Solar Assisted Cooling
– State of the Art –

Intelligent Energy Europe

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Executive Summary

Solar cooling technologies use solar thermal energy provided through solar collectors to power thermally driven cooling machines. Cooling demand is rapidly increasing in many parts of the world, especially in moderate climates, such as in most EU member states. This results in a dramatic increase in electricity demand on hot summer days, which causes an unwanted increase in the use of fossil and nuclear energy and furthermore threatens the stability of electricity grids.

As many cooling applications, such as air conditioning, have a high coincidence with the availability of solar irradiation, the combination of solar thermal and cooling obviously has a high potential to replace conventional cooling machines based on electricity. Larger solar cooling systems have been successfully demonstrated and smaller machines, which could be used in (small) residential and office buildings, are entering the market.

Because solar cooling is not yet widely available, it is important to understand its specific barriers to growth and consequently the best strategies to help overcome these barriers. The following short list will help policy-makers develop and implement suitable support policies for solar cooling. A more detailed list can be found at the end of this document.

Barriers to growth

Technical barriers - Hardware

- Lack of units with small capacities
- Lack of package-solutions for residential and small commercial applications
- Only few available medium temperature collectors
- Low thermal efficiency (COP)
- Often: Need for wet cooling tower

Technical barriers – Software (e.g. planning guidelines, training)

- Very important: no skills today among professionals
- Lack of standardised hydraulic schemes, planning guidelines and simple design tools

Lack of awareness

- Lack of awareness of solar cooling will become a key barrier to growth in the near future

Costs

- Higher initial investment costs compared with conventional cooling systems
- To date, not cost efficient from a business point of view
- Often forgotten in today's financial incentive schemes for solar thermal

Recommendations

Specific RD&D

- Fundamental research:
  - Development of new cooling cycles
  - Development of systems with high temperature lift
- Applied research and development:
  - Improvement of new components, such as small capacity systems
  - For small systems: Development of concepts which lead to pre-engineered solutions
  - For large systems: Development of hydraulic concepts, design guidelines and proven operation and maintenance concepts
  - Development of advanced modelling and simulation tools
- Large number of demonstration projects
  - Essential to achieve a high standardization and proven guidelines
  - Also important to have good references and showcases

Training and awareness raising

- Specific training courses for professionals
- Inclusion of solar cooling technologies into standard education for engineers etc.
- Later: Broad awareness raising campaigns targeted at suitable decision-makers and industry multipliers
- Requirement on EU member states to keep statistics on the energy demand for cooling purposes

Financial incentives

- Inclusion of solar cooling into financial incentive schemes for solar thermal
- Inclusion of solar cooling into White or Renewable Energy Certificate schemes

Regulatory measures

- Inclusion in building regulations: use of renewable energy for cooling
- Discouragement or prohibition of refrigerants with high global warming potential (GWP)

Other policy measures

- Inclusion of cooling into RES-H targets at European and national level

Introduction

The present document was produced within the framework of the Intelligent Energy-Europe project Key Issues for Renewable Heat in Europe (K4RES-H). The project looks at providing guidelines for best practice policies to support renewable heating and cooling (RES-H) technologies. Because most of the current support policies for RES-H focus on commercially available products, this document aims at highlighting one of the promising, upcoming applications for solar thermal: Solar Industrial Process Heat (SHIP)

In solar cooling systems, solar heat is used to drive the cooling process. Thermally driven cooling machines, such as ab- or ad-sorption chillers have been used for decades, but have been powered mainly by industrial waste heat or by district heat. In recent years, demonstration projects have shown the potential to use solar thermal energy to drive those chillers. Because most of the available thermal chillers have large cooling capacities (often several hundred kW), the focus of R&D was largely on developing smaller cooling units as well as to improve the system design. About 100 systems have been installed in Europe and several companies are offering solar cooling solutions as part of their product and service portfolio.

Components of a solar cooling system

A solar cooling installation consists of a typical solar thermal system made up of solar collectors, storage tank, control unit, pipes and pumps and a thermally driven cooling machine. To date, most collectors used in solar cooling systems are the high-efficiency collectors available in the market today (often double-glazed flat plate collectors or evacuated tube collectors). New developments for the medium temperature range (100-250°C) could increase the overall efficiency of the cooling systems.

Technical information on thermally driven chillers

Thermally driven chillers may be characterized by three temperature levels: a high temperature level at which the driving temperature of the process is provided, a low temperature level at which the chilling process is operated, and a medium temperature level at which both, the heat rejected from the chilled water cycle and the driving heat, have to be removed. For this heat removal, in most cases a wet-cooling tower is used.

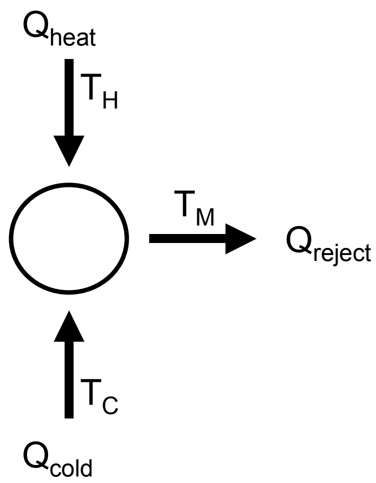


Figure 1: Basic process scheme of a thermally driven chiller

Basic process scheme: Q_{cold} is the heat rejected from the chilled water in the evaporator of the chiller (chilling power), Q_{heat} is the required heat in the generation part to drive the process, and the amount of Q_{reject}, the sum of Q_{cold} and Q_{heat}, has to be removed at a medium temperature level T_M. Q_{heat} is deliverd either by the solar system or by backup heat sources, e.g. by district heat or by a gas burner.

A key figure describing the efficiency of a thermally driven chiller is the thermal Coefficient Of Performance (COP), defined as the fraction of heat rejected from the chilled water cycle ('delivered cold') and the required driving heat, i.e. $COP_{thermal} = Q_{cold} / Q_{heat}$. This is different to the COP_{conv} of a conventional eletrically driven compression chiller, defined by $COP_{conv} = Q_{cold} / E_{electric}$, with $E_{electric}$ representing the electricity consumption of the chiller.

This definition of the $COP_{thermal}$ does not include any additional electric power consumption. A realistic comparison of different technologies thus requires the consideration of the total energy input for heat as well as for pumps, fans, etc. It has to be noted that the smaller the COP, the more heat input is required and the more heat has to be removed by the cooling tower. Vice versa, a high COP value is of advantage in reducing both heat input and electric power for the pumps in the heating cycle and in the re-cooling cycle.

The required chilled water temperature depends on the installed cooling system in the rooms. In cases where dehumidification of the air is required, e.g. falling below the saturation point of the room temperature by using fan coils, chilled water temperatures in the range of 6°C-9°C are required. For the removal of sensible cooling loads only, which can be achieved with cooled supply air or with room installations such as chilled ceilings etc., a chilled water temperature of 12°C-15°C is sufficient, allowing the chiller to operate with a higher performance.

ABSORPTION CHILLERS

Absorption chillers are the most widely used chillers throughout the world. A thermal compression of the refrigerant is achieved by using a liquid refrigerant/sorbent solution and a heat source, thereby replacing the electric power consumption of a mechanical compressor. For chilled water above 0°C, as is used in air conditioning, a liquid H_2O/LiBr solution is typically applied with water as a refrigerant. Most systems use an internal solution pump, but consume only little electric power. In the operation of an H_2O/LiBr absorption chiller, a crystallisation of the solution has to be avoided by internal control of the heat rejection temperature in the machine.

The main components of an absorption chiller are shown in the figure below. The cooling effect is based on the evaporation of the refrigerant (water) in the evaporator at very low pressure. The vaporised refrigerant is absorbed in the absorber, thereby diluting the H_2O/LiBr solution. To make the absorption process efficient, the process has to be cooled. The solution is continuously pumped into the generator, where the regeneration of the solution is achieved by applying driving heat (e.g. hot water). The refrigerant leaves the generator by this process, condenses through the application of cooling water in the condenser, and circulating by means of an expansion valve again into the evaporator.

Typical chilling capacities of absorption chillers are several hundred kW. Mainly, they are supplied with district heat, waste heat or heat from cogeneration. The required heat source temperature is usually above 80°C for single-effect machines and the COP is in the range of 0.6 to 0.8. Double-effect machines with two generator stages require driving temperatures of above 140°C, but the COPs may achieve values up to 1.2.

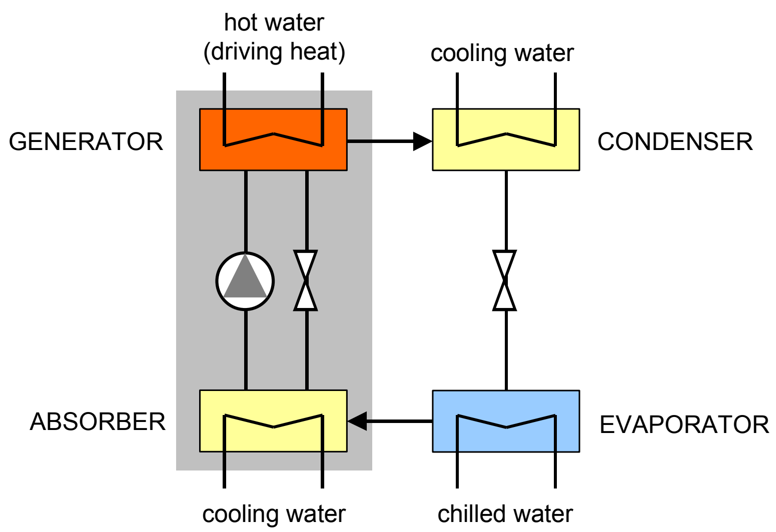


Figure 2: Principle of an absorption chiller

A few absorption chillers with capacities below 50 kW are available. In solar assisted air conditioning systems with absorption chillers, these small units are often implemented. A machine type, developed recently for small capacities, enables part-load operation with reduced chilling power at heat source temperatures of 65°C already and with a COP of still approx. 0.7, which is promising in combination with solar heat. This indicates that there is still potential for performance improvement for absorption chillers.

ADSORPTION CHILLERS

Here, instead of a liquid solution, solid sorption materials are applied. Market available systems use water as a refrigerant and silica gel as a sorbent. The machines consist of two sorbent compartments (denoted as 1 and 2 in the figure below), one evaporator and one condenser. While the sorbent in the first compartment is regenerated using hot water from the external heat source, e.g. the solar collector, the sorbent in the compartment 2 (adsorber) adsorbs the water vapour entering from the evaporator; this compartment has to be cooled in order to enable a continuous adsorption. The water in the evaporator is transferred into the gas phase being heated by the external water cycle; here the useful cooling is actually produced. If the cooling capacity reduces to a certain value due to the loading of the sorbent in the adsorber, the functions of the chambers are switched over. To date, only a few Asian manufacturers produce adsorption chillers. Under typical operation conditions, with a driving heat temperature of about 80°C, the systems achieve a COP of about 0.6, but operation is possible even at heat source temperatures of approx. 60°C. The capacity of the chillers ranges from 50 kW to 500 kW chilling power.

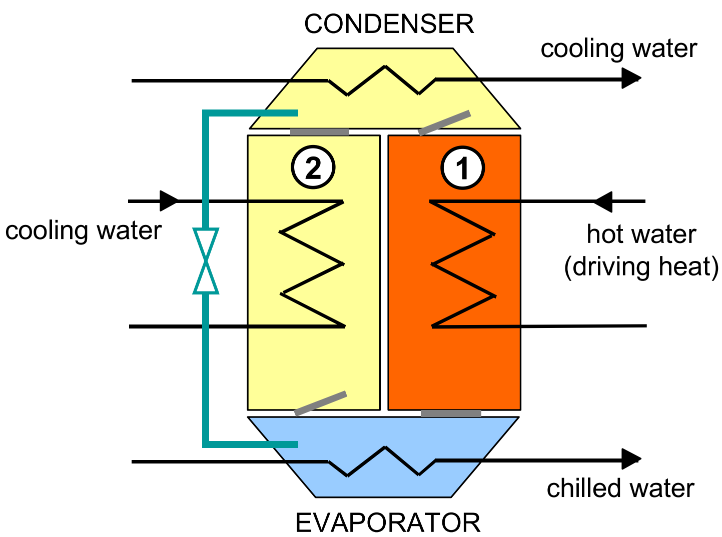


Figure 3: Principle of an adsorption chiller

The simple mechanical construction of adsorption chillers and their expected robustness is an advantage. There is no danger of crystallisation and thus no limitations in the heat rejection temperatures exist. An internal solution pump does not exist and hence only a minimum of electricity is consumed. A disadvantage is the comparatively large volume and weight. Furthermore, due to the small number of items produced, the price of adsorption chillers is currently high. A large potential for improvements of the heat exchangers in the adsorber compartments is expected; thus, a considerable decrease in volume and weight can be assumed in future generations of adsorption chillers.

Technical information on desiccant cooling systems

Desiccant cooling systems are basically open cycle systems, using water as a refrigerant in direct contact with air. The thermally driven cooling cycle is a combination of evaporative cooling with air dehumidification by a desiccant, i.e. a hygroscopic material. For this purpose, liquid or solid materials can be employed. The term ‘open’ is used to indicate that the refrigerant is discarded from the system after providing the cooling effect and new refrigerant is supplied in its place in an open-ended loop. Therefore, only water is possible as a refrigerant since a direct contact to the atmosphere exists. The common technology applied today uses rotating desiccant wheels, equipped either with silica gel or lithium-chloride as sorption material.

SOLID DESICCANT COOLING WITH ROTATING WHEELS

The main components of a solar assisted desiccant cooling system are shown in the figure below. The basic process in providing conditioned air may be described as follows.

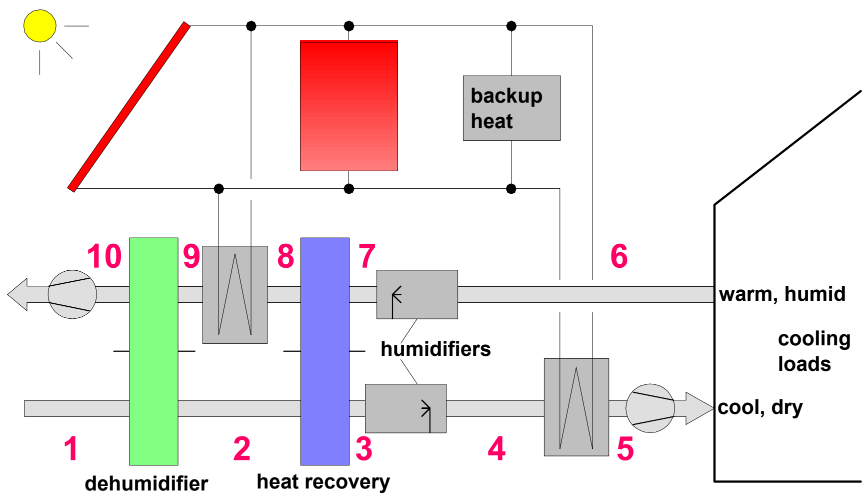


Figure 4

A: Cooling case

Warm and humid ambient air enters the slowly rotating desiccant wheel and is dehumidified by adsorption of water (1-2). Since the air is heated up by the adsorption heat, a heat recovery wheel is passed (2-3), resulting in a significant pre-cooling of the supply air stream. Subsequently, the air is humidified and further cooled by a controlled humidifier (3-4), according to the desired temperature and humidity of the supply air stream. The exhaust air stream of the rooms is humidified (6-7) close to the saturation point to exploit the full cooling potential in order to allow an effective heat recovery (7-8). Finally, the sorption wheel has to be regenerated (9-10) by applying heat in a comparatively low temperature range from 50°C-75°C, to allow a continuous operation of the dehumidification process.

B: Heating case

In periods of low heating demand, heat recovery from the exhaust air stream and enthalpy exchange by using a fast rotating mode of the desiccant wheel may be sufficient. In cases of increased heating demand, heat from the solar thermal collectors and, if necessary, from a backup heat source (4-5) is applied.

Flat plate solar thermal collectors can be applied normally as a heating system in solar assisted desiccant cooling systems. The solar system may consist of collectors using water as fluid and a hot water storage, to increase the utilisation of the solar system. This configuration requires an additional water/air heat exchanger, to connect the solar system to the air system. An alternative solution, leading to lower investment cost, is the direct supply of regeneration heat by means of solar air collectors.

<u>Special design of the desiccant cycle is needed in case of extreme outdoor conditions such as e.g. coastal areas of the Mediterranean region.</u> Here, due to the high humidity of ambient air, a standard configuration of the desiccant cooling cycle is not able to reduce the humidity down to a level that is low enough to employ direct evaporative cooling. More complex designs of the desiccant air handling unit, employing for instance another enthalpy wheel or additional air coolers supplied by chilled water, can overcome this problem.

LIQUID DESICCANT COOLING

A new development, close to market introduction, are desiccant cooling systems using a liquid Water/Lithium-Chloride solution as sorption material. This type of system shows several advantages such as higher air dehumidification at the same driving temperature range as solid desiccant cooling systems, and the possibility of high energy storage by storing the concentrated solution. This technology is a promising future option for further increasing the exploitation of solar thermal systems for air-conditioning.

Solar assisted air conditioning

One of the most widely used applications for solar cooling is air conditioning (often termed “solar assisted air conditioning). The most common technologies used in combination with solar heat are shown in Table 1. Thus, solar assisted air conditioning systems operated to date may be classified into:

- closed systems: these are thermally driven chillers which provide chilled water, that is either used in air handling units to supply conditioned air (cooled, dehumidified), or that is distributed via a chilled water network to the designated rooms to operate decentralized room installations, e.g. fan coils. Market-available machines for this purpose are absorption chillers (most common) and adsorption chillers (a few hundred machines worldwide, but of rising interest in solar assisted air conditioning);
- open systems: allowing complete air conditioning by supplying cooled and dehumidified air according to comfort conditions. The “refrigerant” is always water, since it is in direct contact with the atmosphere. Most common systems are desiccant cooling systems using a rotating dehumidification wheel with solid sorbent.

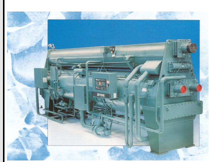
method	closed cycle		open cycle	
refrigerant cycle	closed refrigerant cycle		refrigerant (water) is in contact to the atmosphere	
principle	chilled water		dehumidification of air and evaporative cooling	
phase of sorbent	**solid**	**liquid**	**solid**	**liquid**
				
typical material pairs	water - silica gel	water - water/ lithiumbromide, ammonia/water	water - silica gel, water - lithiumchloride	water - calcium chloride, water - lithium chloride
market available technology	adsorption chiller	absorption chiller	desiccant cooling	close to market introduction
typical cooling capacity [kW cold]	adsorption chiller: 50-430 kW	absorption chiller: 15 kW - 5 MW	20 kW - 350 kW (per Module)	-
typical COP	0.5-0.7	0.6-0.75 (single effect)	0.5->1	>1
driving temperature	60-90°C	80-110°C	45-95°C	45-70°C
solar collectors	vacuum tubes, flat plate collectors	vacuum tubes	flat plate collectors, solar air collectors	flat plate collectors, solar air collectors

Figure 5: Overview of the most common solar assisted air conditioning technologies

Overview of selected demonstration projects

To date, about 100 solar cooling and air-conditioning (A/C) systems have been installed in Europe. Their specific collector area is ~3 m^2/kW for water chillers, or 10m^2 per 1000 m^3/h of air volume flow in desiccant systems. Their primary energy savings potential is between 30-60%, but these potentials are often not yet realised with the current systems (due to sub-optimal design, installation, operation). Cost wise the systems have a pay-back period of 6 years (best systems) to over 20 years, at today's energy prices.

Most of the systems realised so far have been installed in Germany, Spain and Greece:

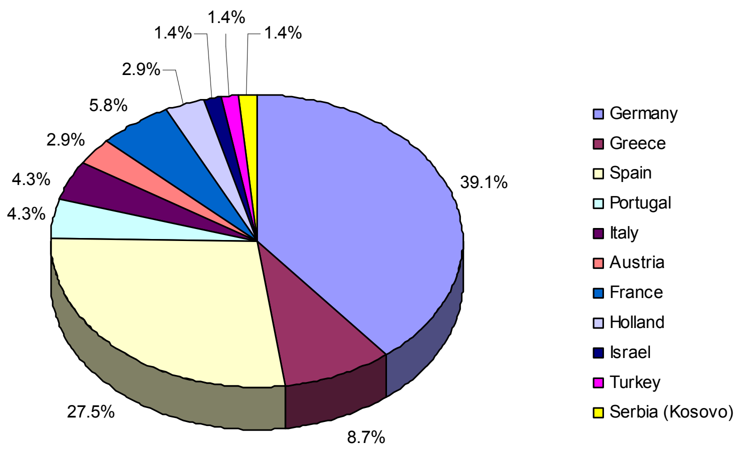


Figure 6: Geographical distribution of solar cooling demonstration projects

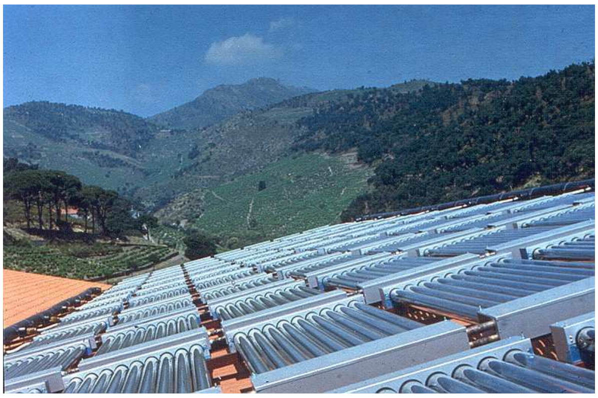
Following are a selected examples of existing systems.

Air-conditioning of a factory

- Use: air conditioning of the production facilities in a cosmetics factory
- Site: Inofita Viotias (appr. 50 km north-east of Athens)
- Solar thermal collector field: 2700 m² flat plate collectors
- Chillers:
    - 2 adsorptions chillers with 350 kW each
    - 3 compression chillers with 350 kW each
- Specifics: This solar cooling system is the largest to-date

Wine store cooling

- Use: cooling of a wine store
- Site: Banyuls (south France)
- Solar thermal collector field: 130 m² evacuated tube collectors
- Chiller: absorption chiller with 52 kW cooling capacity
- Specifics:
    - no back-up system, the system operates autonomously and has no buffer storage
    - one of the oldest systems; operated more than 13 years without any problems



Air-conditioning of a seminar room

- Use: air-conditioning of the seminar room and the cafeteria in an office building of the local chamber for trade & commerce
- Site: Freiburg (south-west Germany)
- Solar thermal collector field: 100 m² of air collectors as the only heat source
- Cooling system: desiccant cooling system (10.200 m³ per hour) with silica gel rotor
- Specifics:
    - no back-up system, no storage
    - simple solar system, simple integration into the air-conditioning plant


Hotel air-conditioning

- Use: air-conditioning of a hotel and steam supply for the hotel laundry
- Site: Dalaman (Mediterranean coast Turkey)
- Solar thermal collector field: 180 m² parabolic trough collectors (aperture area)
- Chiller: double effect absorption chiller (cooling capacity 116 kW, 4 bar saturated steam; COP > 1.2)
- LPG-fired back-up steam boiler
- Specifics:
  - First system with double effect chiller
  - High temperatures: parabolic trough collectors produce steam at 180°C
  - High overall conversion efficiency


Energy and environment

Although electrically driven chillers have reached a relatively high standard in terms of energy consumption, they still require a high amount of electricity and - even more importantly - cause significant peak loads in electricity grids. This is becoming a growing problem in regions with cooling dominated climates. Figure 7 below shows the total newly installed electric capacity due to room air-conditioner (RAC) units since 1998, assuming a replacement of 10% per year and an average electric capacity of 1.2 kW per unit. In recent years, an increasing number of cases have 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 were operated with renewable energies.

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

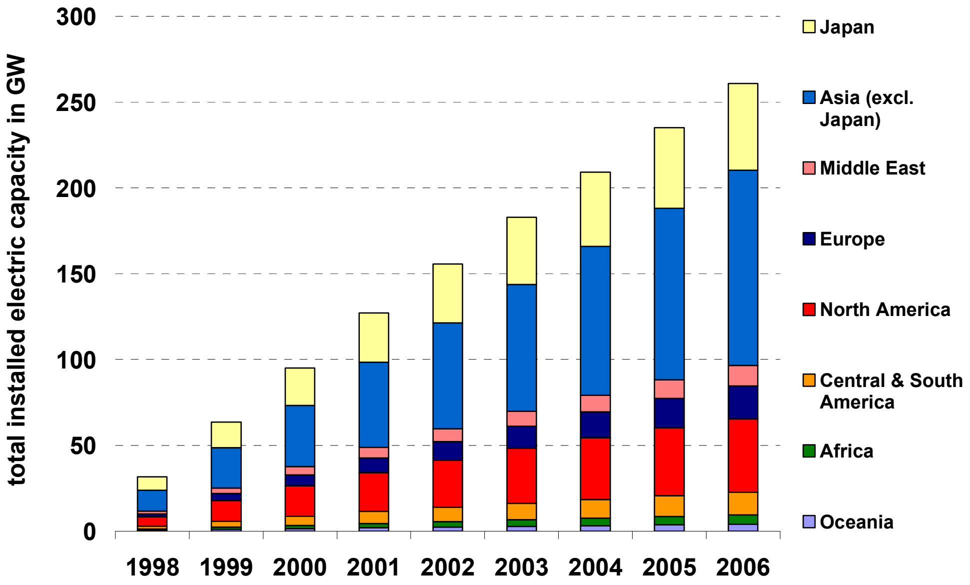


Figure 7: Cumulative newly installed electric capacity due to RAC units

Another topic related to environmental issues concerns the global warming potential of refrigerants. Refrigerant leakage in air-conditioning appliances - in particular in the automotive sector - led to several legislative initiatives towards limitation or even prohibition of classical fluorized refrigerants. Almost all thermally driven technologies use refrigerants which have no global warming potential.

Market potential

A tremendous increase in the market for air-conditioning can be observed worldwide. Figure 8 below shows the sales rates of room air-conditioners (RAC units) in different regions of the world. The number of sold units increased from about 26 million units worldwide in 1998 to more than 40 million units in 2006 (forecast). At the same time, the market for centralized cooling equipment remained almost stable. Which technology is employed - small RAC split units, multi-split systems, centralized chilled water technology, centralized air handling units - depends strongly on both region and load type. However, the dominance of small-split systems in private residences is a common trend worldwide. Therefore, in order to limit the negative impact on the energy consumption and on the electricity network management, new environmentally sound concepts for the small capacity range are of particular importance.

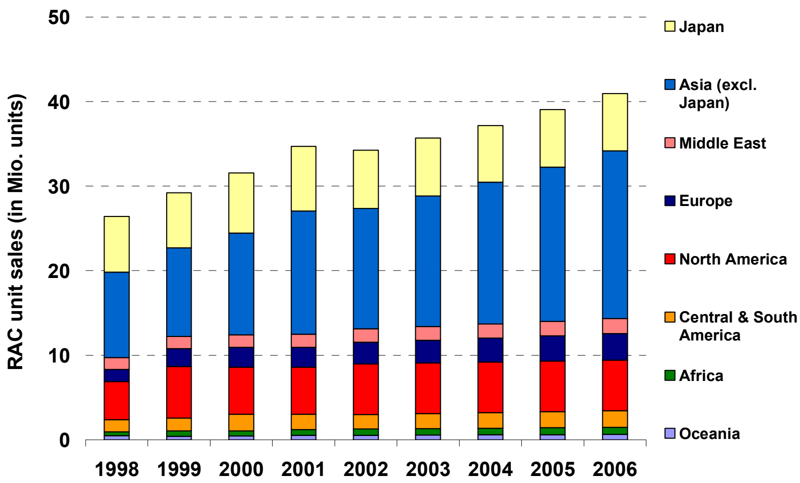


Figure 8: Annual sales of small room air conditioners (RAC units)
(source: F. Butera: The use of environmental energies for sustainable building in Mediterranean climates; Intelligent Building Middle East, Bahrain, December 2005)

Typical solar cooling applications today

- **Hotels:** For this commercial sector, solar air-conditioning offers an interesting marketing opportunity as it makes their hotels more attractive to the rising share of environmentally-conscious tourists. Although the annual cost of a solar assisted air-conditioning system is higher than a conventional system, the resulting additional accommodation costs per guest and per night are expected to be low compared to the average accommodation cost. A further advantage is that existing, medium cooling capacity systems can be employed which are already on the market. Since the maximum required cooling demand is often seen in hotels in the afternoon and evening, appropriate measures in building construction and system design are necessary to optimise the solar system utilisation and to minimize the use of backup cooling systems (e.g., high thermal inertia of the building, night ventilation,..). A market potential is envisaged for southern Europe countries with hot and humid climate.

- **Private building sector:** Private houses with solar thermal systems for combined domestic hot water production and heating support in transition periods (combisystems). The market share for these systems has been increasing in Central Europe in recent years. The systems consist of a comparatively large solar thermal collector system, and use either selective coated flat plate collectors or evacuated tube collectors. For example, for a four-person household a collector area between 10-25 m² is often recommended for combisystems, depending on the type of collector (in 2001, 150.000 m² of vacuum tube collectors were installed in Germany, corresponding to 17% of the total installed collector area). These installations uncover an interesting option to considerably increase the utilization of the large systems for solar air-conditioning in summer. Despite rising energy efficiency standards in the private building sector, rising comfort habits also cause an increasing interest in active cooling systems. A market niche for small solar cooling systems could be seen in the near future if:
    - the additional costs for cooling installation are low, e.g., reversible heat pumps for heating and cooling and no additional cooling backup;
    - small units of thermally driven air-conditioning units with sufficient low driving temperatures (e.g. adsorption heat pumps) are market-available.

  Thus, the market potential would be limited more to central European countries with moderate climates, where cooling in summer is an additional comfort, but is not critical if the system does not work in case of low radiation availability. The utilization of the system is optimal through use for heating support, domestic hot water production and cooling. However, the market potential is not expected to be very large.

- **Wine cellars:** This kind of building is well-adapted to solar cooling systems because wine storage offers a high thermal mass. Generally, the size of a solar cooling system is restricted by the load profile, which is strongly dependant on the climatic conditions and the building structure. However, in this case, the correlation between solar production and cooling load is respected. The marketing impact of the winery installation is very important: For example, the solar cooling system in Banyuls (France) has shown that the owners have benefited from numerous press and TV reports since 1991.

- **Factories:** In Europe, more and more large companies have to respect environmental standards. Special environment departments are now present on company organisation charts and large budgets are available for high environmental quality systems. Solar cooling is highly seductive for company profiles. Most factories have offices for their administration and accounts department. As a first step these offices can become the principal target for solar cooling systems. In a second phase, the industrial process buildings and in particular the laboratories could be persuaded to use solar cooling. Of course, the solar fraction will not be very high in most cases, due to the large areas involved. But if the cooling load is significant throughout the year, the solar cooling system will be operational all the time. Another asset for such a configuration is that the projects can be built faster than in the case of conventional offices, or of public buildings that require public funds.

- **Office buildings:** This type of building has been the most popular among the 60 solar cooling systems installed in Europe since the 80's. In the demonstration project phase, public office buildings can benefit from high grants. The cooling load (with significant internal loads due to computers) corresponds quite well to the solar production, however planners have to be vigilant about an eventual holiday break during July or/and August, making the project economically uninteresting. In the future, this targeted group will remain a niche market for buildings where passive techniques are used in the architecture that means where the owner is engaged in an environment-friendly policy.

Barriers to growth

Technical barriers – Hardware

- Lack of units with small capacities (Long term: technical alternative to split units needed)
- Lack of package-solutions for residential and small commercial applications (domestic hot water, space heating, air conditioning)
- Only few available solar collectors for medium temperatures (100-250°C), which could to drive double- or even triple-effect chillers
- Low thermal efficiency (COP)
- Often: Need for wet cooling tower

Technical barriers – Software (e.g. planning guidelines, training)

- Very important: no skills today among professionals (planers, installers)
- Designs of hydraulic systems not yet standardised, lack of suitable planning guidelines and simple design tools for planners

Lack of awareness

- The technology is still emerging, but as solar cooling systems become more standardised, the lack of awareness - by consumers and professionals - will become a key barrier to growth

Costs

- Higher initial investment costs compared with conventional cooling systems
- To date, not cost efficient from a business point of view
- Often forgotten in today’s financial incentive schemes for solar thermal

Recommendations

Solar cooling has the potential to curb the ever-increasing demand for conventional energies used for cooling purposes. Because of this, it contributes to lessening our dependence on imported fuels and to avoid CO_2 emissions. And by lowering electricity demand at times of peak loads, it increases the stability and costs of the electricity grids.

As solar cooling is still an emerging technology, it faces many growth barriers which are different from other heating and cooling technologies.

Because of these strong benefits, the market penetration of solar cooling should be supported by governments. The following recommendations will help governments focus on overcoming the barriers which are currently most problematic.

Specific RD&D

To date many of the growth barriers are still technological. Therefore, the availability of funding for specific R&D is a key condition for the fast market penetration of solar thermal cooling technologies

- Fundamental research:
  - Development of new cooling cycles and their assessment in comparison to existing technology. For this purpose advanced methodologies such as e.g. exergy analysis need to be developed and applied.
  - Development of systems with high temperature lift in order to remove the need for wet cooling towers
- Applied research and development:
  - Improvement of new components, such as small capacity systems, in order to allow broad market introduction.
  - For small systems: Development of concepts which lead to pre-engineered solutions that can be handled by an installer without particular planning effort.
  - For large systems to be applied in non-residential buildings (hotels, office buildings): Development of hydraulic concepts, design guidelines and proven operation and maintenance concepts.
  - Development of advanced modelling and simulation tools in order to support system planning and design.
- Large number of demonstration projects:
  - Essential to achieve a high standardization and proven guidelines
  - Also important to have good references and showcases.

Training and awareness raising

- Specific training courses for professionals (planners, installers)
- Inclusion of solar cooling technologies into standard education for engineers etc.

- Later: Broad awareness raising campaigns targeted at suitable decision-makers and industry multipliers (house builders, architects/installers, installers, electricity supply companies etc.).
- Requirement on EU member states to keep statistics on the energy demand for cooling purposes.

Financial incentives

- Inclusion of solar cooling into financial incentive schemes for solar thermal.
- Inclusion of solar cooling into White or Renewable Energy Certificate schemes.

Regulatory measures

- Inclusion in building regulations (based on the Energy Performance in Buildings Directive): Reduction of cooling loads through solar cooling and/or use of renewable energy for cooling.
- Discouragement or prohibition of refrigerants with high global warming potential (GWP), which are used in most conventional cooling machines.

Other policy measures

- Inclusion of cooling into RES-H targets at European and national level.