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FEASIBILITY ASSESSMENT AND PERFORMANCE EVALUATION OF ROOFTOP SOLAR PHOTOVOLTAIC SYSTEMS AT THE TOP OF THE 2ND BUILDING ON CAMPUS OF THE AZERBAIJAN ARCHITECTURE AND CONSTRUCTION UNIVERSITY

Prof. Fagan Aliyev, Prof. Farhad Aliyev, Ismayil Hajiyev

Azerbaijan Architecture and Construction University

Baku, Azerbaijan

ie_academy@yahoo.com

Azerbaijan Architecture and Construction University

Baku, Azerbaijan

farhad.aliyev@azmiu.edu.az

Azerbaijan Architecture and Construction University

Baku, Azerbaijan

ismayilgadjiyev1998@gmail.com

Abstract: This study evaluates the technical, economic, and environmental feasibility of installing a rooftop solar photovoltaic (PV) system on a university building in Azerbaijan. Using Meteonorm-derived solar radiation data and high-efficiency PV technologies, we modeled annual electricity output, financial returns, and environmental impact for a 139.5 kW system covering 652.8 m^2 of usable rooftop area. Results indicate an annual energy yield of 134,266 kWh, potential annual savings of $13,426.56, and a payback period of approximately 8.3 years. The system is expected to reduce CO_2 emissions by approximately 60.4 metric tons annually. These findings confirm the viability of rooftop PV applications in university settings, contributing to institutional sustainability goals and clean energy adoption in the region.

Keywords: Rooftop solar energy, photovoltaic systems, Azerbaijan, educational institutions, energy efficiency, renewable energy, carbon reduction

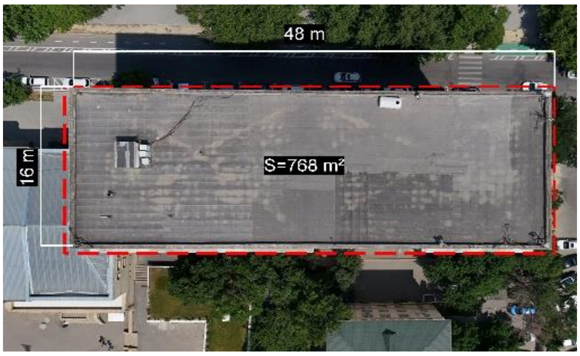
1.Introduction

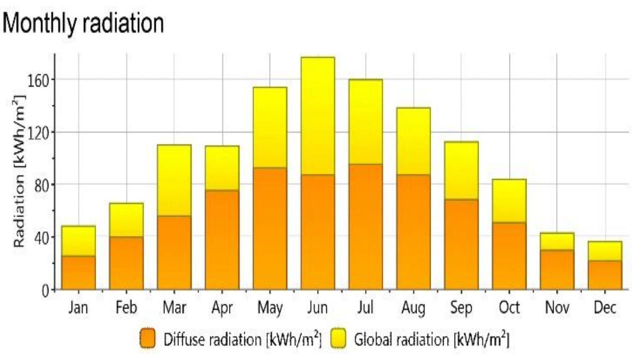
The global transition to renewable energy sources is accelerating, driven by climate change mitigation goals and the need for energy security. Educational institutions, as knowledge hubs and high-energy consumers, present ideal candidates for decentralized clean energy solutions. In regions like Azerbaijan, which receive ample solar radiation throughout the year, rooftop solar PV installations can offer both economic and environmental benefits. This paper presents a detailed feasibility assessment of installing a solar PV system on a university building rooftop in Baku, evaluating potential energy output, financial returns, and avoided carbon emissions [1].

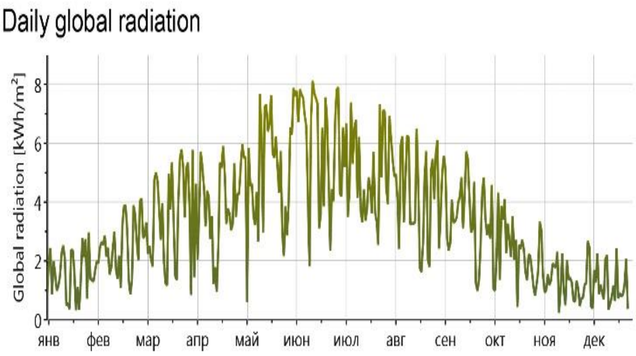
2. Experimental Section

2.1. Site Characteristics.

The proposed site is the rooftop of "AzMU 2-ci korpus" building in Baku, Azerbaijan, with a total surface area of 768 m². Considering architectural limitations and shading factors, an effective 85% of the rooftop was deemed usable, totaling 652.8 m².







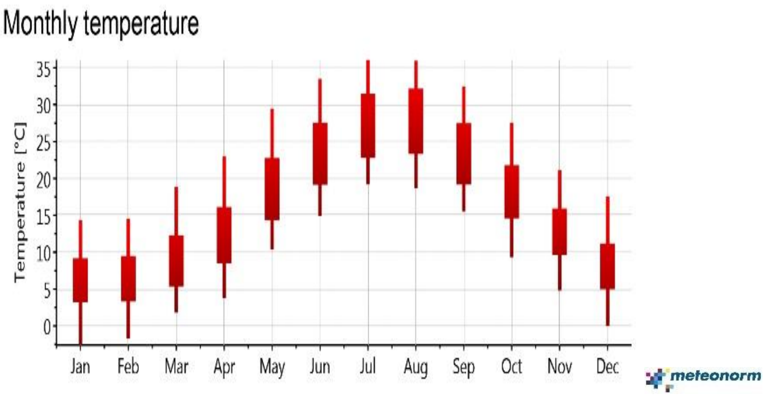


Figure 1. General information of building and site Characteristics

2.2. Solar Resource Assessment.

Solar radiation data were obtained from Meteonorm charts, estimating monthly global horizontal irradiation (GHI) values between 50 kWh/m² in winter and 170 kWh/m² in summer. These values were used to calculate the potential electricity generation on a monthly and annual basis [2,3].

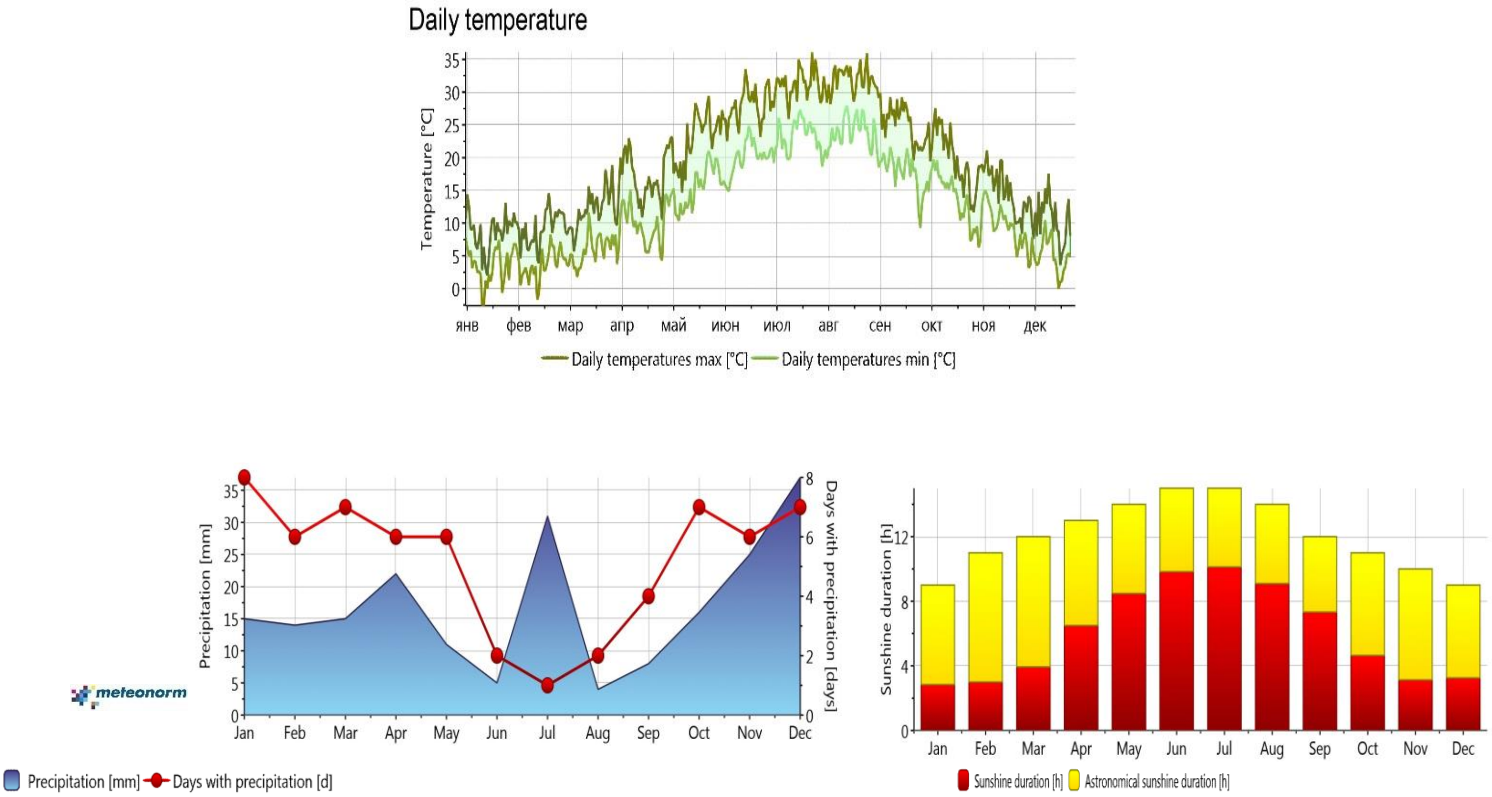


Figure 2. Solar Resource Assessment

2.3. System Design and Technical Parameters.

The PV system is designed using 310 high-efficiency monocrystalline panels (450 W each), covering the usable roof area. The total installed capacity is 139.5 kW. Assumptions for energy modeling include:

- Module Efficiency: 18%
- Performance Ratio (PR): 0.75 (accounting for real-world losses)

2.4. Energy Output Calculation The monthly and annual energy output was calculated using:

$$Energy_{month} = GHI_{month} \times A \times \eta \times PR$$

Where:

- GHI_{month}: Monthly global radiation [kWh/m²]
- A: Rooftop area (652.8 m²)
- η: Panel efficiency (18%)
- PR: Performance ratio (0.75)

Table 1. Monthly Global Solar Radiation and Estimated Energy Output of the Proposed Rooftop PV System

	Month	Global Radiation (kWl	Estimated Energy Out
1	Jan	55	5702.4
2	Feb	70	7257.599999999999
3	Mar	100	10368.0
4	Apr	110	11404.8
5	May	140	14515.199999999999
6	Jun	170	17625.6
7	Jul	160	16588.8
8	Aug	150	15552.0
9	Sep	130	13478.400000000001
10	Oct	100	10368.0
11	Nov	60	6220.799999999999
12	Dec	50	5184.0

3. Results and Discussion

3.1. Energy Performance

The proposed rooftop photovoltaic (PV) system is expected to generate approximately 134,266 kWh of electricity annually. Based on the installed capacity of 139.5 kW, the system achieves a specific energy yield of approximately 962 kWh/kW/year, which is consistent with the typical performance of photovoltaic systems operating under the climatic conditions of Azerbaijan. These results demonstrate that the available solar resource is sufficient to ensure reliable and efficient electricity generation throughout the year [4,5].

3.2. Financial Viability

The economic assessment indicates that the proposed PV system is financially feasible. Assuming an installation cost of $800 per kW, the total investment required is estimated at $111,600. Considering an average electricity tariff of $0.10 per kWh, the system is expected to provide annual electricity cost savings of approximately $13,426.56. Based on these assumptions, the estimated simple payback period is about 8.3 years, after which the generated electricity will continue to provide long-term financial benefits with relatively low operating and maintenance costs.

3.3. Environmental Impact

In addition to its economic advantages, the proposed photovoltaic system offers significant environmental benefits. Using a regional electricity emission factor of 0.45 kg CO_2 per kWh, the system is expected to reduce carbon dioxide emissions by approximately 60.4 metric tons annually. This reduction contributes to lowering the university's carbon footprint and supports both institutional sustainability objectives and national renewable energy and climate change mitigation strategies.

3.4. Panel Recommendations Top-tier PV technologies suitable for installation include:

- SunPower Maxeon 6 AC (22.8% efficiency)
- REC Alpha Pure-R (22%, lead-free)
- Q CELLS Q.Peak Duo ML-G10+ (21.4%, cost-effective) These options offer durability, high performance, and warranty benefits suitable for long-term institutional use [6].

Figure 3. Drone View Illustrating the Impact of Solar Radiation and Wind on the Second Educational Building

3.5 Proposed South Façade Design for the Second Educational Building of the Azerbaijan University of Architecture and Construction (AzUAC)

The Environmental Benefits of Wooden Façade Louvers for University Buildings: In the modern era, principles of environmental sustainability play a crucial role in urban planning and architecture. In particular, there is a growing demand for eco-efficient solutions in the design and renovation of educational institutions, including university buildings. In a dynamic and rapidly urbanizing city like Baku, this issue becomes even more relevant. Within this context, wooden façade louvers stand out as a promising alternative in façade design, offering both aesthetic appeal and environmental advantages [7].

Figure 4. Design of building

3.6 Energy Efficiency and Thermal Insulation

Wooden materials possess high thermal insulation capabilities. In cities with a semi-arid subtropical climate, significant energy is consumed to cool buildings in summer and heat them in winter. Wooden louvers protect the building's façade from direct solar heat, helping to maintain a balanced indoor temperature. This reduces the need for air conditioning and heating systems, thereby lowering overall energy costs. Thus, the use of wooden louvers in university buildings enhances energy efficiency and reduces the demand for electricity, thereby lessening the environmental impact.

Figure 5. Current condition and proposed design

Wooden facade slats can be recycled or naturally decomposed at the end of their production and usage cycles without causing harm to the soil or environment. This characteristic aligns them with the principles of the circular economy. In contrast, the recycling of materials like concrete and metal is more energy-intensive and results in higher carbon emissions. If the wood is sourced from FSC (Forest Stewardship Council) certified or other sustainably managed forests, it further enhances environmental responsibility. By choosing such materials, our university not only complies with international green building standards but also sets an example in fostering ecological awareness among students.

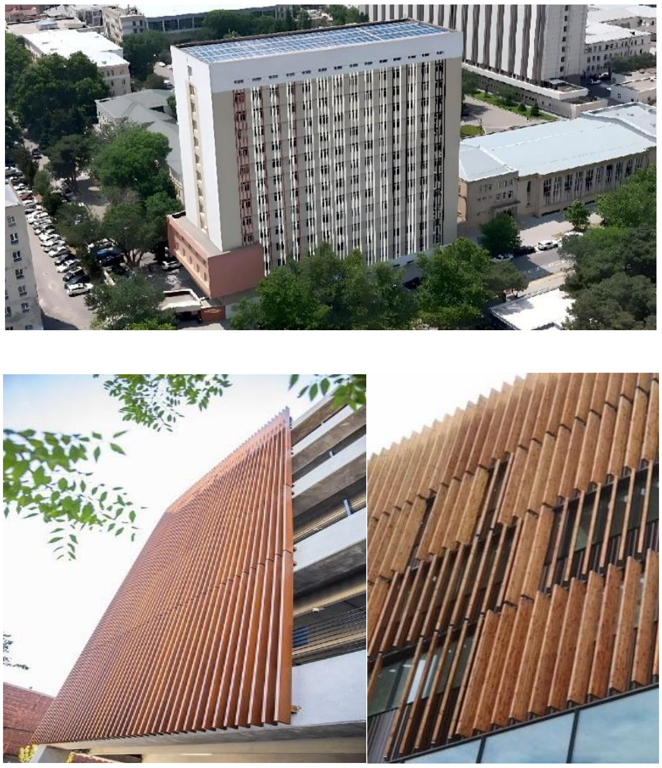


Figure 6. Proposed Wooden Louver Façade Design

Wooden facade lamellas are an environmentally, functionally and aesthetically favorable choice for university buildings. They reduce the carbon footprint, increase energy efficiency, and are compatible with sustainable development goals with their potential for reuse. The use of such materials not only produces ecological results, but also contributes to the formation of an ecological culture in the younger generation. The preference of universities for such approaches supports the overall ecological state of the city and the sustainable urbanization strategy.

4. Conclusion

The findings confirm that rooftop solar PV systems on university buildings in Azerbaijan are both economically viable and environmentally beneficial. With a moderate payback period and substantial CO_2 savings, such systems support the energy transition goals and demonstrate leadership in sustainability within the education sector. The approach and outcomes of this study can be replicated across similar institutions and regions.

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