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Solar Combi+ system with a 4,5 kW absorption chiller: best choice for different cases

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Topic: 5: System Design and Simulation

Introduction

Within the EIE SolarCombi+ project, different small scale Thermally Heat Driven chillers have been simulated in Solar Combi + systems, where DHW space heating and cooling is partially provided by solar energy. A deep study of the simulations results in Continental and Mediterranean locations with a Rotartica absorption chiller makes it possible to evaluate the most promising sizing and configuration in residential sector.

For each chiller numerous simulations in TRNSYS have been carried out. Variations in parameters such as solar collector area and storage volume have been investigated in order to study their effect in the system performance. Variations in configurations such as solar collector type, distribution system and different heat rejection technologies have been considered in the study as well, [1].

A comparative analysis has been done taking into account the most relevant energetic and economical figures. Thus the effect of varying parameters has been evaluated. Furthermore it is possible to identify the best configuration with optimal sizing of the system for each case.

The paper is concluded presenting a comparison between heat rejection components simulated in a best SC+ configuration located in Naples for a residential case.

Best configurations

A comparative analysis has been done considering the most relevant figures and evaluating the effect of varying different parameters. The simulations have been conducted for two solar collector types, i.e. Evacuated Tubes and Flat Plate, two distribution system, i.e. Cooling Coil and Fan Coil, and for three heat rejection technologies, i.e. Wet Cooling tower, Dry air Cooler with and without a fogging device.

In Table 1 the best configurations are presented together with the optimal solar collector area and storage buffer volume. Total Solar Fraction, electrical Coefficient Of Performance, relative Primary Energy Savings and costs per Primary Energy Saved are the terms considered for the evaluation.

Naples	WC				HC				DC			
R100	ET		FP		ET		FP		ET		FP	
CC	6.4	m^2/kW	6.4	m2/kW	5.4	m^2/kW	5.4	m2/kW	4.6	m^2/kW	4.6	m^2/kW
	75	l/m^2	75	l/m2	75	l/m^2	75	l/m^2	75	l/m^2	75	l/m^2
	SF	78.4	SF	74.5	SF	74.5	SF	69.9	SF	72.2	SF	67.6
	elCOP	16.9	elCOP	16.7	elCOP	17.4	elCOP	17.2	elCOP	16.5	elCOP	16.4
	rPES	59.7	rPES	54.2	rPES	55.4	rPES	49.1	rPES	52.0	rPES	45.6
	cPES	0.15	cPES	0.09	cPES	0.18	cPES	0.12	cPES	0.20	cPES	0.15
FC	5.4	m^2/kW	5.4	m^2/kW	4.3	m^2/kW	4.3	m^2/kW	3.6	m^2/kW	3.6	m^2/kW
	75	l/m^2	75	l/m^2	75	l/m^2	75	l/m^2	75	l/m^2	75	l/m^2
	SF	82.0	SF	78.1	SF	75.2	SF	69.8	SF	71.7	SF	66.2
	elCOP	12.1	elCOP	11.9	elCOP	12.5	elCOP	12.2	elCOP	11.6	elCOP	11.5
	rPES	59.1	rPES	53.1	rPES	50.9	rPES	43.1	rPES	45.3	rPES	37.5
	cPES	0.20	cPES	0.13	cPES	0.26	cPES	0.21	cPES	0.34	cPES	0.29
Toulouse	WC				HC				DC			
R100	ET		FP		ET		FP		ET		FP	
CC	6.4	m^2/kW	6.4	m2/kW	5.4	m^2/kW	5.4	m2/kW	4.6	m^2/kW	4.6	m^2/kW
	75	l/m^2	75	l/m2	75	l/m^2	75	l/m^2	75	l/m^2	75	l/m^2
	SF	46.2	SF	45.6	SF	45.9	SF	43.0	SF	45.2	SF	42.3
	elCOP	51.2	elCOP	40.8	elCOP	42.3	elCOP	42.0	elCOP	39.2	elCOP	38.8
	rPES	40.0	rPES	37.7	rPES	38.7	rPES	35.5	rPES	37.8	rPES	34.6
	cPES	0.13	cPES	0.08	cPES	0.15	cPES	0.09	cPES	0.16	cPES	0.11
FC	5.4	m^2/kW	5.4	m^2/kW	4.3	m^2/kW	4.3	m^2/kW	3.6	m^2/kW	3.6	m^2/kW
	75	l/m^2	75	l/m^2	75	l/m^2	75	l/m^2	75	l/m^2	75	l/m^2
	SF	46.0	SF	45.4	SF	44.8	SF	42.0	SF	43.1	SF	40.6
	elCOP	43.5	elCOP	34.4	elCOP	34.6	elCOP	34.3	elCOP	34.3	elCOP	30.5
	rPES	39.4	rPES	36.7	rPES	36.7	rPES	33.6	rPES	34.6	rPES	31.9
	cPES	0.14	cPES	0.10	cPES	0.17	cPES	0.12	cPES	0.21	cPES	0.15

Table 1 The best simulation results containing different cases for residential building in Naples and Toulouse.

Comparison between different heat rejection technologies

The impact that different type of heat rejection technology has on the overall performance of the plant is here evaluated considering several indexes as the Primary Energy Savings, Costs per Primary Energy saved and CO_2 saved, [2]. Special considerations have been taken about the Total Solar Fraction together with the Stagnation Time.

Looking at the results reported in Table 1 for a residential case located in Naples, a configuration with 5 m²/kW of solar collector area and a storage volume of 75 l/m² has a high energy savings potential. Around 70% of solar fraction and more than 50% of relative Primary Energy savings can be expected with the previous ranges. Finally a cooling coil distribution together with evacuated tubes as solar collector identifies the best configuration which has been used for the following analysis.

Wet Cooling towers, Dry air Coolers with and without fogging device have the properties to be installed easily due to their well known design procedure and long time term of experience. For this reason within the SolarCombi+ project the previous technologies have been considered as conventional technologies.

Vice versa Horizontal Geothermal Probes and Swimming Pool are nowadays more and more entering onto the market but still their integration in solar air conditioning system is under investigation. In this study a geothermal probes system with a length of 500 m and buried at a depth of 2 m below the ground has been simulated with the TRNSYS Type 952. An outdoor swimming pool with a surface of 100 m² and a volume of 150 m³ has been simulated with the TRNSYS Type 344.

In Figure 1 all the five heat rejection technologies are compared in terms of absolute and relative Primary Energy saved. The latter term is related to the Primary Energy consumption which would be achieved with a reference system, i.e. with a conventional gas burner and compressor chiller.

In Figure 2, CO_2 saved and Costs per Primary Energy saved are shown for the same residential case located in Naples with evacuated tubes collectors. The Costs per PEsaved has been calculated assuming 50% of incentives for the total installation.

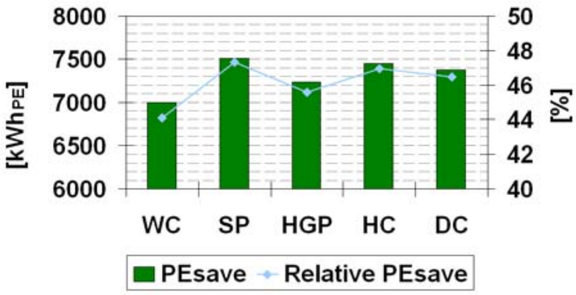

Figure 1 Absolute and relative PEsaved for a residential case located in Naples with cooling coil and evacuated tubes.

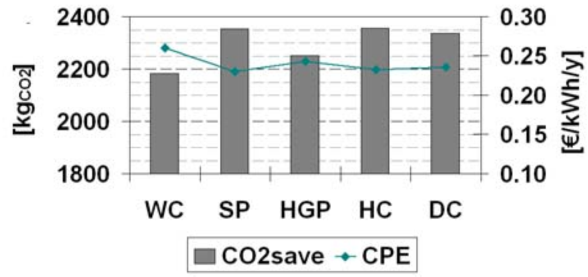

Figure 2 CO_2 and Costs per PEsaved for a residential case located in Naples with cooling coil and evacuated tubes.

The same analysis has been performed considering two solar collector technologies, i.e. Flat Plate and Evacuated Tubes. With this configuration just three of the five heat rejection technologies have been investigated.

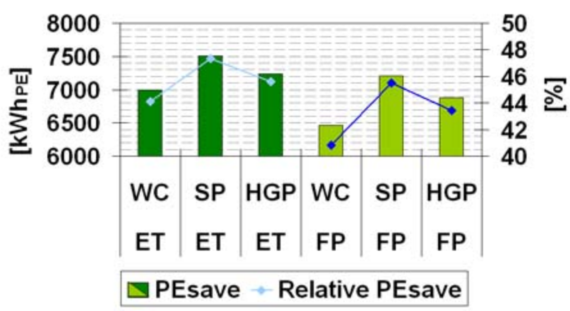

Figure 3 Absolute and relative PEsaved for a residential case located in Naples with cooling coil and two different solar collector type, i.e. Evacuated Tubes and Flat plate.

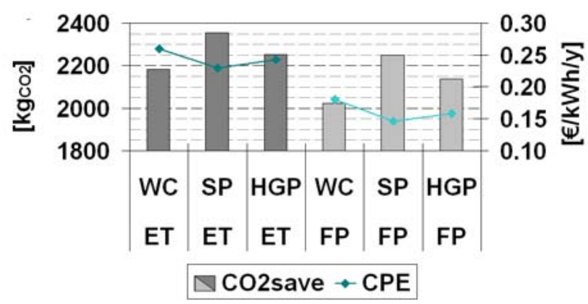

Figure 4 CO_2 and Costs per PEsaved for a residential case located in Naples with cooling coil and two different solar collector type, i.e. Evacuated Tubes and Flat plate.

Due to the large collector area and small summertime loads, combisystem are more frequently exposed to an excess in solar heat production than are solar water heaters,

[3]. However in a SolarCombi+ system thanks to the coupling of a Thermally Heat Driven chiller with a large solar collector area, the stagnation condition should be less frequently than are in a combisystem. In Figure 5 the stagnation condition has been observed principally when the space heating and cooling is not required along the year, i.e. 75% in April, May, September and October.

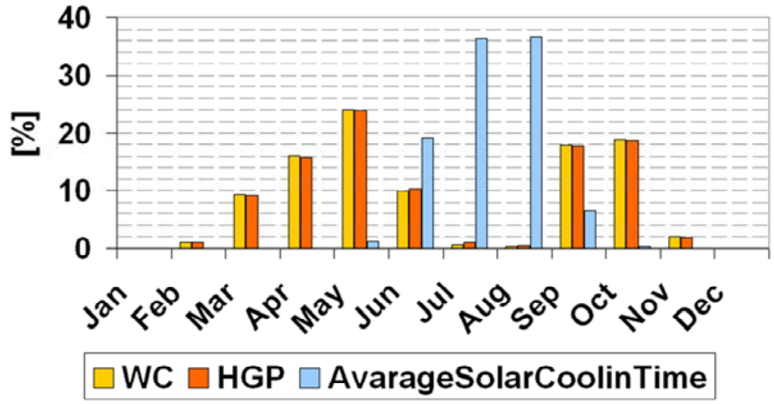

Figure 5 Stagnation and Solar Cooling Profile during a year.

Finally a total solar fraction calculated with a weighted average of the three energy contributions as DHW, space heating and cooling has been obtained for the same configuration and sizing.

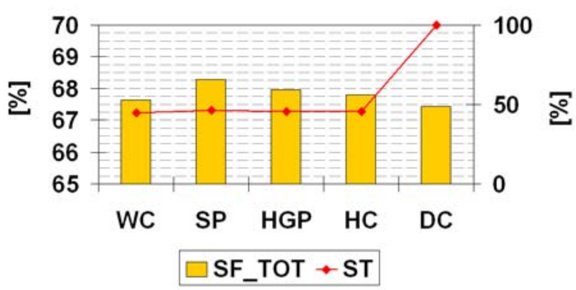

Figure 6 Total Solar fraction and stagnation time for a residential case located in Naples with cooling coil and evacuated tubes.

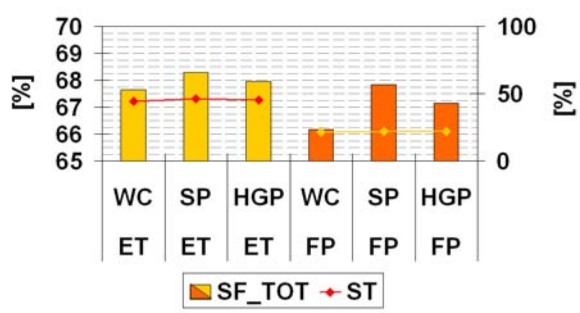

Figure 7 Total Solar fraction and stagnation time for a residential case located in Naples with cooling coil and two different solar collector type, i.e. Evacuated Tubes and Flat plate.

More then 65% of total solar fraction has been registered in all the cases with both Evacuated tube and Flat plate solar collectors, Figure 6 and Figure 7.

Conclusions

An appreciate range of residential building loads can be covered with SolarCombi+ systems, considering technically and energetically. For a proper study of its viability a deeper study will be needed in order to evaluate also economically. The best configurations are available from an online data base at the project homepage www.solarcombiplus.eu.

Particular attention and effort has been spent to proof the feasibility of two unconventional heat rejection components, i.e. horizontal geothermal probes and swimming pool. The presented results have indicated that the option solutions in terms of Primary Energy savings and Costs are equivalent to the conventional ones, i.e. Wet Cooling Tower, Dry Air Cooler with and without a fogging device.

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[2] D. Torsello, F. Besana, G. Franchini, Transient Simulation of Solarcombi+ System: Analysis of Different Heat Rejection Technologies and Their Impact on Overall Performances, Master Thesis, Università degli Studi di Bergamo, Dalmine - Italy, July 2009.

[3] R. Hausner, C. Fink, Stagnation behavior of solar thermal system, A Report of IEA SHC – Task 26, November 2002.