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 “Berulia”

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1. Project information

1.1 General information on the project

Name of building: Bluesun hotel „Berulia“

Owner of building: Sunce Koncern d.d.

Location of building: Brela, Croatia

Coordinates of building: 43.362471 N, 16.938868 E

Hotel is built in 1969 and renovated in 2002.

Location of the complex and its surroundings is illustrated by Picture 1.

Picture 1. Location of the Berulia hotel

Hotel complex consists of multiple buildings.

Total area of hotel: 15 773 m^2

Total area of the building to cool: 9 469 m^2

Total volume of the building to cool: 27 062 m^3

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1.2 Existing cooling and heating equipment

The Bluesun hotel "Berulia" use HVAC system for cooling and cold water is produced in compressor water chiller. Water chiller unit have COP of 3.

The Bluesun hotel "Berulia" has central system for heating and hot water production. Heat for space heating and hot water is produced with boiler installed capacity of 480 kW. Boiler is using extra light fuel oil.

Hot water, produced in 480 kW boiler, is entering heating hub of the hotel "Berulia" from where its distributed to the heating loops of the hotel by pumps. In each heating loop, there are pairs of pumps. In case of malfunction of the main pump, second pump is replacing broken one. Temperature dilatation of water is managed by expansion vessel.

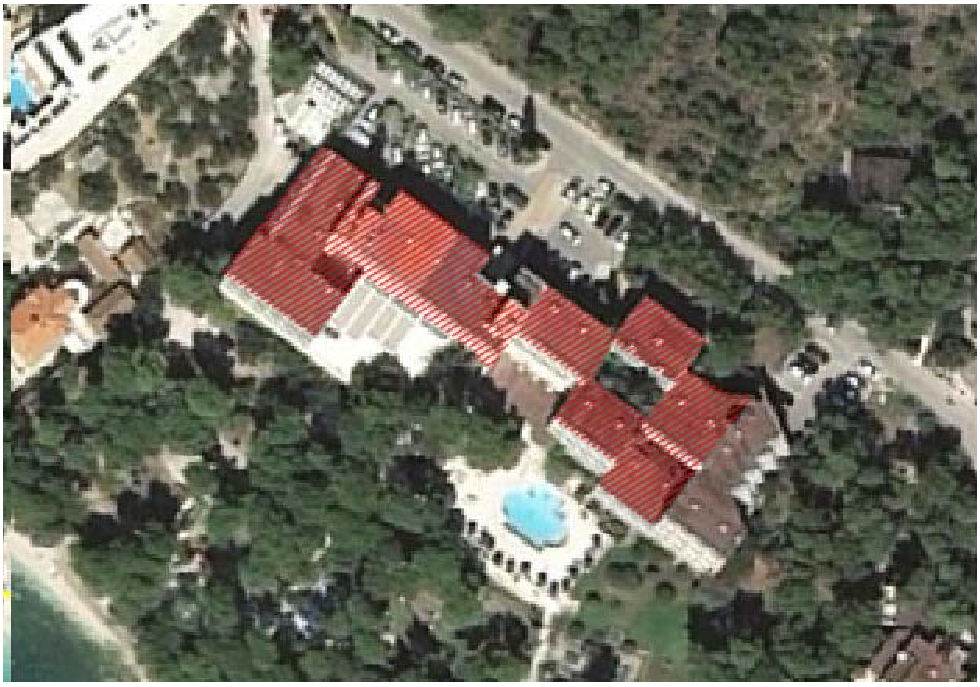
Distribution of heat from distribution system and cold from water chillers is done by usage of HVAC system and fan coil units in the majority of the hotel spaces.

1.3 Orientation of the study

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

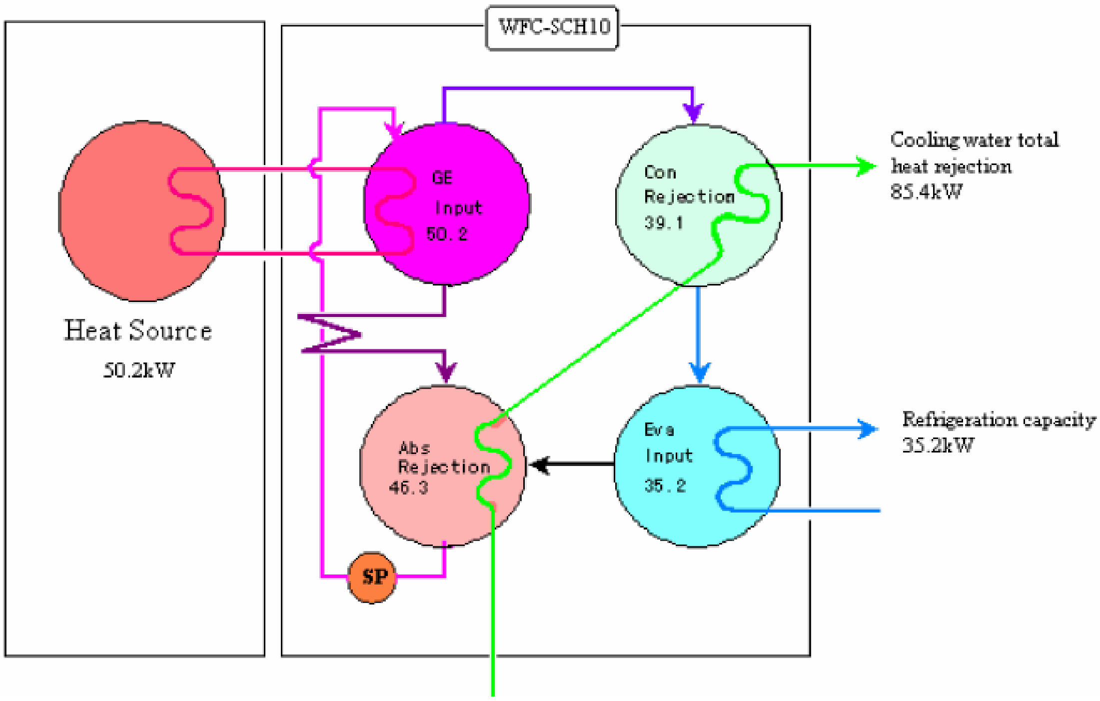
As its main purpose is to suit needs of its guests priority of cooling is set on whole building.
While hotel does not work in winter months, in the months of May and October there can be expected some need for space heating.

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 of roof reserved for solar thermal collector field

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. Operation of example system WFC-SCH10 is illustrated by Picture 3.



Picture 3. Operation of solar cooling system WFC-SCH10

2. Information on case study building

2.1 Building structure

Walls: 32 cm, concrete with a plaster coating

Ceiling: 18 cm concrete, with a layer of gravel on it and concrete panels

Windows: Aluminium with two layer insulation glass.

Hotel complex consists of multiple buildings in modern architectonic solution. Forced ventilation system exists as a part of HVAC system.

2.2 Occupancy of the building

Bluesun hotel "Berulia" has capacity of 329 rooms.

There are many service rooms in the hotel. The biggest one 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. Technical data

	Energy - related comparison	Unit	System 1	System 2
1	Collector type	-	Vacuum collectors	Vacuum collectors
2	Collector Area (absorber)	m^2	1 494	747
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 chillers	kW	455	245
10	Nominal power of cooling tower	kW	1 045	540

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 2. Absorption units - system 1

	Energy - related comparison – System 1	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

Table 3. Absorption units - system 2

	Energy - related comparison – System 2	Unit	WFC-SC 50	WFC-SC 30
1.	Absorption unit type	-	LiBr/H2O	LiBr/H2O
2.	Cooling capacity	kW	175.8	105.6
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	310

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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	1800	900
3	Net Collector Area (absorber)	m^2	1494	747

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 done 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 4. Existing machinery room in hotel „Berulia“

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. Resultes for two scenarios

	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		1 532 128	1 532 128
3.	Energy production for cooling from collector	kWh/a		951 250	552 944
4.	Energy production for heating from collector	kWh/a		-	-
5.	Energy production for hot water from collector	kWh/a		104 203	104 203
6.	Amount of back-up energy for space cooling	kWh/a		580 877	979 183
7.	Amount of back-up energy for space heating	kWh/a		-	-
8.	Amount of back-up energy for hot water heating	kWh/a		-	-

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. Project costs evaluation

	Economic assessment	Unit	System 1	System 2
1	Solar collector	€	240 576	120 568
2	Storage tank	€	Included	Included
3	Absorption unit	€	176 836	128 156
4	Cooling tower	€	Included	Included
5	Measuring system	€	Included	Included
6	Installation costs	€	Included	Included
7	Planning	€	10,435	6 218
8	Other costs	€	240 012	143 017
9	Total Investments	€	667 860	397 960

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	€	186 682	108 515
2.	Annual cost for fossil fuels	€	69 895	69 895
3.	Annual maintenance cost	€	-	-
4.	Annual water costs	€	-	-
5.	**Total annual costs**	**€**	256 578	178 411

5.2 Economic assessment

In this section internal rate of return, simple payback period and net present value for two 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 8. Economic assessment results

	Economic assessment	Unit	System 1	System 2
1.	Internal Rate of Return (100% Private Equity)	%	0.67	2.23
2.	Internal Rate of Return (75% PE + 25% ERDF)	%	3.00	5.03
3.	Internal Rate of Return (50% PE + 50% ERDF)	%	8.69	10.93
4.	Net Present Value (100% Private Equity)	€	-272 581	-126 846
5.	Net Present Value (75% PE + 25% ERDF)	€	-115 021	-32 961
6.	Net Present Value (50% PE + 50% ERDF)	€	42 538	60 924
7.	Payback period (100% Private Equity)	Year	19	16
8.	Payback period (75% PE + 25% ERDF)	Year	14	12
9.	Payback period (50% PE + 50% ERDF)	Year	9	8

It is shown that both systems become feasible only with 50% co-financing by the ERDF.

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 9. Environmental impact and energy efficiency

	Environmental analysis	Unit	System 1	System 2
1.	Saved electric energy	kWh	237 812	138 236
2.	CO_2 emissions for electricity	kg/kWh	0,27675	0,27675
3.	CO_2 saving due to electricity savings	kg	65 814	38 256
4.	Saved fossil fuel energy for heat	kWh/a	103 857	103 857
5.	CO_2 emissions for fossil fuel	kg/kWh	0,26	0,26
6.	CO_2 saving due to fossil fuel saving	kg	27 002	27 002
7.	**Total energy saving**	**kWh/a**	**341 669**	**242 093**
8.	**Total CO_2 saving**	**kg**	**92 810**	**65 260**

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7. SWOT Analysis

<table>
<tr><th colspan="2">SWOT Analysis for pilot plant location</th></tr>
<tr><th>Strengths</th><th>Weaknesses</th></tr>
<tr><td>
• 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
</td><td>
• poor shape of the buildings
• non optimal solutions of building materials
• higher cooling and heating demand because of building’s permeability caused by non optimal solutions
• weak interest in new technologies
</td></tr>
<tr><th>Opportunities</th><th>Threats</th></tr>
<tr><td>
• 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
</td><td>
• 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 in training of current staff
• some workers may hardly adapt to the new system, while others could refuse
• problematic administration and paperwork which could increase installation time for project in case of the EU projects
</td></tr>
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