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EVALUATION OF THE FINANCIAL EFFICIENCY OF RENEWABLE ENERGY PROJECTS USING THE EXAMPLE OF A 20 kW SOLAR PHOTOVOLTAIC PLANT

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Abstract: The article evaluates the financial efficiency of a 20 kW class solar photovoltaic power plant installed in a parking structure on the territory of the National Research Institute of Renewable Energy Sources based on real operational data. The plant consists of 45 Green Sun Solar photovoltaic modules with a power of 410 W, and the total nominal DC power of the modules is 18.45 kWp. In January-July 2026, the plant generated 13,600 kWh of electricity. 100% of the generated energy was directed to cover the internal electricity consumption of the institute. The financial assessment used net present value (NPV), internal rate of return (IRR), levelized cost of electricity (LCOE), and discounted payback period (DPP). The baseline calculation resulted in an NPV of 88.7 million soums, an IRR of 28.4%, an LCOE of 542 soums/kWh, and a discounted payback period of 4.75 years. The results showed that on-site consumption of the generated electricity is a cost-effective model for small-scale photovoltaic power plants.

Keywords: solar photovoltaic power plant, self-consumption, financial efficiency, NPV, IRR, LCOE, payback period.

Introduction

The use of solar photovoltaic power plants allows reducing electricity costs, reducing the amount of energy consumed from the centralized power grid, and increasing the economic sustainability of energy facilities. As a result of the decline in the cost of photovoltaic technologies, solar energy is becoming one of the most competitive electricity generation technologies in the world. According to IRENA, the global average LCOE of new large-scale solar PV projects in 2024 was 0.043 USD/kWh.

However, the economic efficiency of a photovoltaic power plant depends not only on the cost of equipment, but also on the actual production volume, consumption model, electricity tariff, operating costs and time value of capital. Therefore, it is of particular importance to evaluate financial indicators based on data from real operating plants.

The purpose of this study is to evaluate the financial efficiency of a 20 kW class solar photovoltaic power plant located on the territory of the institute based on its real generation indicators.

The object of the study is a grid-connected solar photovoltaic power plant installed above a parking lot on the territory of the National Research Institute of Renewable Energy Sources.

The plant has 45 Green Sun Solar 410 W photovoltaic modules installed:

PDC=45*410=18,450~W=18,45~kWp.

Thus, although the system is used in practice as a 20 kW class FES, the net nominal DC power of the photovoltaic modules is 18.45 kWp.

The generated electricity is not sold to the external network and is used entirely to cover the internal electricity consumption of the institute. In the calculation, the cost of electricity purchased by the institute from the network was assumed to be 1,100 soums/kWh, and the cost of selling to the external network was assumed to be 800 soums/kWh for comparison.

The power flow of the station in real time was also monitored through the monitoring system. The system's information on production, transmission to the network, consumption and battery status is presented in Figure 1.



Figure 1. Real-time energy flows of a solar photovoltaic plant (production, network, consumption and battery status).

The monitoring results for January–July 2026 are presented in Table 1.

Month Production, kWh Savings, million soums

1-jadval

Yanvar	800	0,88
Fevral	1 100	1,21
Mart	1 800	1,98
Aprel	2 100	2,31
May	2 500	2,75
Iyun	2 600	2,86
Iyul	2 700	2,97
Jami	**13 600**	**14,96**

For seven months, the plant produced 13.6 MWh of electricity. As a result of the full consumption of this electricity within the institute, electricity costs in the amount of:

S7months=13600×1100=14960000

sums were avoided.

If the same energy were sold to the network at a price of 800 sums/kWh, the following would be the profit:

Rsales=13600×800=10880000

sums.

Thus, the consumption of the generated energy within the institute itself provided an additional economic benefit of:

ΔS=14.96−10.88=4.08 million sums

in seven months.

The monitoring platform also recorded the generation volume in days, and it was found that the production indicators were relatively stable in accordance with weather conditions during the observed period. This situation is reflected in Figure 2.

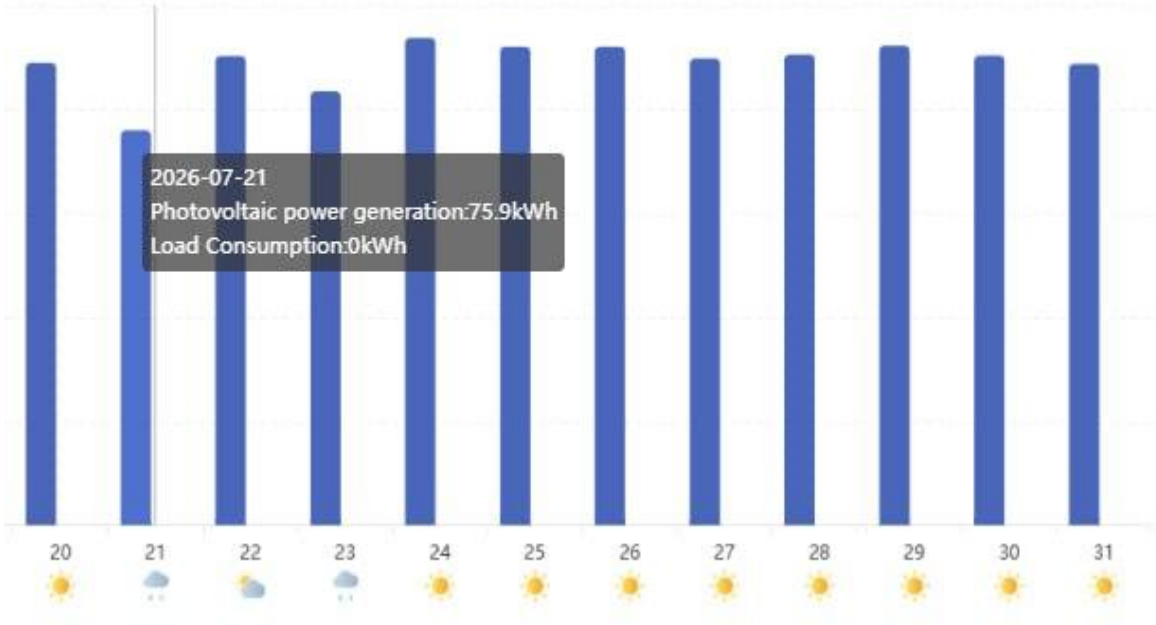


Figure 2. Solar PV power plant electricity generation by day.

Since only real data for January–July 2026 were available at the time of the study, the August–December generation for the annual financial model was initially estimated based on the observed seasonal profile.

In the baseline scenario, the annual generation was assumed to be:

September≈21.9 MWh/year

.

In this case, the comparable annual generation is:

Yf=21900/18.45=1187 kWh/(kWp\cdotpyil)

and the calculated capacity utilization factor is approximately 13.6%.

This value of 21.9 MWh/year is a baseline estimate for the financial calculations in the article and should be updated when real data for August–December at the end of 2026 are available.

It was also determined that the maximum production value of the station is observed during daytime hours according to the daily generation curve in the monitoring system. The dynamics of daily production and general aggregate indicators are presented in Figure 3.



Figure 3. Daily production curve and total production indicators of the solar photovoltaic power plant.

The first annual savings from the consumption of electricity at the institute itself at an estimated production of 21.9 MWh/year are:

$S_{yil}=21900\times1100=24090000$ soums/year

.

Net economic cash flow in the first year after deducting operating costs:

$CF1=24.09-0.80=23.29$ million soums/year

The main financial results obtained according to the 20-year model are as follows:

Indicator Estimated value

Calculated CAPEX 80.0 million soums

Annual production 21.9 MWh

First year gross economy 24.09 million soums

NPV +88.7 million soums

IRR 28.4%

LCOE ≈542 soums/kWh

DPP ≈4.75 years

The NPV of +88.7 million soums indicates that the project generates positive economic value even at a 12% discount rate.

The estimated IRR of 28.4% is significantly higher than the base 12% discount rate. This indicates the investment attractiveness of the plant under the assumed conditions.

The LCOE value is approximately:

$LCOE\approx542$ soums/kWh

, which is almost two times lower than the purchase price of electricity for the institute of 1,100 soums/kWh.

In other words, the estimated cost of electricity generated by the plant over a 20-year service life is approximately 49% of the current purchase price of grid electricity.

The discounted payback period was 4.75 years. During the subsequent operation period, the plant generates mainly net economic benefits.

The analysis of the energy flows in Figure 1 and the daily generation curve in Figure 3 shows that the plant operates stably during the daytime and transmits the main amount of energy to the grid. This confirms the technically stable operation of the solar plant for this facility.

Conclusion

This study assessed the technical, economic and financial efficiency of a 20 kW class solar photovoltaic power plant installed in a parking structure on the territory of the National Research Institute of Renewable Energy Sources based on real operational data. In January-July 2026, the plant generated 13.6 MWh of electricity, which was used entirely for the needs of the institute, saving electricity costs in the amount of 14.96 million soums. Compared to selling this energy to the grid at a tariff of 800 soums/kWh, the self-consumption model provided an additional economic benefit of 4.08 million soums in seven months.

Based on the seasonal production profile, the annual generation of the plant was estimated at 21.9 MWh. At this production volume, the annual gross economic effect is 24.09 million soums, and the first year net cash flow after deducting operating costs is 23.29 million soums. With a service life of 20 years, an estimated CAPEX of 80 million soums, a discount rate of 12% and an annual module degradation of 0.5%, the NPV is determined as +88.7 million soums, an IRR of 28.4%, an LCOE of 542 soums/kWh and a discounted payback period of 4.75 years.

The results showed that the consumption of the generated solar electricity for the facility's own needs is economically more efficient than selling it to the grid. In particular, in the estimated annual generation, the self-consumption model creates an additional economic value of 6.57 million soums per year compared to selling it to the grid. Therefore, the introduction of small-capacity parking-type photovoltaic power plants in state organizations, scientific institutions and other facilities with sufficient daytime electricity consumption can be considered an effective solution to reduce electricity costs and increase the share of renewable energy use. At the same time, the annual production of 21.9 MWh and CAPEX of 80 million soums are still estimates. Recalculation of financial indicators with the availability of complete monitoring data at the end of 2026 and the actual cost estimate of the plant will further increase the accuracy and reliability of the results.

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