ClimateWell© package solution description

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Version 3.0

Institution

ClimateWell™

Stockholm, January 21, 2010

Identification of most promising markets and promotion of standardised system configurations for the market entry of small scale combined solar heating & cooling applications
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Intelligent Energy Europe

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1 Introduction

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.

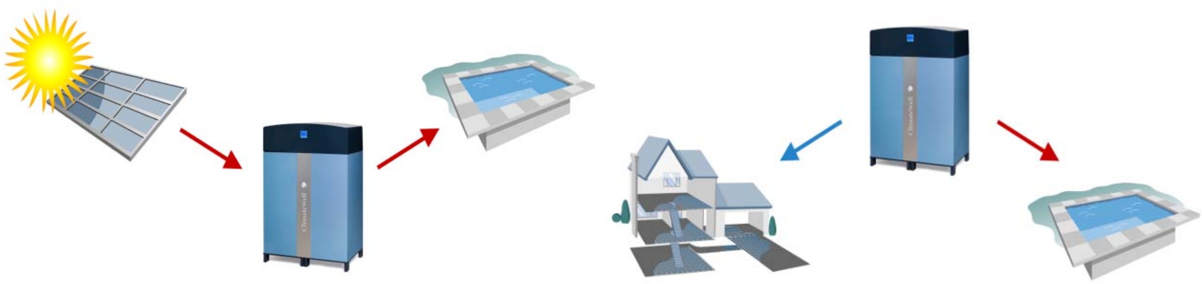
2 The Chiller

The machine consists of three parts: two twin barrels that work independently and one plumbing unit that connects the two barrels to the external circuits. The machine is connected to three external circuits: the thermal energy supply, the heat sink and the cooling/heating distribution.

The thermal energy supply is the circuit where the solar panels, the burner or other energy source powers the ClimateWell Solar Chiller. The heat sink dissipates all the energy that is collected from the house and all the energy that is collected from the solar panels. As for the heat sink, it is possible to use a pool, a geothermal borehole or a cooling tower. The cooling/heating supply distributes the cooling and heating in the house. There are several ways to distribute the cooling and heating.

The two barrels work in two different phases: charging and discharging. When a barrel is charging, it is connected to the heat sink and to the thermal energy supply. When a barrel is discharging, it is connected to the heat sink and to the cooling/heating distribution. In standard operation the machine works in what is called normal mode, which means that one barrel is charging while the other is discharging. Consequently the machine is always able to both supply cooling and charge with the thermal energy supplied.

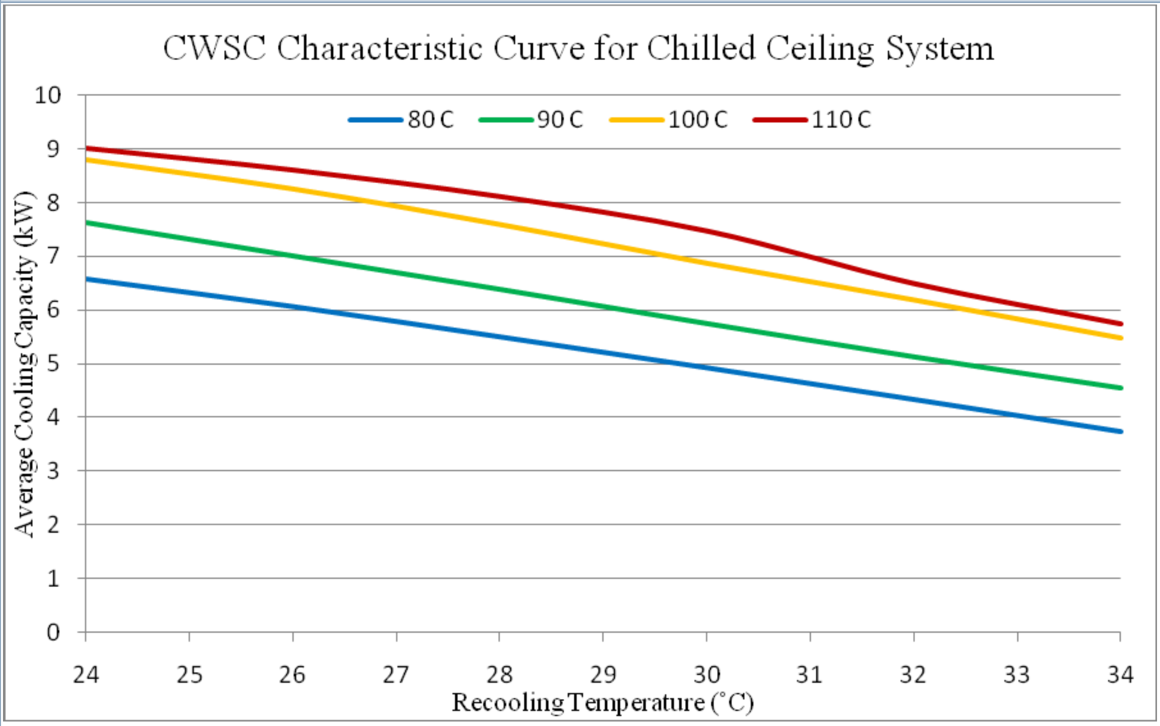
Charge Discharge



Operational Data			ClimateWell Solar Chiller
Heat Source Circuit	Flow		25 - 30 l/min
	Typical Power Range		15 - 20 kW
	Operational Temperature	Out	75 °C – 100 °C
		In	85 °C – 110 °C
	Operational Pressure		3 bars
	Maximum Pressures		6 bars
	Type of Fluid		Propylene Glycol 1,2 L ≥ 15 % concentration
Distribution Circuit	Flow		25 - 30 l/min
	Nominal Power		*See Power Curves*
	Operational Temperature	Out	10 °C – 16 °C
		In	15 °C – 21 °C
	Type of Fluid		Propylene Glycol 1,2 L ≥ 15 % concentration
Heat Rejection Circuit	Flow		50 - 60 l/min
	Operational Temperature	Out	30 °C to 45 °C
		In	< 30 °C
	Type of Fluid		Propylene Glycol 1,2 L ≥ 15 % concentration

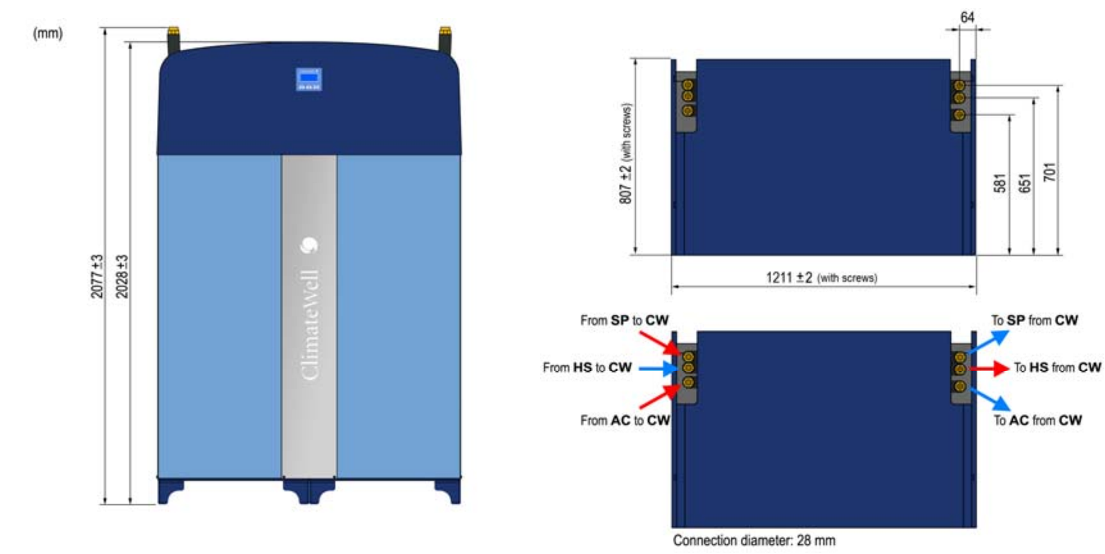
Technical Data		ClimateWell Solar Chiller
Average Power Consumption	Electrical	18 W
COP	(Thermal)	Triple state absorption process COP 0.68. Implemented COP will depend on installation characteristics, typically 0,52-0,57.
The Maximum Temperature to ClimateWell	From Heat Source	120°C
Maximum Pressure	From Heat Source	10 bar
Pressure Drop	Heat Source Circuit	30 kPa at 25l/min
	Heat Rejection Circuit	38 kPa at 50l/min
	Distribution Circuit	45 kPa at 25l/min
Energy Storage Capacity	Cooling	56 kWh
Weight		990 kg
Fluid Volume	Operational	74,5 l
Salt Solution	Lithium chloride	LiCl

ClimateWell Solar Chiller



Electrical connections		ClimateWell Solar Chiller
	Vac	230
Communication	Protocol	RS 232 19200, 8,None, 1
Output Signals	AC pump	On/off (5V/0V 20 mA)
	SP pump	On/off (5V/0V 20 mA)
	HS pump	On/off (5V/0V 20 mA)
	Output mode status	Cooling/Heating (5V/0V 20 mA)
Input signals	Output mode	Normally open Toggle between heating and cooling when closed
	AC pump status	On/off (5V/0V 20 mA)

ClimateWell Solar Chiller



3 System's Components

3.1 Solar Collectors

Use only certified highly efficient solar collectors with selective absorber plates. Both flat plate and evacuated tube collectors can be used although evacuated tubes generally offer higher efficiencies for high temperature ranges. Since low pressure drop, delta temperature between inlet and outlet, and emptying behaviour during stagnation are very important parameters in solar cooling installations, flat plate collectors with double harp hydraulics are not recommended. For evacuated tube collectors both direct flow and heat pipe solutions can be used. The number of collector panels in each bank of the array should be according to the panel manufacturer's guidelines.

- Design the individual collector banks so that the temperature difference between inlet and outlet at maximum irradiation is no more than 20˚C for the nominal flow.
- Install reversed return hydraulics to ensure the same pressure drop in each bank in the collector array regardless of the flow. This is a requisite for using variable flow in the collector loop.
- Install temperature sensors in each collector bank inlet and outlet. These sensors are used to make sure that the same flow is passing each collector bank in the array. Manual bypass flow meters can also be used in each bank.
- Use an immersed solar collector temperature sensor on any bank in the collector array, and a second sensor close to ClimateWell unit outlet for pump control. Make sure that the sensor is measuring the collector temperature and not the flow temperature in the pipes. A temperature sensor attached to the pipe cannot be used for pump control since the sensor must be able to measure the absorber plate temperature even when the solar pump is off.
- The specific collector flow rate (the flow rate through one collector) should be according to manufacturer specifications and the hydraulic configuration should be designed to match the flow demanded by the Climatewell units. Generally the total solar field flow is in the range of 20 to 50 l/hr per m2 aperture area depending on the type of solar collector. Figure 1 – Figure 3 illustrates some examples on possible hydraulic configurations for different solar collectors.

Figure 1: Double meandering hydraulics with two parallel banks with each eight collectors also connected in parallel. Both direct flow and heat pipe evacuated tubes can be connected in a similar way, with the difference that the collectors in each bank is internally connected in series instead of in parallel.

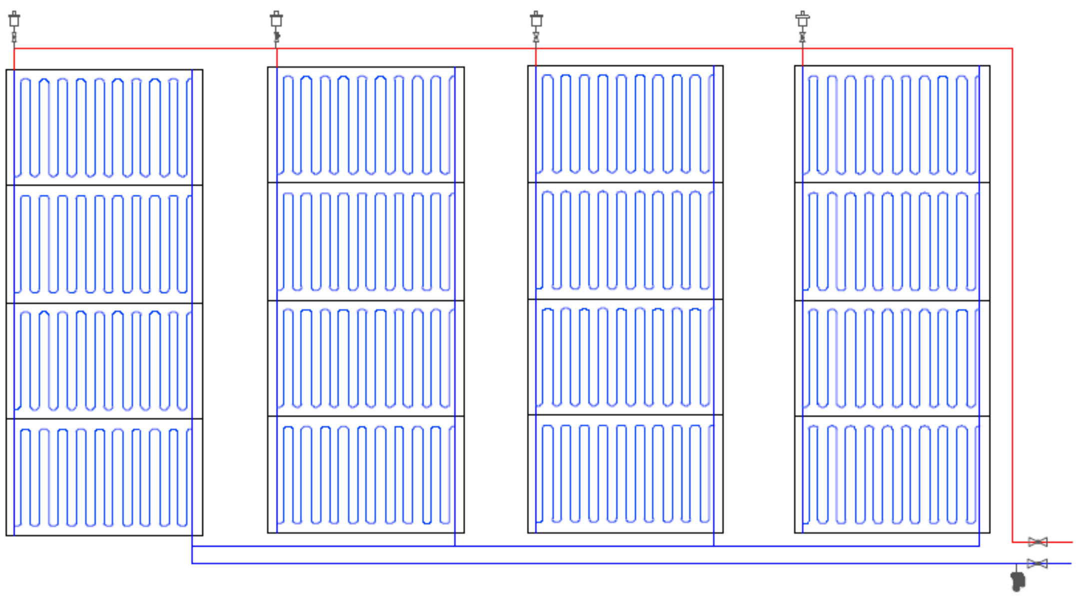


Figure 2: Double meandering hydraulics with four parallel banks with each four collectors also connected in parallel. Both direct flow and heat pipe evacuated tubes can be connected in a similar way, with the difference that the collectors in each bank is internally connected in series instead of in parallel.

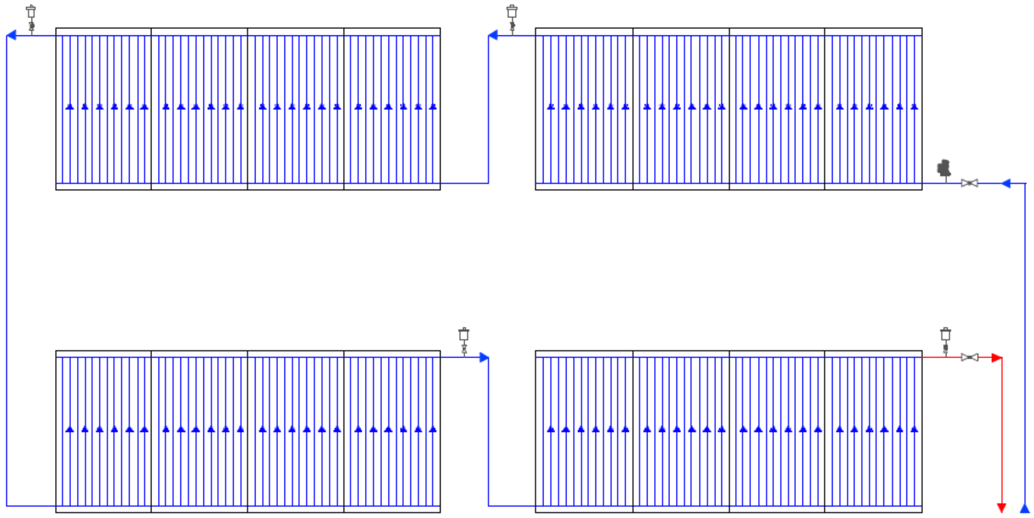


Figure 3: Simple harp hydraulics with four banks connected in series with each four collectors connected in parallel. Simple harp is a high flow solar collector and it is recommended to have at least four collectors in series in order to obtain sufficient flow through each collector. More than four collectors in parallel in one bank are not recommended because the flow is then unevenly distributed.

3.1.1 Collector Fluid

Use only reversibly evaporisable heat transfer fluid based on propylene glycol and non-toxic corrosion inhibitors with pH buffering capacity for utilization in solar heating installations. The fluid should be able to withstand at least 170˚C without being altered.

3.1.2 Stagnation Behaviour

- Use a safety algorithm for the solar pump that automatically shuts off the solar pump if the collector temperature exceeds 130˚C.
- The solar pump must under no circumstances be turned on during collector stagnation.
- Install pipe work for both flow and return with a continuous upward slope towards the solar field. This will give a slower and more controlled vapour transport during stagnation.
- Make sure that the vapour always has somewhere to expand. There must be an unhindered path from the solar collectors to the expansion vessel in order to avoid pressure peaks.

3.1.3 Pipes

- Design pipe dimensions to have 0.5-1.5 m/s flow velocity, but never more than 10 mm/m (mm pressure head per length meter pipe) pressure drop.

- Use only copper or stainless steel pipe material in any high temperature circuit. Stainless steel offers the most efficient and reliable performance for the collector loop.
- Always follow or exceed local or regional normative when designing the pipe work.

Higher flow velocities than 1.5 m/s will give unnecessarily high pressure drop in the loop, and lower velocities than 0.5 m/s will make it impossible for air bubbles to reach the purge unit while increasing the thermal losses. In order to avoid confusion when connecting the pipes the flow and return can have different colours, see Figure 15.

3.1.4 Losses

Insulation should be of a sufficient thickness and standard in order to limit heat loss from the pipes to and from the collector field. Less than 0.15 W/K per length meter pipe is recommended.

- The insulation must be resistant to weathering and meet or exceed the requirements of standards such as EN 483 or EN 513.

Collector inclination, orientation and shading affect the performance of the solar cooling installation to varying degrees.

- Optimum inclination is usually close to, or slightly lower, the latitude of the location.
- Always try to orient the solar field towards the equator where efficiency will be highest. Small deviations from the optimum azimuth will have limited or no adverse affect on performance.
- Never install a solar field close to large obstacles that can potentially shade the collectors. If mountains, trees or other objects are located in a way that may shorten the daily operation time during certain periods of the year this must be taken into account during the design phase of the installation.

3.2 Distribution System

3.2.1 Air Handling Unit

An air handling unit (AHU) can be connected to a conventional ventilation ducting system with inlet air diffusers in each area, or to a VAV (Variable Air Volume) system.

An AHU in combination with ClimateWell and a backup system with a conventional chiller must always have 2 separate cooling coils since the 2 systems operate at different chilled water temperature levels. In order to maintain a high COP on the conventional chiller and a good performance from the ClimateWell units, these two circuits should never be mixed.

For each coil inside the AHU a separate 3-way valve control the air supply temperature via the BMS-system (Building Monitoring System) or a conventional control system. Typical components in an AHU are listed below starting at the air inlet and going along the air flow.

- Sand trap (DIN std EN779).
- Mixing section for inlet and return air.
- Filter (DIN std EN779).
- Pre-cooling coil for ClimateWell units (12-17˚C). Pressure drop <30 kPa on water side and <100 Pa on air side.
- Cooling coil for conventional chiller/boiler.
- Damper section
- Fan section with low SFP-value (EN 13779 SFP: Specific Fan Power, W/m³/s).
- Silencer

The air flow should be designed for maximum 2.5 m/s air velocity over the cooling coil sections. If not, condense drop eliminators after the coil are necessary. The pressure drop over the coils should be as low as possible to avoid unnecessarily large circulating pumps/fans. Use air fans with as low SPV-values (W/m^3/s) as possible. Table 1 illustrated an example of an AHU specification.

Table 1: Example of design data for an air handling unit.

Design data: AHU1			
Supply air; m3/sec	3.80	Chilled water temp./KB2	+7/+12˚C
Ext static pressure (Pa)	350	Coil: Air inlet temp./RH	+27˚C/50%
Return air; m3/sec	3.50	Prefilter	MERV 6
Ext static pressure (Pa)	225	Filter	MERV 13
Coil 1:	Al/Copper	Heat Exchanger/Plate Cross Air	None
Capacity (kW)	60	Exhaust air; m3/sec	0.4
Chilled water temp./KB1	+12/+17˚C	Frequency control	Yes/no
Coil: Air inlet temp./RH	+27/50%	Max sound level outlet before silencer	90 dBA
Coil 2:	Al/Copper	Max sound level outlet after silencer	55 dBA
Capacity (kW)	120		

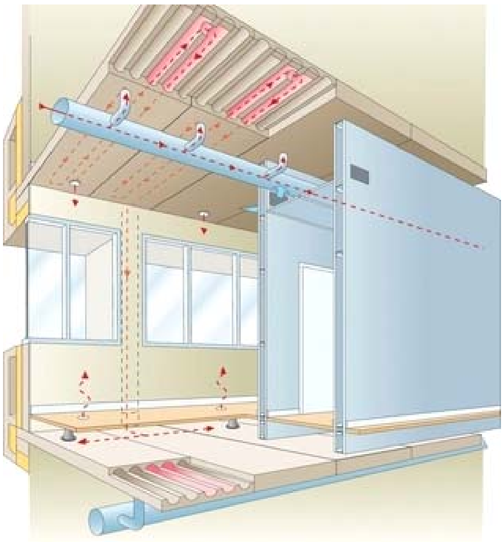
3.2.2 ClimaDeck

ClimaDeck hollow core slab system offers one of the most energy-efficient HVAC solutions available on the market while providing top rated comfort levels. This is possible by adding a massive thermal storage to the air distribution; the building itself.

ClimaDeck can be combined with all types of Air-Conditioning/Air Handling units (AHU) units. From the AHU-unit, generally placed on the roof, supply air ducts run in vertical shafts down to each floor inside the building and then to horizontal ducts placed in central corridors usually within false ceilings. Small branch ducts feed air into each slab, and the air then enters a room via diffusers fixed to the outlet of the slab. Diffusers are normally located close to external walls, or evenly spread over the ceiling in the office landscape. The exhaust air is normally transferred into the central corridor plenum and is returned to the AHU-unit in a conventional way.

The main distribution ductwork in the corridor is similar in construction to that found in conventional systems. The main difference with ClimaDeck is that every individual structural hollow core slab is supplied with a small quantity of air from the main supply duct.

The ClimaDeck system is different from conventional technologies because it is integrated with the heavy structure of the building. The last part of the ductwork system for the supply air consists of hollow core concrete slabs instead of traditional steel ducts, see Figure 4.



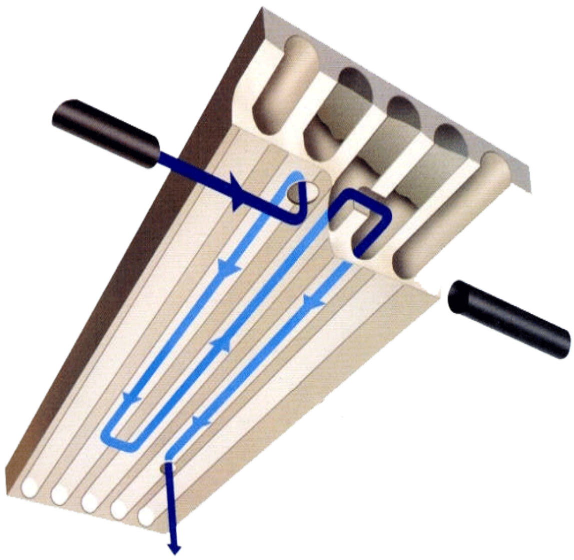


Figure 4: a) Connection with ClimaDeck and the air distribution ducts. b) Air flow inside the hollow core slabs.

ClimaDeck uses the thermal storage capacity of the structural mass in the building to regulate the internal temperatures. The effectiveness of the building's thermal mass is enhanced by passing supply air through the slab before it enters the room. The slabs work as heat exchangers between the supply air and the rooms, see Figure 4.

The floor/ceiling slabs serve many purposes: Besides from being the structural floor it also conveys fresh air into the building while serving as an energy store.

Error! Reference source not found. shows how the slabs are incorporated into the building and how the main supply duct would normally be situated in the corridor. No ducts and therefore no false ceilings are required in individual rooms. This allows total freedom for the interior designer to locate, or re-locate in the future, the internal wall partitions.

3.2.3 Chilled Beam System

In application with an AHU in areas/rooms with higher heat load, like meetings or conference rooms a chilled beam system is highly recommended.

Chilled beams are very effective and easy to install and connect to the Climatewell chilled water circuit, since the chilled beams require higher water temperatures in order to avoid condensation inside the units.

The base load into these areas is supplied by the AHU/Ventilation system and the top load is supplied by the chilled beams, often in combination with air supply inside the chilled beams.

The chilled beams are controlled by a separate room sensor/control opening the valve for the extra chilled water into the coil for maintaining the room temperature under high load conditions. Some chilled beams are designed to be a part of a suspended ceiling and are very easy to install retrofit. No noise from the chilled beams themselves is another great advantage.

3.3 Heat Rejection

ClimateWell© recommends that the rejected heat be used in a useful way. Heat rejection solutions that support an added value are preheating of domestic hot water and pool heating. Preheating of DHW can be combined with any other heat rejection system and be an important part of the overall system savings by making use of the thermal energy twice. A swimming pool is an easy and effective way of rejecting heat especially in the residential sector. The swimming pool provides a cost-effective way of

rejecting heat and at the same time adds a value to the rejected heat, especially during spring and autumn when the bathing season can be prolonged.

If the rejected heat cannot be used for anything useful then it should cost as little as possible to reject the heat. Therefore ClimateWell© recommends geothermal rejection systems if no added value can be given to the low grade heat. Geothermal solutions exist as both vertical and horizontal solutions where the heat is released into the ground. A geothermal rejection solution can also be used as a low grade heat source in winter times providing heat through the absorption machine.

If none of the above described systems are feasible, or if the absorption chiller can be connected to existing conventional rejection systems, then a wet or dry cooling tower can be used. The downside with using an active rejection system is that it costs electricity and/or water to reject the heat and hence lowers the overall performance of the system. By using an efficient control strategy for fan speed and rejection flow these solutions can still be attractive.

Two or more heat rejection system can be used in a single installation and they can be connected either in series or in parallel. Figure 5 and Figure 6**Error! Reference source not found.** illustrates how different rejection systems can be coupled together.

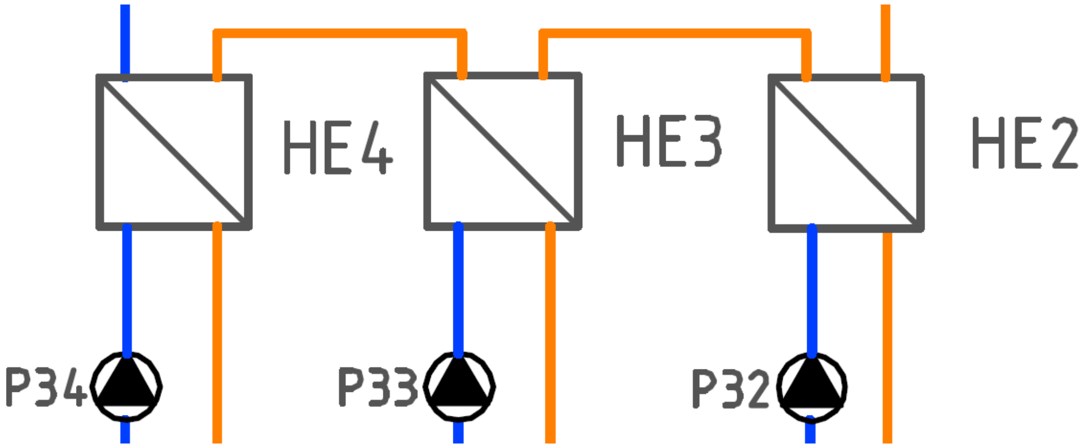


Figure 5: Connection in series for three different heat rejection systems. Preheating of DHW (HE2) has always highest priority and is therefore placed first in the flow direction. A wet cooling tower (HE4) has always lowest priority and is therefore placed last.

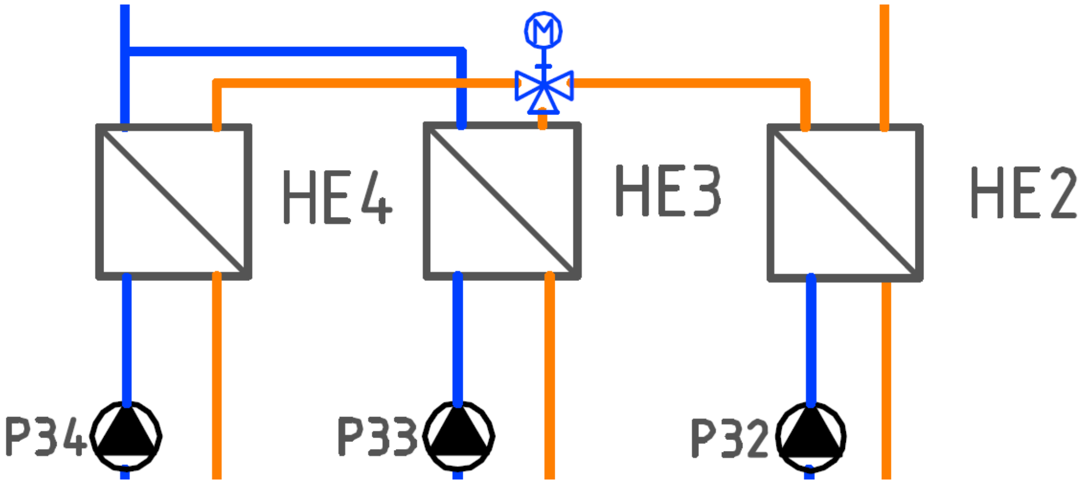


Figure 6: Connection in parallel for two rejection systems (HE3 and HE4) connected in series with a third system (HE2) with highest priority.

3.3.1 Swimming Pool

A swimming pool can be the only heat rejection system in the solar cooling installation, but can also be used in combination with other solutions if size is not sufficient or if strictly temperature regulated. Use connection in parallel with secondary heat rejection system if the pool heating season is during a short period of the year. If not connection in series can be used to simplify control logic. If preheating of domestic hot water is used connection is series is always recommended. It is important to use a pump, on the pool side of the heat exchanger that can work at ambient pressure. Normal circulation pumps need a higher incoming pressure and will not work well in a non pressurized circuit.

Figure 7: A pool heat exchanger from Bowman. The heat exchanger has plastic fittings on the pool side that can withstand maximum 100˚C.

It is also important to choose a heat exchanger that will withstand the corrosive environment present in pool application. The material used in the heat exchanger must be chosen depending on what chemicals are used in

the pool water. A heat exchanger that can withstand chlorinated water might not withstand salt treated water or seawater. Figure 7 shows an example of a shell and tube heat exchanger especially designed for pool applications. It can handle both chlorine water and seawater and has very low pressure drop.

3.3.2 Wet Cooling Tower

A wet cooling tower is the most conventional way of rejecting heat in solar cooling applications. The evaporative cooling allows the tower to deliver temperatures below the ambient dry bulb temperature which is a necessity for solar cooling installations in warmer climates. When dimensioning the cooling tower maximum and average wet bulb temperatures for the location must be taken into account. For guidelines on how to dimension a cooling tower, contact ClimateWell's project management department or the cooling tower manufacturer.

3.3.3 Preheating of DHW

Preheating of DHW is the most favourable of all heat rejection systems since the exergy levels are used very efficiently. First the heat is used for producing cooling and later the same energy can heat up the tap water. The disadvantage with this rejection system is that it is dependent on the tap water consumption and can therefore never be used as the only system for heat rejection. It can neither be used as the sole source for heating the tap water because maximum available temperatures are below sanitary requirements.

3.4 Storage

3.4.1 Thermal Storage

The use of open buffer tank is recommended in installations with both DHW and heating demand, especially if high hygienic standards are required. For smaller installations, or if no heating is required from the solar installation, domestic hot water tanks can be readily used.

3.5 DHW Preparation

There are basically two different schools when it comes to domestic hot water preparation. Either hot water for consumption is prepared and stored in DHW tanks before use, or the water is heated up instantaneously at demand. The main advantage with the first solution is that high peak demands can be covered with small capacities on heat exchangers, but with

the side effect that storing warm water (<53˚C) may create hygienic problems. The latter solution gives high hygienic standards since cold water is heated instantaneously, but requires that heat exchangers are dimensioned for the peak power demand. Figure 8 illustrates how the two solutions can be combined with solar heating and preheating.

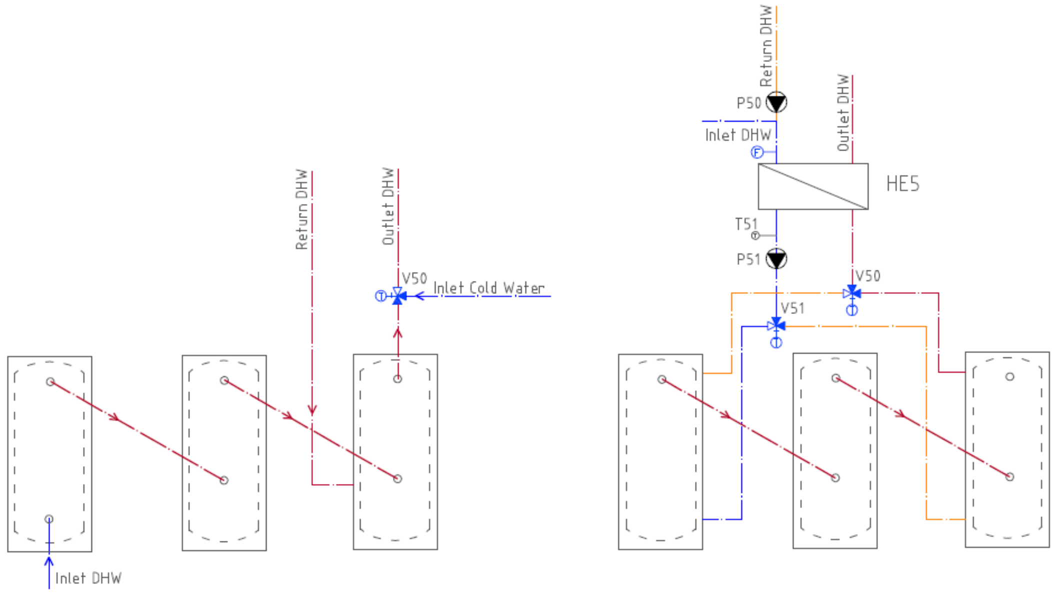


Figure 8: Domestic hot water solutions with (left) DHW tanks and (right) open buffer tanks and instantaneous hot water preparation. The three tanks are starting left: preheating tank (20-40˚C), solar tank (40-70˚C) and boiler tank (60˚C).

3.6 Hydraulic Design

All components connected to the collector loop must have a high temperature classification.

3.6.1 Solar Pump Station

The solar pump station is the connection between the solar collectors and the rest of the components in the installation. There are standard pump stations for small to medium size installations existing on the market that come pre-installed and leak tested with all the necessary safety equipments. An example of a pump station is illustrated in Figure 14 and a list of the necessary components can be seen below. For larger installations preassembled pump stations are not common, and the components are normally assembled and installed on site.

1. Variable speed circulation pump
2. Safety relief valve
3. Filling/drain valve
4. Pressure gauge
5. Flow meter
6. Air trap and vent
7. Flow temperature gauge
8. Return temperature gauge
9. Insulation shell
10. Shut-off and check valves
11. Expansion vessel connection

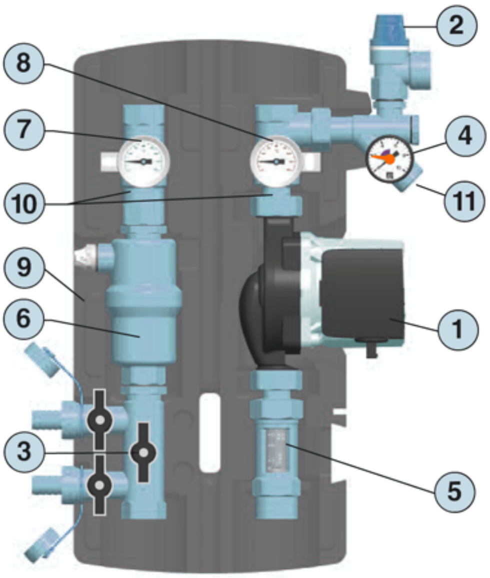


Figure 14: Example of a solar pump station designed for small to medium size solar installations.

3.6.2 Expansion Vessel

Make sure that the expansion vessel pre-pressure and the final system filling pressure are measured with a digital instrument. The expansion vessel should be of high temperature rating for solar applications and be installed before the solar pumps. In small installations it can be installed after the non return valve on the flow pipe to the solar collector.

- Design expansion vessel in accordance with VDI6002 or local standards.
- A service valve should be installed between the expansion vessel and the safety valves equipped with a lockable handle
- The expansion vessel should be placed below the pump station in order to stop hot water rising in the pipes from reaching the vessel.

Failure to correctly dimension the size and the pre-pressure of the expansion vessel can lead to air leaking into the system during cold nights or that the safety valves open and the collector fluid is lost during high thermal stress.

3.6.3 Cooling Vessel

A cooling vessel may be required depending on the hydraulic design of the system. If the location of the pump is sufficiently distant from the collector field and during a standstill event the collector field can expand equally along both the flow and return pipes without vapour reaching the pump then a cooling vessel is not required. However, if a check valve is required before the pump for protection meaning that the collector field is only able to expand along the flow pipes a cooling vessel may be required. In this case if the fluid volume of the pipes between the collector field outlet and the expansion vessel inlet is less than the volume to be held by the expansion vessel then a cooling vessel must be added to protect the expansion vessel. The volume of the cooling vessel must be such that when added to the fluid volume of the pipes between the collector field outlet and the expansion vessel inlet the total volume exceeds the volume to be held by the expansion vessel. Which method to use must be decided on a case to case basis depending on distance to solar field and stagnation behaviour of the collectors used.

3.6.4 Deairation

Install at least one air purge unit (APU) per circuit anywhere in the system with a residence volume (2-5 pipe diameters in length) for air in a T-section or elbow. An automatic purge valve can be used, but controlled by a manual valve that should always be closed during normal operation. Increase the pipe size in that section to lower the flow velocity. The purge system can be placed close to the pump station for easy maintenance. In larger installations several APU units are recommended. Figure 15 illustrates how an APU should look like.

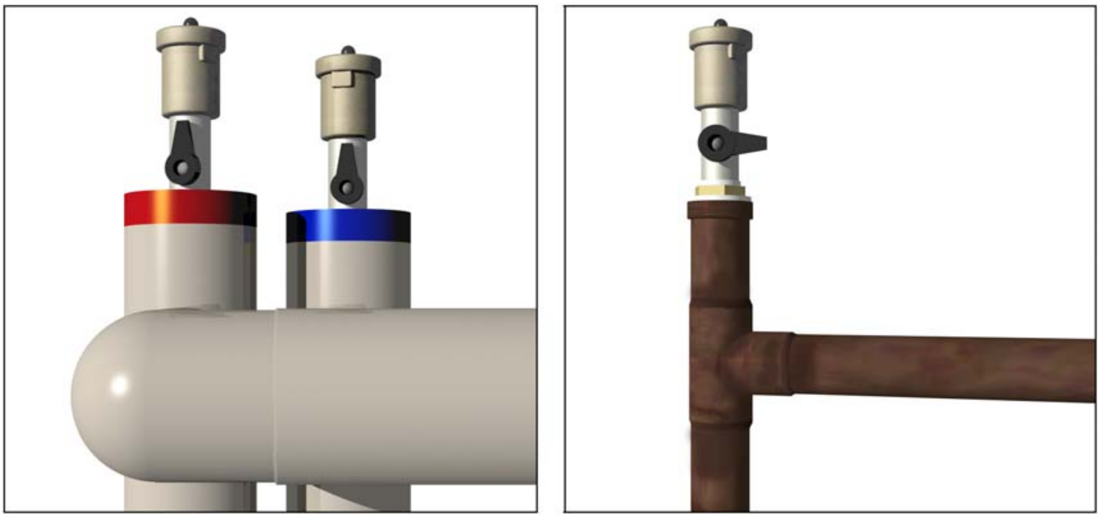


Figure 15: Example of an APU consisting of an automatic purge valve, a manual valve and a residence volume for air. Different colours are used for flow and return.

3.6.5 Strainer

- It is recommended to install a strainer of 1-1.5 mm mesh before the pump with service valves on each side.

The strainer is a filter with large mesh that will collect dirt in the circuit. Connections for measuring the pressure over the strainer are recommended to know when it needs to be cleaned or replaced. When installing a strainer it is important that maintenance is really performed and strainer is cleaned or replaced when dirty. Failure to do so may lead to clogging of the system and unrepairable damage to pumps.

3.6.6 Safety Valves

- Double safety valves for 6 bars are recommended for larger installations, separated by a 3-way ball valve for easy maintenance.
- If the static pressure is more than 2 bars safety valves of 8 bars or higher must be used.

If the collector field is very large or far away from the pump station additional safety valves close to the collector field are recommended.

- If there is any risk for vapour reaching the solar pumps during stagnation, a non-return valve must be installed after the solar pumps on the return pipe to the collectors in order to protect the pumps.

A second non return valve can also be used in the flow pipe of the collector to prevent self circulation in this single pipe up to the collector.

3.6.7 Heat Exchangers

- Use flat plate heat exchangers with recommended 3˚C logarithmic temperature difference for the design power of the circuit.
- A maximum of 30 kPa pressure drop over the heat exchanger is recommended. If possible similar flow should be used on both sides of the heat exchanger.

The design power for the different heat exchanges can be obtained using the ClimateWell Solar Cooling dimensioning tool. Typical heat transfer values for a single ClimateWell Solar Chiller installation are 20-25 kW for heat rejection and 7-10 kW for distribution.

If the collector field is located far away from the machine room making costs for collector fluid unrealistically high, a flat plate heat exchanger close to the collector field can isolate the primary solar side from the rest

of the installation. This will leave the ClimateWell units without any freeze protection and extreme care has to be taken in the design of the installation. Failure to do so may lead to irreparable damage to the ClimateWell units.

3.6.8 Pumps

The electrical efficiency of the system is of highest importance, and fluid pumping is one of the key factors influencing this efficiency. Like most solar installations a Solar Cooling system is often run at partial load (off peak hours). This is illustrated in Figure 16 where it can be seen that a system runs at its full capacity very few hours in a year.

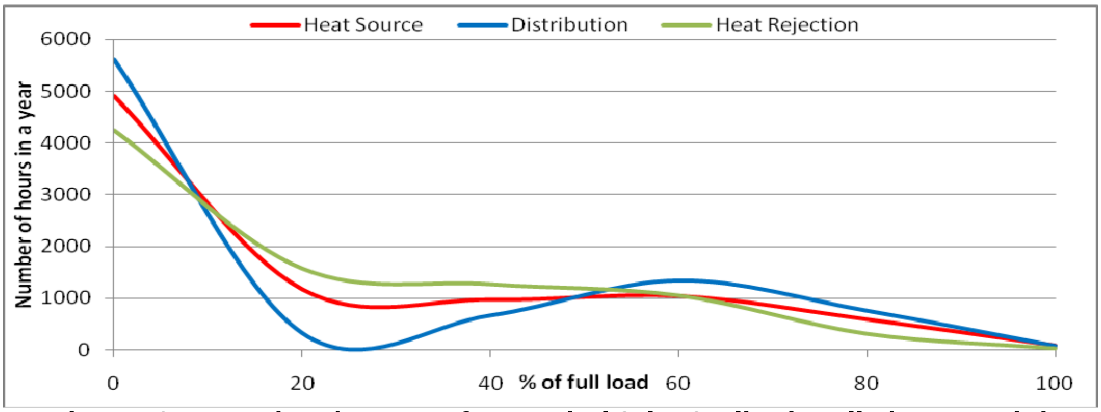


Figure 16: Pump duration curve for a typical Solar Cooling installation. Here it is apparent that good partial load efficiency is necessary since the system is mostly operating between 20 and 80% of full capacity.

In order to have high overall efficiency it is important to have good partial load efficiency. This can be solved by installing variable speed pumps in the collector- and heat rejection circuits. The temperature difference between the inlet and outlet in each circuit can be used to generate a signal to the frequency converter in the pump. A temperature difference of 10 to 12˚C is recommended. For small pumps simpler methods can be used for varying the speed.

4 System Schematic

The standard hydraulic schematic used for the simulations is shown below. This schematic has been designed to fulfill most requirements for any heat driven chiller. It is however hard to meet all requirements and to optimize for every chiller with one type of schematic, even if small changes can be made for each individual chiller.

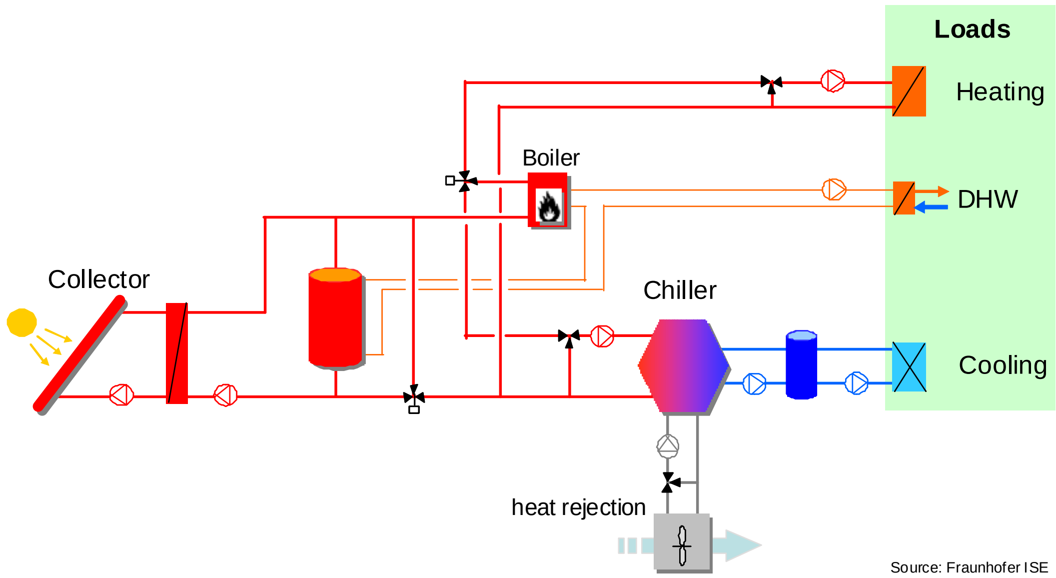


Figure 9: The standard hydraulic schematics used in the Solar Combi+ project.

During the course of the project obtained knowledge and experience in system design has improved our understanding of the system and how to integrate a ClimateWell© unit with the highest possible performance and robustness. Below, a list of ClimateWell© specific traits and peculiarities is illustrated.

- Unit designed to work without hot water storage.
- Internal process inseparable and hence a freeze protection medium is necessary to avoid un-repairable damage to the unit.
- Internal cold/hot storage integrated in the unit.
- Possibility to store solar heat from day to night in salt crystals.
- The unit has only one working medium (all circuits are mixed internally).
- Integrated storage and optimal temperature ranges make boiler produced cooling difficult to implement with any high efficiency.

Conclusions from the simulation work done by Eurac are listed below.

- Small or no improvements with increased thermal storage.
- Storage volume is only important for heating purposes. The possibility to store excess heat in the ClimateWell© unit further decreases the economic gains with a large storage volume.
- Cooling output is decreased significantly by providing instant cooling upon demand. Better results can be obtained by using the thermal mass of the building and varying the cooling capacity according to solar irradiation. The storage needs to be developed further in order to provide instant cooling upon demand with high efficiency.
- Boiler produced cooling does not give any or poor savings on primary energies.

Changes to the hydraulic schematics to implement the conclusions above are listed below.

- Separate the hot water storage from cooling production. The water storage is then dimensioned according to the DHW or heating demand of the building.
- Incorporate the ClimateWell© unit into the primary solar circuit. By doing this, freeze protection is provided to the unit and one pump can be omitted when working with an air system. In order to separate the primary glycol mixture from the secondary water circuit an internal coil can be used in the hot water storage. If a water based distribution system is used, then an additional heat exchanger is necessary on the cold side. A separate project has evaluated the strengths and threats on having the ClimateWell© unit in the primary solar circuit.
- The boiler is only used for heating and DHW. The connection and the pump from the boiler to the chiller are omitted.
- The boiler is connected in series with the absorption chiller in order to provide heating with the chiller. When the chiller cannot meet the entire load of the building the boiler gives part load support.

The changes to the hydraulic schematics result in somehow different schematics that are illustrated in Figure 10 and Figure 11. Work remains to design pump and valve stations to be able to offer a standardized plug and play installation kit for quick and easy installation.

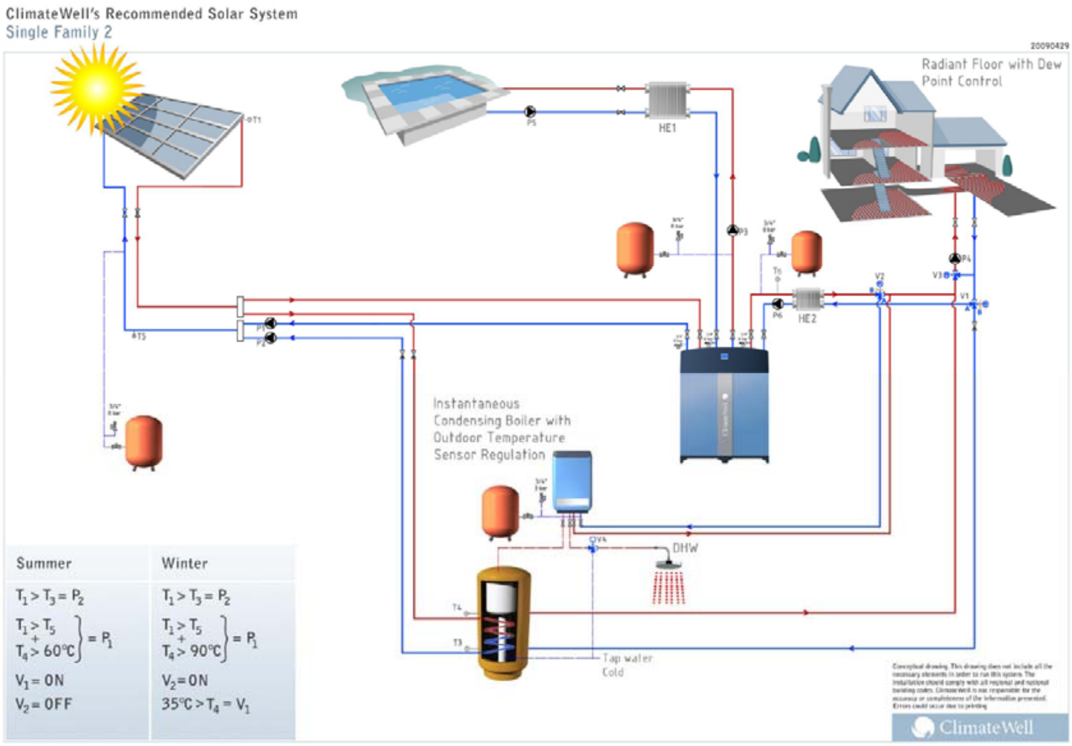


Figure 10: ClimateWell©'s recommended hydraulic schematics for residential applications. If an air handling distribution system is used HE2 is not necessary.

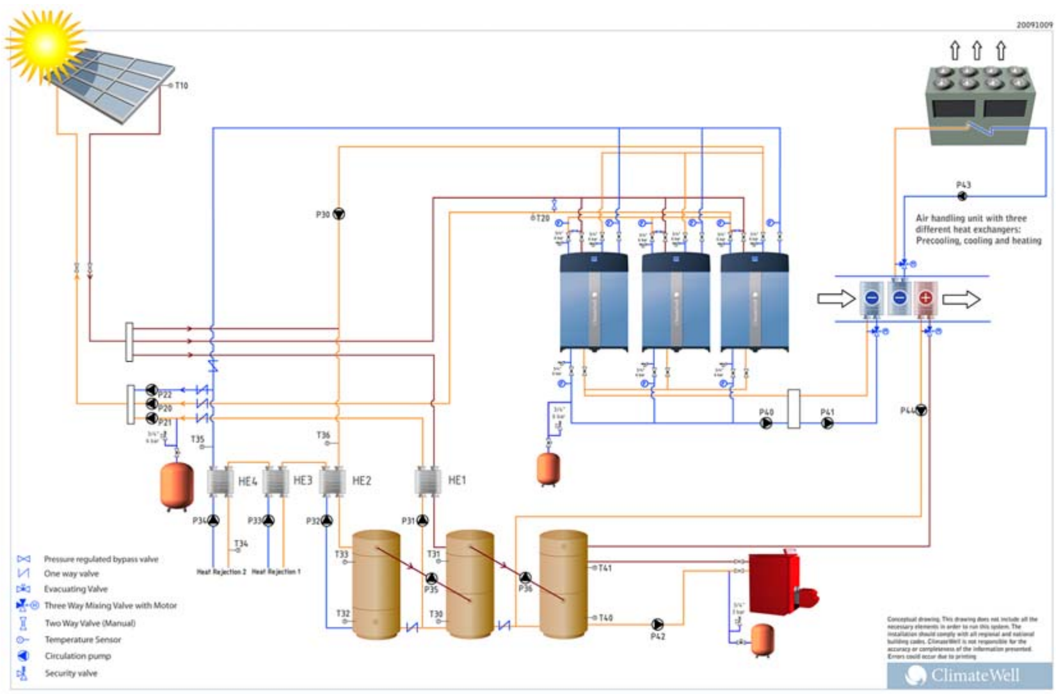


Figure 11: ClimateWell©'s recommended hydraulic schematics for commercial applications. No heat exchanger is necessary on the cold side because the liquid/air heat exchanger separates the primary circuit from the air stream.

5 Proposed Package Solution

Since solar irradiation and climate conditions vary significantly depending on location and every project has its traits and peculiarities, ClimateWell recommends that every project be analyzed in the ClimateWell Solar Cooling 1.1 simulation tool. In this program a dynamic and flexible building model can be simulated against a solar cooling system with high precision. The program has been designed to offer several different building types and a flexible system that can be dimensioned to the demands of the building with small or no engineering capacity. Figure 12 shows some images from the program that is used both internally at ClimateWell as well as by ClimateWell's partners and distributers.

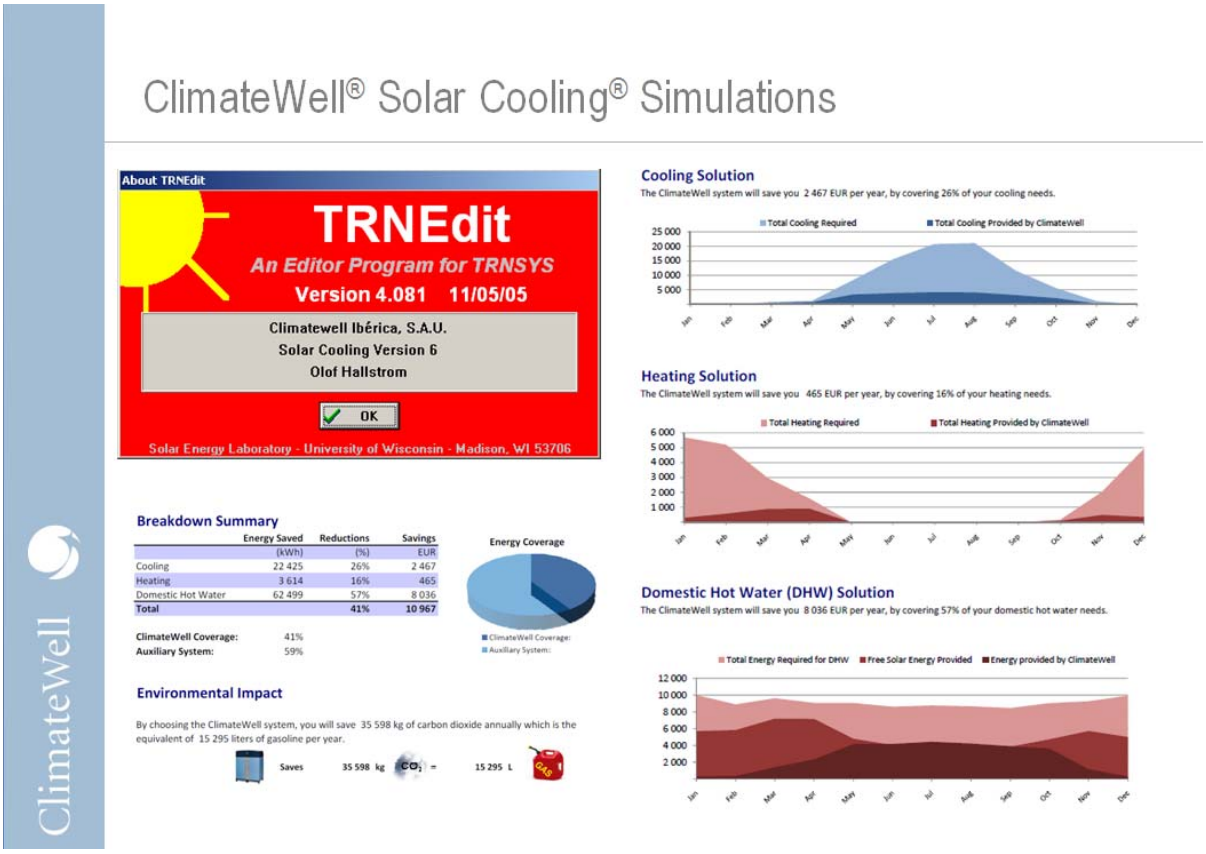


Figure 12: Images from ClimateWell Solar Cooling 1.1. The program provides transient simulation and results presented in a user friendly 6-page pdf-template.

6 Summary

This document has been developed to be used as a guideline for designing Solar Cooling installation together with ClimateWell's licensed partners. The document includes key components and component configurations that are crucial for well functioning and reliable Solar Cooling installations. Due to the fact that real projects might deviate more or less from the standard configurations described in the following chapters, it is important to treat this document as a platform for continuous mutual communication between ClimateWell and its partner in the design of specific Solar Cooling projects.