solarcombi+

D4.2: Rotartica package solution description

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Version 1

Institutions

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Arrasate, 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

Content

1 Introduction

Thermal solar energy represents an alternative to the use of fuel oil or all types of fossil fuel powered boilers, useful in DHW and heating applications, as well as air-conditioning. Solar thermal collectors could be dimensioned taking into account both heating and cooling demand, avoiding the stagnation of the collector during summer time. Besides, cooling demand is coincident with solar radiation so when higher the solar radiation is, higher the cooling requirements are (see figure 1).

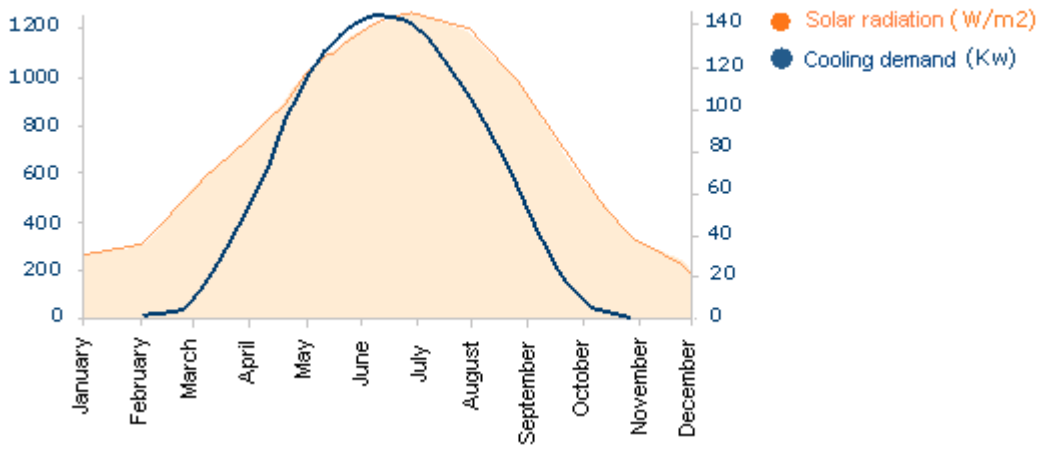


Figure 1:Cooling demand and solar irradiation example

In the framework of Solar Combi+ project, a package solution based on a ROTARTICA absorption machine for Solar Combi + systems has been defined. Solar Combi plus systems use heat from solar thermal collectors to provide heating in winter, cooling in summer and domestic hot water all the year. The package solution will enable planners and independent craftsmen to install reliable Solar Combi+ systems.

2 ROTARTICA: Basic information

ROTARTICA is an absorption LiBr machine of small capacity (appropriate for applications such as: uni-family houses, small shops, etc.), with high efficiency in its performance cycle, giving the opportunity to run the machine without cooling tower use in some applications.

The chiller units (see figure 2) are powered by hot water from solar thermal energy and use environmentally friendly refrigerants (i.e. they use water instead of CFCs, HCFCs etc.).

Figure 2: ROTARTICA absorption machine(Solar 045 and Solar 045V models)

In the Solar Line, absorption takes place in a single-effect system that generates a cooling power of 4.5 kW (from 2 to 8 kW depending on the conditions) with a COP of 0.62 (in terms of solar cooling).

Solar line has two models, as it is shown in table 1:

Table 1: Rotartica solar models basic characteristics

rotartica	Model	Cooling capacity.	Installation	Powered by	Absorption
Thermal Solar Line	SOLAR 045v	4.5kw	Outside	Thermal solar energy	Simple effect
	SOLAR 045	4.5kw	Inside	Thermal solar energy	Simple effect

ROTARTICA has developed "ROTARTICA Technology", based on the absorption cycle and applying the same principles but in a rotary environment, to improve the efficiency of the cycle by enhancing the mass and heat transfer processes. As a result of this, the size and weight of the unit can be reduced and there is an improvement on the system's effectiveness with respect to traditional absorption applications. The thermal difference (from hot outlet water temperature to cold outlet water temperature) is also increased, so depending on the application there is no need for a cooling tower, thus preventing bacteria such as legionella from propagating.

Main advantages and disadvantages of Rotartica compared with conventional systems are resumed in table 2:

Table 2: ROTARTICA advantages and disadvantages compared with a conventional system.

ADVANTAGES	DISADVANTAGES compared with conventional systems
▪ Renewable solar thermal energy use. ▪ Health risks are eliminated as there is no imperative need for a cooling tower (depend on applications). ▪ Water is used as a refrigerant instead of CFCs and HCFCs, etc., as water is used as a refrigerant.	▪ Technology on development. ▪ More complex installations demand package solutions. ▪ Higher initial cost.

The basic solar model (SOLAR 045) consist of the rotary unit, where the thermodynamic process takes place and core of the machine, control card, including safety systems and external connections.

The other model SOLAR 045v includes all the components of the basic solar model 045 and a heat rejection system based on a heat exchanger and a fan, and two pumps for the cooling and re-cooling circuits.

The model with a heat rejection unit included has a volume of 0.95 m^3 (1.150*1.092*0.760 m) and weighs 280 kg. Solar 045 models have a volume of 0.61 m^3 (0.865*1.050*0.670 m) and weighs 240 kg.

ROTARTICA's Generator Units (GU's) or rotary units, the final product, their physical principles and the majority of their components are protected by patents and international market laws.

3 Rotartica services

3.1 ROTARTICA Global Solution

Rotartica has offered a Global Solution to engineering and installers in order to make the development of this kind of installations easier. The aim was to guarantee the optimum operation of the unit and of the installation as a whole, based on dynamic simulation. The basic Hydraulic Unit (H.U.) consists of: the heat rejection system, pumps, valves, auxiliary boiler if needed and other necessary components.

The main components of this Global Solution (see figure 3) are basically:

- Hydraulic Unit (H.U.)
- Fan coils
- Solar thermal collectors

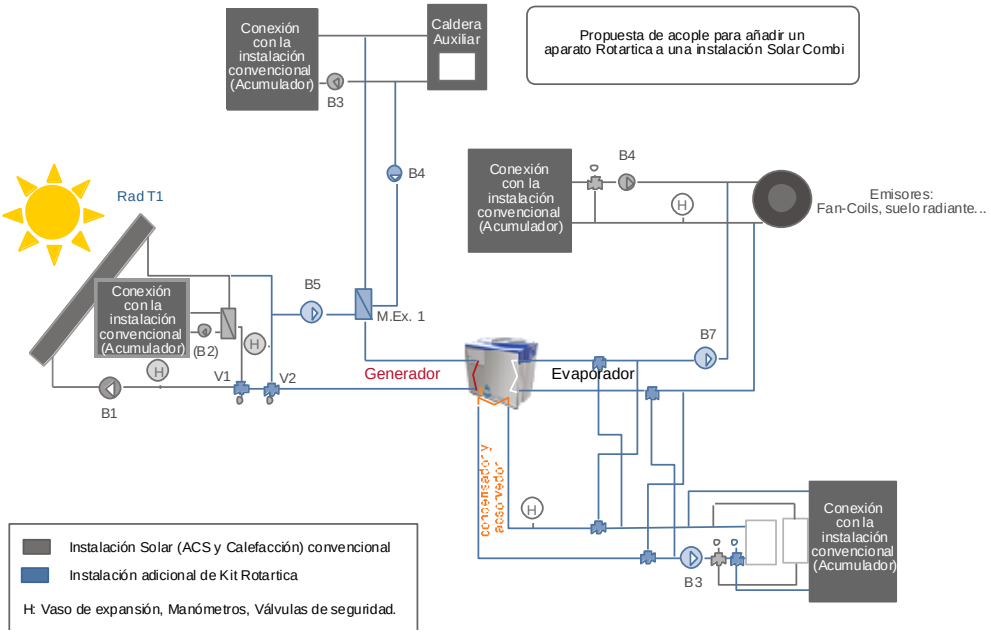


Figure 3: Example of Rotartica machine coupled in a Solar Combi installation .

As shown in the example, the absorption chiller is basically integrated with the rest of the installation in a simple process: the connection of the primary solar circuit to the pre-formed intake using 1" connectors and then to the outlet, which may consist of cold-only (feed and return) or hot and cold (four pipes) water lines. The "cold-only" version detailed in the figure 4 corresponds to the ROTARTICA Solar 045v model in which the residual hot water circuit is dissipated within the unit itself via a heat exchanger and a fan.

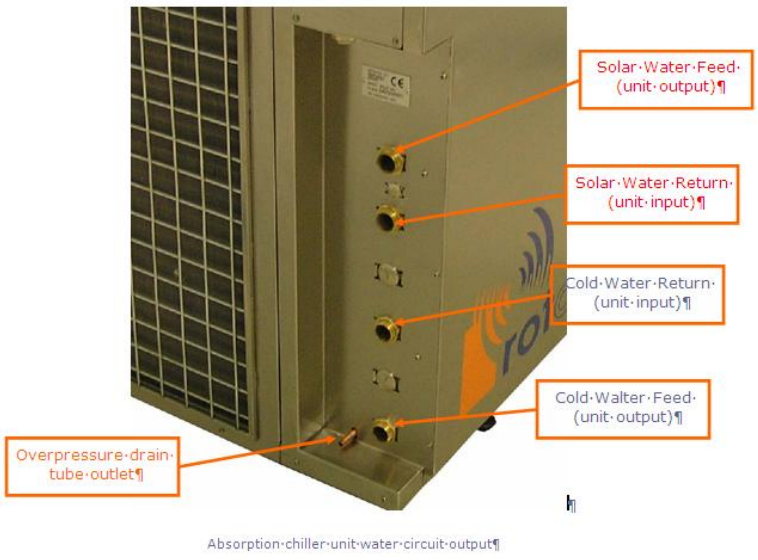


Figure 4:ROTARTICA absorption machine connections

3.2 Training courses

Other service has been the specific training in this area, necessary for installers, in addition to support with starting up the installation with ROTARTICA.

One of ROTARTICA's goals has been to create an easy-to-install product with practically no need for maintenance of the main unit.

4 System configurations

4.1 Rotartica Solar 045: Hydraulics circuits

Nominal performance of ROTARTICA Solar 045 absorption machine is schematically represented in the figure 5.

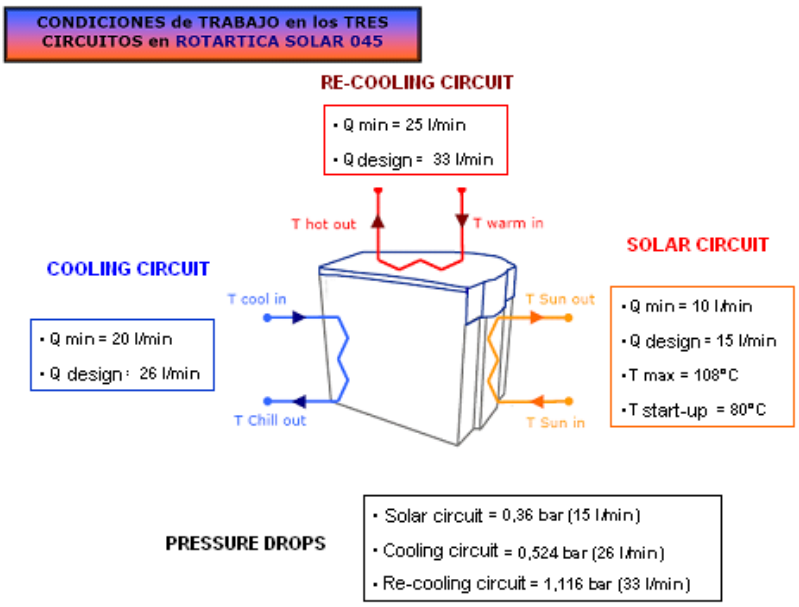


Figure 5: ROTARTICA Solar 045 hydraulics circuits

Three hydraulic circuits are described as follows:

- Solar Circuit, is the circuit that provides heat to the machine. The heat can have diverse sources, such as, solar thermal collectors, cogeneration systems, boilers and other residual heat sources.

- Cooling circuit. The cold water generated by the unit can be distributed by fan-coils, chilled ceiling or others.
- Re-cooling circuit: The exhausted heat can be rejected by a heat exchanger and a fan, geothermal probes, swimming pools, etc.

It is very important to remark the flexibility of Rotartica machine to work under different heat supplied media, distribution systems and heat rejection systems. It allows high versatility in different SolarCombi + applications.

4.2 SolarCombi+ system configuration

SolarCombi+ system configuration proposed for Rotartica machine for Spanish market is the C1, defined and simulated inside Solar Combi + Project. The criteria for its selection were basically to avoid the connection between solar storage tank and auxiliary heat supply system, due to the legal conditions in Spain (CTE Code, HE Energy Save document, point 4, chapter 3.3.3.2 about connections).

C1 configuration is shown in figure 6. In the scheme the auxiliary heat supply is represented by a boiler as an example, but it could be any other. In the same way distribution system for heating and cooling is represented separately, but it is the same and common distribution system for the building. Finally, heat rejection system is represented as a heat exchanger with a fan, but of course could be also any other.

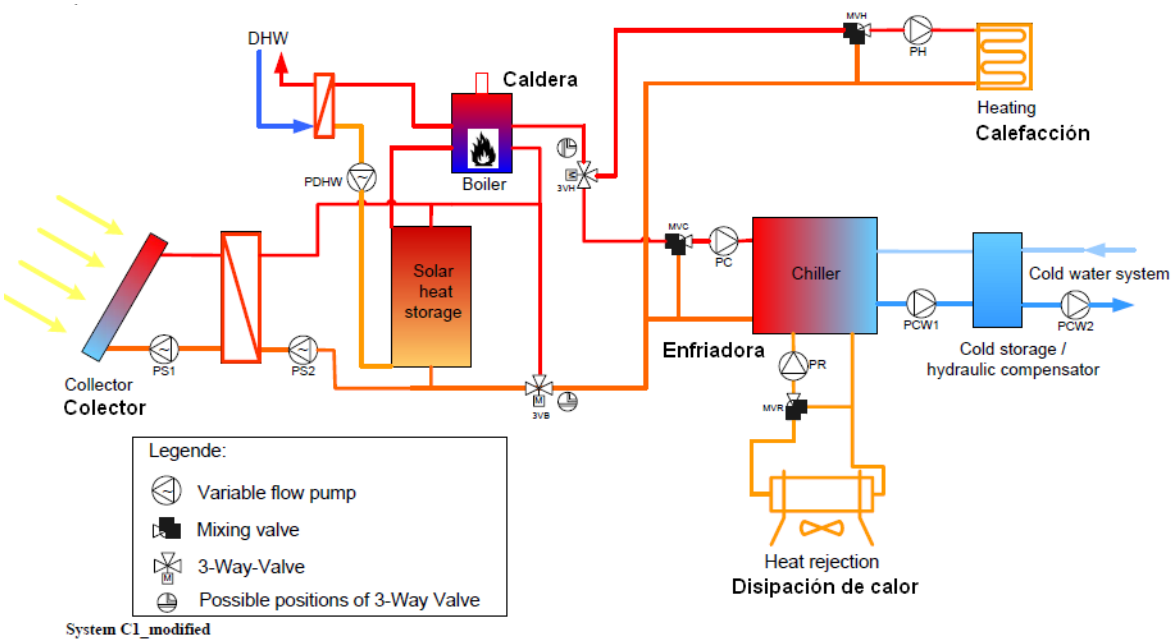


Figure 6: SolarCombi+ project C1 System configuration scheme

It is possible to use ROTARTICA inside E1 configuration, but it would be proposed for other markets that allow the direct connection between the solar storage tank and the auxiliary heating system. Thus, simulation results run with E1 configuration for Rotartica machine case give a 10% Primary energy saving improvement compared to the same case in C1 configuration.

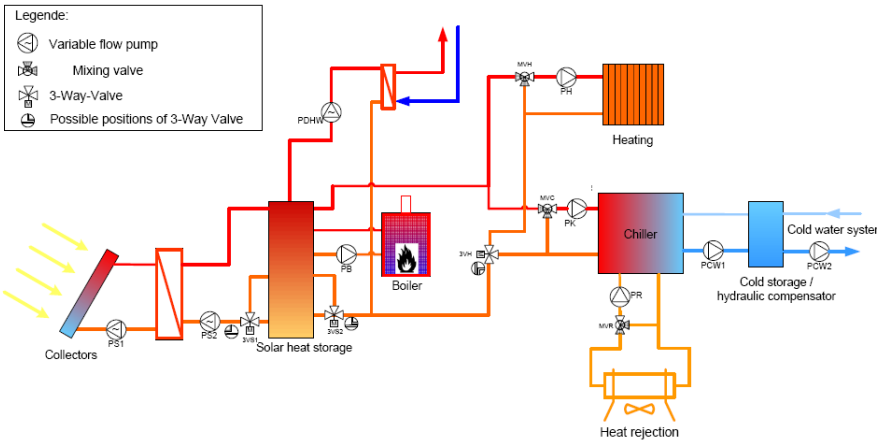


Figure 7: SolarCombi+project E1 system configuration scheme

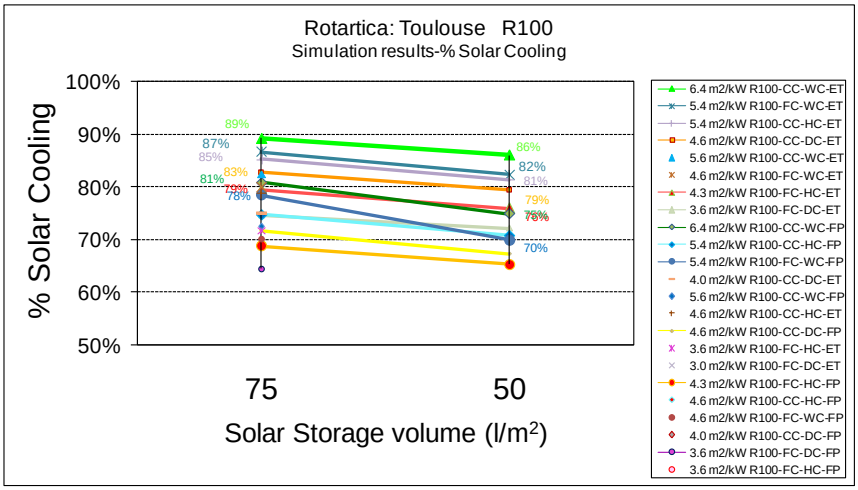
4.2.1 Simulation results

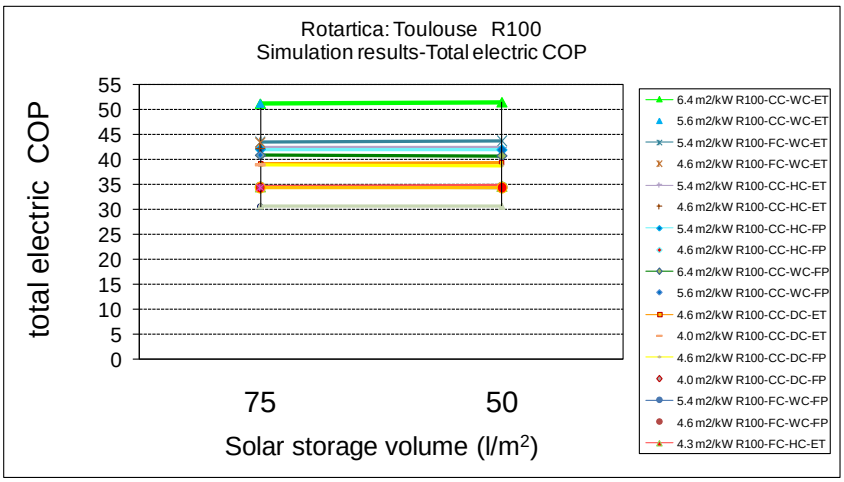
Hundred of simulations have been run based on the C1 Solar Combi + System configuration with a Rotartica machine. Collector size and type, solar storage tank size, distribution system and heat rejection system, has been considered as variables for three different buildings in three different European locations. The methodology used and simulation results are included as deliverables of SolarCombi+ project, and are accessible in the website www.solarcombiplus.eu. The results contributed to the optimization of Solar Combi+ system dimensioning, from both technical and economical point of view.

In this report only one case simulation results, residential building in Toulouse, will be given as an example. From these simulation results (see figure 8) it is possible to define the most interesting and energy efficient dimensioning for an specific case or also, taking into consideration that one variable is fixed, for example the system used as heat rejection, defined the best possible solution.

As an example, in the case shown the evacuated tube collectors give much better results than the flat plate collectors, unless its price is higher. So, for a case with chilled ceiling relative primary energy savings increase in a 11% using evacuated tubes instead of flat plate ones. And, also, the solar cooling percentage increases in an 18%.

So, taking into consideration simulation results database, it is possible to give some recommendations about the Solar Combi + System definition and its components dimensioning.





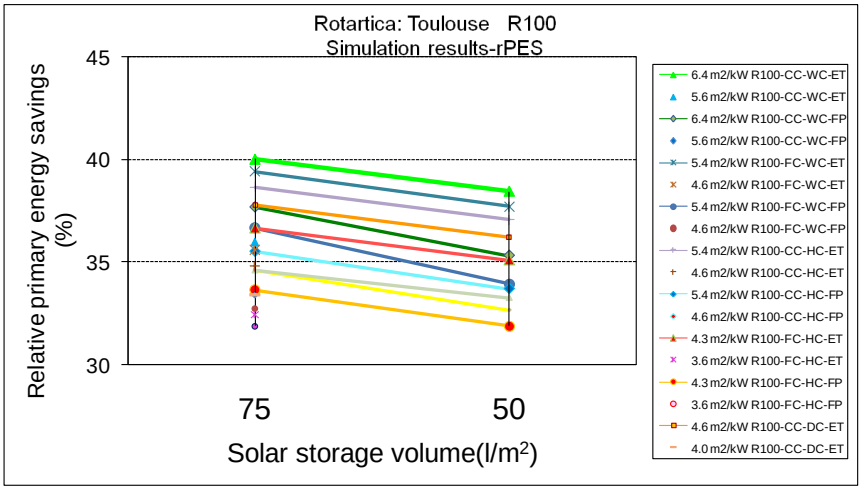


Figure 8: Simulation results for a Solar Com,bi+ system in C1 Configuration based on a Rotartica machine (case Toulouse residential building).

5 Proposed package solution

Rotarkit (figure 9), has been designed as a package solution for Solar Combi installation for heating, DHW and air-conditioning production. This kit ensures quality and reduces cost by easing:

- the plant conception and engineering
- the plant assembly
- the plant commissioning
- the maintenance of the whole plant

And, at the same time it supports different plant versions based on a unique plant concept (different HR concepts including a pool, different heat supplies, etc).

The kit is based on the simulation results run for ROTARTICA machine in a C1 configuration, especially targeting for the Spanish market. The main idea is to give priority to solar energy use, for DHW and heating, as well as for air-conditioning, improving the overall efficiency of the installation.

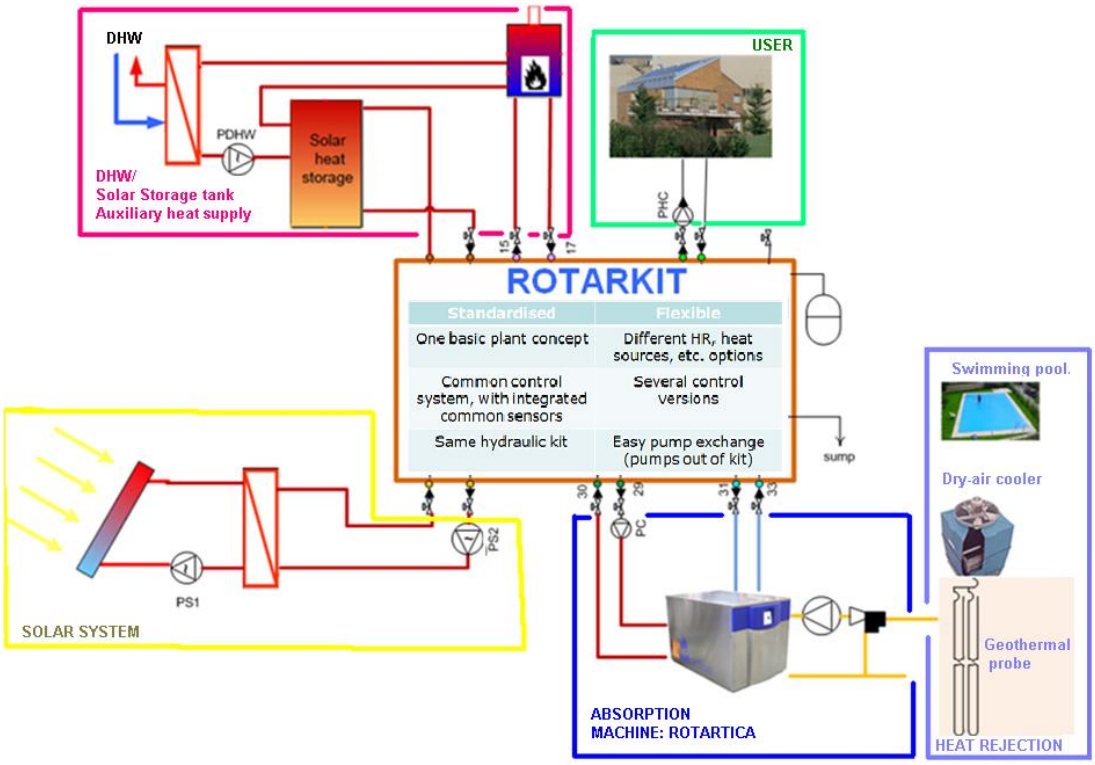


Figure 9: Concept scheme of ROTARKIT package solution for Solar Combi + installations.

The kit will allow the installers to easily connect the different subsystems of a Solar Combi+ installation, mainly :

- Solar Subsystem: It allows the solar thermal energy use, for heating and DHW, as well as for air-conditioning as heat source for the absorption machine.
- User Subsystem: It demands DHW, heating and air-conditioning, so control strategy of ROTARKIT will satify user demands, maximizing the overall efficiency of the system.
- DHW and Heating subsystem: It allows solar thermal energy storage, and also auxiliary heat supply when the heat provided by the solar collector field is insufficient to cover the demands. It includes DHW service and heating.
- Air-conditioning subsystem: It provides air-conditioning to the user, with an absorption machine.
- Heat Rejection subsystem: It allows to reject the excess of heat of the absorption machine through different technologies, such as: wet cooling tower, dry air cooler, geothermal probe and swimming pool.

Basically, the kit consists of some valves and connections (see figure 10). Different subsystem connections are in the outside of the kit, provided with manual valves to simplify assembly, maintenance or repairs. Three circuit's pumps are planted also outside, close to the kit, totally accessible in order to easy the dimensioning depending on the application and the replacement in case of breakdown.

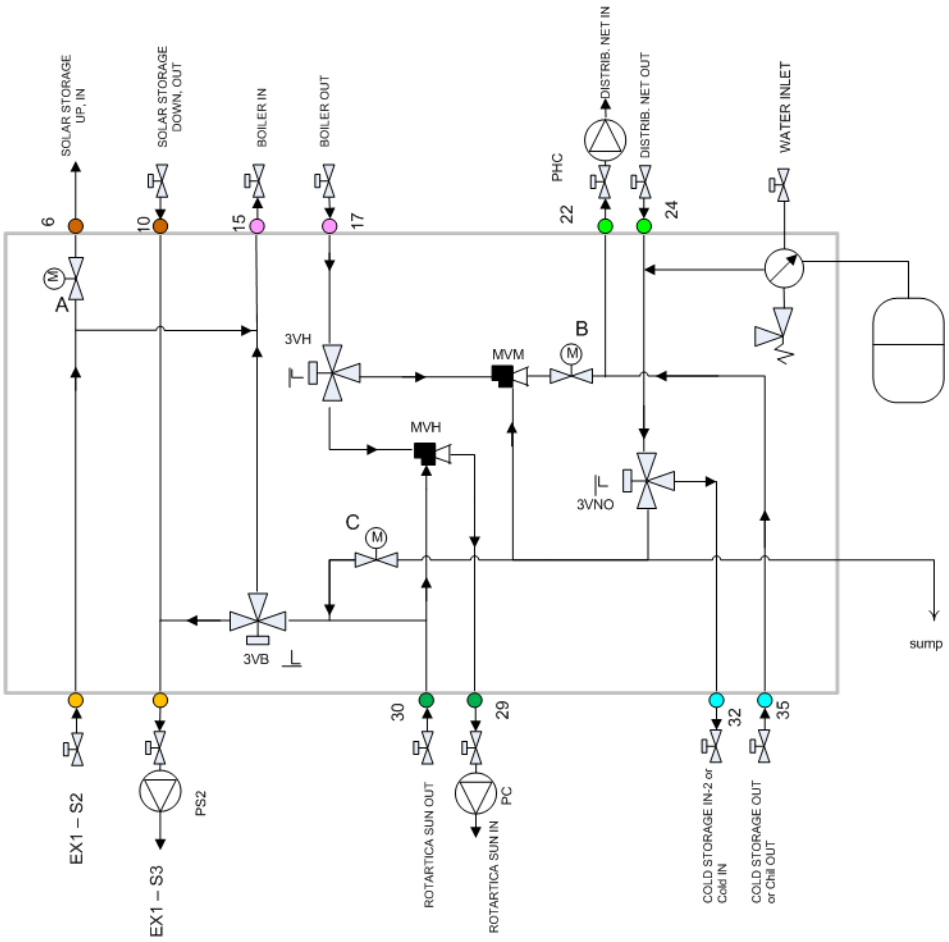


Figure 10: ROTARKIT based on C1 scheme (Spanish market)

The control will be also included in the kit, so different operation modes will be possible, according to an integral control algorithm that includes all the security measures to avoid stagnation of the solar collectors and freezing in wintertime.

The hydraulic scheme is linked to an integrated plant control system. Seven basic operation modes are possible:

- Mode 1, Summer, Direct Solar Air-conditioning
- Mode 2, Summer, Solar Air-conditioning through solar storage tank
- Mode 3, Summer, Air conditioning using auxiliary boiler (not recommended)
- Mode 4, Winter, Direct solar heating
- Mode 5, Winter, Solar heating through solar storage tank

- Mode 6, Winter, Heating using auxiliary boiler / or other heat supplies
- Mode 7, winter and summer, Domestic hot water service (in parallel, heating or cooling service could be also provided)

It is possible to design a Solar Combi+ installation without any auxiliary boiler, which obviously will have a higher primary energy saving, assuming that the system will be able to cover a percentage of the total demand of the user, based on the simulation results. Each case should be valorized and the user will have the key to select one or other option. Anyway, if the user decided not to use the auxiliary boiler and after some months prefer to include one, it will be very simple with the kit, only the connections "boiler in" and "boiler out" should be used.

Last but not least, Rotartica is able to work as a heat pump, and an amplified kit version should be defined for that purpose. It is not considered in this document.

6 Summary

Solar Combi + installations, which provide DHW, heating and Air-Conditioning to a building, could have considerable primary energy savings and total electrical efficiency improvements compared with conventional systems. The good performance of the system depends on a correct design of the hydraulic scheme as well as its control strategy.

Different adsorption/absorption chillers have been simulated in two of the selected C1 and E1 hydraulic schemes, inside SolarCombi+ project. Both schemes provided primary energy savings in the locations defined (Toulouse, Naples and Strasbourg), for different variables values.

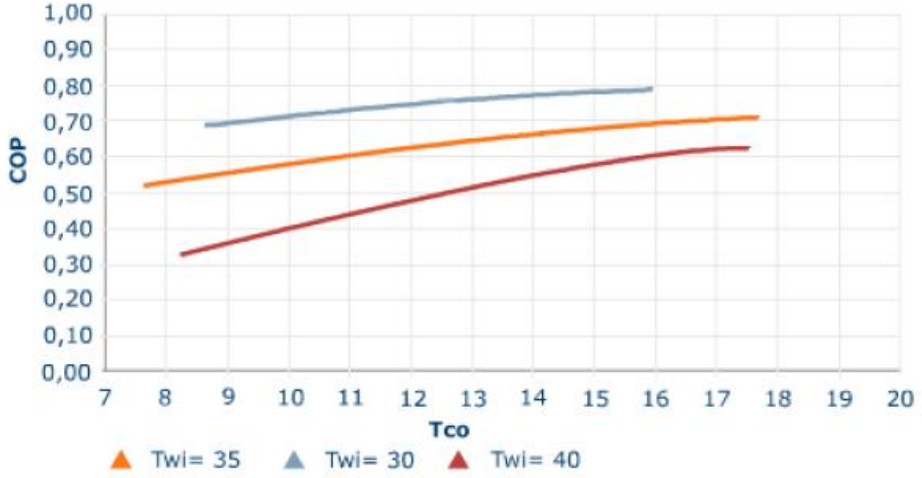
These innovative installations have high design and engineering cost that could be substantially reduced using the proposed kit or package solution. This is the main reason to design and define a kit for SolarCombi+ installations with an

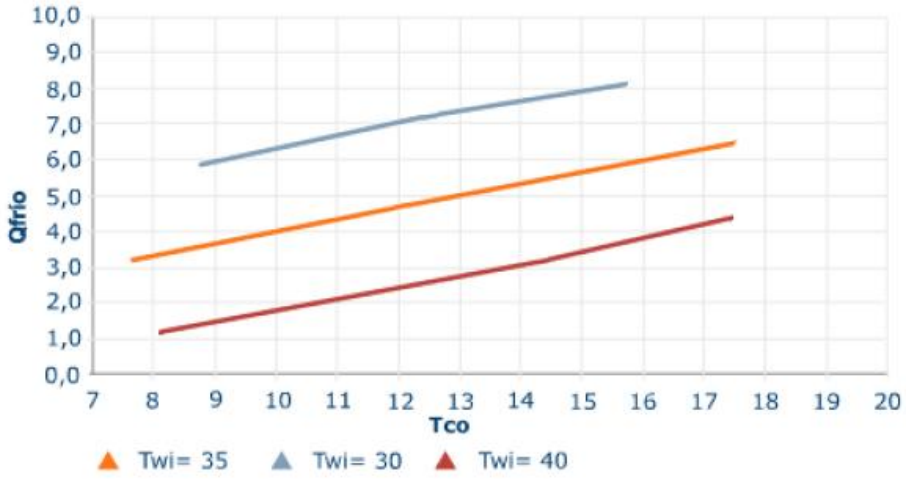
absorption machine. Basically, the advantages of the kit will be cost reduction, quality improvement and easy assembly.

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 auxiliary heat supply systems whenever possible. The manufacturer will define some control temperatures with the aim to reduce energy consumption and provided comfort to the user.

Annex I: Rotartica Technical data

Operating curves for a supply temperature of 90ºC:





Qfrío= Cooling power (kW) **Tco**= Cold water feed (ºC) **Twi**= Hot water return to condenser (ºC)

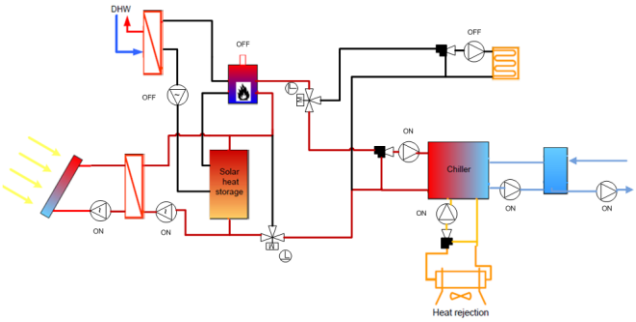
ROTARTICA			
PRESTACIONES DE PRODUCTO		ENFRIADORA SOLAR Aire-Agua	
	Tecnología	ABSORCIÓN DE SIMPLE EFECTO LiBr/H20	
	Marca	**ROTARTICA**	
	Modelo	SOLAR 045 y SOLAR 045v	
Datos de producto	Empresa	ROTARTICA	
	Producto	Enfriadora Aire-Agua	
	Potencia nominal de refrigeración	4,5 kW	
	Accionamiento	Agua calentada a 90ºC	
	Absorbente/Refrigerante	LiBr/H2O	
		SOLAR 045	**SOLAR 045v**
Circuito Agua FRÍA	Capacidad (kW)	4,50	
	Caudal (m3/h)	1,56	
	Pérdida de carga (bar)	0,52	
Circuito Agua DISIPACIÓN	Capacidad (kW)	11,70	-
	Caudal (m3/h)	1,98	-
	Pérdida de carga (bar)	1,12	-
Circuito APORTE ENERGÍA	Aporte calor al generador (kW) a 90º	7,20	
	Caudal (m3/h)	0,90	
	Pérdida de carga (bar)	0,36	
Suministro eléctrico	Consumo eléctrico Aparato de Absorción (kW)	0,40	1,11
Temperaturas	Nominal de entrada al Generador (ºC)	90	
	Nominal de salida frío (ºC)	12	
	Nominal de salida disipación (ºC)	40	-
	Ambiente (influye para disipación seca)	30	
Dimensiones	Largo (mm)	1130	1202
	Ancho (mm)	720	803
	Altura (mm)	790	1202
	Volumen (m3)	0,64	1,16
	Peso (kg)	240	290

Condiciones nominales:

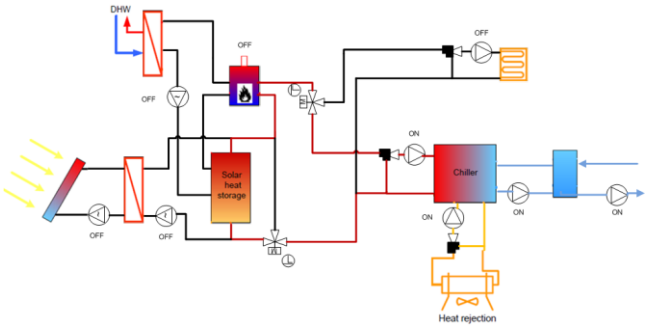
Circuito primario: 90ºC y caudal 15 l/min, **Circuito agua fría:** 12ºC y caudal 26 l/min, **Circuito agua caliente retorno:** 35ºC (disipación seca) y caudal 33 l/min

NOTA: No existe una norma para aparatos de absorción SIN torre de refrigeración. En su defecto se utilizan las condiciones indicadas anteriormente.

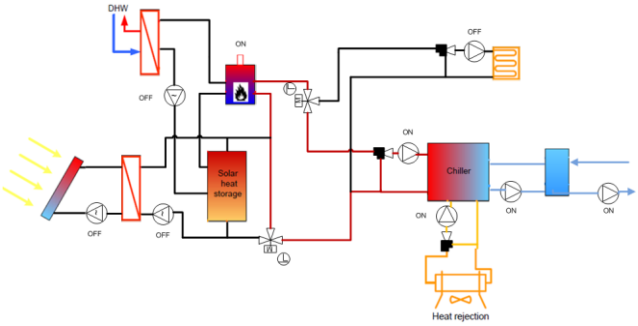
Anexo II: Rotarkit performance modes



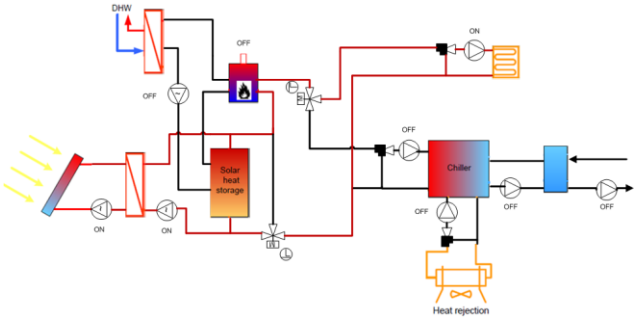
Mode 1: Solar Air-conditioning



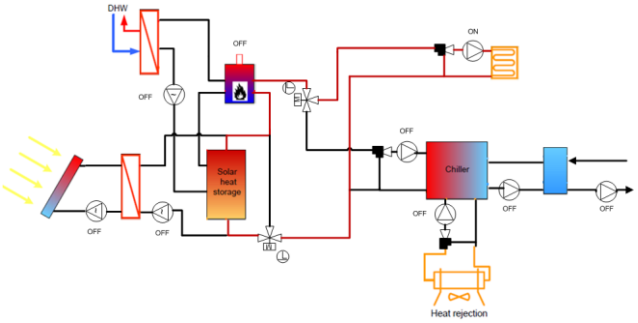
Mode 2: Air-conditioning through solar storage tank



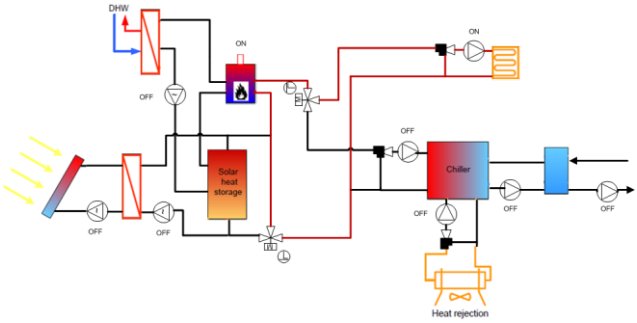
Mode 3: Air-conditioning based on an auxiliary heat supply system



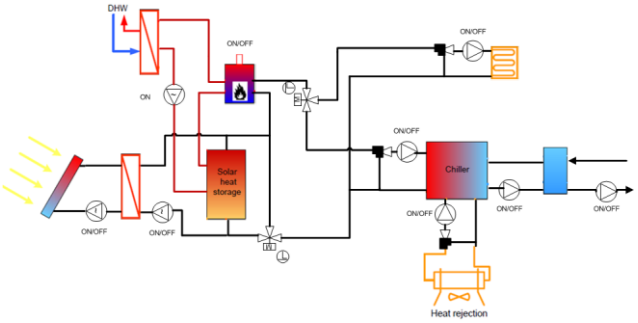
Mode 4: Solar Heating



Mode 5: Heating through solar storage tank



Mode 6: Heating based on an auxiliary heat supply system



Mode 7: DHW service