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 elementary school Ivan Gundulić, Dubrovnik

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Contents

1. Project information

1.1 General information on the project

Name of building: Elementary school Ivan Gundulić

Owner of building: The city of Dubrovnik

Location of building: Dubrovnik, Croatia

Coordinates of building: 42°39' N, 18°05' E

The school is more than 200 years old but it is constantly renewed.

Location of the school and its sports hall is illustrated by Picture 1.

Picture 1. Location of the Elementary school Ivan Gundulić

Total area of school: 2 819 m^2

Total area of the building to cool: 2 8199 m^2

Total volume of the building to cool: 11 966 m^3

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

1.2 Existing cooling and heating equipment

Elementary school Ivan Gundulić uses air conditioners for cooling. The air conditioner has a COP of 3.2 and a power input of around 1.6 kW. The air conditioning devices installed in a sports hall has a COP of 3 and power input of 3 kW. Total number of air conditioners in school is 57.

Elementary school Ivan Gundulić has a central system for heating and hot water supply. Hot water demand is negligible compared to the heating demand. Heat energy for heating and hot water supply is produced in a boiler. The boiler is using extra light fuel oil. From the beginning of September 2014 the school uses only electrical energy to cover heating and cooling needs.

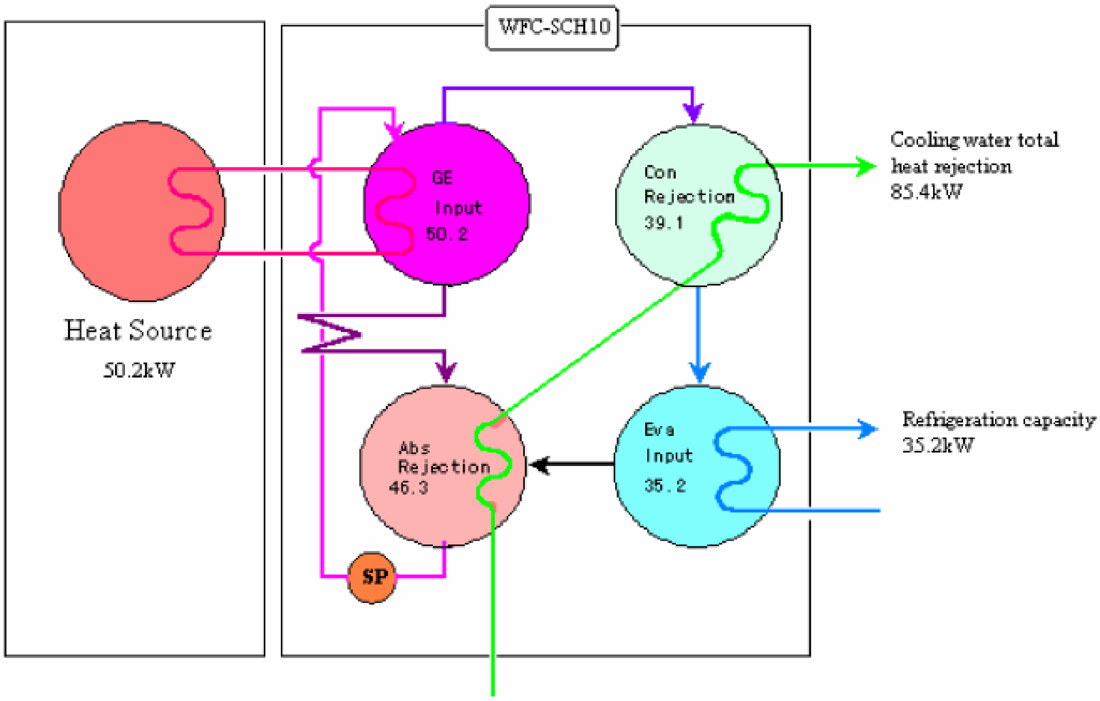
1.3 Orientation of the study

School works from September 8 to June 10. In winter break and summer break school does not work. Summer break is longer than winter break. In that period, July and August, only a few offices within school are working and demand for cooling energy is negligible compared to demand for cooling energy in September, May or June.

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. System 1 is proposed to fulfil basic and peak load for cooling. System 2 is proposed to fulfil only basic load and utilizes a 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 schools operating cost. 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: 30 cm, concrete with a plaster coating

Windows: Aluminium with two layer insulation glass.

Picture 4. Window in classroom

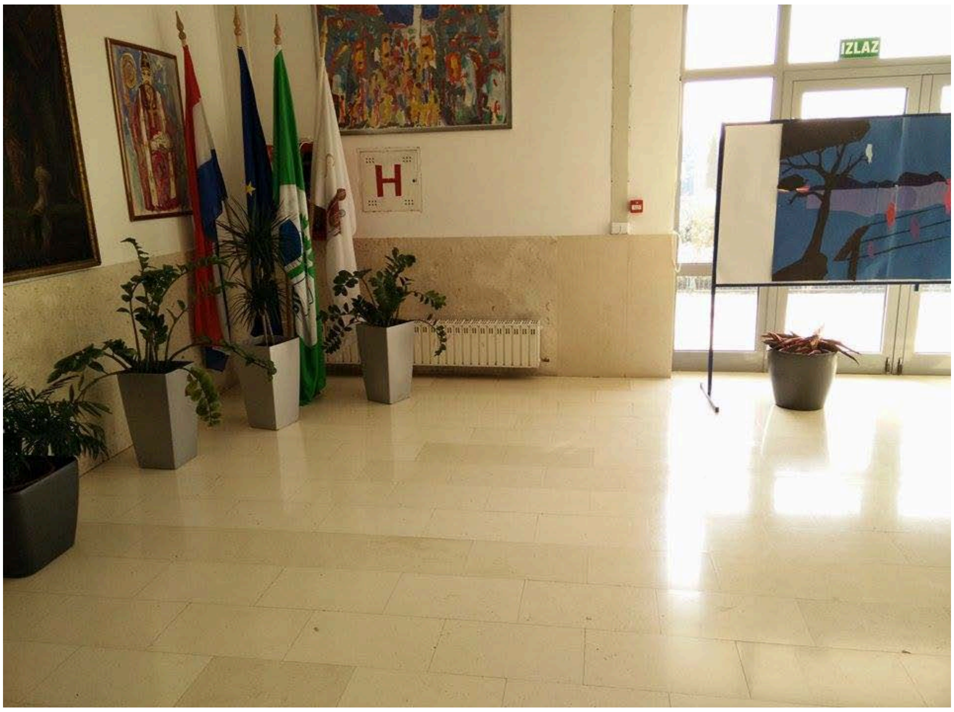
2.2 Occupancy of the building

The school has a total of 37 classrooms along with a sports hall. Also, there are several offices within the school.

The share of a hallway and other premises are estimated at 25% of the total area of the school.

Average number of students per classroom is 20.

Number of people working in the school is constant.



Picture 5. School lobby

Picture 6. School classroom

Picture 7. Sports hall

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 school.*

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

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	810	747
3	Volume of heat storage	m^3	20	20
4	Volume of chilled water storage tank	m^3	3	3
6	Heating power of back-up heater	kW	not existing	not existing
8	Nominal chillers power, compression chillers	kW	250	250
9	Nominal chillers power, thermally driven chillers	kW	87.5	52.5

3.2 Absorption unit data

In the analysis three 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 20	WFC-SC 5
1.	Absorption unit type	-	LiBr/H2O	LiBr/H2O
2.	Cooling capacity	kW	70	17.5
3.	Hot water temperature	°C	88	88
4.	Volume of system heat storage	m^3	20	
5.	Chilled water temperature	°C	7	7
6.	Volume of chilled water storage tank	m^3	3	
7.	Electricity consumption	W	260	60

Table 3. Absorption units - system 2

	Energy - related comparison – System 2	Unit	WFC-SC 10	WFC-SC 5
1.	Absorption unit type	-	LiBr/H2O	LiBr/H2O
2.	Cooling capacity	kW	35	17.5
3.	Hot water temperature	°C	88	88
4.	Volume of system heat storage	m^3	20	
5.	Chilled water temperature	°C	7	7
6.	Volume of chilled water storage tank	m^3	3	
7.	Electricity consumption	W	210	60

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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	810	648
3	Net Collector Area (absorber)	m^2	664	538

4. Thermal balance of solar cooling pilot plant

4.1 Meteorological data

The energy required for heating and cooling is calculated from hourly meteorological data using methodology given in the HRN ISO 13970 standard. Meteorological data used in the calculations are the hourly data from "METEONORM" program for the location of the building.

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 5. Project costs evaluation

	Economic assessment	Unit	System 1	System 2
1	Solar collector	€	152 972	102 246
2	Storage tank	€	Included	Included
3	Absorption unit	€	68 000	60 000
4	Cooling tower	€	Included	Included
5	Measuring system	€	Included	Included
6	Installation costs	€	Included	Included
7	Planning	€	Included	Included
8	Other costs	€	180 796	132 747
9	Total Investments	€	401 768	294 992

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

Table 6. Annual costs

	Economic assessment	Unit	System 1	System 2
1.	Annual costs for electricity	€	8 447	7 180
2.	**Total annual costs**	**€**	8 447	7 180

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 (PI), 75% private investment and 25% from public resource (PR, public resource), 50% private investment and 50% from public resource.

Table 7. Economic assessment results

	Economic assessment	Unit	System 1	System 2
1.	Internal Rate of Return (100% Private Equity)	%	-	-
2.	Internal Rate of Return (75% PE + 25% PR)	%	-5	-4
3.	Internal Rate of Return (50% PE + 50% PR)	%	-2	0
4.	Net Present Value (100% Private Equity)	€	-312 282	-218 929
5.	Net Present Value (75% PE + 25% PR)	€	-211 840	-145 181
6.	Net Present Value (50% PE + 50% PR)	€	-111 398	-71 433
7.	Payback period (100% Private Equity)	Year	48	41
8.	Payback period (75% PE + 25% PR)	Year	36	31
9.	Payback period (50% PE + 50% PR)	Year	24	21

It is shown that both systems are not feasible even with 50% co-financing by the ERDF.

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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.

Table 8. Environmental impact and energy efficiency

	Environmental analysis	Unit	System 1	System 2
1.	Saved electric energy	kWh	67 371	57 265
2.	CO_2 emissions for electricity	kg/kWh	0.27675	0.27675
3.	CO_2 saving due to electricity savings	kg	18 645	15 848
4.	**Total energy saving**	**kWh/a**	**67 371**	**57 265**
5.	**Total CO_2 saving**	**kg**	**18 645**	**15 848**

7. SWOT Analysis

Strengths

Main strength for supporting this project is that this kind of projects is supported and encouraged from the EU. The EU supports the advancement of technology in terms of development and installation of the system which are classified as a renewable energy source. Also, currently in Croatia, the Environmental Protection and Energy Efficiency Fund (FZOEU) is granting funds for co-financing these projects with the use of renewable energy source. Use of these systems would reduce consumption of electric energy and Extra Eight Heating Oil (FOEL) which would have an impact on CO_2 emission. Relatively big roof area and good insolation are also good strengths.

Weaknesses

Due to already installed air conditioning devices, it is not possible to achieve great electricity savings in a period of cooling. Also low energy demand is resulting in low energy savings. Another problem is that school stopped using FOEL to cover heating demand. Instead of that, heating demand was completely covered by air conditioners.

Opportunities

If decided to invest in solar cooling/heating system, this pre-feasibility study could provide a good base for a feasibility study which could lead to the withdrawal of the funds from the EU. This could also lead to investments in similar projects, but on different structures and locations. Students and their parents could learn about new, modern and clean technology and also they could increase their awareness about CO_2 emissions, energy savings and so on.

Threats

The biggest problems and threats which could endanger this project are current economic crisis. Despite that this project could be co-financed from FZOEU or EU, owner of the building, city of the Dubrovnik, still need to make the first step. Complex and problematic paperwork and administration could also slow down the whole project.

<table>
<tr><th colspan="2">Solar cooling/heating in the elementary school Ivan Gundulić, Dubrovnik</th></tr>
<tr><th>Strengths</th><th>Weaknesses</th></tr>
<tr><td>

support from the EU
financial support from Croatia
reduced consumption of electric energy
reduced consumption of FOEL (fuel oil extra light)
reduced pollution
reduced CO_2 emission
better ecological approach
relatively big roof area
good insolation

</td><td>

already installed air conditioning devices
mild winters in which FOEL wasn't used

</td></tr>
<tr><th>Opportunities</th><th>Threats</th></tr>
<tr><td>

good fundament for a feasibility study, which could give better and accurate results
financial support from EU
greater opportunity for financing similar projects
encouraging new ideas
giving an example to the students and their parents
education of students about clean and modern technology

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unstable economic situation in Croatia because of economic crisis
problematic paperwork and administration which, could increase installation time of the project
despite financing from Croatia or EU the owner of the building still must invest in this projects

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