Adriacold

“Diffusion of Cooling and Refreshing Technologies using the Solar Energy Resource in the Adriatic Regions”

Project Code: 2°ord./0030/1

Pre-feasibility study of new solar cooling/heating system in hotel “Marina”

Work Package:	WP6
Action:	6.2
Deliverable due date *(as in the AF):*	31/08/2014
Responsible partner:	FB 7 – UNIZAG FSB
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Deliverable code (if applicable only):	Od_6.2
First Created:	01/11/2014
Last Updated:	19/12/2014
Version:	Final

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1. Project information

1.1 General information on the project

Name of building: Bluesun hotel „Marina“

Owner of building: Sunce Koncern d.d.

Location of building: Brela, Croatia

Coordinates of building: 43.369868 N 16.927135 E

Hotel was built in 2002.

Hotels appearance and view on the complex is presented in Picture 1.

Picture 1. Location of the hotel Marina

Total areas of each building as shown in Table 1*:*

Table 1. Buildings areas in complex of the hotel "Marina"

Name of block	*No. of floors*	*Area*
Block A	*6 floors*	*6 173 m^2*
Block B	*5 floors*	*2 223 m^2*
Block C	*5 floors*	*4 448 m^2*
Total area of hotel		*12 845 m^2*

The project is co-funded by the European Union Instrument for Pre-Accession Assistance

Buildings in complex are marked with their respective names in *Picture 2*.

Picture 2. Complex of the hotel "Marina"

Total area of the building to cool: 11 325 m²

Total volume of the building to cool: 32 367 m^3

1.2 Existing cooling and heating equipment

The Bluesun hotel „Marina“, use HVAC system for cooling and cold water is produced in two CIAT ILK 1000A compressor water chillers, installed in 2002. Each water chiller unit have maximum cooling capacity of 270kW. HVAC units used in Bluesun hotel Marina were made by Proklima company.

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Bluesun hotel „Marina „does not have internal system for heat production. Heat for space heating and production of hot water is delivered by heat distribution system from hotel „Maestral“. Heat is produced for three hotels („Maestral“, „Soline” and „Marina“) in two 1600 kW Buderus extra light fuel oil boilers.

Hot water, from heat distribution system, is entering heating hub of the hotel „Marina“ from where its distributed to six heating loops by pumps. In each heating loop, two pumps are installed. In case of malfunction of the main pump, second pump is taking its function. Temperature dilatation of water is managed by two expansion vessel with volumes of 400 l and 250 l, respectively.

Distribution of heat from distribution system and cold from water chillers is done by usage of HVAC system and fan coil units in the majority of the hotel spaces.

1.3 Orientation of the study

Hotel opens its doors in the month of May and closes it in the October, which means that cooling is needed whole time of its operation.

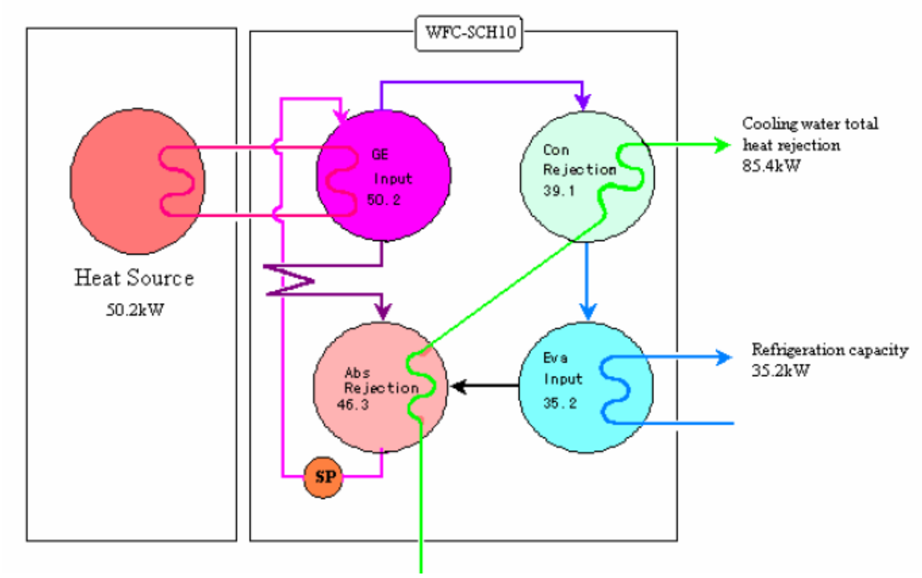
As its main purpose is to suit needs of its guests, priority of cooling is set on whole building.
While hotel does not work in winter months, in the months of May and October there can be expected some need for space heating.

Use of solar collectors, installed as a part of solar cooling system, in winter months for heating of hotel, heating of hot water and heating of water pools could reduce hotels operating cost and prolong its working period.

In proposed solutions (two systems described in the Section 3.1), majority of the roof area is needed to install sufficiently large solar thermal collectors field. This idea is illustrated by Picture 3 for the first solution (system 1) which is proposed to fulfil basic and peak load for cooling. System 2 is proposed to fulfil only basic load and utilizes a lot less roof area.

Picture 3. Area of roof of the complex buildings reserved for solar thermal collector field

Excess of heat produced by absorption system could be used in kitchens of three Bluesun hotels „Marina”, „Maestral“ and „Soline“ which are relatively close to each other (Picture 1). Basic operating scheme of solar cooling systems with installed WFC-SCH10 is presented on Picture 4. It can be concluded that optimal performance and feasibility of the system will depend on management of redundant hot water that remains on significant temperature after the process. This is well suited situation for hotel „Marina“ which, due to its large area, has extensive need for DHW and can utilize this hot water.



Picture 4. Operation of solar cooling system WFC-SCH10

2. Information on case study building

2.1 Building structure

Walls: 26 cm, concrete with a plaster coating

Ceiling: 15 cm concrete, with a layer of gravel on it and concrete panels

Windows: Aluminium with two layer insulation glass

The hotel complex consists of three blocks which are interconnected, as shown in Picture 1 and 2. Estimated building shape factor is 0,3.

Forced ventilation system exists as a part of HVAC system.

2.2 Occupancy of the building

The Bluesun hotel "Marina" has total capacity of 288 rooms where are 111 rooms with one bed and 177 rooms with two beds.

These rooms are divided into blocks, so that block A has 71 room with one bed and 20 rooms with 2 beds, block B has 65 rooms with 2 beds and block C has 40 room with one bed and 92 rooms with 2 beds.

There are many service rooms in the hotel. The biggest of them are: reception, restaurant, kitchen, machinery room etc.

Number of guests in building is proportional to bed occupation.

Number of people working in hotel is constant the whole time hotel is open for guests.

In winter months when hotel is not working, there are only few people that are working on maintenance of building and security.

3. Technical aspects of solar cooling plant

3.1 Technical data

Descriptions of proposed solutions are presented in *Table 2*.

System 1 *represents solution which aims to cover peak and basic cooling load in the complex.*

System 2 *represents solution which aims to cover basic cooling load in the complex.*

Table 2. Technical data for proposed systems

	Energy - related comparison	Unit	System 1	System 2
1	Collector type	-	Vacuum collectors	Vacuum collectors
2	Collector Area (absorber)	m^2	1 556	809
3	Volume of heat storage	m^3	60	60
4	Volume of chilled water storage tank	m^3	5	5
5	Volume of Domestic Hot Water (DHW) storage	m^3	40	40
6	Airflow (air-handling unit)	m^3/h	2	2
7	Heating power of back-up heater	kW	not existing	not existing
8	Nominal chillers power, compression chillers	kW	540	540
9	Nominal chillers power, thermally driven chiller	kW	420	245
10	Nominal power of cooling tower	kW	825	440

3.2 Absorption unit data

In the analysis four types of absorption cooling units were used. With usage of more cooling units, installed cooling units are used only when they are needed. Heat storage is shared between used units.

Table 3. Absorption unit - system 1

	Energy - related comparison – System 1	Unit	WFC-SC 50	WFC-SC 20
1.	Absorption unit type	-	LiBr/H2O	LiBr/H2O
2.	Cooling capacity	kW	175.8	70.3
3.	Hot water temperature	°C	88	88
4.	Volume of heat storage	m^3	60	60
5.	Chilled water temperature	°C	7	7
6.	Volume of chilled water storage tank	m^3	5	5
7.	Electricity consumption	W	590	260

Table 4. Absorption unit - system 2

	Energy - related comparison – System 2	Unit	WFC-SC 30	WFC-SC 10
1.	Absorption unit type	-	LiBr/H2O	LiBr/H2O
2.	Cooling capacity	kW	105.6	35.2
3.	Hot water temperature	°C	88	88
4.	Volume of heat storage	m^3	60	60
5.	Chilled water temperature	°C	7	7
6.	Volume of chilled water storage tank	m^3	5	5
7.	Electricity consumption	W	310	210

3.3 Solar collectors data

Short description of unit selected, available area for placement of solar collectors, size of solar collectors, absorber are per unit and for installed system

Table 5. Solar collectors data

	Energy - related comparison	Unit	System 1	System 2
1	Collector type	-	Vacuum	Vacuum
2	Gross Collector Area	m^2	1 875	975

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3.4 Cooling tower data

By using simulation, which is made as a part of this study, needed capacity of cooling towers for each proposed system is determined. Selection of specific cooling tower is not included in this study.

3.5 Machinery room data

Machinery room is a station for distribution of heat and cold. It's a part of the hotel building and its containing heating hub of the hotel with all pumps and valves, expansion vessels, HVAC units and DHW storage.

Picture 5. Existing machinery room in hotel "Marina"

4. Thermal balance of solar cooling pilot plant

4.1 Meteorological data

Meteorological data used for calculations are hourly data from "METEONORM" program for location of the building.

A calculation of heat energy gained from solar collectors is based on hourly solar radiation from past year and absorber area of solar collectors used. Energy required for heating/cooling is calculated from hourly meteorological data using methodology given in HRN ISO 13790 standard.

4.2 Calculation results for selected pilot plant

Information about calculated data such as production of energy for solar collectors, annual needs for hot water, annual needs for cooling, energy needed for back-up.

Table 6. Resultes for two scenarios

	Energy - related comparison	Unit	Reference	System 1	System 2
	General data				
1.	Energy consumption for space heating	kWh/a		0	0
2.	Energy consumption for space cooling	kWh/a		918 626	918 626
3.	Energy production for cooling from collector	kWh/a		756 639	545 179
4.	Energy production for heating from collector	kWh/a		0	
5.	Energy production for hot water from collector	kWh/a		292 500	292 500
6.	Amount of back-up energy for space cooling	kWh/a		161 986	373 446
7.	Amount of back-up energy for space heating	kWh/a		0	0
8.	Amount of back-up energy for hot water heating	kWh/a		0	0

5. Economic analysis

5.1 Project cost evaluation

In this section economic cost of the project will be elaborated. Also, savings obtained through new project will be clarified.

Table 7. Project cost evaluation

	Economic assessment	Unit	System 1	System 2
1	Solar collector	€	250 671	130 663
2	Storage tank	€	Included	Included
3	Absorption unit	€	169 882	128 157
4	Cooling tower	€	Included	Included
5	Measuring system	€	Included	Included
6	Installation costs	€	Included	Included
7	Planning	€	10 514	6 470
8	Other costs	€	241 818	155 292
9	Total Investments	€	672 885	414 111

In table below data on energy savings are elaborated in details for different cases.

Table 8. Annual costs for two systems

	Economic assessment	Unit	System 1	System 2
1.	Annual costs for electricity	€	19 411	13 986
2.	Annual cost for fossil fuels	€	25 647	25 647
3.	Annual maintenance cost	€	-	-
4.	Annual water costs	€	-	-
5.	**Total annual costs**	**€**	45 057	39 633

5.2 Economic assessment

In this section internal rate of return, simple payback period and net present value for scenarios will be presented. Investment costs which will be considered are 100% private investment (PE), 75% private investment and 25% from regional development fund (ERDF) or similar fund, 50% private investment and 50% regional development fund

Table 9. Economic assessment resultes

	Economic assessment	Unit	System 1	System 2
1.	Internal Rate of Return (100% Private Equity)	%	3.67	8.03
2.	Internal Rate of Return (75% PE + 25% ERDF)	%	7.00	12.50
3.	Internal Rate of Return (50% PE + 50% ERDF)	%	13.06	19.87
4.	Net Present Value (100% Private Equity)	€	-154 501	31 848
5.	Net Present Value (75% PE + 25% ERDF)	€	4 244	129 544
6.	Net Present Value (50% PE + 50% ERDF)	€	162 989	227 239
7.	Payback period (100% Private Equity)	Year	14.0	9.8
8.	Payback period (75% PE + 25% ERDF)	Year	10.5	7.4
9.	Payback period (50% PE + 50% ERDF)	Year	7.0	4.9

It is shown that system 2 is already feasible in case of 100% Private Equity, in restrictions of depth of this study.

It can be recommended for the owner to invest in feasibility study for system 2, in order to collect further information and proceed with realisation of the project.

6. Environmental analysis

In this section, influence of implementation of proposed technological solution on the reduction of GHG-s is discussed. It is shown that system 1 would help reduce more CO_2emissions and would also be more energy efficient, but system 2 is also very good on both fields.

Table 10. Environmental analysis - saved energy, fuels and reduction of GHG emissions

	Environmental analysis	Unit	System 1	System 2
1.	Saved electric energy	kWh	189 159	136 295
2.	CO_2 emissions for electricity	kg/kWh	0.27675	0.27675
3.	CO_2 saving due to electricity savings	kg	52 350	37 719
4.	Saved fossil fuel energy for heat	kWh/a	29 1528	29 1528
5.	CO_2 emissions for fossil fuel	kg/kWh	0.26	0.26
6.	CO_2 saving due to fossil fuel saving	kg	75 797	75 797
7.	**Total energy saving**	**kWh/a**	**480 688**	**427 823**
8.	**Total CO_2 saving**	**kg**	**129 310**	**114 680**

7. SWOT Analysis

SWOT Analysis for pilot plant location	
Strengths	**Weaknesses**
• supported by the EU • financial support from Croatia and EU • reduced consumption of electric energy • reduced consumption of FOEL (fuel oil extra light) • reduced pollution and cleaner technology • better ecological approach • high insulation, good advantage for installation of solar collectors • big roof area	• poor position of buildings between themselves within the complex • poor shape of the buildings • non optimal solutions of building materials • higher cooling and heating demand because of building's permeability's caused by non optimal solutions • weak interest in new technologies
Opportunities	**Threats**
• good fundament for feasibility study which could give better and accurate results • more financial support, especially from EU • greater opportunity for financing similar projects • better and quality education of modern technologies and systems for hotel staff • staff will be more aware of consuming energy • encouraging new ideas • chance for attracting media attention which could raise hotel reputation • better market positioning • positive results from proposed cases	• unstable economic situation in Croatia because of economic crisis • despite the financial help by the EU, hotel owner must invest in maintenance of new system, new staff and tuition of current staff • some workers may hardly adapt to the new system, while others could refuse • problematic administration and paperwork which could procrastinate whole project

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