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 "Maestral"

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1. Project information

1.1 General information on the project

Name of building: Bluesun hotel "Maestral"

Owner of building: Sunce Koncern d.d.

Location of building: Brela, Croatia

Coordinates of building: 43.369424 N, 16.928783 E

Hotel is built in 1965 and renovated in 2002.

Location of the hotel is illustrated by Picture 1.

Picture 1. Location of the Maestral hotel

Total area of building: 5 557 m^2

Total area of the building to cool: 5 557 m^2

Total volume of the building to cool: 14 985 m^3

1.2 Existing cooling and heating equipment

The Bluesun hotel "Maestral" use HVAC system for cooling and cold water is produced in compressor water chiller installed in 1992. Water chiller unit have maximum electric power of 51 kW.

The Bluesun hotel "Maestral" has central system for heating and hot water production and it produces heat for two more hotels: "Marina" and "Soline". Heat distribution system is connecting these three hotels. Heat for space heating and production of hot water is produced by two 1600 kW "Buderus" boilers. "Buderus" boilers are using extra light heating oil.

Hot water, produced by two 1600 kW "Buderus" boilers, is entering heating hub of the hotel "Maestral" from where its distributed to other two connected hotels and to the heating loops of the hotel "Maestral". In each heating loop, there are pairs of pumps. In case of malfunction of the main pump, second pump is taking its function. Temperature dilatation of water is managed by expansion vessel.

Distribution of heat from distribution system and cold from water chillers is done by use 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 again closes it in the October, which means that its 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 2 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 2. Area reserved for solar collector field

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.

2. Information on case study building

2.1 Building structure

Walls: 40 cm, concrete with a plaster coating

Ceiling: 21 cm concrete, with a layer of gravel on it and concrete panels

Windows: Aluminium with two layer insulation glass in the majority of hotel and one layer glass in some parts.

Hotel consists of one building with pool and some area for relaxation of guests. Its estimated building shape factor is 0.32.

Forced ventilation system exists as a part of HVAC system.

2.2 Occupancy of the building

Bluesun hotel "Maestral" has capacity of 66 rooms.

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

Number of guests in building is proportional with bed occupation.

Number of people working in hotel is constant.

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 1.

***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 1. Proposed solutions - technical data

	Energy - related comparison	Unit	System 1	System 2
1	Collector type	-	Vacuum collectors	Vacuum collectors
2	Collector Area (absorber)	m^2	747	467
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	204	204
9	Nominal chillers power, thermally driven chillers	kW	210	245
10	Nominal power of cooling tower	kW	455	290

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3.2 Absorption unit data

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

Table 2. Absorption units - system 1

	Energy - related comparison – System 1	**Unit**	**WFC-SC 30**	**WFC-SC 20**	**WFC-SC 10**
1.	Absorption unit type	-	LiBr/H2O	LiBr/H2O	LiBr/H2O
2.	Cooling capacity	kW	105.6	70.3	35.2
3.	Hot water temperature	°C	88	88	88
4.	Volume of heat storage	m^3	60	60	60
5.	Chilled water temperature	°C	7	7	7
6.	Volume of chilled water storage tank	m^3	5	5	5
7.	Electricity consumption	W	310	260	210

Table 3. Absorption units - system 2

	Energy - related comparison – System 2	**Unit**	**WFC-SC 20**	**WFC-SC 10**
1.	Absorption unit type	-	LiBr/H2O	LiBr/H2O
2.	Cooling capacity	kW	70.3	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	260	210

3.3 Solar collectors data

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

Table 4. Solar collectors data

	Energy - related comparison	Unit	System 1	System 2
1	Collector type	-	Vacuum	Vacuum
2	Gross Collector Area	m^2	900	563
3	Net Collector Area (absorber)	m^2	747	467

3.4 Cooling tower data

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

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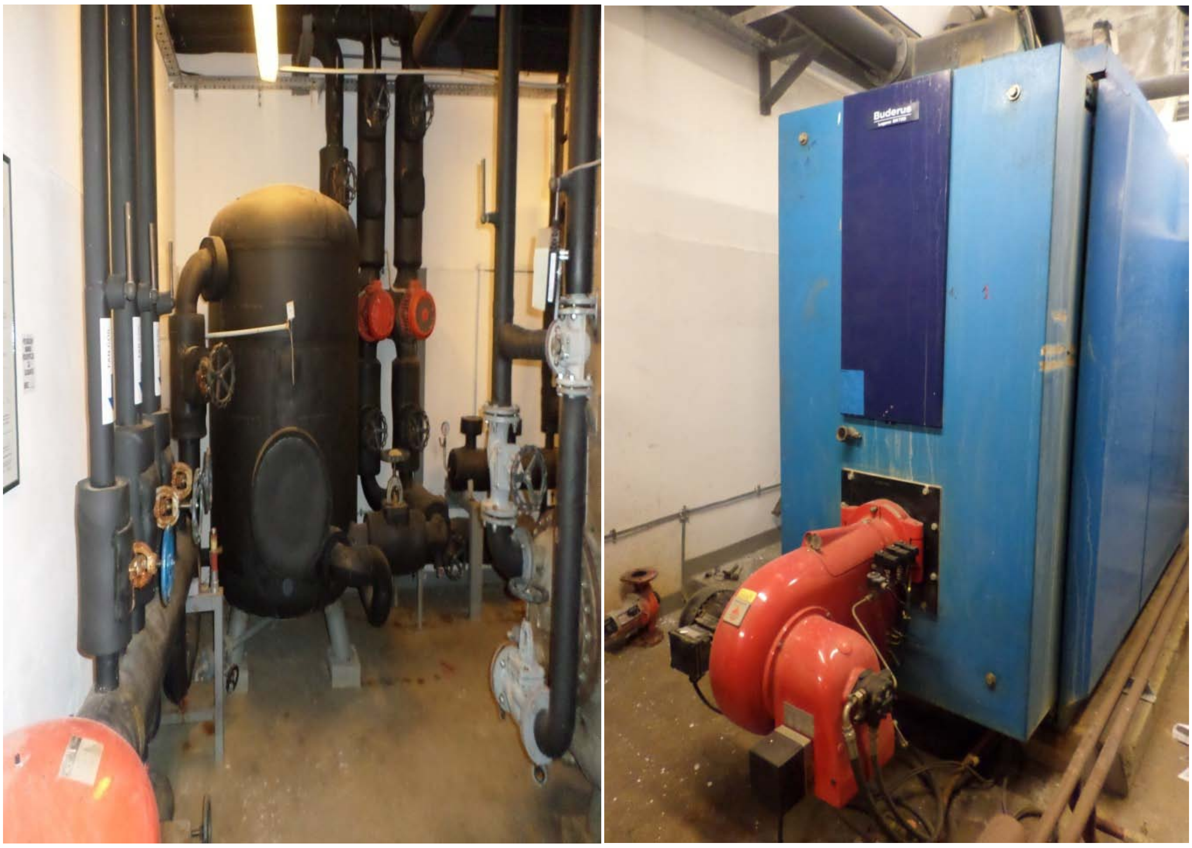
3.5 Machinery room data

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 3. Existing machinery room in hotel "Maestral"

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 5. Energy consumption - alternatives

	Energy - related comparison	Unit	Reference	System 1	System 2
	General data				
1.	Energy consumption for space heating	kWh/a		-	-
2.	Energy consumption for space cooling	kWh/a		591 390	591 390
3.	Energy production for cooling from collector	kWh/a		432 388	312 706
4.	Energy production for heating from collector	kWh/a		-	-
5.	Energy production for hot water from collector	kWh/a		95 326	95 326
6.	Amount of back-up energy for space cooling	kWh/a		159 002	278 683
7.	Amount of back-up energy for space heating	kWh/a		-	-
8.	Amount of back-up energy for hot water heating	kWh/a		-	-

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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 6. Economic assessment

	Economic assessment	Unit	System 1	System 2
1	Solar collector	€	120 568	75 145
2	Storage tank	€	Included	Included
3	Absorption unit	€	121 202	106 300
4	Cooling tower	€	Included	Included
5	Measuring system	€	Included	Included
6	Installation costs	€	Included	Included
7	Planning	€	6 044	4 536
8	Other costs	€	139 018	104 331
9	Total Investments	€	386 834	290 313

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

Table 7. Annual costs

	Economic assessment	Unit	System 1	System 2
1.	Annual costs for electricity	€	11 092	8 022
2.	Annual cost for fossil fuels	€	8 358	8 358
3.	Annual maintenance cost	€	-	-
4.	Annual water costs	€	-	-
5.	**Total annual costs**	**€**	19 450	16 380

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

	Economic assessment	Unit	System 1	System 2
1.	Internal Rate of Return (100% Private Equity)	%	0,68	1,83
2.	Internal Rate of Return (75% PE + 25% ERDF)	%	4,00	4,5
3.	Internal Rate of Return (50% PE + 50% ERDF)	%	8,71	10,36
4.	Net Present Value (100% Private Equity)	€	-157.626	-99.282
5.	Net Present Value (75% PE + 25% ERDF)	€	-66.365	-30.793
6.	Net Present Value (50% PE + 50% ERDF)	€	24.895	37.696
7.	Payback period (100% Private Equity)	Year	19	17
8.	Payback period (75% PE + 25% ERDF)	Year		
9.	Payback period (50% PE + 50% ERDF)	Year	9	8

Table 8. Results of economic analysis

It is shown that only with 50% co-financing systems becomes feasible.

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_2 emissions and would also be more energy efficient, but system 2 is also very good on both fields.

Table 9. Environmental impact of solutions and energy efficiency

	Environmental analysis	Unit	System 1	System 2
1.	Saved electric energy	kWh	108 097	78 176
2.	CO_2 emissions for electricity	kg/kWh	0.27675	0.27675
3.	CO_2 saving due to electricity savings	kg	29 915	21 635
4.	Saved fossil fuel energy for heat	kWh/a	95 009	95 009
5.	CO_2 emissions for fossil fuel	kg/kWh	0.26	0.26
6.	CO_2 saving due to fossil fuel saving	kg	24 702	24 702
7.	**Total energy saving**	**kWh/a**	**203 109**	**173 186**
8.	**Total CO_2 saving**	**kg**	**54 990**	**46 340**

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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 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 understanding by hotel staff of necessary improvements • 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	• despite the financial help by the EU, hotel owner need to invest large amount of money • 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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