MANAGING AND POSSIBLE IMPROVEMENT OF ENERGY EFFICIENCY OF SPORTS BUILDINGS; CASE STUDY SERBIA

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ABSTRACT:
The majority of sports buildings in Serbia were constructed between 1960 and 1980, a period when energy efficiency was not a top priority. Even if energy efficiency was considered, the technology and materials used during that time have become outdated in terms of efficiency. These buildings primarily rely on traditional, fossil fuel-based energy sources. With increasingly strict regulations on energy efficiency, it is crucial for these facilities to undergo renovation and subsequent maintenance to reduce energy consumption.
Sports buildings are naturally well-suited for the integration of Renewable Energy Sources (RES), given their spacious open areas and outdoor surfaces. However, this paper investigates the implementation of passive solar technologies in these manmade structures as a means of achieving energy savings. The case studies involve sport center built in Belgrade during the 1980s. Various passive measures, as zenithal lighting, are applied to the building structure, along with the measures resulting benefits in terms of reducing total annual energy consumption for space heating and improving indoor environmental comfort. Gained conditions were simulated using the software package Integrated Environmental Solutions Virtual Environment (IES VE 2016).
Finally, bearing in mind the need to raise awareness about the sustainable aspect of all structures, including such facilities, among management, basic recommendations in maintenance and decision-making will be given as a foundation for future steps in understanding such an important context.
Keywords: *sports buildings, energy efficiency, passive strategies for improvement, management*

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1. INTRODUCTION

Energy consumption is closely related to the required conditions of indoor comfort, which should be suitable for sports activities, services, and other activities. Small halls can be ventilated only naturally if their surface area is less than 1000 m^2; otherwise, they should be equipped with mechanical ventilation. Cross-ventilation yields very favorable results. Mechanical ventilation is necessary to supply a space with a certain amount of fresh air and to remove unpleasant odors and moisture. Main ventilation systems should be equipped with heat recovery systems.

Sport facilities are complex; besides zoning and different comfort conditions for different parts of the facility, there are other requirements concerning comfort that should be met or paid attention to. Built-in ventilation systems should provide approximately 128 m^3/min of ventilation air in the sports arena, playground, with special attention to the airspeed, which should not exceed 0.1 m/s near the ground to avoid disrupting the game on the field. [1]

2. CASE STUDY

Building model of the Sport Center Vozdovac in Belgrade, that is analyzed in the paper was created in the Integrated Environmental Solution software package, Virtual Environment IES VE 2016. (Fig.1.)

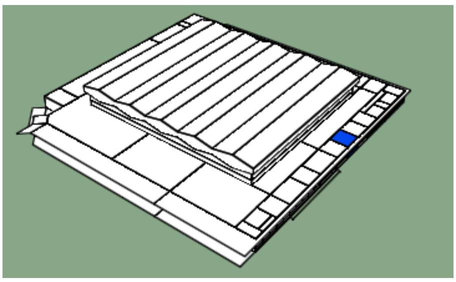


Fig. 1. Model of Sports Center "Voždovac" IES VE 2016

Construction details are collected based on the original project documentation and detailed work records. Internal comfort parameters have been adopted from local and international practices and foreign regulations in the absence of data in local ordinances for this type of facility.

The operating profile of the facility can be divided into occupancy profile of users, operation profile of electrical equipment and lighting, heating and ventilation operation profile, as well as hot water usage profile The usage profile of artificial lighting is linked to user occupancy. [2]

The most unfavorable situation is considered when it comes to technical systems - hall is in operation until late evening hours (from 08:00-24:00 for recreational users). Sports events also take place on weekends, meaning energy is consumed in locker rooms and wardrobe areas. The rest of the building operates from from 07:00 to 14:00 for the building, which are the working hours of the administration and support staff during the workweek, with negligible exceptions. These data were taken into account during the modeling of the existing state of the facilities and the creation of simulations for different groups of buildings. Due to different occupancy modes and equipment content, it would be necessary to simulate comfort conditions for significantly different spaces: an office in the north, locker rooms in the basement, the main hall, and a small hall in the south. However this paper shows data only for the main sport hall.

Due to the extensive work and simulation of comfort conditions in terms of thermal, visual, and hygienic comfort, conditions are simulated only for a universal sports hall and the rest of the facility - which represents office space. It is necessary to divide the facility into two zones; the sports hall and the administrative part - caused by completely different operating modes, structural characteristics, and comfort conditions, as well as activities taking place in these spaces.

It should be mentioned that in the existing state of the facilities loads from people who stay in certain spaces and emit heat, then loads from lighting and electrical equipment are given. Based on the given values of installed equipment, the software package calculates the gains together with the achieved solar gains for a specific area, in this case, Belgrade. [1]

2. PASSIVE MEASURES IMPROVEMENT

The position of the central part of the facility gives us the opportunity to enhance the daylighting comfort only from the roof. During sunny days, the intensity of daylight in the universal hall is satisfactory. If it's cloudy, the intensity of daylight is improved by zenithal lighting, for which simulations have been performed. After simulating the conditions in the hall for roof openings of 2 x 45 m, 3 x 45 m, and 4 x 45 m, it turned out that the most optimal solution for the size of zenithal lighting on the roof of the hall is 2 x 45 m. Double glazing filled with argon and with a low-emissivity coating has been installed (according to the EE RS Regulation U=1.27 W/m^{2}K, U glass only=1.14 W/m^{2}K, g=0.5, according to EnerPHIt/EnerPHIt+ U=1.0 W/m2K, U glass only=0.79 W/m^{2}K, g=0.3). The achieved results in energy consumption and comfort index for the universal hall, by implementing measures of introducing zenithal lighting according to the Energy efficiency Regulation in Serbia, [3] having in minfd that the facility is in Serbia and according to EnerPHIt/EnerPHIt+ certification [4], are shown in Table 1.

Table 1. Simulation results with improvement of building with zenithal light

Results	***RS Regulation***	***RS Regulation + zenithal light***	**EnerPHIt/EnerPHIt$^+$**	**EnerPHIt/EnerPHIt$^+$ + *zenithal light***
$Q_{H,nd}$ [kWh/m^2]	847,9	858,1	810,5	820,4
Energy grade $Q_{H, nd, rel}$	E	E	D	D
Energy saving [%]	17,0	16,0	20,7	19,7
Comfort index од 6-8	22,6	22,8	23,7	23,4

The results have shown that energy savings for heating, as well as improvements in comfort (slightly improved for scenario RS EE Regulation + zenithal lighting), cannot be achieved by the construction of a zenithal window as prescribed by the EE RS Regulation (Figure 2) or according to the parameters prescribed by the EnerPHIt/EnerPHIt+ certification (Figure 3).

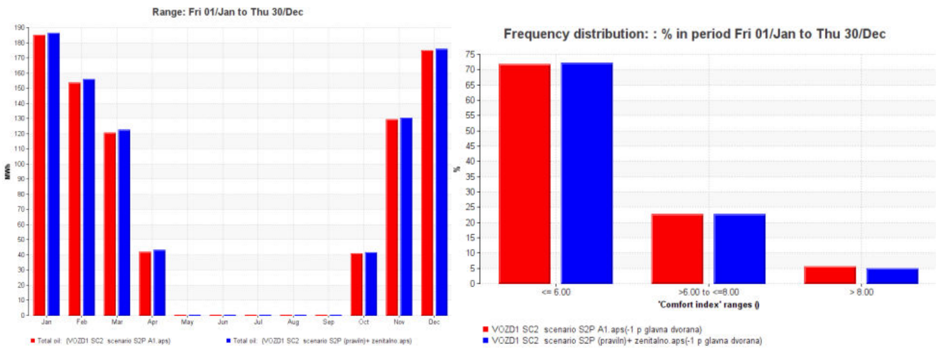
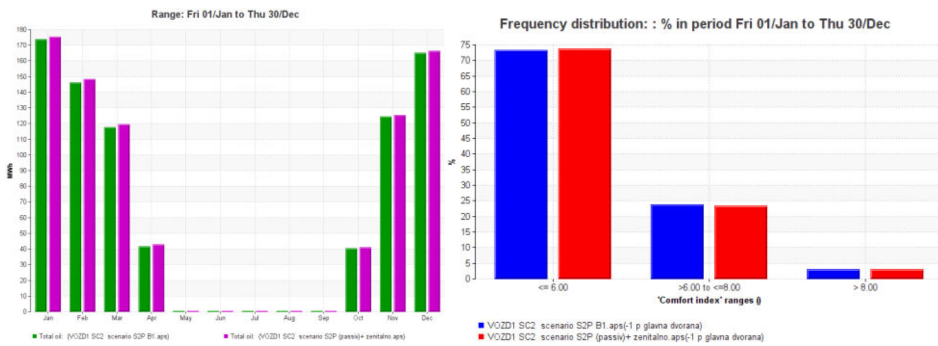


Figure 2. Comparative analysis of simulation results for energy consumption (top) and comfort index (bottom) for zenithal lighting, improvement according to the RS Regulation

The results of dynamic simulations for scenario C2P+ zenithal lighting with measures regulated by the EnerPHIt/EnerPHIt+ certification are shown in Figure 3.



Total oil- потрошња енергије за грејање; мазут
Comfort index ranges- опсег индекса комфора

Figure 3. Comparative analysis of comfort index and heating energy consumption for scenario -zenithal light during occupancy in the hall improvement by EnerPHIt/EnerPHIt+ (passive)

Conditions were simulated following the application of special enhancements, passive systems defined due to the specificity of the base solutions and shapes. In the SC2 model, natural lighting in the universal hall on cloudy days is improved by zenithal lighting. The image depicts the illumination of the hall after the implementation of enhancements in scenario + zenithal lighting (Figure 4).

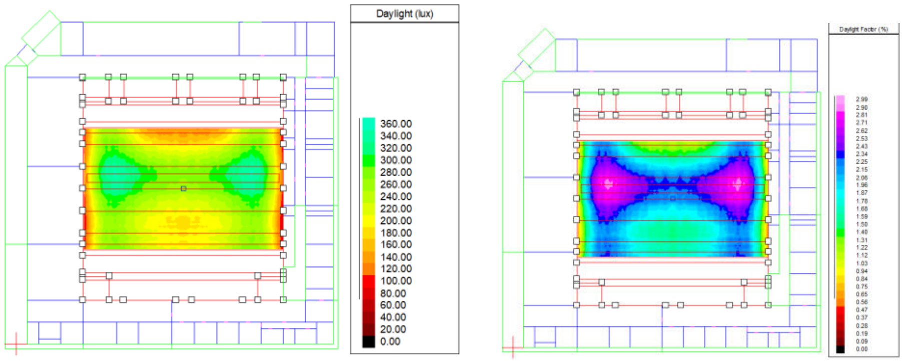


Figure 4. Natural lighting in the universal hall after the implementation of scenario + zenithal lighting, shown in lux (left) and DF % (right)

By installing zenithal lighting, favorable lighting conditions for recreational sports activities can be achieved in the hall. The average illumination of the hall is 249.01 lux, which is very favorable. Professional sports activities primarily occur during the late afternoon and evening hours when artificial lighting is primarily used.

3. MANAGING ENERGY EFFICIENCY

Sports facilities have specific demand patterns and operational requirements, resulting in significant energy consumption. The issue of the sustainability and efficiency of facilities requires clever and practical solutions. In order to create environmentally and socially resilient cities, it is essential to support sports facilities that are efficient and sustainable [5].

Managing energy efficiency in sports facilities is crucial for reducing operational costs, minimizing environmental impact, and promoting sustainability. Over the past ten years, literature developed business models to accomplish the objective of sustainable development in business strategies in order to lessen negative external consequences and generate new beneficial effects for society and the environment [6]. These strategies collectively help reduce energy consumption, lower operating costs, and promote sustainability in sports facilities. Improving insulation and window design, integrating renewable energy sources, optimizing lighting, heating, and cooling systems, and implementing smart building technology are just a few of the various strategies used in the effort to fight against energy inefficiency in buildings. In numerous cases, implementing these techniques into action might end in a 50% decrease in energy consumption [7].

At the other hand, authors highlight the beneficial effects of good governance in promoting sustainability and drawing capital, which in turn drives the growth of environmentally friendly sports facilities. Encouragement of green FDI, the implementation of environmentally friendly taxes, the promotion of sustainability in corporate management, and the use of trade agreements to facilitate the trade of green energy utilities are some of the suggested policy measures to support the deployment of green energy in sports and public facilities [8].

3. CONCLUSION

Characteristics of existing sports facilities relevant to energy renovation have been identified, and reference models have been defined on which defined individual and package measures have been applied to achieve energy optimization for the climate conditions of Belgrade. Guidelines and recommendations have been provided for achieving optimization of energy performance in the processes of energy renovation of these facilities. A specific methodology has been created as a recommendation for energy-saving in universal sports halls, resulting in expected scientific contributions to research. After selecting reference models for investigating the performance of objects for the application of various individual and package measures, numerical simulations were conducted via the IES VE simulation platform. Energy optimization measures were tested on individual elements of the building envelope as a whole, only in the administration part, and only in the central part of the universal hall. The specificity in the structure and design of sports buildings has led to the application of special enhancements, such as passive strategies, increasing openings, and natural ventilation of space, after which conditions of thermal, visual, and hygienic comfort were simulated. Dynamic simulations were conducted individually with the application of special measures and in combination with three defined basic scenarios.
Although the energy class in European countries is determined based on the required annual primary energy, in Serbia, as mentioned several times, it is determined by the relative value of the annual final energy consumption for heating [%], representing the percentage ratio of the specific annual heating demand QH,nd [kWh/m^{2}a] and the maximum allowable $Q_{H,nd,max}$ [kWh/m^{2}a] for a certain category of buildings. For the applied passive measure, constructing zenithal lighting on the roof of the building, excluding the consideration of structural aspects, a significant improvement in visual comfort within the building has been achieved. Energy savings due to the additional solar gain of 3% have slightly improved the comfort index, particularly in terms of thermal comfort. It must be mentioned that proper management within the building is very significant in all aspects, especially when it comes to energy savings and all issues related to energy efficiency.

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4. LITERATURE

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