Solutions for the energy efficiency of buildings located near watercourses through SRE integration. Case Study

Soluții pentru eficiența energetică a clădirilor situate în apropierea cursurilor de apă prin integrarea SRE. Studiu de caz

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Abstract. *Currently, approximately 40% of the energy demand in the European Union (EU) is used in buildings and the energy demand for cooling and heating is increasing every year, so the energy efficiency of buildings represents a problem of increased interest and of extreme relevance. The article proposes, through the case study, the installation of a photovoltaic system for the production of electricity on the roofs of the buildings and the cooling and heating of the building using a water-to-water heat pump. Having the advantage of the location of the studied buildings on the banks of the river Bega in the town of Timisoara, the case study proposes the cooling of the spaces in the buildings in two variants, namely in the spring and autumn when the outside temperature is not very high using the river water directly ("free cooling"), and in the summer for the hot months, a water-to-water heat pump to cool the cooling agent to the parameters necessary to achieve a proper air conditioning.*

Key words: *free cooling, water-water heat pump, photovoltaic system, SRE*

1. Introduction

Currently, approximately 40% of the energy demand in the European Union (EU) is used in buildings, of which 80% is the energy required for thermal needs (heating and water preparation in the building), and the energy demand for cooling is increasing every year. Regardless of its form, energy is an indispensable resource for contemporary life. Considering the increase in the requirements related to the energy economy through the sustainable use of human resources, the energy efficiency of buildings represents a problem of increased interest and of extreme relevance [1].

Of the total electricity consumed by a building, in 2018, 18.5% was used to ensure the cooling of the interior spaces, and it is expected that by 2050 this

consumption will triple, due to the increase in the number of air conditioning devices used. Consequently, an efficiency of the air conditioning systems is required in order to reduce the energy consumption and still maintain the cooling parameters required to achieve the comfort of the occupants [2,3].

The integration of renewable energy sources (RES) is no longer a fad but a necessity to reduce the carbon footprint and energy consumption. A safe and sustainable source of energy is the solar one, which together with the modernization of the installations inside the buildings, can contribute both to the implementation of the measures taken by the EU and to the reduction of greenhouse gas emissions and to the prevention of dangerous climate changes [4].

Free cooling is an economic and ecological alternative to the production of cold, successfully used in many countries around the world for cooling data centers. Considering that less mechanical energy is used, the use of harmful refrigerants and fossil fuels that are responsible for keeping the systems in operation is reduced. In order to create a free water cooling system, we have as the first condition to have a water source near the objective, such as sea, river or fountain water [5].

In spring and autumn, when the temperatures inside the buildings are not very high, the cooling requirement being low compared to the summer months, in the situation where there is a cold source of water nearby, this potential can be used directly without involving a other equipment to achieve cooling using electricity. In the functional diagram from Fig. 1 presents the technical solution of free cooling by bypassing the Chiller. The production of electricity often involves air pollution, so the realization of this bypass leads to the reduction of electricity consumption and implicitly to the reduction of greenhouse gases [5].

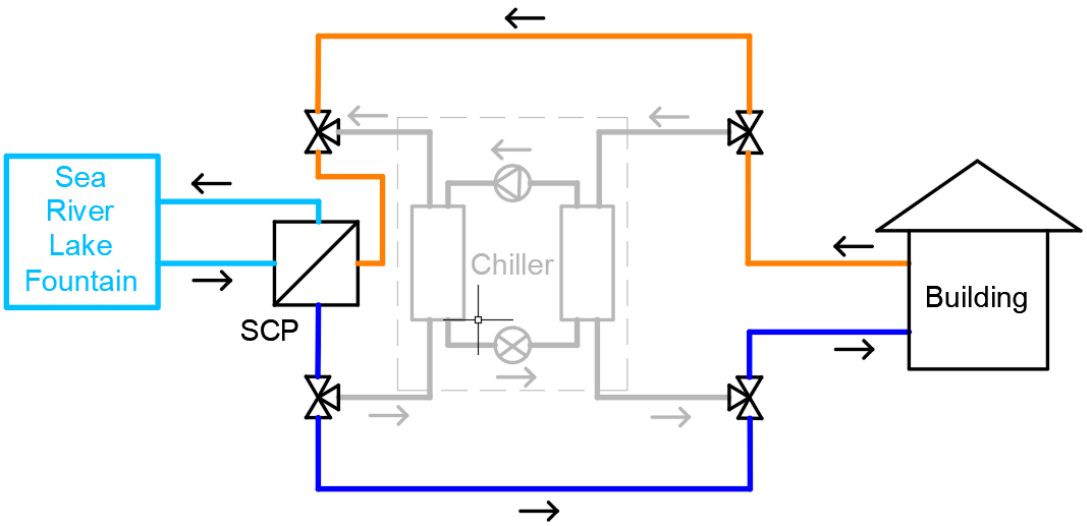


Fig. 1. Operation of the cooling system during spring and autumn

During the summer, when the air temperature in the buildings increases considerably, simultaneously with the increase in the water temperature from the available source, the proper air conditioning in the building spaces can no longer be

achieved by the "free cooling" method, so the installation is switched to version with Chiller (Fig. 2) [5].

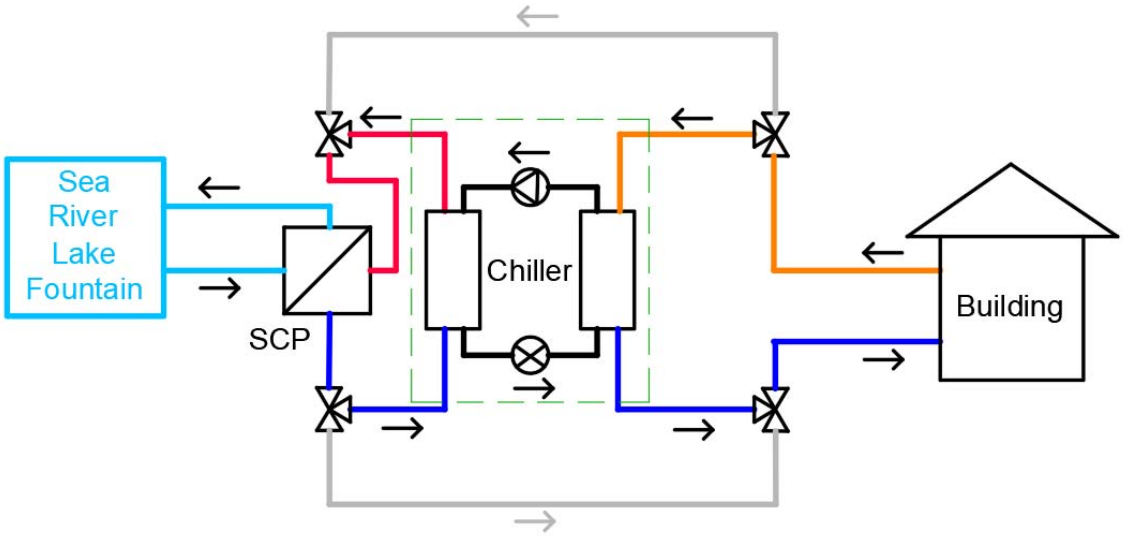


Fig. 1. Operation of the cooling system during the summer

2. Case Study

To carry out the simulations, the simulation programs Polysun SPTX Constructor [6] were used, a comparative study was carried out regarding the performance of the building's heating system, between the current situation and the proposed modernization solution.

The study was carried out on 3 buildings located on the banks of the Bega river that crosses the town of Timisoara (Fig. 3). Building 1 has a maximum height of 5 m, terrace-type roof with a covering made of sandwich panels, Building 2 has a maximum height of 11.5 m, a roof made in 4 pitches with a galvanized sheet covering, and Building 3 has a maximum height of 15 m with a cover made of tiles.

At the moment, the studied buildings are not provided with a centralized air conditioning system that ensures a comfortable temperature in all occupied spaces, but local air conditioning devices are used. This solution has several disadvantages, including the existence of a large number of equipment, most of the time from different manufacturers, which leads to a high cost of use and maintenance. Another aspect would be the fact that in the existing situation the cold source for the air conditioning devices is the air which, compared to the water from the river, reaches a much higher temperature, which determines a much lower COP compared to the solution of using a heat pump the water.

Fig. 3. Situation plan for the studied buildings

The study proposes the implementation of a hybrid system of air conditioning, free cooling and cooling with the help of a heat pump, simultaneously with the production of electricity using photovoltaic solar panels. The electrical energy produced will be able to be used both in the existing internal installation and for powering the heat pump, and the surplus energy produced can be delivered to the NES. The functional scheme of the proposed installation is presented in Fig. 4.

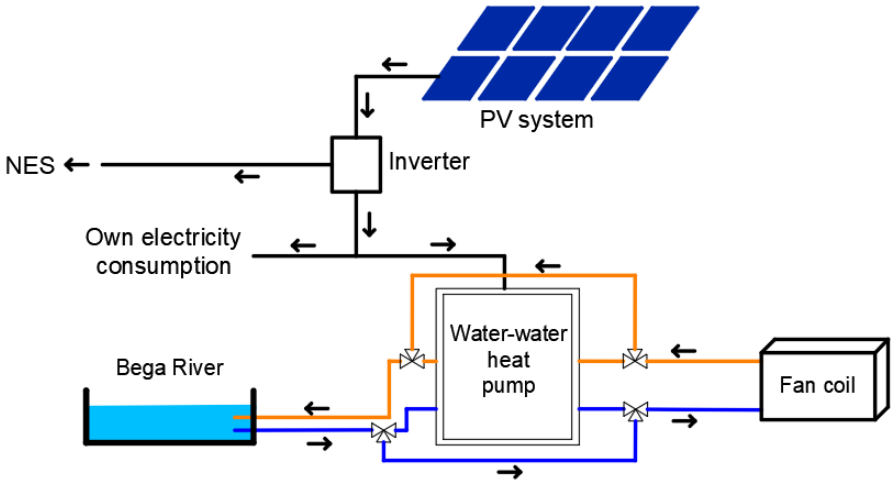
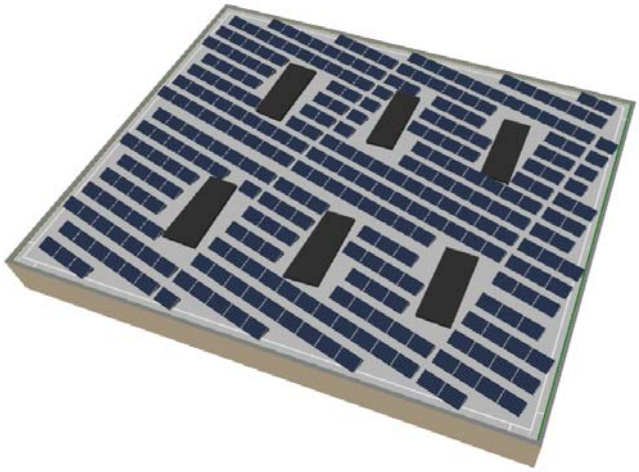
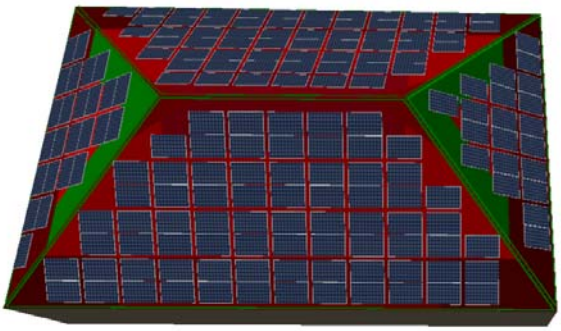


Fig. 4. Functional scheme of the proposed installation

The PV system is composed of 672 EvoCells 400 MIB modules with a maximum production power of 400 Wp, with a total installed power of 268.8 kWp. The positioning of the photovoltaic panels on the studied buildings is shown in Fig. 5.



a)



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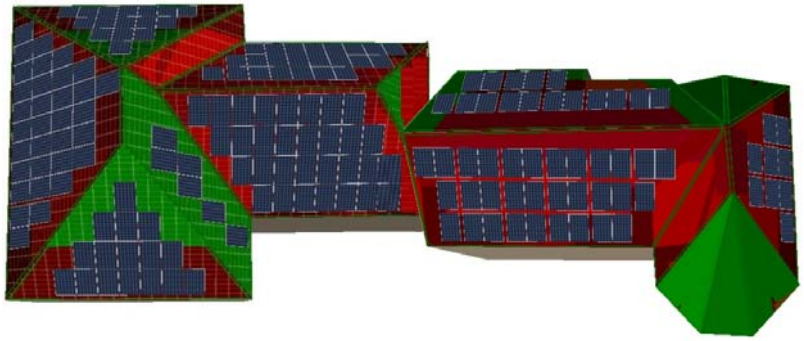

c)

Fig. 5. Placement of PV modules on the studied buildings [6]
a) Building 1, b) Building 2, c) Building 3

An important aspect that must be taken into account in the design phase of the photovoltaic panel system is that of their shading by nearby construction elements (parapet, skylight). By shading the panels, the amount of sunlight reaching their surface is reduced, thus affecting the output power. Photovoltaic cells are each like a link in a chain, the shaded cell being the "weakest link" that determines the reduction of the power availability of all the other links, a principle that also applies to the

photovoltaic modules connected to each other. Finally, the shading of a module in a string can significantly reduce the output power of that string, but not of a parallel string [7]. Through the simulation it can be seen in Fig. 6 which are the panels on Building 1 shaded and to what extent, so that their tying in strings is done according to this aspect or possibly to eliminate the panels that are not efficient or negatively affect the operation of the photovoltaic system.

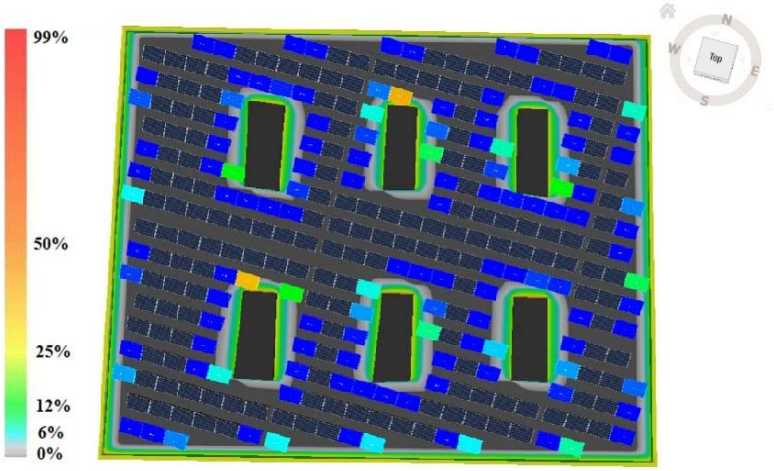

Fig. 6. Umbrirea panourilor fotovoltaice [6]

Following the simulation of the proposed photovoltaic system, a total annual energy produced of 110.84 MWh resulted, the monthly production can be seen in the graph in Fig. 7.

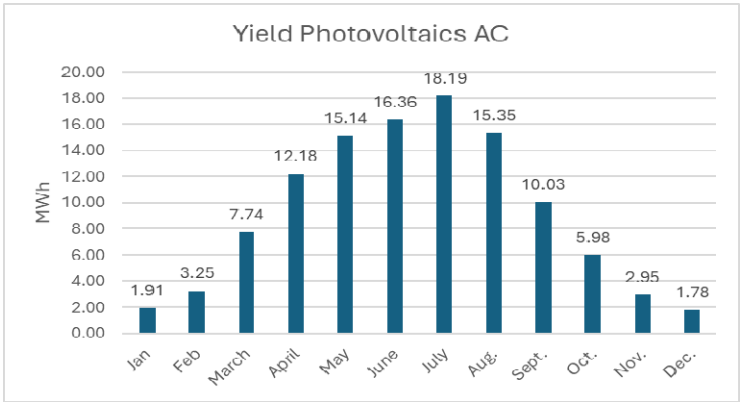

Fig. 7. The monthly alternating current production of the photovoltaic system [6]

An important aspect that must be taken into account is the fact that energy produced with the help of photovoltaic panels has the great advantage of reducing the amount of CO2 compared to the production of electricity using classic fuels. In Fig. 8 shows the amount of CO2 saved using this method of electricity production.

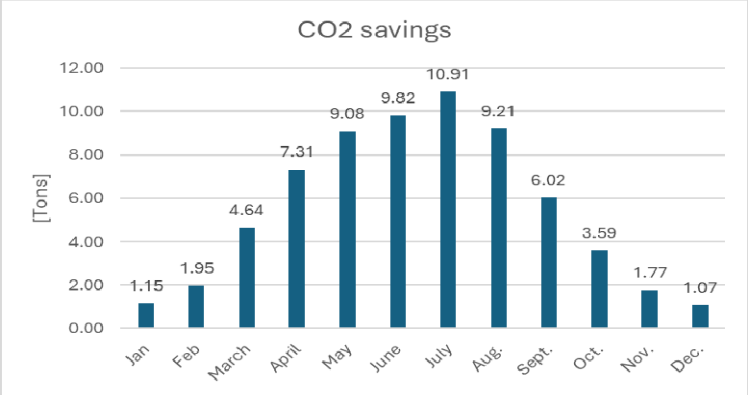

Fig. 8. CO_2 savings [6]

4. Conclusions

The modernization of buildings and installations is an essential step that must be carried out to obtain a reduction in energy consumption to ensure the comfort of the occupants. The heating and cooling of the spaces where we carry out our activities have become more and more problems that must be treated together to find the most sustainable solutions with low energy consumption. Regarding the case study carried out, the heating of the studied buildings can be achieved by reversing the cycle of the heat pump and introducing the hot water produced by it into the interior installation. Referring concretely to the buildings located near water sources (sea, lake, river course), for cooling in particular there is the advantage of using the "free cooling" option in the months that are not very warm and the water temperature is quite cold so that the water heat pump is bypassed and it is introduced directly into the air conditioning system.

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