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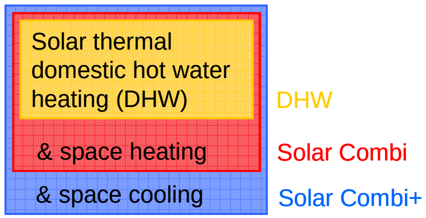
Small-Scale Solar Heating and Cooling Systems

Package Systems for Combined Air Conditioning, Domestic Hot Water Preparation and Space Heating

Standardized System Solutions
Package Solutions on the Market



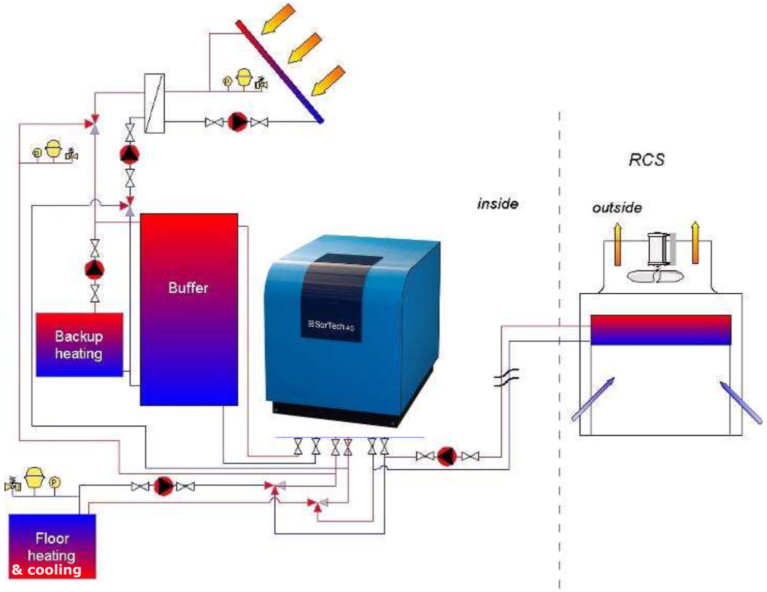
February 2010

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

What is a Solar Combi Plus System? 3
Most Promising Climatic Regions...4
Suitable Collector Technology 6
Standard System Configurations 9
Recommendations on System Design 11
Package System - Climatewell..14
Package System - SOLution 16
Package System - SorTech 18
Contact 20



Example: **Green Lighthouse Copenhagen**
First CO_2-neutral building in Denmark

Heat resource: 30 m² flat plate collector
Heat rejection: Drycooler with spraying (RCS 08)
Cooling: Fancoils, AHU
Engineering and Realization: COWI / Solar A/S / SorTech AG


Package System - SorTech

Cooling and Heating

Adsorption Chillers with 8 or 15 kW cooling capacity

SorTech AG develops, manufactures and distributes adsorption chillers in the small scale performance range. The chillers are compact, highly efficient and noiseless. The electricity consumption of an ACS 08 is only 7 W – this is unmatched worldwide. Driving temperature as low as 55°C is sufficient to drive the chillers. That’s why SorTech chillers are a perfect match for solar-driven cooling. Furthermore, the machines can also be used for heating assistance with the integrated heat pump mode.

As a contribution to the SolarCombi+ project efforts SorTech now offers auxiliary equipment to simplify planning and to facilitate installation and operation.

Hence, SorTech not only delivers adsorption chillers but also heat rejection systems, which are optimized for operation with the chillers and pump stations in different variations. Those pump stations include all necessary infrastructure for connecting the buffer store, heat rejection and cold distribution system to the chiller. Additionally, SorTech assists you in planning and design.

SorTech chillers have been installed in Germany, Austria, Switzerland, Italy, Spain, France and Greece. The systems consist of different components in the heat rejection and cold distribution system. The chillers work reliably especially at varying temperatures.

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What is a Solar Combi Plus System?

Solar combi plus systems use heat from solar thermal collectors to provide heating in winter, cooling in summer and domestic hot water (DHW) all year round. The figure below sketches the main components, which make up a typical system: (i) the solar thermal collector to provide the heat usually backed up by an auxiliary heat source, (ii) a storage tank can either be installed on the hot side, as shown in the figure, on the cold side or on both, (iii) a domestic hot water preparation unit, (iv) the sorption chiller is fed with hot water (70-100°C), (v) heat rejection at intermediate temperature (30-40°C) to a cooling tower (dry or wet) or another heat sink (e.g. a swimming pool), (vi) the cold distribution system (e.g. a chilled ceiling, fan-coils or air handling units) and (vii) the heat distribution (preferably a low temperature system).

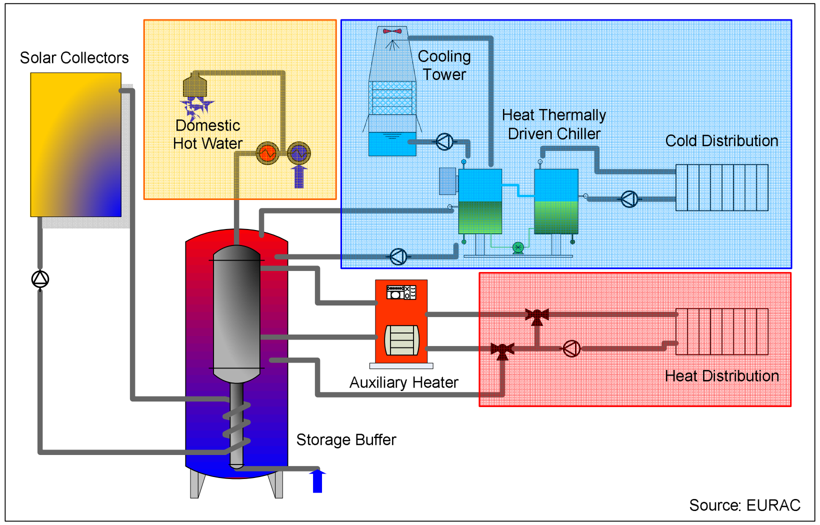


Figure 1 - Typical setup of a solar combi plus system

Most Promising Climatic Regions

Solar combi plus systems are most suitable for buildings with both heating and cooling demand. This depends first of all on the climatic conditions.

Figure 2 shows a map of the distribution of heating degree days in Europe. Heating degree days (HDD) are defined as the sum of the differences between the daily average indoor and outdoor temperature. An indoor temperature of 21°C was assumed. The map is divided into five different regions: The two regions with HDD above 5000 Kd are not considered suitable for solar combi plus systems because there is not enough need for cooling. On the other hand in the region below 3000 Kd, there are some areas with extremely little heating demand which can also be excluded.

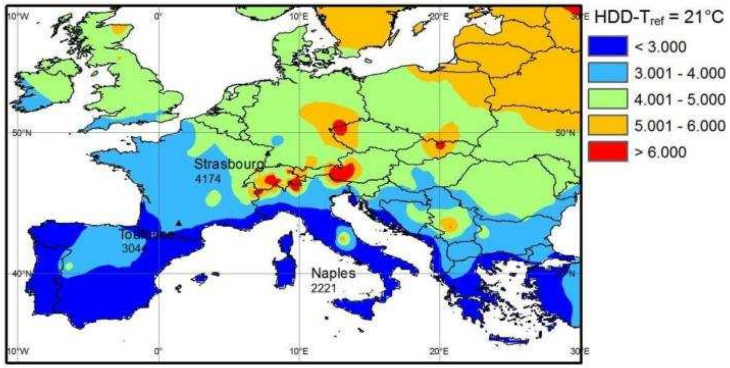
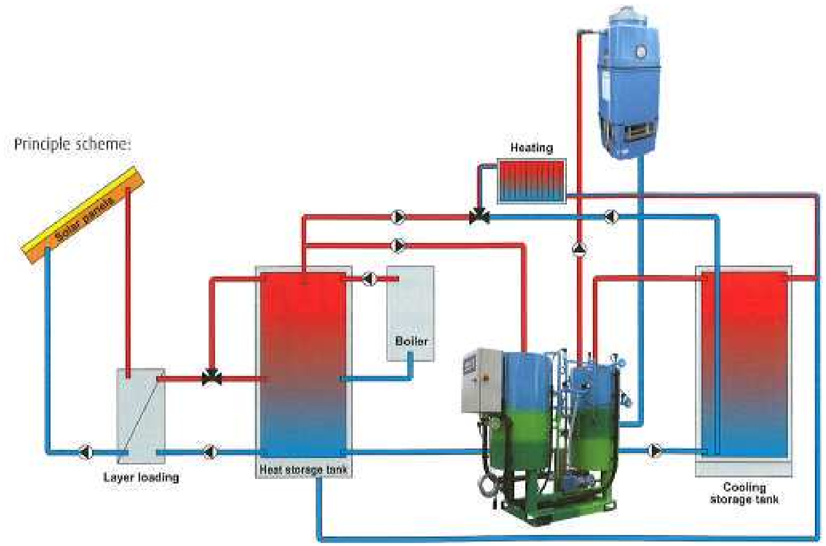


Figure 2 - Heating degree days in Europe

While the winter parameter (HDD) is a good figure for the heating needs of the building, the summer factor (CDD) can only be used for a first approximation because it does not take into account humidity (latent heat) and solar and internal

System Schematics



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SOL*ution* can also provide the following services to you:

- Technical support
- Engineering of projects
- Mounting of systems
- Start up of systems

Take a look at

www.sol-ution.com

and you will find more information about the company and the solar thermal systems SOLution can provide to you.

Package System - SOLution

SOLution offers absorption solar heating and cooling sets with a nominal chiller power of 15kW, 30 kW and 54kW (systems up to 200 kW upon request).

Liquid sorbent: Lithium Bromide

Refrigerant: Water

Example		
Chilled water 	Cooling capacity In Out Flow rate	15 kW 17°C 11°C 1.9 m³/h
Hot water 	Thermal power In Out Flow rate	21 kW 90°C 80.5°C 2 m³/h
Cooling water 	Thermal power In Out Flow rate	35 kW 30°C 36°C 5 m³/h
	Thermal COP of the chiller Electricity consumption	0.71 0.3 kW

gains, which in some cases contribute to a great extent to the cooling demand of a building. CDD are defined similarly to the HDD but with a reference indoor temperature of 26°C.

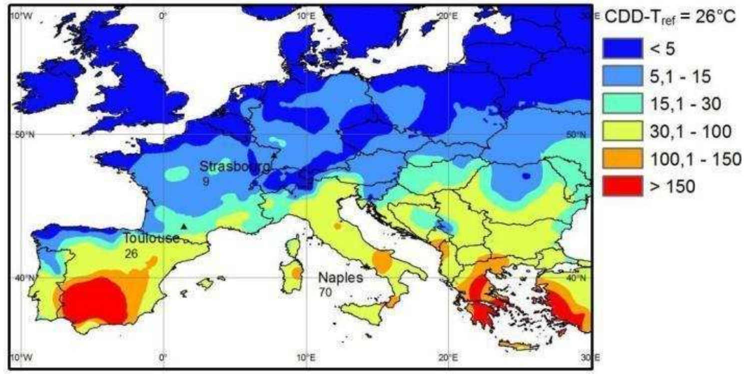

Figure 3 - Cooling degree days in Europe

The map in Figure 3 shows again different zones across Europe. In the blue zones, there is not much cooling demand and for residential buildings this cooling demand can be satisfied using passive cooling technologies rather than active systems. However, also in these Central European locations solar combi plus systems may be suitable for buildings with high internal gains (e.g. office buildings) or existing buildings with high solar gains where passive measures are not feasible.

As can be expected, Southern European countries are better suited for solar cooling systems than Central European climates because of higher cooling demand and more available solar radiation. However, only locations that have also significant heating demand are ideally suited for solar combi plus systems because the solar thermal collectors can be used year around for both heating and cooling.

Suitable Collector Technology

There are several different collector technologies available on the market. Which technology is best suited for a particular application depends on the needed operation temperature. For solar combi plus systems, there are 4 relevant temperature levels:

- 40°C for a low temperature space heating system
- 60°C for domestic hot water preparation
- 70°C typical driving temperature for adsorption chillers
- 90°C typical driving temperature for absorption chillers

The efficiency curves of different collector models should now be compared at the highest necessary temperature level. Figure 4 shows efficiency curves for three collector technologies.

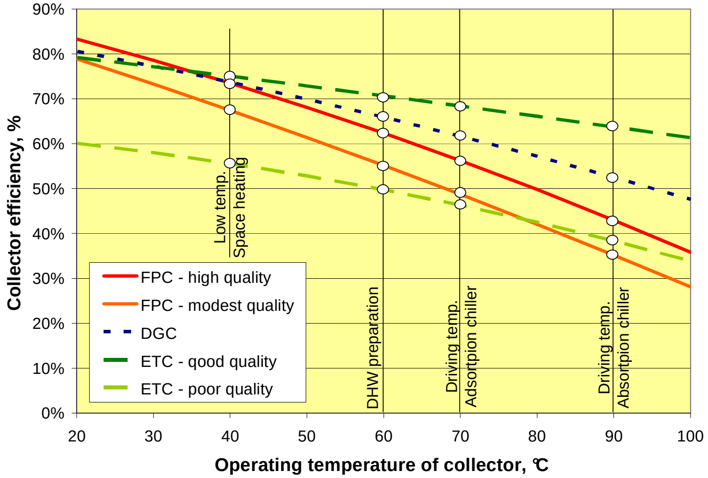

Figure 4 - Typical collector efficiency curves based on aperture area of different collector types (FPC – Flat plate collector, DGC – Double glazed collector, ETC – Evacuated tube collector). Assumptions: 800 W/m² global radiation at normal incidence and an ambient temperature of 20°C.

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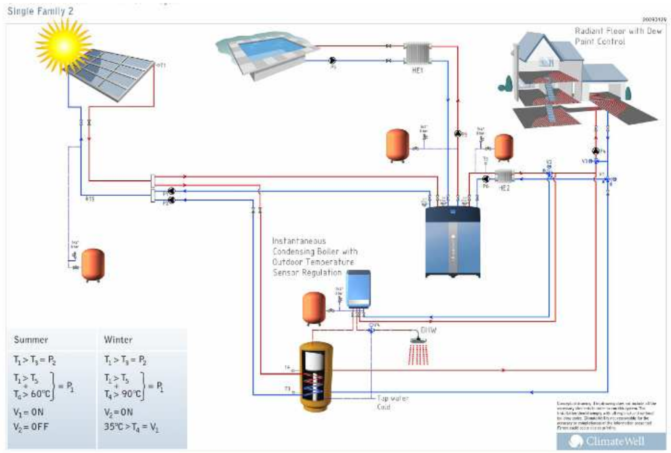
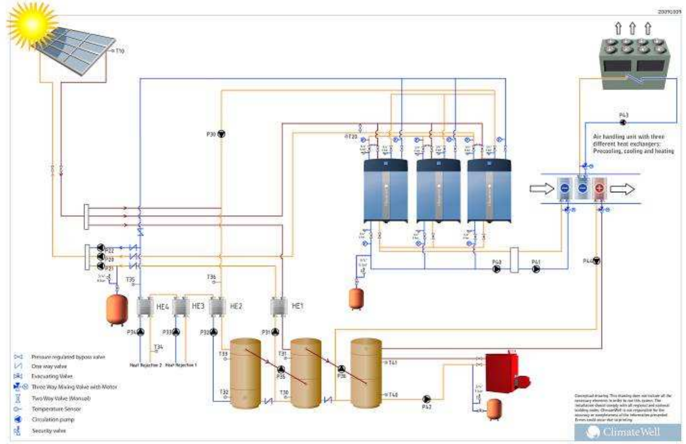
Residential Schematics



Multi-unit Schematics



Please visit the ClimateWell website at www.ClimateWell.com for more information about our systems or contact us at info@ClimateWell.com.

Package System - Climatewell

ClimateWell's Solar Cooling product combines the best features of absorption and adsorption with its patented triple state absorption technology. Among many features low electricity consumption, no noise, no crystallization problems and the integrated storage capacity are some of the most important ones.

ClimateWell has offices in both Stockholm and Madrid and a manufacturing plant in Olvega, Spain.

Within the Solarcombi+ project standard package solutions have been developed that will minimize the pre-engineering efforts for each project and hence lower the overall system costs. Some results from that work are shown on the next page. Further detailed information on ClimateWell package solutions can be found in Deliverable 4.4 on the project web page.

Different solutions were developed for different applications. The schematics below are suitable for small residential- and hotel applications respectively.

The first thing to notice is that there are very different qualities on the market. The red and orange curves show a typical good quality flat plate collector and a modest quality one respectively. For evacuated tube collectors the range of qualities is even larger. In between these technologies, double glazed collectors have recently entered the market. Those are basically flat plate collectors with an additional glass cover or Teflon foil to reduce heat losses from the collector.

Figure 5: Flat plate collectors (picture source: Sonnenklima)

At low temperatures (as necessary for a low temperature space heating system) the differences in efficiency between the different collector technologies are relatively small (except for poor quality evacuated tube collectors which are not suitable for this application). However, the more the operating temperature increases the more important a good quality collector becomes. Evacuated tube collectors typically have the smallest heat losses and are therefore best suited for high temperature applications. However, even among evacuated tube collectors, it is important to pay attention to install a high quality collector. On the other hand, good quality flat plate collectors or double glazed collectors can in many cases almost keep up with evacuated tube collectors. It may be worth to install a slightly larger surface area of double glazed or flat plate collectors instead of investing in possibly significantly more expensive good quality evacuated tube collectors. For each particular application, annual simulations are recommended in order to identify the best collector technology for the needed temperature level and available radiation.

Figure 6: Evacuated tube collectors at Venice Marina (picture source: Climatewell)

Figure 7: Double glazed flat plate collectors at the town hall / service center of the city of Gleisdorf, Austria (picture source: AEE INTEC)

Figure 13 – Solar cooling system installed on a roof in Granada Spain (picture source: IKERLAN)

Avoid Fossil Fuel Backup System for Cooling

Other options to reduce fossil fuel consumption are to install a biomass boiler or to use waste heat as heat backup system or an electrically driven compression chiller as cold backup. This will increase primary energy savings but also increase investment costs.

Figure 14 – Aerial view of solar cooling system in Granada, Spain (picture source: IKERLAN)

Use Chilled Ceiling Distribution Systems

Chilled ceiling systems are more favorable compared to fan coil systems in terms of chiller performance due to a higher temperature level in the chilled water circuit. However they are more expensive to install and often more critical to use in heating mode for application in office and residential buildings.

Figure 11: Chilled ceiling elements in a school in Butzbach, Germany (picture source: Fraunhofer ISE)

Figure 12 - Solar heating and cooling system in a municipal administration building in Vienna, Austria (picture source: SOLution)

Consider Solar Autonomous System for Cooling

To maximize primary energy savings it should always be considered to design a system without backup for cooling in summer. If a system is designed large enough, solar fractions for cooling can be above 90% and using the backup system for cooling can be avoided.

Standard System Configurations

The following figures show two typical system configurations for small scale systems for solar heating, cooling and domestic hot water preparation.

The first configuration shown in Figure 8 has a central heat storage tank with different temperature zones for space heating, DHW preparation and driving heat for the chiller. This tank is heated by both the solar thermal collectors and the auxiliary heater. For charging the store from the solar collectors, there is a switching valve that allows drawing the return flow to the collectors either from the middle or from the bottom of the tank. This allows reaching the needed temperature level in the storage tank for driving the chiller more quickly.

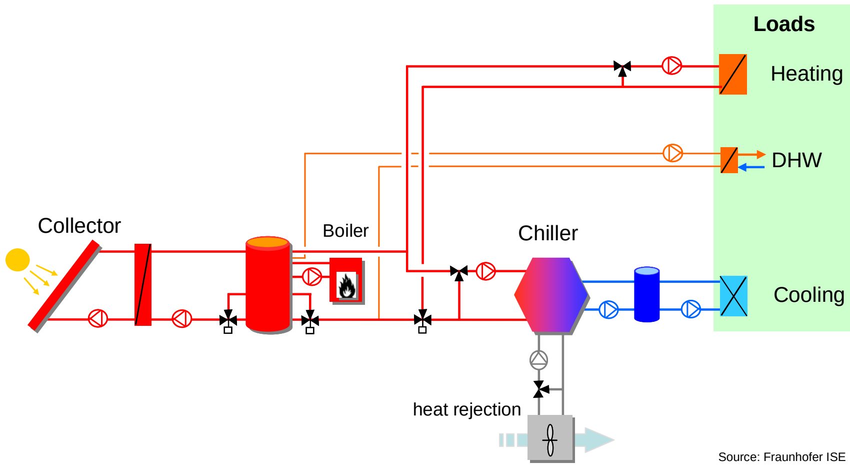


Figure 8 - Typical system configuration with the auxiliary boiler charging the main heat storage tank

Similarly, the return flow from the chiller or space heating loop can be fed into the tank at different heights depending on its temperature level.

In summer time, energy is drawn from the tank to drive the chiller. For the domestic hot water preparation, an external plate heat exchanger is used. In winter time the energy in the storage tank is used for space heating and DHW preparation.

The configuration shown in Figure 9 is adapted to the Spanish market where the auxiliary boiler is not allowed to charge the solar heat storage tank. Therefore, the auxiliary boiler is connected in series to the solar heat storage tank.

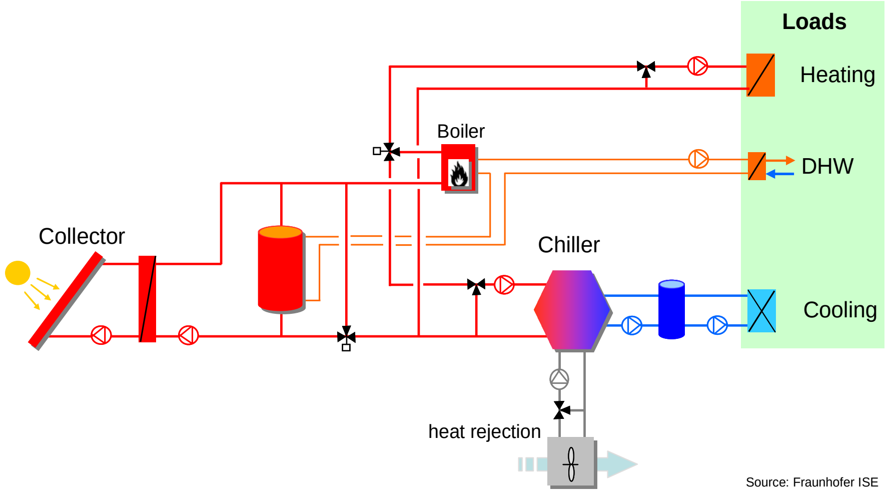


Figure 9 - Typical system configuration with auxiliary boiler connected in series to solar heat storage tank

Recommendations on System Design

Following some recommendations for good design of solar combi plus systems are given based on the results of many simulations of different system configurations at different locations across Europe that were carried out within the EU project SolarCombi+.

Large Collector Areas Perform Best

Well-sized systems have a collector size of about 3.5 to 5 m²/kW reference chilling capacity and a hot storage volume of 50 to 75 l/m² collector aperture area. If the system is dimensioned according to this rule of thumb, high total solar fractions can be obtained and the system operates close to the optimum in terms of primary energy savings and the costs of these primary energy savings.

Figure 10: 7.5 kW adsorption chiller (picture source: SorTech)

Implement Optimized Control Algorithm

The control strategy influences the performance of the system considerable in terms of both solar fractions and primary energy consumption. That means that an individual adaptation of the system control to the chiller as a function of location, application and configuration offers significant potential for improvement. Especially the control of pumps and the heat rejection fan must be studied.