solarcombi+

SONNENKLIMA package solution description

SONNENKLIMA

Version 1

TECSOL

Perpignan, October 2009

Identification of most promising markets and promotion of standardised system configurations for the market entry of small scale combined solar heating & cooling applications
EIE/07/158/SI2.466793 09/2007 – 02/2010

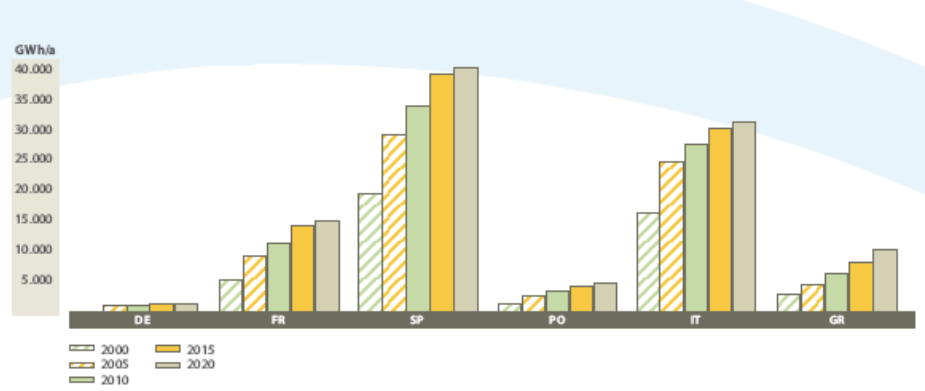
Intelligent Energy Europe

Table of Contents

1 Introduction

1.1 Increasing interest in air conditioning

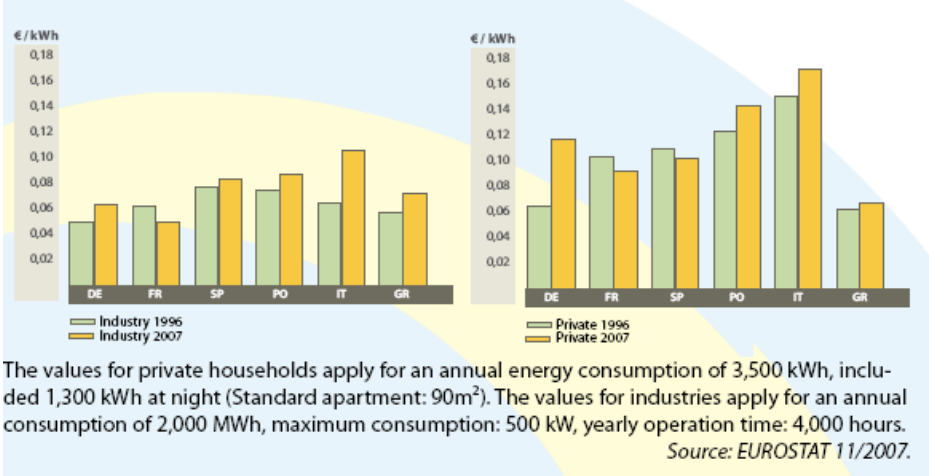
The demand for air-conditioned rooms is growing. However, since conventional air-conditioning systems consume a lot of energy, air-conditioning has, up to now, been expensive and has increased the load on power networks. The high power consumption of conventional air-conditioning systems is putting an increasing strain on the global climate, due to their high emissions of greenhouse gases.



Power needed for cooling [in GWh/a] in the following countries:
DE - Germany, FR - France, SP - Spain, PO - Portugal, IT - Italy, GR - Greece.

Source: EECCAC, 2003.

For example, the energy demands for air conditioning in Germany have increased from 71 GWh/a (2000) to 122 GWh/a (2005), which is a 72% increase over a period of five years. For the same period of time, the EU-15 countries showed a 51% hike in consumption.



The values for private households apply for an annual energy consumption of 3,500 kWh, included 1,300 kWh at night (Standard apartment: 90m²). The values for industries apply for an annual consumption of 2,000 MWh, maximum consumption: 500 kW, yearly operation time: 4,000 hours.

Source: EUROSTAT 11/2007.

This increasing interest in air-conditioning technologies can be explained by a stronger wish for comfort, growing internal and external cooling loads due to the use of electrical devices, and the use of more and more glass on buildings. At the same time, the cost of electricity for private households, small businesses, trades and commerce, authorities and service providers, as well as all industries, has increased significantly.

1.2 Solar Cooling - Use of existing potentials

Electricity and heat are increasingly produced from renewable energies. Notably, many private households are choosing to install solar systems for their home heating and cooling needs. Undoubtedly one of the many arguments for a decentralized energy supply is the growing cost.

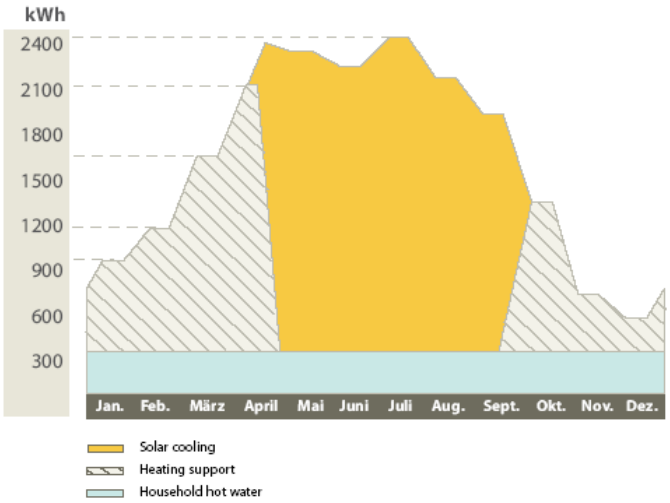
Illustration: Solar installation for the solar cooling of the Centre for Environment and Technology [CUT] in Osnabrück.

Source: SK SonnenKlima, 2005.

However, in the summer, the opportunities provided by solar installations are not yet used to their maximum potential. The large amount of heat produced is not needed, since the heating requirements are very low during this season. – Solar installations are therefore not working to capacity; and they are not working for long periods of time. This is especially true for big thermal solar installations.

With this in mind, the SONNENKLIMA SUNINVERSE absorption chiller was developed to serve two purposes – to make efficient use of existing solar installations, and to satisfy the need for cooling. It uses the excess energy/heat produced during the summer months for the cost-efficient and climate neutral air-conditioning of buildings. In this case, the peaks of heat availability, that are typical of solar installations, overlap with the peak demands for building cooling.

The primary energy demand for building air-conditioning (i.e. heating and cooling) can be significantly reduced through the year-round use of the solar installation.



The diagram shows the energy yield of a solar cooling and heating system consisting of a 40m² gross collector surface and the **sun***inverse* absorption chiller.
Source: Measurements 2004, SK SonnenKlima GmbH.

1.3 SONNENKLIMA available documentation

The SONNENKLIMA package solution and product is described in detail in the documents:

SolarCombiPlus_SONNENKLIMA_Solar cooling brochure.pdf

(Language: English, status: public, cf. Annex II)

SolarCombiPlus_SONNENKLIMA_SUNINVERSE technical dataz.pdf

(Language: English, status: public, cf. Annex III)

SolarCombiPlus_SONNENKLIMA_SUNINVERSE technical description.pdf

(Language: English, status: public, cf. Annex IV)

SolarCombiPlus_SONNENKLIMA_Checklist.pdf

(Language: English, status: public, cf. Annex V)

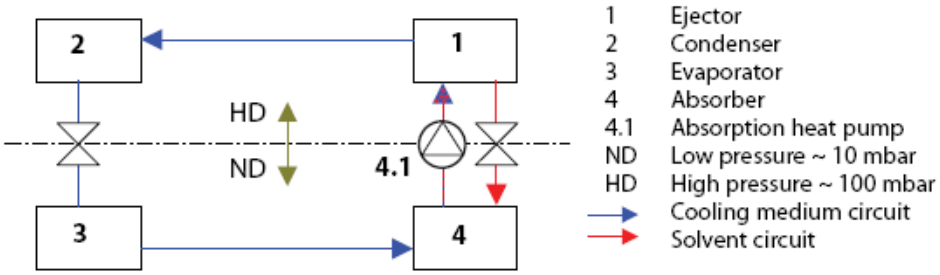
These documents are also available under request to SONNENKLIMA.

Due to the comprehensive information on the system solutions in the above listed documentation, only brief information will be summarized in the following.

2 The chiller

2.1 The principle of the absorption chiller - cooling made of heat

The SUNINVERSE absorption chiller uses two environmentally friendly substances to produce cold: a very hygroscopic salt - lithium bromide (LiBr) - and ordinary distilled water. Lithium bromide (LiBr) serves as a solvent in the single-stage process circuit and water serves as a cooling medium. In the absorber, LiBr is totally hydrated by water according to the absorption principle. The result is a homogenous two-component mixture.



The different steps in the circuit are:

Ejector (1): At very low pressure, the LiBr is separated from the water using the drive heat (55-105°C). The water is changed into vapour, and the LiBr sinks down into the absorber.

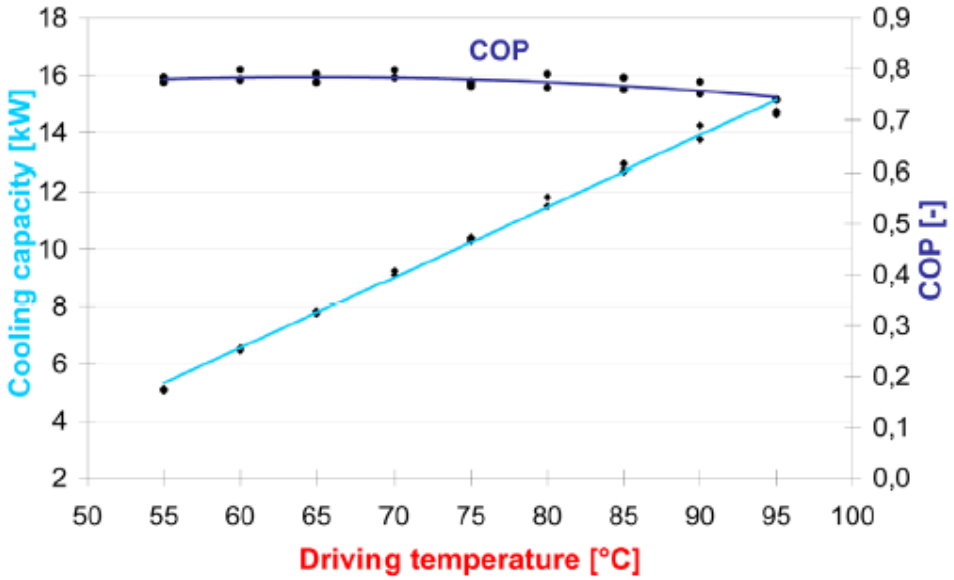
Condenser (2): By removing heat, the vapour is liquefied and becomes water. The water sinks down into the low pressure zone.

Evaporator (3): At very low pressures, a temperature of 5-15°C is sufficient to make the water evaporate again. The required heat is taken from the environment and will produce the desired effect: Cooling.

Absorber (4): The cooling medium vapour is attracted by the salt (LiBr) and is dissolved in the water by heat radiation. The solution is pumped into the ejector, and the circuit is closed. Two special physical characteristics are used for the process circuit: Liquids can be moved between two pressure levels with little mechanical effort, and liquids can evaporate at low pressures and very low temperatures.

2.2 The SUNINVERSE chiller

The thermal absorption chiller SUNINVERSE from SONNENKLIMA GmbH operates with minimal use of electrical energy, and produces cooling from solar heat.



At a drive temperature between 55 and 75°C, a maximum COP of between 0.78 and 0.80 is attained. Nominal operating conditions: Volumetric flow rate, cold water: 15°C, cooling water: 27°C.

Source: TU Berlin, 2007.

The quality of the absorption process of the chiller is expressed with the Coefficient of Performance (COP).

SUNINVERSE attains a high thermal coefficient of performance (COP = 0.78)

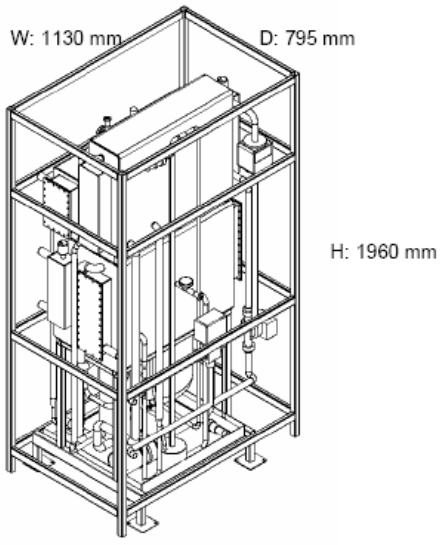
$$\text{COP} = \text{Wärmeverhältnis } \frac{\text{refrigerating performance [kWthermal]}}{\text{drive performance [kWthermal]}} = 0{,}78$$

and has good partial load behavior. One kilowatt hour of thermal drive energy produces approximately 780 Wh of cooling energy. The absorption chiller SUNINVERSE operates with different system components at different operating points. The associated performance values were taken from our demonstration projects that served to test different systems in continuous operation in customer-oriented applications.

Apart for use in new buildings and the combination possibilities with district heat or cogeneration, the SUNINVERSE is easily compatible with existing water-based cooling systems.

Nr.	Standard performance	Drive performance	Back-cooling performance	Cooling surface	Required collector surface	Dimensions (mm)	Weight (kg)
1	1o kW	15 kW	25 kW	~180 m²	30 ~ 40 m²	H: 1960 B: 1130 T: 795	Transport: 500 Operation: 550
2	16 kW	24 kW	40 kW	~290 m²	48 ~ 64 m²		

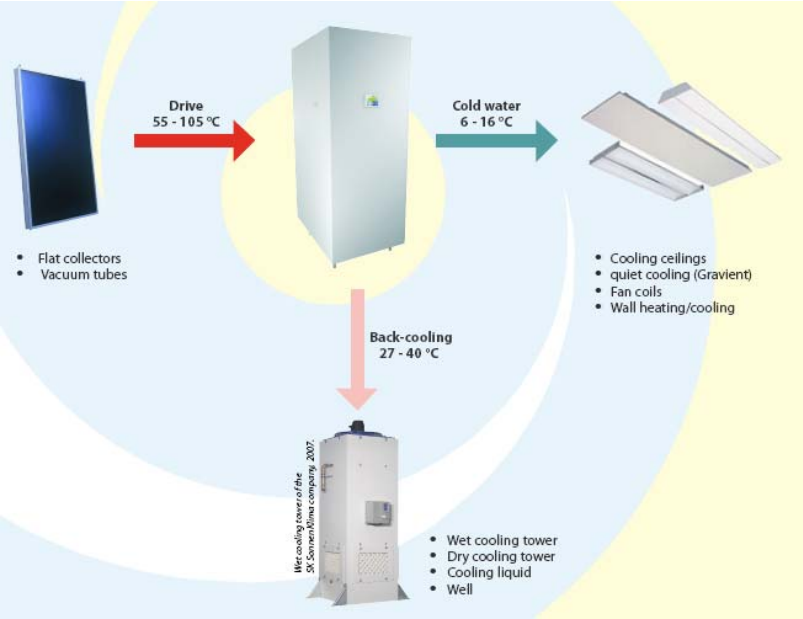
The solar operation guarantees minimal operating costs, and thus reduces the consumption of electrical energy. In addition, the use of a harmless cooling medium makes the operation of the machine environmentally friendly.



Its small size allows the SUNINVERSE to be easily transported (through doorways). The choice of the installation site can be made without taking into consideration the noise level. The machine runs very quietly and needs very little maintenance due to its superior design.

3 System's components

The SUNINVERSE absorption chiller works according to the principles of solar cooling. It uses the excess heat produced by the solar collectors for room cooling.



The heat from the solar collectors is supplied to the process circuit of the absorption chiller. Cold water is the medium that is used to cool the rooms of the buildings.

The SUNINVERSE absorption chiller is the core of the air-conditioning systems. It adapts to the needs, is customized to building conditions and will create a comfortable climate in the targeted building. If the system is optimally designed, it will work to capacity with minimal operating costs. Several components are available for the use of the SUNINVERSE absorption chiller and described in the next subchapters.

3.1 Heat rejection

The open wet cooling tower wct23kW was specially designed for operation with the SUNINVERSE absorption chiller from SK SONNENKLIMA GmbH. It functions according to the evaporation principle and is optimally adapted to the performance of the absorption chiller. The make-up water requirements depend on the outside temperature, the operation period, and the requested average performance.

During operation with the SUNINVERSE absorption chiller, the cooling tower is run in an energy-saving manner to keep power consumption low. The fan speed is controlled by the frequency inverter, which is included in the installation package. The cooling tower sump has an integrated and easily cleanable double coarse filter for particle sizes of between 2,2mm and 1,2mm, to prevent a contamination of the back-cooling system by insects or pollen.

Another very promising system available is the hybrid coolers, which are actually dry coolers fitted with water sprays to increase its performances. And of course, the chiller can be operated as well with a dry cooler, but this is still not a mature point.

Technical Data:

Specifications		Unit	wct23kW
Heating performance		kW	23
Water quantity		m³/h	2,6
Hot water temperature		°C	35
Cold water temperature		°C	27
Moist air temperature		°C	21
Air temperature		°C	30
Hydraulic connection			2 x 1" AG
Pressure drop nozzle		mbar	430
Sump volume		l	70
Max. additional water needs due to evaporation		l/h	26
Hydraulic connection addtional water			½" AG
Rotational speed		U/min	0 - 1420
Max. air quantity		m³/h	7300
Noise level at maximum speed		dB(A)	65
Max. power consumption		kW	0,37
Voltage		V	1~ 200 – 240V
Protective system			IP55
Dimensions incl. connections	Height H Width B Depth T	mm mm mm	1850 1000 610
Weight	Operation Transport	kg kg	70 150

3.2 Collectors

The collectors provided with the SONNENKLIMA Solar Combi + kits are flat plate collectors produced by a partner company: Phönix Sonnenwärme. This company usually offers solar domestic hot water and solar heating complete installations. Nevertheless, SONNENKLIMA is also able to provide his Solar Combi+ kit with another type of collectors.

Phönix Infinity 3 collector description:

• Long lifetime due to high quality "Made in Germany"

• Maximum system performance due to environment friendly vacuum coated total-surface-absorber

• Simple and cost-saving installation due to a proven mounting-system and light collectors

• Very flexible mounting-alternatives due to an around-going mounting-slot

• Total-surface-absorber with high-selective eta Plus-cover for the optimized yield

• Collector is suitable for Pitch- and Flat-Roof-Mounting

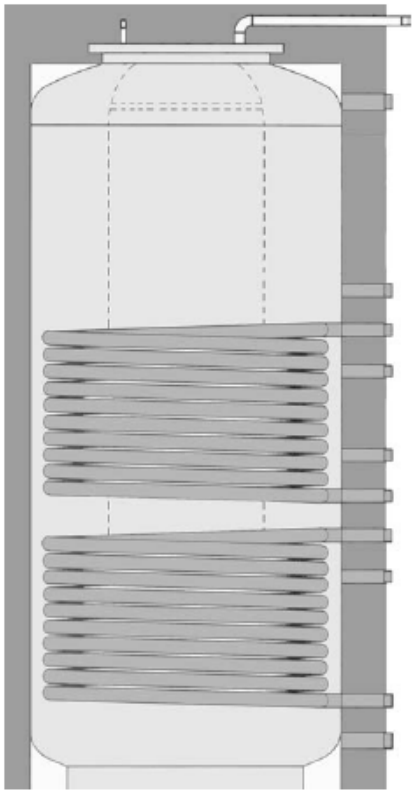
• Powder-coater collector frame in three colors: brown (RAL 8019), anthracite (RAL 7016), silver (RAL 9006)

Technical data	
Collector dimension (HxBxT)	1,87 x 1,15 x 0,095 m
Gross area	2,15 m²
Absorber coating	eta plus_Al, highly selective
Absorbency	95 %
Optical efficiency	80,1 %
Weight	34 kg
Warranty	general terms and conditions of the PHOENIX SonnenWärme AG

Type	PHÖNIX Infinity 3
Manufacturer	PHÖNIX SonnenWärme AG
Minimum collector slope	20°
Emissivity	5%
Efficiency factors	$k_1 = 3{,}65$ W/m²K $k_2 = 0{,}0169$ W/m²K²
Max. stagnation temperature	203°C
Heat transfer medium capacity	1,13 litre
Effective absorber area	2,0 m²
Test reports	collector test report by ISFH ISO 12975-1/2, Solar Keymark

3.3 Storage Tank

The storage tank provided with the SONNENKLIMA Solar Combi + kit is also produced by the same partner company: Phönix Sonnenwärme. By default, the solar heating/cooling kit will be supplied with the Phönix Sonnenwärme "Universal Buffer Storage Tank, Type UPK", but of course, the kit can also be provided with another type of tank.



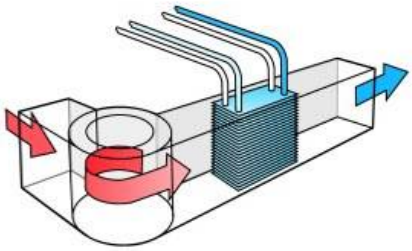
Phönix tank description:

- Storage tank capacity: 650, 450 and 200 litres
- Material: Steel or Stainless steel
- Heat exchangers: 2 tube heat exchangers, each with a surface area of 2.00 m2
- Connections: Heating: 1" and 5/4" external thread, flat gasket; hot and cold water and circulation: 3/4" external thread, flat gasket; solar supply and return: 1" external thread, flat gasket; vent: 3/8" external thread
- Circulation: Connection through 3/4 " external thread, flat gasket is possible (only recommended for a time- or thermostat-controlled circulation pump)
- Insulation: Polyurethane foam, 100 mm, replaceable. Top (130 mm) removable, inspection tap via flange cover, D = 0,037 W/mK
- External dimensions with insulation: 1.98 m x 0.90 m

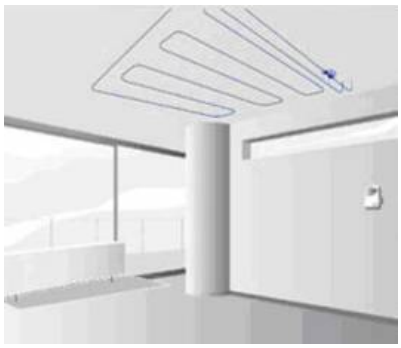
3.4 Distribution system

The distribution system technology implemented for the heating and cooling can be fan coils or a radiant technology system (cooling ceiling). Usually, the cooling ceilings lead to the best performances.

SONNENKLIMA doesn't recommend any special distribution system; either a fan coil system or a cooling ceiling can fit to the SK Solar Combi + installation. However, if the building already exists, it is possible that a fan coil distribution system be already installed, and moreover the fan coils technology is far easier to implement.



Fan Coil Scheme



Cooling Ceiling Scheme

4 System schematics

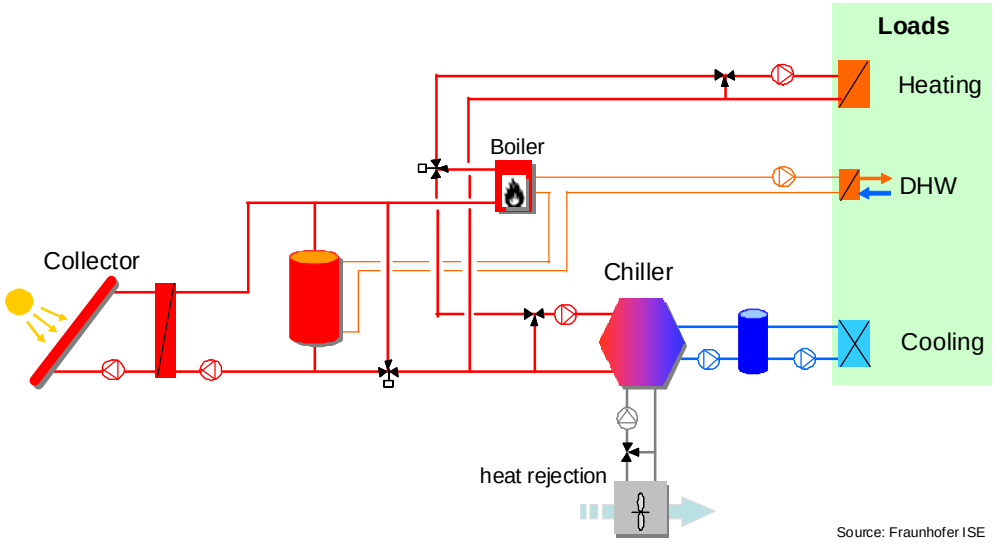
Two different configurations were designed by SONNENKLIMA: The first one is equipped with a hot backup system; the second one is equipped with a reversible hot/cold heat pump backup.

→ Two approaches: Backup chiller or Backup load supply

Monovalent systems or gas fired backup for SC+ (Heating + DHW)

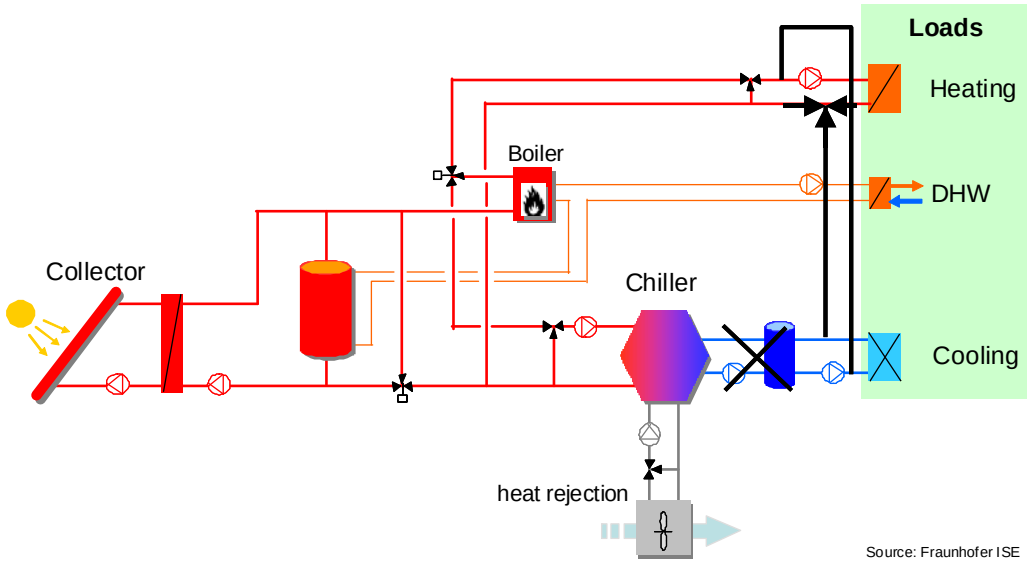
Reversible Heat pump backup

The SONNENKLIMA configuration used for the simulation and preparation of the package solution can be represented by the following scheme:

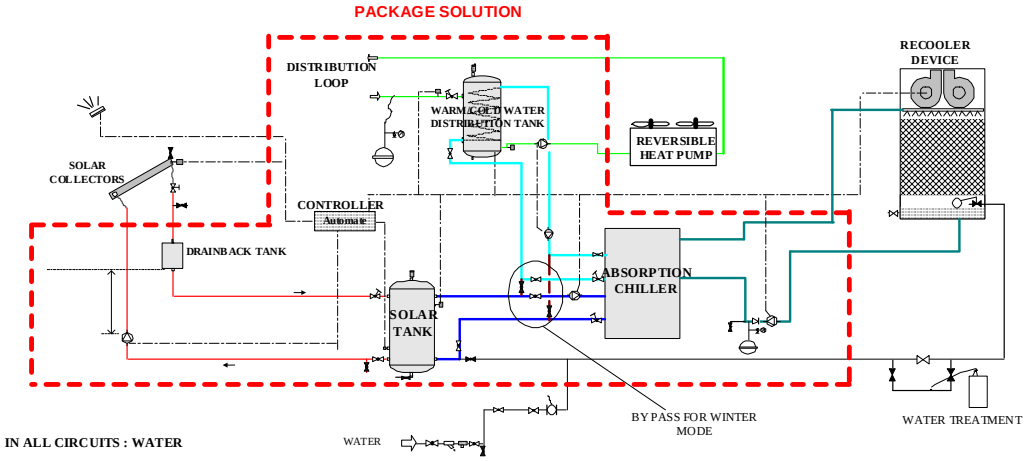


From this starting point, according to the results presented in the next chapter and according to the SK marketing strategy, two approaches were adopted corresponding to 2 types of back up:

Back up chiller : monovalent systems or gas fired back up for SC+ package solution (heating + DHW in addition)



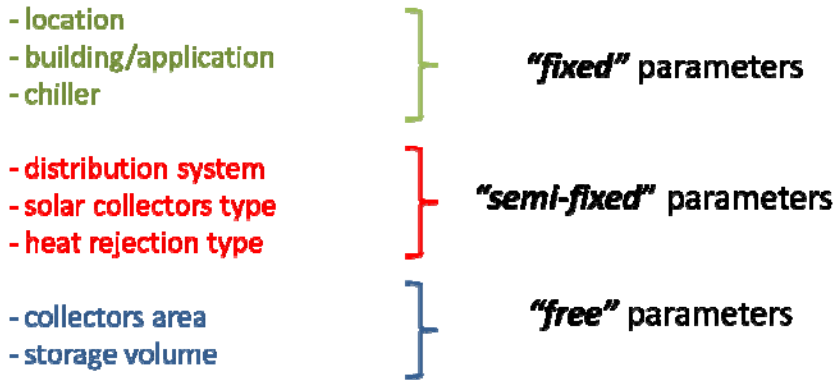
Back up load supply : reversible heat pump as a back up



5 Proposed Package Solution

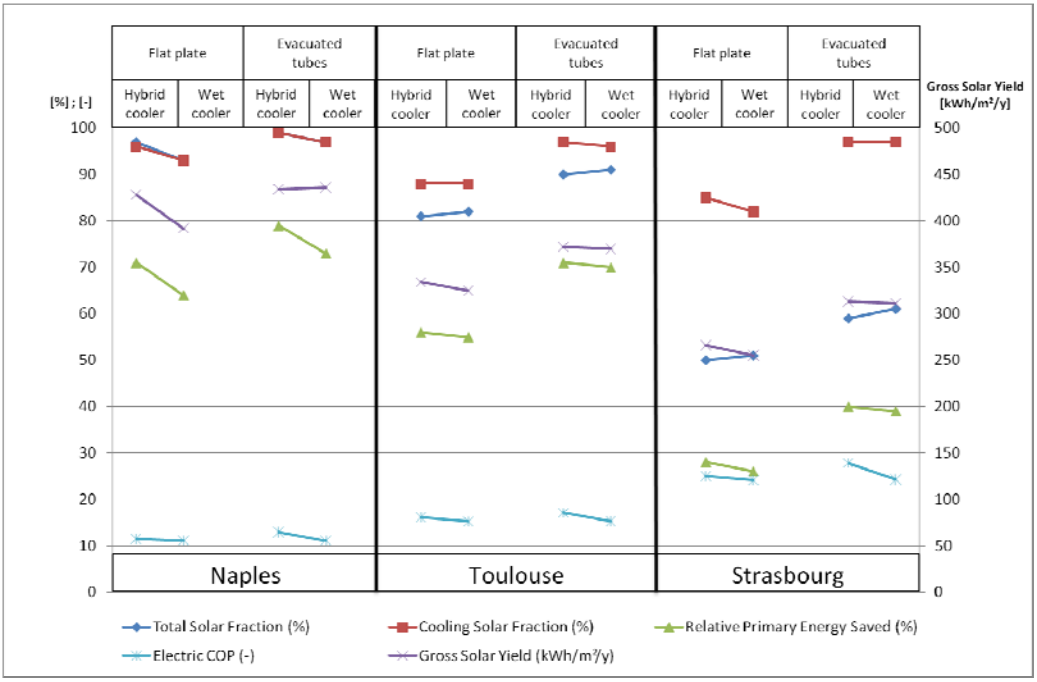
SONNENKLIMA designed in collaboration with Tecsol two packaged solutions to provide solar cooling, heating, and domestic hot water. The first one is equipped with a hot backup system; the second one is equipped with a reversible hot/cold heat pump backup.

Several parameters have to be taken into consideration and sized carefully. Some of these parameters are fixed for the considered project like the location of the project, the type of building where the SolarCombi+ system will be established, or the type of chiller (the chiller used in the SONNENKLIMA SolarCombi+ package is the 10kW SUNINVERSE chiller). Other parameters are semi-fixed like the distribution system (fan coil or cooling ceiling), the solar collector type (flat plate or evacuated tube), and the heat rejection type (cooling tower, dry cooler, or hybrid cooler: dry cooler and water sprays). The others parameters like the collector area or the storage volume are free (but still limited by a certain range…)



Calculations were performed using the program TRNSYS taking into account a lot of parameters variations, and the results were stored and analyzed.

For example as seen in the graph below, the total solar fraction, the cooling solar fraction, the relative primary energy saved, the electric COP, and the gross solar yield can be plotted depending on the system parameters. For this example, the location (Naples, Toulouse, Strasbourg), the type of collector (flat plate or evacuated tubes), and the heat rejection system (hybrid cooler or wet cooler) vary, and the other parameters are fixed: we choose fan coil for the distribution system, the building is an office building, the collectors area is 5 m^2/kW_{ref}, and the storage volume is 75 l/m^2.



For this example it is noticeable that globally, the evacuated tubes collectors present the best performances. In opposition to every other values, the electric COP is better in Strasbourg that in Naples. And apparently a hybrid cooler is almost always better than a wet cooler.

Other calculations using the program TRNSYS was performed in order to cover a large range of parameter variations, and so to have a large range of results. Thanks to these results, the best configurations was identified and summarized in the three next tables for the three different climate zones:

Strasbourg	Residential/office	suninverse

	WC		DC		HC	
FC	ET	FP	ET	FP	ET	FP
					✓	
CC	ET	FP	ET	FP	ET	FP
					✓	

Toulouse	Residential/office	suninverse

	WC		DC		HC	
FC	ET	FP	ET	FP	ET	FP
					✓	✓
CC	ET	FP	ET	FP	ET	FP
					✓	✓

Naples	Residential/office	suninverse

	WC		DC		HC	
FC	ET	FP	ET	FP	ET	FP
						✓
CC	ET	FP	ET	FP	ET	FP
						✓

Table caption:

WC = Heat rejection system: Wet cooler (cooling tower)
DC = Heat rejection system: Dry cooler
HC = Heat rejection system: Hybrid cooler
FC = Distribution system: Fan coil
CC = Distribution system: Cooling ceiling
ET = Collector type: Evacuated tubes
FP = Collector type: Flat plate

This results permit to conclude that for a Strasbourg climate, the hybrid cooler is the most adapted rejection heat system, either fan coil or cooling ceiling can be used as a distribution system, and the evacuated tubes collectors are better for this cold climate. For a Toulouse climate, the hybrid cooler is the most adapted rejection heat system, either fan coil or cooling ceiling can be used as a distribution system, and also either evacuated tubes collectors or flat plate collectors can be used. For a Naples climate, the hybrid cooler is the most adapted rejection heat system, either fan coil or cooling ceiling can be used as a distribution system, and the flat plate collectors are better for this warm climate.

Then the parameters which were free have to be determined. Calculations led to the following results:

- Recommendation of a single distribution system (FC) depending on customer needs.
- Storage<2m³
- Collectors aperture surface 35-45m²

6 Summary

Solar Combi + installations, which provide domestic hot water, heating and air-conditioning to a building, could have considerable primary energy savings and total electrical efficiency improvements compared with conventional systems. The good performances of the system depend on a correct design of the hydraulic scheme as well as its control strategy.

Different adsorption/absorption chillers were simulated for the SolarCombi+ project. The schemes provided primary energy savings in the locations defined (Toulouse, Naples and Strasbourg), for different variables values.

These innovative installations have high design and engineering cost that could be substantially reduced using the proposed kit or package solution. This is the main reason to design and define a kit for SolarCombi+ installations. Basically, the advantages of the kit will be cost reduction, quality improvement and easy assembly.

The kit provides high versatility, allowing the use of different auxiliary heat supply as well as heat rejection and distribution systems, depending on the specific case. The control will be oriented to improve the performance in the most efficient way, avoiding backup primary energy consumption whenever it's possible. The manufacturer will define some control temperatures with the aim to reduce energy consumption and provided comfort to the user.

7 Annex I: PHÖNIX Infinity 3 Brochure

PHÖNIX Infinity 3

Flat plate collector
Gross area 2,15m²

- Long lifetime due to high quality "Made in Germany"
- Maximum system performance due to environment-friendly vacuum coated total-surface-absorber
- Simple and cost-saving installation due to a proven mounting-system and light collectors
- Very flexible mounting-alternatives due to an around-going mounting-slot
- Total-surface-absorber with high-selective eta Plus-cover for the optimized yield
- Collector is suitable for Pitch- and Flat-Roof-Mounting
- Powder-coater collector frame in three colours: brown (RAL 8019), anthracite (RAL 7016), silver (RAL 9006)

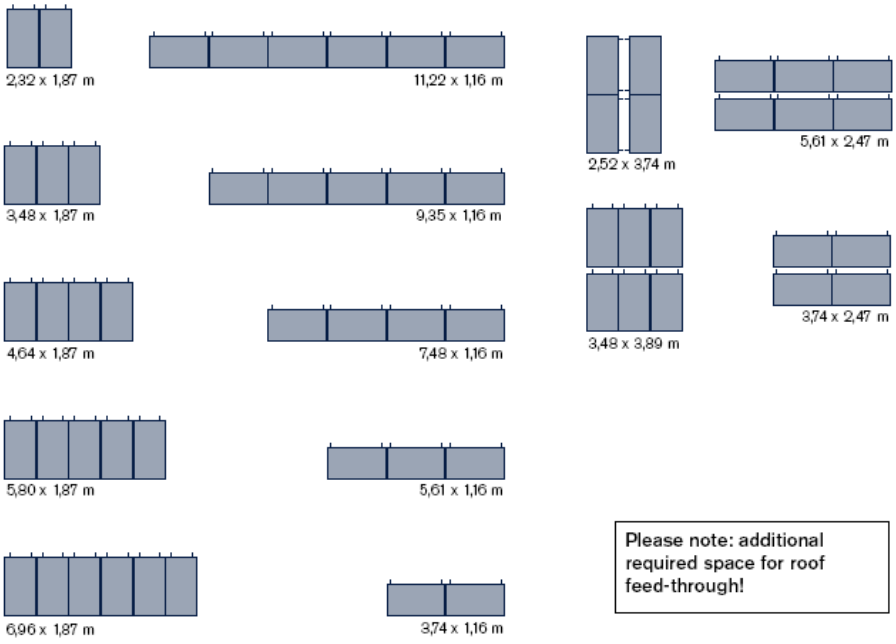
Technical data

Collector dimension (HxBxT)	1,87 x 1,15 x 0,095 m
Gross area	2,15 m²
Absorber coating	eta plus_Al, highly selective
Absorbency	95 %
Optical efficiency	80,1 %
Weight	34 kg
Warranty	general terms and conditions of the PHOENIX SonnenWärme AG

PHÖNIX SonnenWärme AG

Type	PHÖNIX Infinity 3
Manufacturer	PHÖNIX SonnenWärme AG
Minimum collector slope	20°
Emissivity	5%
Efficiency factors	$k_1 = 3{,}65$ W/m²K $k_2 = 0{,}0169$ W/m²K²
Max. stagnation temperature	208°C
Heat transfer medium capacity	1,13 litre
Effective absorber area	2,0 m²
Test reports	collector test report by ISFH ISO 12975-1/2, Solar Keymark

Collector installation possibilities (Length x Height) :



Please note: additional required space for roof feed-through!

Presented by:

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www.sonnenwaermeag.de

8 Annex II - SolarCombiPlus SONNENKLIMA Solar cooling brochure

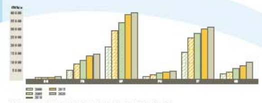
Increasing Interest In Air-Conditioning

The demand for air-conditioned rooms is growing. However, since conventional air-conditioning systems consume a lot of energy, air-conditioning has, up to now, been expensive and has increased the load on power networks. The high power consumption of conventional air-conditioning systems is putting an increasing strain on the global climate, due to their high emissions of greenhouse gases.

For example, the energy demands for air conditioning in Germany have increased from 71 GWh/a (2000) to 122 GWh/a (2005), which is a 72% increase over a period of five years. For the same period of time, the EU-15 countries showed a 51% hike in consumption.

This increasing interest in air-conditioning technologies can be explained by a stronger wish for comfort, growing internal and external cooling loads due to the use of electrical devices, and the use of more and more glass on buildings.

At the same time, the cost of electricity for private households, small businesses, trades and commerce, authorities and service providers, as well as all industries, has increased significantly.



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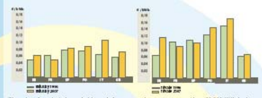

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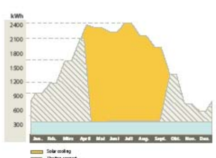
Source: EUROSTAT 11/2007.

Solar Cooling - 3

Solar Cooling - Use of existing potentials

Illustration: Solar installation for the solar cooling of the Centre for Environment and Technology [CUT] in Osnabrück.
Source: SK SonnenKlima, 2005.



The diagram shows the energy yield of a solar cooling and heating system consisting of a 40m² gross collector surface and the sun*inverse* absorption chiller.
Source: Measurements 2004, SK SonnenKlima GmbH.

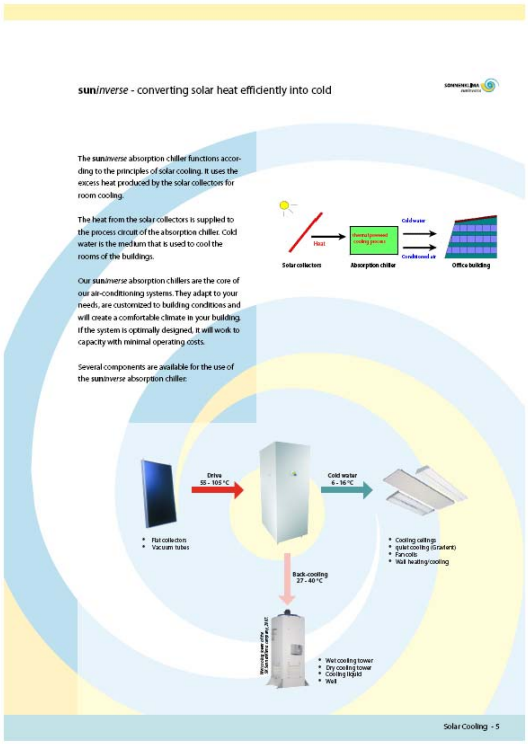
Electricity and heat are increasingly produced from renewable energies. Notably, many private households are choosing to install solar systems for their home heating and cooling needs. Undoubtedly one of the many arguments for a decentralized energy supply is the growing cost.

However, in the summer, the opportunities provided by solar installations are not yet used to their maximum potential. The large amount of heat produced is not needed, since the heating requirements are very low during this season. - Solar installations are therefore not working to capacity; and they are not working for long periods of time. This is especially true for big thermal solar installations.

With this in mind, the sun*inverse* absorption chiller was developed to serve two purposes - to make efficient use of existing solar installations, and to satisfy the need for cooling. It uses the excess energy/heat produced during the summer months for the cost-efficient and climate neutral air-conditioning of buildings. In this case, the peaks of heat availability, that are typical of solar installations, overlap with the peak demands for building cooling.

The primary energy demand for building air-conditioning (i.e. heating and cooling) can be significantly reduced through the year-round use of the solar installation.

4 - Solar Cooling



sun*inverse* - converting solar heat efficiently into cold

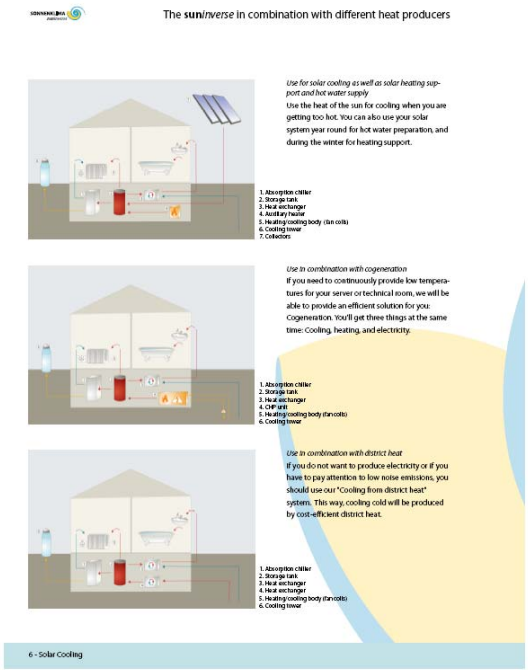
The sun*inverse* absorption chiller functions according to the principles of solar cooling. It uses the excess heat produced by the solar collectors for room cooling.

The heat from the solar collectors is supplied to the process circuit of the absorption chiller. Cold water is the medium that is used to cool the rooms of the buildings.

Our sun*inverse* absorption chillers are the core of our air-conditioning systems. They adapt to your needs, are customized to building conditions and will create a comfortable climate in your building. If the system is optimally designed, it will work to capacity with minimal operating costs.

Several components are available for the use of the sun*inverse* absorption chiller:

Solar Cooling - 5



The sun*inverse* in combination with different heat producers

Use for solar cooling as well as solar heating support and hot water supply

Use the heat of the sun for cooling when you are getting too hot. You can also use your solar system year round for hot water preparation, and during the winter for heating support.

1. Absorption chiller
2. Storage tank
3. Heat exchanger
4. Auxiliary heater
5. Heating/cooling body (fan coils)
6. Cooling tower
7. Collectors

Use in combination with cogeneration

If you need to continuously provide low temperatures for your server or technical room, we will be able to provide an efficient solution for you: Cogeneration. You'll get three things at the same time: Cooling, heating, and electricity.

1. Absorption chiller
2. Storage tank
3. Heat exchanger
4. CHP unit
5. Heating/cooling body (fan coils)
6. Cooling tower

Use in combination with district heat

If you do not want to produce electricity or if you have to pay attention to low noise emissions, you should use our "Cooling from district heat" system. This way, cooling cold will be produced by cost-efficient district heat.

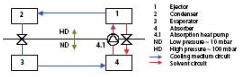
1. Absorption chiller
2. Storage tank
3. Heat exchanger
4. Heat exchanger
5. Heating/cooling body (fan coils)
6. Cooling tower

6 - Solar Cooling

The principle of the absorption chiller - cooling made of heat

The sun*inverse* absorption chiller uses two environmentally friendly substances to produce cold: a very hygroscopic salt - lithium bromide (LiBr) - and ordinary distilled water.

Lithium bromide (LiBr) serves as a solvent in the single-stage process circuit, and water serves as a cooling medium. In the absorber, LiBr is totally hydrated by water according to the absorption principle. The result is a homogenous two-component mixture.



The different steps in the circuit:

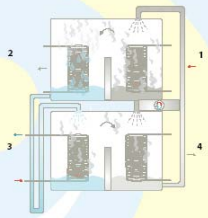
Ejector (1): At very low pressure, the LiBr is separated from the water using the drive heat (55-105°C). The water is changed into vapour, and the LiBr sinks down into the absorber.

Condenser (2): By removing heat, the vapour is liquefied and becomes water. The water sinks down into the low pressure zone.

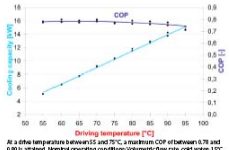
Evaporator (3): At very low pressures, a temperature of 5-15°C is sufficient to make the water evaporate again. The required heat is taken from the environment and will produce the desired effect: Cooling.

Absorber (4): The cooling medium vapour is attracted by the salt (LiBr) and is dissolved in the water by heat radiation. The solution is pumped into the ejector, and the circuit is closed.

Two special physical characteristics are used for the process circuit: Liquids can be moved between two pressure levels with little mechanical effort, and liquids can evaporate at low pressures and very low temperatures.



The sun*inverse* - ideal for use in solar cooling

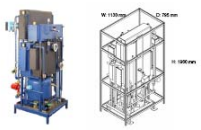


At a drive temperature between 65 and 75°C, a maximum COP of between 0.78 and 0.80 is attained. Nominal operating conditions: Volumetric flow rate, cold water: 13°C, cooling water: 27°C.

Source: TU Berlin, 2007.

$$COP = \text{Wärmeverhältnis} \frac{\text{refrigerating performance [kWthermal]}}{\text{drive performance [kWthermal}} = 0,78$$

No.	Standard performance	Drive performance	Full-cooling performance	Cooling surface	Required cooling water inflow	Dimensions (mm)	Weight (kg)
1	16 kW	15 kW	28 kW	~300 m²	35 – 40 m³	H. 1960 B. 730 T. 780	Transport: 505 Operation: 559
2	16 kW	24 kW	40 kW	~350 m²	40 – 44 m³		



The thermal absorption chiller sun*inverse* from SK Sonnenklima GmbH operates with minimal use of electrical energy, and produces cooling from solar heat.

The quality of the absorption process of the chiller is expressed with the Coefficient of Performance (COP).

Sun*inverse* attains a high thermal coefficient of performance (COP = 0.78) and has good partial load behaviour.
One kilowatt hour of thermal drive energy produces approximately 780 Wh of cooling energy.

The absorption chiller sun*inverse* operates with different system components at different operating points. The associated performance values were taken from our demonstration projects that served to test different systems in continuous operation in customer-oriented applications.

Apart from use in new buildings and the combination possibilities with district heat or cogeneration, the sun*inverse* is easily compatible with existing water-based cooling systems.

The solar operation guarantees minimal operating costs, and thus reduces the consumption of electrical energy. In addition, the use of a harmless cooling medium makes the operation of the machine environmentally friendly.

Its small size allows sun*inverse* to be easily transported (through doorways).
The choice of the installation site can be made without taking having to take into consideration the noise level. The machine runs very quietly and needs very little maintenance due to its superior design.

Our offer for solar cooling

SK SonnenKlima GmbH cares for and supports customers, together with many distributors, all over Europe from the first questions about solar cooling until the installed system is functioning. Consultations take into account customer needs and individual conditions, in order to recommend the correct components for an optimal system. Once sunniverse is installed, we take care of measurements, regulations, maintenance and control of the whole system to guarantee smooth operation.

Our scope of services includes:

- Consulting
- Planning
- Project management
- Transport
- Installation
- Start-up
- Maintenance
- Online control

We offer our customers an exclusive service and a guarantee for the optimal use of each component. The specialist service provided by our engineers ensures a long lifetime for the system, the optimal amortization of your investment and, last but not least, rooms with a comfortable climate.

Our online control is an additional service that allows us to evaluate the functionality of your system, at any time, and to make corrections if needed.

Our scope of delivery includes:

- Absorption chiller
- Back-cooling (e.g. wet cooling tower)
- Regulating unit incl. data logging unit for outside temperatures and volumetric flows/performances
- Visualization and remote control (internet connection required)
- Temperature sensors for hot, cooling and cold water
- Hot water pump and three-way mixing valve for temperature regulation

Investment in the future

Versatility

Solar cooling can be used everywhere where the sun shines, ensuring that a lot of solar heat is available. However, sunniverse can also be combined with many other heat transfer mediums, as a drive to air-condition rooms.

The significant savings of electricity, and the related reduced operating costs compared to conventional air-conditioning systems are - together with climate neutrality - convincing arguments for solar cooling.

Loan Programs in Germany

Loans are available, from the German Federal Office of Economics and Export Control (BAFA), for the installation of thermal solar systems and/or solar collectors for hot water preparation (for the supply of process heat, for solar cooling), or for heating support. However, even at the countries or regional levels, loans are available for installations that meet the regulations of the German Energy-Savings Ordinance (EnEV).

Types of financial assistance/subsidies:

- Grants
- Combinations are possible, as long as the sum of credits, grants and financial assistance does not exceed the expenses.

Contact

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Our associated partners in Europe are:

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enus
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Brochure sponsored by:

dena

Date: November 2007; errors excepted.

9 Annex III – SolarCombiPlus SONNENKLIMA SUNINVERSE technical data

SONNENKLIMA
suninverse

Absorption chiller 10 kW

technical data
(demonstration project design)

minimum operation temperature 55° C
COP ≅ 0.78

Included in delivery

Absorption chiller

Wet cooling tower with nominal capacity of 25 kW

Control unit including data logger for external temperatures and mass flows

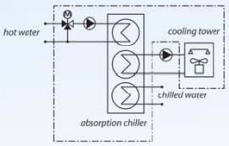
Visualisation, remote control- and supervision (broad band connection required)

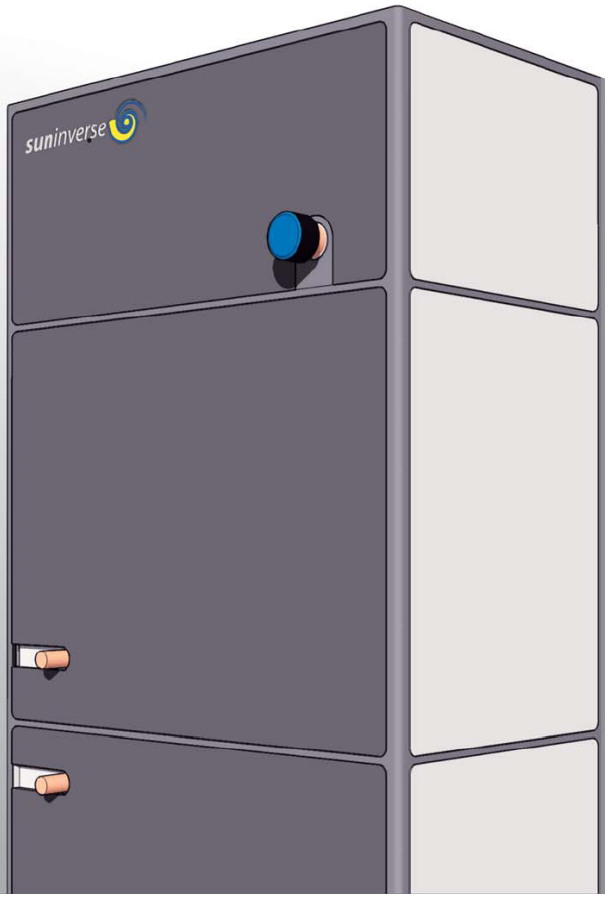
Temperature sensor for hot-, cold- and chilled water

Hot water pump and three-way-valve for chilled water temperature control

Note:

Cool- and chilled-water-pump are not inlcuded in delivery. All work outside the dashed line (– · – · –) will not be done by SK SonnenKlima GmbH.





SONNENKLIMA
suninverse

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EFRE

Absorption chiller 10 kW (demonstration project design)

view without case

Note:

1. The refrigerating capacity depends on supply temperature and mass flow of hot-, cool- and chilled-water. The given refrigerating capacity refers to the chillers nominal operation. At demand we are glad to deliver data for differing temperatures.
2. Maximum pressure for hot and chilled water circle: 2.5 bar.
3. Chiller ´s control unit contains a data logger for external powers in hot- cold- and chilled water circle. For the remote data transfer and supervision a broad band connection is necessary.
4. Hot water pump and three-way-valve are included in delivery.

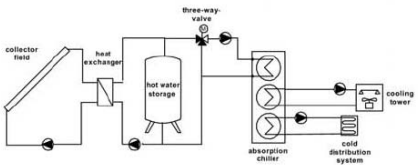
Technical data (demonstration project design)

specifications		unit	*sun*inverse	
			operation with fan-coils	operation with ceiling
refrigerating capacity nominal/maximal		kW	8,8 / 11,7	10 / 15,8
		USRT	2,5 / 3,3	2,8 / 4,5
		BTU/h	30026 / 39932	34120 / 53925
chilled water circle	temperature nominal/maximal (out - in)	°C	6-12	15-18 / 15-20
	mass flow nominal/maximal	m³/h	1,3 / 1,7	2,9
	internal pressure drop	mbar	350	
	connection		1 ½" outside thread, flat sealing	
hot water-circle	temperature nominal/maximal (in)	°C	85 / 95	75 / 95
	mass flow nominal/maximal	m³/h	1,2	1,2
	internal pressure drop	mbar	200	
	connection		1 ¼" outside thread, flat sealing	
cold water-circle	temperature nominal/maximal (in - out)	°C	35-27 / 36-27	35-27 / 39-27
	mass flow nominal/maximal	m³/h	2,6	2,6
	internal pressure drop	mbar	320	
	connection		1 ½" outside thread, flat sealing	
electrical connection	voltage	V	230 V ~ 1 ph 50Hz	
	solution pump	W	70	
	refrigertion pump	W	50	
dimensions	height H	mm	1960	
	width B	mm	1130	
	depth T	mm	795	
weight	operation	kg	550	
	transport	kg	500	

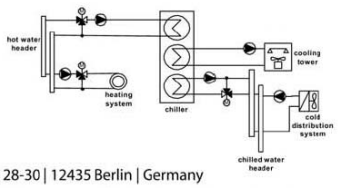
subject to change without prior notice

Recommended system structure

(A) Solar cooling



(B) District heating or CHP
(combined heat and power unit)



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10Annex IV – SolarCombiPlus SONNENKLIMA SUNINVERSE technical description

sun*inverse*

Technical Description

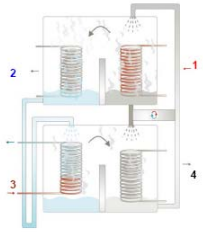
Contents

Function of the sun*inverse* absorption chiller

SK SonnenKlima GmbH has developed a one-stage absorption chiller that functions with harmless and climate-neutral substances, lithium bromide (a salt) and ordinary distilled water. The principal of absorption chilling is quite simple:

The energy of the drive evaporates the cooling medium, water, thus separating it from its carrier, lithium bromide. Then, the cooling medium is liquefied in the condenser. In the subsequent expansion zone, the water is rapidly cooled down and can therefore absorb the room heat, for example using a convector, and the room temperatures will go down. The heat absorbed from the room is released - i.e. the energy required for the separation of the water and lithium bromide - via the cooling tower into the atmosphere.

SK SonnenKlima GmbH's newly developed absorption chiller offers significant advantages over other systems that have been available on the market: The machine functions with low-temperature heat, starting at 55°C, that can be produced by waste heat (for example from a CHP unit) or by district heat.



- **Ejector (1):** At very low pressure, the LiBr is separated from the water using the drive heat (55-105°C) das LiBr. The water is changed into vapour, the LiBr sinks down into the absorber.
- **Condenser (2):** By heat removal, the vapour is liquefied and becomes water. The water sinks down into the low pressure area.
- **Evaporator (3):** At very low pressures, a temperature of 5-15°C is sufficient to make the water evaporate again. The required heat is taken from the environment and will produce the desired effect: *Cooling*.
- **Absorber (4):** The cooling medium vapour is attracted by the salt (LiBr) and dissolved in the salt by heat radiation. The solution is then pumped into the ejector. The circuit is closed.

The system has a very good efficiency over the entire operation range so that good results are obtained, even with varying solar radiation and in the partial-load range (see "Performance chart for suninverse®). With a COP of 0,78 that can be attained by the system, about 780 watthours of cooling energie are produced out of 1000 watthours of thermal energy.

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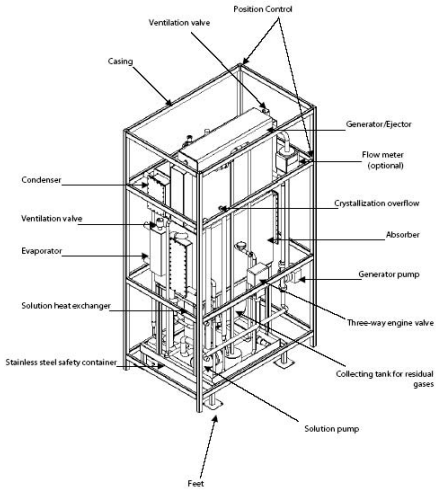
Design of the sun*inverse* absorption chiller



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Page 4 of 13

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Technical data for sun*inverse* absorption chiller

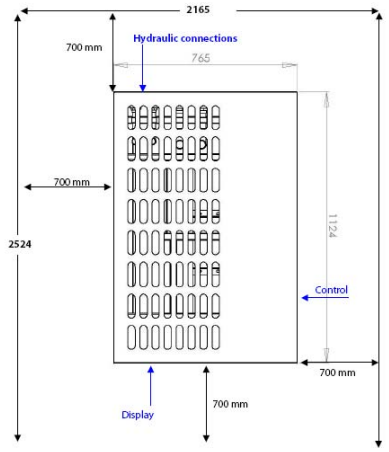
specifications		unit	*suninverse*	
			operation with fan-coils	operation with ceiling
refrigerating capacity nominal/maximal		kW	8,8 / 11,7	10 / 15,8
		USRT	2,5 / 3,3	2,8 / 4,5
		BTU/h	30026 / 39932	34120 / 53925
chilled water circle	temperature nominal/maximal (out - in)	°C	6-12	15-18 / 13-20
	mass flow nominal/maximal	m³/h	1,3 / 1,7	2,9
	internal pressure drop	mbar	350	
	connection		1 ½" outside thread, flat sealing	
hot water-circle	temperature nominal/maximal (in)	°C	85 / 95	75 / 95
	mass flow nominal/maximal	m³/h	1,2	1,2
	internal pressure drop	mbar	200	
	connection		1 ¼" outside thread, flat sealing	
cold water-circle	temperature nominal/maximal (in - out)	°C	35-27 / 36-27	35-27 / 39-27
	mass flow nominal/maximal	m³/h	2,6	2,6
	internal pressure drop	mbar	320	
	connection		1 ½" outside thread, flat sealing	
electrical connection	voltage	V	230 V ~ 1 ph 50Hz	
	solution pump	W	70	
	refrigertion pump	W	50	
dimensions	height H	mm	1960	
	width B	mm	1138	
	depth T	mm	795	
weight	operation	kg	550	
	transport	kg	500	

subject to change without prior notice

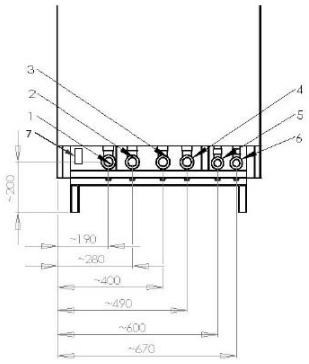
Page 5 of 13

Installation site and space requirement for the sun*inverse* absorption chiller

To give the installer easy access to all the components during the annual maintenance, we recommend the following:
leave about 70cm of space around it (wall, solar storage tank, etc.). Very important: the hydraulic connections and access the controls must be left free.



Connections and pitch measurements of the sun*inverse* absorption chiller

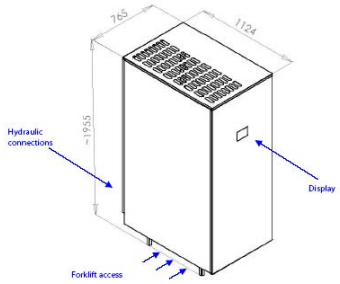


1 Cold water **outlet** 2 Cold water **inlet**	1½ " external thread, flat sealing
3 Cooling water **outlet** 4 Cooling water **inlet**	1½ " external thread, flat sealing
5 Hot water **inlet** 6 Hot water **outlet**	1¼ " external thread, flat sealing
7 Cable lead-through	Power supply for the control

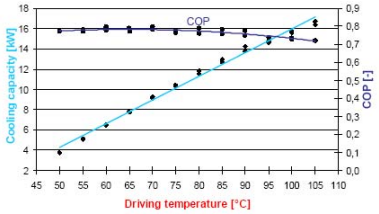
Packaging measurements of the sun*inverse* absorption chiller

Due to its dimensions, sun*inverse* can be easily be transported (fits through doors). The installation on feet allows for easy transportation of the system with a forklift or a forklift truck.

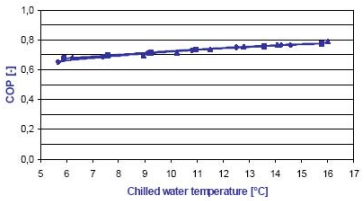
The choice of the installation site can be made without taking having to take into consideration the noise level. The machine runs very quietly and needs very little maintenance due to its advantageous design.



Performance charts for the sun*inverse* absorption chiller



Performance and thermal efficiency of sun*inverse* at different drive temperatures (Nominal conditions volumetric flows, 15°C cold water, cooling water 27°C).



Thermal efficiency of sun*inverse* at different cold and hot water temperatures (hot water 75-85-95°C, nominal conditions volumetric flows, cooling water 27°C).

The wet cooling tower – optimal back-cooling for the sun*inverse* absorption chiller

The open wet cooling tower wct23kW was specially designed for operation with the sun*inverse* absorption chiller from SK SonnenKlima GmbH. It functions according to the evaporation principle and is optimally adapted to the performance of the absorption chiller.
The make-up water requirements depend on the outside temperature, the operation period, and the requested average performance. During operation with the sun*inverse* absorption chiller, the cooling tower is run in an energy-saving manner to keep power consumption low. The fan speed is controlled by the frequency inverter, which is included in the installation package. The cooling tower sump has an integrated and easily cleanable double coarse filter for particle sizes of between 2,2mm and 1,2mm, to prevent a contamination of the back-cooling system by insects or pollen.

Technical Data:

Specifications		Unit	wct23kW
Heating performance		kW	23
Water quantity		m³/h	2,6
Hot water temperature		°C	35
Cold water temperature		°C	27
Moist air temperature		°C	21
Air temperature		°C	30
Hydraulic connection			2 x 1" AG
Pressure drop nozzle		mbar	430
Sump volume		l	70
Max. additional water needs due to evaporation		l/h	26
Hydraulic connection additional water			½" AG
Rotational speed		U/min	0 - 1420
Max. air quantity		m³/h	7300
Noise level at maximum speed		dB(A)	65
Max. power consumption		kW	0,37
Voltage		V	1~ 200 – 240V
Protective system			IP55
Dimensions incl. connections	Height H Width B Depth T	mm mm mm	1850 1000 610
Weight	Operation Transport	kg kg	70 150

The control – a solution for the entire solar cooling system

The control of the sun*inverse* absorption chiller is provided by the entire solar cooling system, including all components that are required for year-round operation. In the summer, the focus is on cooling, in the other seasons, on providing heat.

The system is equipped for remote control of solar cooling and heating, to ensure the optimal operational safety, and the latest version of the control software. The client only to have an internet connection for this reason.

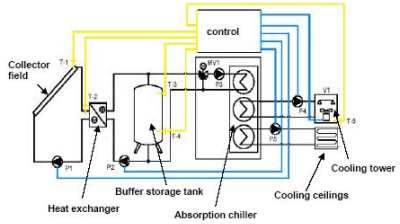


Illustration: Standard - Schema of solar cooling with control connections to the sensors (yellow) and actuators (blue). Shown are all the electrical connections that must be connected to the control during installation.

The sensors and actuators shown in the table below must be connected to the control on site by the technician. Although only a few trained technicians exist for solar cooling, it goes without saying that we will help you to find a competent technician.

Sensors	Function	Actuators	
T-1	Collector temperature	P1	Solar pump
T-2	Temperature Heat exchanger	P2	Storage charging pump
T-3	Storage tank temperature top	P4	Cooling tower pump
T-4	Storage tank temperature below	P5	Evaporator pump
T-5	Back-cooling temperature	V1	Cooling tower fan

To use the absorption chiller with district heat or other heat sources (such as a CHP unit), please contact us directly. We offer system solutions for many applications and can help you and give you advice for very specific applications.

For more detailed information, please visit our website www.sonnenklima.de, or contact us at the address below:

Address:

SK SonnenKlima GmbH
Am Treptower Park 28-30
D - 12435 Berlin

info@sonnenklima.de
Tel.: +49 (0) 30 53 00 07 700
Fax: +49 (0) 30 53 00 07 17
www.sonnenklima.de

Our associated partners in Europe are:

PHÖNIX SonnenWärme AG
www.sonnenwaermeag.de

enus
www.enus.de

Presented by:

Date: November 2007; errors excepted.

11 Annex V – SolarCombiPlus SONNENKLIMA Checklist

Part 1 General Data

Last Name: _____ First Name: _____

Email: _____

Street: _____

Postal Code: _____ City: _____

For companies/organisations/authorities:

Name: _____

_____

P.O. Box: _____

Street: _____

Postal Code: _____ City: _____

Contact: _____

Email: _____

Required System:

- ☐ Solar cooling
- ☐ Solar cooling and solar heating support/hot water
- ☐ Cogeneration (CHP unit)
- ☐ Other: _____

Part 2 System Data

Is there already air conditioning/a cooling system in the building?

☐ Yes

- ☐ Cooling ceiling: _____ m² active surface
- ☐ Quiet cooling (Gravivent): _____ m² active surface
- ☐ Fan coils: _____ m³/h air volume
- ☐ Wall heating/cooling: _____ m² active surface
- ☐ Other: _____

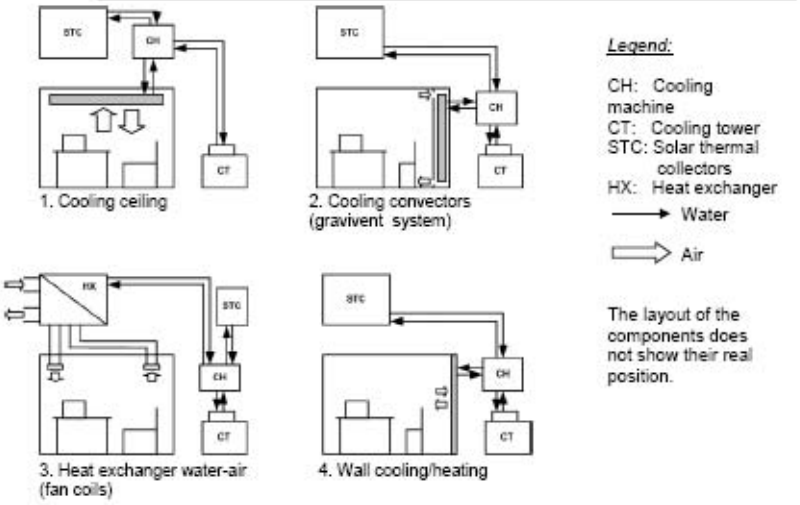
☐ No

What kind of air conditioning/cooling system is required in the building?

- ☐ Cooling ceilings
- ☐ Quiet cooling (Gravivent)
- ☐ Fan coils
- ☐ Wall heating/cooling
- ☐ Other: _____

What kind of return cooling system is required for the building?

- ☐ Wet cooling tower
- ☐ Dry cooling tower
- ☐ Cooling liquid
- ☐ Well
- ☐ Other: _____



Is there already a solar system in the building?

☐ Yes

☐ Flat collectors:	_____	m² absorber surface
☐ Vacuum tubes:	_____	m² absorber surface
☐ Air collectors:	_____	m² absorber surface
☐ Swimming pool absorber:	_____	m² absorber surface

☐ Other:

_____

☐ No
Which of the above systems would you prefer?

_____

Type of collector installation:

☐ Free standing or flat roof ☐ Tile roof mounting
☐ Roof-integrated mounting ☐ Wall mounting

Does a CHP unit already exist in the building?

☐ Yes, data below:

Thermal performance in kW: _____

Energy source: ☐ Oil ☐ Gas

Cooling water supply temperature: _____ °C

Cooling water flowrate: _____ Litre/h

☐ No
Which energy source would you prefer for your CHP unit, which thermal performance is required?

_____

Surface to be heated: _____ m²

Surface to be cooled: _____ m²

Height of the rooms: _____ m

If applicable:

Specific cooling needs: _____ kWh/m² a (a=year)

Specific heating needs: _____ kWh/m² a (a=year)

Use of the building:

- ☐ Single-family house (hot water consumption, mostly in the morning)
- ☐ Single-family house (hot water consumption, mostly in the evening)
- ☐ Apartment building
- ☐ Tourist apartment
- ☐ Office building
- ☐ Restaurant
- ☐ Authorities
- ☐ Retail store
- ☐ Youth hostel
- ☐ Student residence with restaurant
- ☐ Student residence w/o restaurant
- ☐ Senior residence
- ☐ Other: _____

Climate data:

City: _____

Geographical latitude/longitude: _____

Geodetic height above German reference surface (NN): _____

	Dec.	Jan.	June	July	Aug.	Year
Average outdoor temperature in °C						
Maximum outdoor temperature in °C						
Minimum outdoor temperature in °C						
Most frequent wind direction						
Average wind speed in m/s						
Average global sun radiation in kWh/m²						
Percentage of diffuse/direct sun radiation						
Precipitation in mm						
Relative air humidity %						

Climate data should be based on DIN 4710. (If unknown, please do not complete.)

Please specifiy any other sources of information _____

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