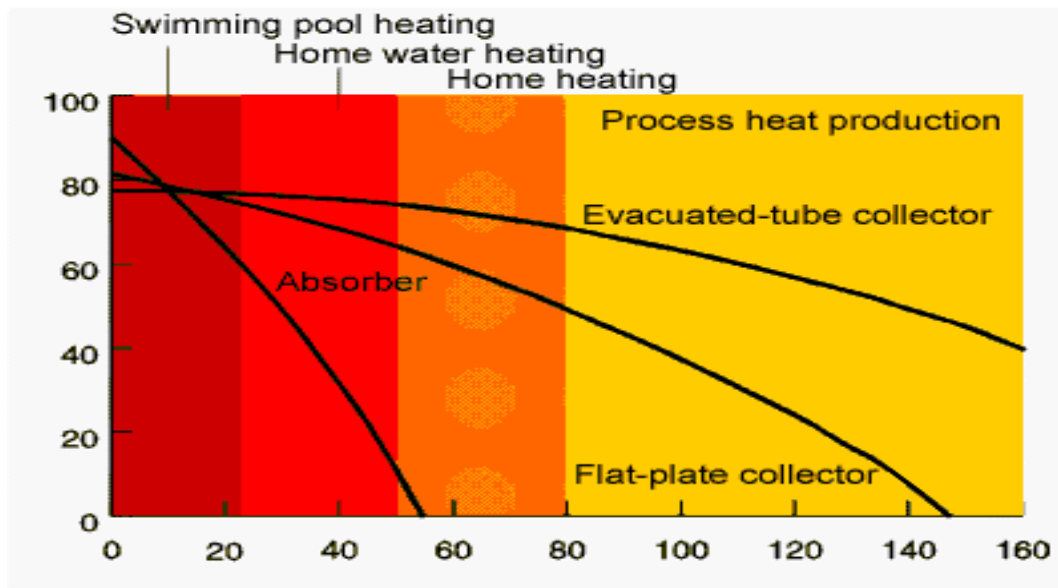
The heat loss is indicated by the thermal loss factor or k-value. This is given in watt per m<sup>2</sup> collector surface and the particular temperature difference (in °C) between the absorber and its surroundings. The higher the temperature difference, the more heat is lost. Above a specific temperature difference, the amount of heat loss equals the energy yield of the collector, so that no energy at all is delivered to the solar circulation system.

A good collector will have a high conversion factor and a low k-value.

## Information (2)

### Which collector is suitable for which situation?

The desired temperature range of the material to be heated is the most important factor in choosing the correct type of collector. An uncovered absorber is certainly not suitable for producing process heat. The amount of radiation on that spot, exposure to storms, and the amount of space must all be carefully considered when planning a solar array.



Graph of efficiency and temperature ranges of various types of collectors (radiation: 1000 W/m<sup>2</sup>)

The specific costs of collectors are also important. Evacuated-tube collectors are substantially more expensive (at 511,29 - 1278,23 Euro /m<sup>2</sup> collector surface) than flat-plate collectors (153,34 to 613,55 Euro /m<sup>2</sup>) or even plastic absorbers (25,60 to 102,26 Euro /m<sup>2</sup>). However, a good collector does not guarantee a good solar system. Rather, all components should be of high quality and similar capacity and strength.

# Market Situation / Manufacturers (1)

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## Absorption chillers:

Most single effect absorption chillers available on the market have a cooling capacity of more than 100 kW. Only few products are on the market with a smaller cooling power.

Companies offering absorption chillers are predominantly from the USA and Asia (Japan, Korea, China, India). Among small absorption chillers the system WFC 10 by Yazaki (35 kW) has the largest market share.

Moreover, small single effect LiBr systems are supplied by the companies Broad Air (20kW), Robur Corporation (17kW - 88kW) and by EAW (Westenfeld, 15KW).

Additionally, absorption chillers with a fairly low cooling power are being developed by small companies, for example Phönix (Germany) and SolarFrost (Austria), as well as by a number 9 of research institutes: University of Applied Science Stuttgart (Germany), Joanneum Research (Austria), INETI (Portugal), UPC (Spain), etc.

## Adsorption chillers:

There are only two manufacturers of this kind of adsorption chillers worldwide. Both are Japanese manufacturers. Table A lists the performance characteristics from two commercially available adsorption chillers.

## Desiccant Cooling:

There are more than 9 manufactures of desiccant wheels worldwide. Table B shows a list of desiccant wheel manufacturers provided by the handbook of IEA SHC Task 25 [Henning, H.M. (2004a)].

It is important to mention that desiccant wheels are not an independent market product but are purchased by manufacturers of air-handling units. Prices for desiccant wheels differ strongly on the size of the air-handling unit, on the applied materials and on the manufactures itself.

## Market Situation / Manufacturers (2)

Manufacturer	Cooling power	Driving temperature [°C]	Design conditions and rated COP	
Mycom	70 kW water/silica gel	60-90	T <sub>air</sub>	80 °C
			T <sub>cooling water</sub>	30 °C
			T <sub>chilled water</sub>	9 °C
			COP	0.61 °C
Table A Nishiyodo	105 kW water/silica gel	55-95	T <sub>air</sub>	80 °C
			T <sub>cooling water</sub>	28 °C
			T <sub>chilled water</sub>	8 °C
			COP	0.61 °C

Company	Country of origin	Desiccant	Wheel Size
Munters USA	USA	SiGel, AlTi, Silicates, New Proprietary	0.25 – 4.5 m
Munters AB	Sweden	SiGel, AlTi, Silicates, New Proprietary	0.25 – 4.5 m
Seibu Giken	Japan	SiGel, Am, Silicates, New Proprietary	0.10 – 6.0 m
Nichias	Japan	SiGel, Mol, Sieves	0.10 – 4.0 m
DRI	India	SiGel, Mol, Sieves	0.30 – 4.0 m
Klingenburg	Germany	Al oxide, LiCl	0.60 – 5.0 m
Table B PorFlute	Sweden	SiGel, Mol, Sieves	0.50 – 3.0 m
Rotor Source	US	SiGel, Mol, Sieves	0.50 – 3.0 m
NovelAire	US	SiGel, Mol, Sieves	0.50 – 3.0 m

# Costs

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A cost analysis was carried out in IEA SHC Task 25 [Henning, H.M. (2004a)] and the results are listed in the following:

- **The annual cost of all the solar configurations is higher than that of the conventional reference system. The difference between the annual cost of the solar and conventional system is lower if an absorption chiller is used rather than an adsorption chiller; this is mainly due to the high initial costs of adsorption chillers. The lowest value in annual cost among the solar variants studied is found for absorption chiller with stationary CPC collector and thermal back-up (the best-case system).**
- **The collector area has to be significantly larger if flat-plate collectors are applied; the increase is 50-90% compared to a stationary CPC collector depending on the system considered.**
- **The primary energy savings are higher for the configurations with adsorption chillers. The reason is that these machines operate with lower driving temperatures, thus increasing the useful collector output.**
- **The lowest cost of saved primary energy is also achieved with the base-case configuration. This cost is about 0.10 €/per kWh.**
- **The system design leading to the lowest cost for saved primary energy is quite different for systems using a thermal back-up and for those using a back-up on the cold production side. In general, the use of conventional, electrically driven chiller as the back-up leads to smaller collector areas and storage volumes than the use of a back-up heat source, if the minimum of cost of saved primary energy is taken as target function.**

# Solar Cooling Related Web-Sites (1)

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[www.iea-shc.org](http://www.iea-shc.org)

international energy agency, solar heating and cooling

[www.iea-shc-task25.org](http://www.iea-shc-task25.org)

Task to improve conditions for the market entry of solar assisted cooling systems

[www.ocp.tudelft.nl/ev/res/sace.htm](http://www.ocp.tudelft.nl/ev/res/sace.htm)

education and research –solar air conditioning in Europe-

[www.raee.org/climasol](http://www.raee.org/climasol)

agency for energy and environment

[www.tecsol.fr/rafrsol/index.html](http://www.tecsol.fr/rafrsol/index.html)

consultant in renewable energy applications

[www.energiesparverband.at](http://www.energiesparverband.at)

energy agency to promote new energy technologies

[www.iwt.tugraz.at](http://www.iwt.tugraz.at)

education and research

[www.ise.fhg.de](http://www.ise.fhg.de)

consulting, design, simulation and projects

[www.ise.fhg.de/english/fields/field1/mb3/index.html](http://www.ise.fhg.de/english/fields/field1/mb3/index.html)

## Solar Cooling Related Web-Sites (2)

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[www.air.com/solar\\_cooling.htm](http://www.air.com/solar_cooling.htm)

liquid desiccant air conditioner

[www.eva.ac.at](http://www.eva.ac.at)

non profit energy research and policy institution

[www.joanneum.at](http://www.joanneum.at)

non-university research institutions, desiccant cooling

[www.solid.at/html/d-solar\\_cooling.htm](http://www.solid.at/html/d-solar_cooling.htm)

planning, delivery, installation and service, absorption cooling

[www.solel.com/products](http://www.solel.com/products)

solar thermal technology , parabolic trough

[www.schott.com/solarthermal/english/applications/solar\\_cooling.html](http://www.schott.com/solarthermal/english/applications/solar_cooling.html)

special glass, solar thermal

[www.conergy.de](http://www.conergy.de)

system supplier in regenerative energies

[www.opus.kobv.de/tuberlin/volltexte/2006/1290](http://www.opus.kobv.de/tuberlin/volltexte/2006/1290)

## Solar Cooling Related Web-Sites (3)

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[www.conergy.com.au](http://www.conergy.com.au)

[www.esv.or.at/esv/index.php](http://www.esv.or.at/esv/index.php)

energy agency, innovative energy technologies

[www.eurac.edu/Focus/WaterSunWind/energy\\_henning\\_de.htm](http://www.eurac.edu/Focus/WaterSunWind/energy_henning_de.htm)

research and further education

[www.energy.kth.se](http://www.energy.kth.se)

research and education in energy for the future

[www.solarfrost.com](http://www.solarfrost.com)

advanced ammonia absorption chiller, research and development

[www.arsenal.ac.at](http://www.arsenal.ac.at)

contact for research questions , mobility and energy

[www.sol-ution.com](http://www.sol-ution.com)

solar energy, solar cooling and heating

[www.austriasolar.at](http://www.austriasolar.at)

association supplier of thermal solar plants

# Solar Cooling Related Web-Sites (4)

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[www.top50-solar.de](http://www.top50-solar.de)

[www.ilkdresden.de](http://www.ilkdresden.de)

develops innovative solutions and accompanies the installation

[www.zae.physik.tu-muenchen.de](http://www.zae.physik.tu-muenchen.de)

[www.zae-bayern.de](http://www.zae-bayern.de)

center for applied energy research

[www.grammer-solar.de](http://www.grammer-solar.de)

plans and implements solar thermal systems,air collectors, DEC

[www.sfv.de](http://www.sfv.de)

solar energy development association

[www.valentin.de](http://www.valentin.de)

software programs for design and calculation of solar systems  
free of charge online calculation

[www.swt-technology.de/html/negst.html](http://www.swt-technology.de/html/negst.html)

Project NEGST, new generation of solar thermal systems

[www.yazaki-group.com](http://www.yazaki-group.com)

small absorption chillers

# Solar Cooling Related Web-Sites (5)

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[www.broad.com](http://www.broad.com)

**solar collectors, absorption chillers**

[www.robur.com](http://www.robur.com)

**absorption chillers**

[www.eaw-energieanlagenbau.de](http://www.eaw-energieanlagenbau.de)

**absorption chillers**

[www.sonnenwaermeag.de](http://www.sonnenwaermeag.de)

**absorption chillers, TRNSYS-Type 177 to download**

# Reference Library (1)

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**A Solar Ammonia Absorption Ice Maker, (1996), Jaroslav Vanek, Mark Green, Steven Vanek, Home Power Nr. 53**

**Arbeitsgemeinschaft erneuerbare Energie, [www.aee.at](http://www.aee.at)**

**Building Design for Regions with Hot Climates, (2000), B. Givoni, UCLA Los Angeles, USA**

**Desiccant Klimaanlage Hartberg, DI Dr. Erich Podesser, Joanneum Research, Institut für Energieforschung, [www.joanneum.at](http://www.joanneum.at)**

**Design of a Solar Driven Cooling Unit Based on the Diffusion Absorption Principle, (2001), Eicker, Jakob, Schneider, Bauer, Spindler, Brendel, Negro, Dipolder, Fachhochschule Stuttgart, Deutschland**

**EG Solar, [www.eg-solar.de](http://www.eg-solar.de)**

**Entwicklung eines solaren Kühl- und Pasteurisierungssystems, Prof. Dr. Gerhard Kunze, Johannes Kepler Universität Linz**

**Errichtung und Betrieb einer Desiccant Klimaanlage zur Technologie Demonstration im Forschungshaus des Ökopark Hartberg, (2000), E. Podesser, R. Stieglbrunner**

**European Directory of Sustainable and Energy Efficient Building, (1999), Firmendaten**

**Klimatisierung über Sorption: Entfeuchten und kühlen ohne Strom, Bayrisches Zentrum für Angewandte Energieforschung, DI E. Läveman, [www.muc.zae-bayern.de](http://www.muc.zae-bayern.de)**

**Konzeptstudie zum Einsatz einer Sorptionsgestützten Klimatisierung mit Regeneration durch Solarluftkollektoren, Wolfgang Dotzler, Grammer Solar + Bau, Deutschland, [www.grammer-sb.de](http://www.grammer-sb.de)**

## Reference Library (2)

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- Konzeptstudie zum Einsatz einer Solaren Klimatisierung in Verbindung mit Vakuum-Röhren-Kollektoren für ein Bürogebäude in Hamburg, Grammer Solar + Bau, Deutschland, [www.grammer-sb.de](http://www.grammer-sb.de)**
- Offene Adsorptionsspeicher mit Zeolith, (2000), Andreas Hauer, Bayrisches Zentrum für Angewandte Energieforschung, Abt. 4, Solarthermie und Biomasse, [www.muc.zae-bayern.de](http://www.muc.zae-bayern.de)**
- SACE Solar Air-Conditioning in Europe Report, (2002), European Union**
- Solar angetriebener Kühlschrank, Zeo-Tech Zeolith-Technologie GmbH, [www.zeo-tech.de](http://www.zeo-tech.de)**
- Solar autarke Sorptionsgestützte Klimaanlage mit Solarluftkollektoren, (2002), Carsten Hindenburg, Fraunhofer Institut Solare Energiesysteme, Deutschland**
- Solar Heating and Cooling Projects, Christos Korres, Heliostat Ltd.**
- Solare Gebäudeklimatisierung, (2000), Fraunhofer Institut Solare Energiesysteme, Dr. Hans-Martin Henning, Servitech, Spanien**
- Solare Gebäudeklimatisierung mit thermischer Solarenergie, (1999), Erneuerbare Energie, Karsten Hindenburg und Hans-Martin Henning**
- Solare Gebäudekühlung, (1999), Thermolux Solar, Benidorm, Spanien**
- Solare Kälte für ein Kühlhaus in Indien, (1999), Peter Treffinger und Kai Oertel, Sonnenergie, Deutschland**
- Solare Klimatisierung von Gebäuden, Henning, Erpenbeck, Luginsland, Gerber, Amerlan, Fraunhofer Institut für Solare Energiesysteme, [www.ise.fhg.de](http://www.ise.fhg.de)**

## Reference Library (3)

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- Solare Kühlanlage Produktionshalle Landkreis Calw, (1999), Solares Heizen, Deutschland**
- Solare Kühlmaschine mit einer Leistung von 2 kW, Dr. Gerhard Kunze, [www.hausderzukunft.at](http://www.hausderzukunft.at)**
- Solare Kühlung Arsenal Research, [www.arsenal.ac.at](http://www.arsenal.ac.at)**
- Solare Kühlung des EAR-Towers in Pristina, [www.solid.at](http://www.solid.at)**
- Solare Wasserentsalzungsanlage, (1998), Isabelle Ulber, Sonnenergie, Deutschland**
- Solares Energiegebäude Konzept Götz, (1995), Götz GmbH, Deutschland**
- The Potential of Solar Energy Use in Desiccant Cooling Cycles, (1996), H.M. Henning, T. Erpenbeck, C. Hindenburg, I.S. Santamaria**
- Understanding Passive Cooling Systems, Daniel Halacy, Volunteers in Technical Assistance, Arlington, Virginia, USA**
- Wärme und Kälte aus der Sonne, (1996), S. Müller, S. Zech, Sonnenenergie, Deutschland**

# Contact



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Homepage: [www.energycabin.com](http://www.energycabin.com)

## EnergyCabin - Mobile Cooling System Driven by Solar Energy and Biomass

### Version EnergyCabin ECool

The EnergyCabin Version ECool is a factory prepared mobile, solar driven energy system, built in containers, which provides cold water for air-conditioning or similar application. The EnergyCabin ECool uses solar panels and a thermal back-up system, which consists of a wood pellet or wood chip boiler. A fully automated control unit controls and regulates the cooling system.

### Technical Data

Rated Output:  
EnergyCabin ECool is available in different sizes, which cover a broad range of capacities:

Technology: Water/Lithium-Bromide Absorption Chiller	
Rated Output [kW]	Solar Panel Area [m <sup>2</sup> ]
15	50
35	110
70	220
105	330
140	440
210	650

### Demonstration Project

An EnergyCabin ECool cools the 'Lake Pleasant Outdoor Education Center' in Maricopa, Arizona. The cooling load of 70 kW is provided by an absorption chiller in combination with a thermal solar system. The EnergyCabin ECool enabled the Arizona Public Service and Maricopa County to change over easily their cooling system based on a compression chiller to system based on a thermally driven chiller.

#### Technical Data:

- ECool 70, rated output 70 kW
- Chiller: Yazaki WFC-SC20
- Solar panel area: 168 m<sup>2</sup>
- No thermal back up system
- Hot water tank: 4000 l
- Cold water tank: 600 l



EnergyCabin ECool with cooling tower mounted on top



Interior view with control unit