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A techno-economic analysis of a single-axis tracked bifacial photovoltaic plant connected in Albanian distribution system

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Tracking PV
Distribution System
Power losses

Abstract

This paper presents a techno-economic analysis of a 10 MWp photovoltaic (PV) plant installed in the south-west of Albania. To increase its performance, a single-axis solar tracking system with bifacial modules has been chosen. Moreover, the optimal design and sizing of the PV plant is determined through software, considering various factors. In this context, the results show that the annual yield of the on-grid PV system will be 1,670 kWh/kWp. In the same vein, the calculations present that the internal rate of return IRR is 20.6%, which indicates that the project will have a positive return on the investment value. Meanwhile the payback period of the investment is 4.8 years, which is considered as an investment that provides high income. These values are quite attractive for investors. On the other hand, the impact of this PV system on the distribution system parameters has been studied. While an improvement is seen in the voltage levels of the nodes, some of the lines and transformers show technical losses due to their loading.

Introduction

Growing concerns about global warming, environmental pollution and security of energy supply have increased interest in the use and development of renewable energy sources (RESs). For example, according to IEA, compared to 2022, by 2027, it is expected that RESs capacity will grow by almost 2400 GW (or 75%) [1]. Several factors have influenced this increase in RES penetration, such as: market conditions, investment costs, technology diversity, resource availability, proximity to the distribution or transmission network, etc. Another very important factor are government policies such as incentive fees, support schemes, or banking policies (loans) for the support and development of these technologies.

Among RESs, solar photovoltaic (PV) can provide suitable solutions to global climate change and give its impact to the global energy crisis. Moreover, in countries like Albania (energy production in which is based almost entirely on hydropower (99.28%), always questioning its reliability), the increase in installed PV capacities would affect the diversification of sources of electricity production [2-3]. It is worth mentioning that Albania has great potential for the use of solar energy, especially in its western part where Global Horizontal Irradiation (GHI) reaches a maximum of 1750 kWh/m^2 per year. In this context, most of the PV plants installed in Albania (29MW) are located in the Fier area. In addition, Law 24/2023 [4] on promoting the use of energy from RESs has increased the demand for the construction of new PV power plants.

On the other hand, the performance of photovoltaic systems has always been increasing. In particular, this performance depends on the optimal design and sizing of the PV plants [5]. In the same vein, authors in [6] show that the average energy produced by a panel with single axis tracker was 1.35 times greater than that of a fixed panel system. Furthermore, authors in [7] argue that bifacial PV produce 9 % to 23 % more power than monofacial PV.

In the end, determining the most suitable point for connecting PV plants to the electrical system is a very important issue. For this purpose, their impact on network parameters should be considered, such as: voltage levels, loading of distribution lines and transformers and active power losses [8]. In this context, this paper deals with a techno-economic analysis of a Single-Axis Tracked Bifacial Photovoltaic Plant, connected in the Fieri distribution system area.

Material and Method

The methodology used to carry out this analysis combines the previous experiences undertaken in Albania in the field of feasibility studies and potential investments in RESs, more specifically in the generation of electricity through PV plants as well as forms of good management in the provision of this service. The study is based on solar radiation data averaged and published by SolarGis, likewise based on GlobalSolarAtlas computer modelling and the calculation program PV*SOL Premium 2022 (R7) [9]. These programs are used as a model for simulating and evaluating data and performance, besides to calculate expected yield. For example, according to the simulations in SolarGis Albania, the annual average GHI for the Fieri area is about 1669.4 kWh/m^2.

On the other hand, the financial part has been analysed in relation to the value of the investment, the method of financing, the repayment of the loan, the return of the investment and the incomes from the sales in the energy exchange. Meanwhile, AS DAISY Off-Line Bizon software [10] was used to calculate the impact of the photovoltaic system on the parameters of the distribution system, connected to its most suitable point.

Results and Discussions

Technical analysis

The optimal design and sizing of the Single-Axis Tracked Bifacial PV Plant is shown in Figure 1. Specifically, the on-grid PV system with a total power of 10 MWp consists of: 17220 Bifacial PV modules (RECOM PANTHER 650 Wp, 20.9%), 96 inverters (SUNNY TRIPOWER CORE2 STP 110-60), 2 Smart Transformation Stations (2x6000kVA), AC and DC cables, and one bidirectional meter.

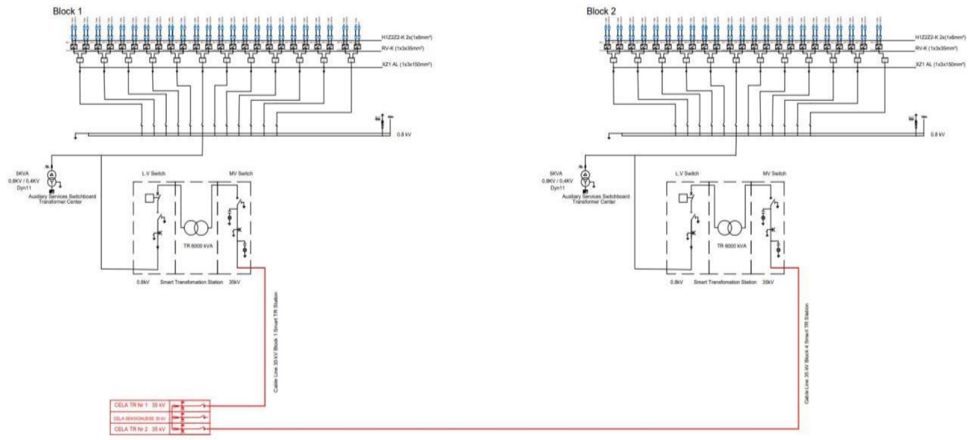

Figure 1. The principal electrical scheme of the PV plant

The on-grid PV system's, with 92% of Performance Ratio (PR), will generate 17950 MWh/Year (with annual yield 1,670 kWh/kWp). Furthermore, the other main simulation results of the technical analysis are shown in Table 1.

Table 1. Technical analysis.

Items	Value
Installed capacity	11.2 MWp (DC), 10 MW (AC)
PVs area	53492 m^2
Orientation	South (Single Axis Tracker)
CO_2 emissions avoided	8435 ton
Assessment period	25 years
Number of working hours	1,794.94 hours/year

Financial analysis

While the total investment cost is 7.04 million €, the payback period and the Internal rate of return of the project according to the calculated flows will be respectively 4.8 years and 20.6%. Furthermore, in this calculation, it is assumed to receive a loan in the value of 80% of the total cost (with +/-3.5 % annual interest rate for 10 years). Furthermore, an average price of 113.58 €/MWh is provided for the calculation of the income from the sale of energy (HUPX- Hungarian Power Exchange Ltd.). In addition, a more detailed presentation of the cumulative cash flow in years is given in Figure 2. These values are quite attractive for investors.

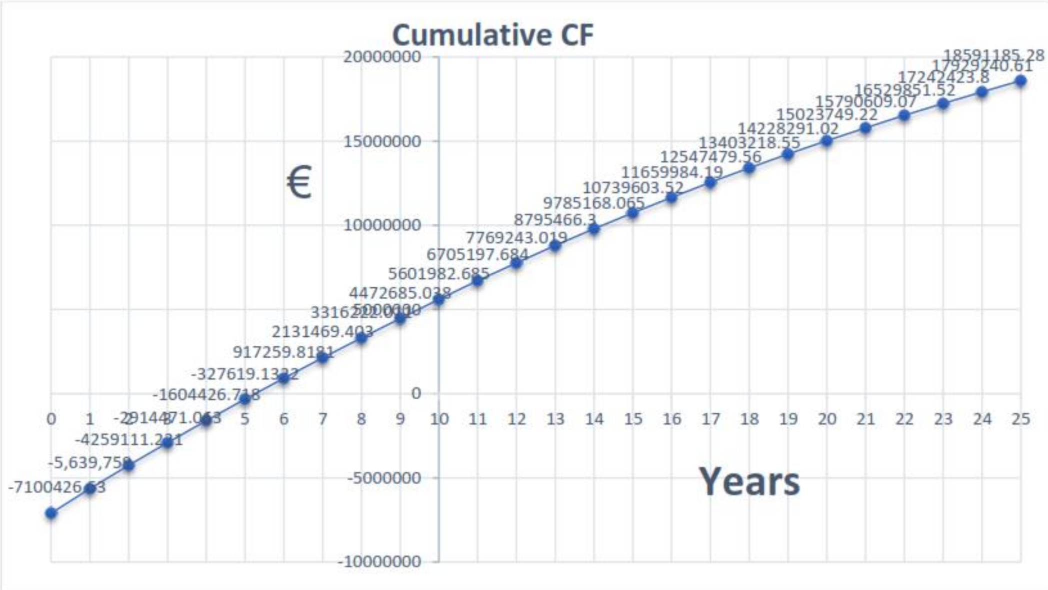

Figure 2. Cumulative Cash Flow

Connection to the distribution network

In the area where solar PV is located, the existing electrical network, at the 35 kV, 10 kV and 6 kV voltage levels, is owned by the distribution system operator. After the simulations, it turns out that the best connection point would be on the 35kV Kafaraj-Povelçe line. This is the closest line to the PV system, as well as the energy losses in this case would be lower. For this purpose, from the point of view of the stability of the static parameters of the network and its security, the connection is made through the construction of a 35 kV line with two circuits (0.7 km in total), with 120/20 mm^2 Aluminium Conductor steel-reinforced Cable (ACSR). In this context, Figure 3 shows the impact of the connection of the PV plant in the voltage nodes of the distribution system, as well as in the losses of lines and transformers.

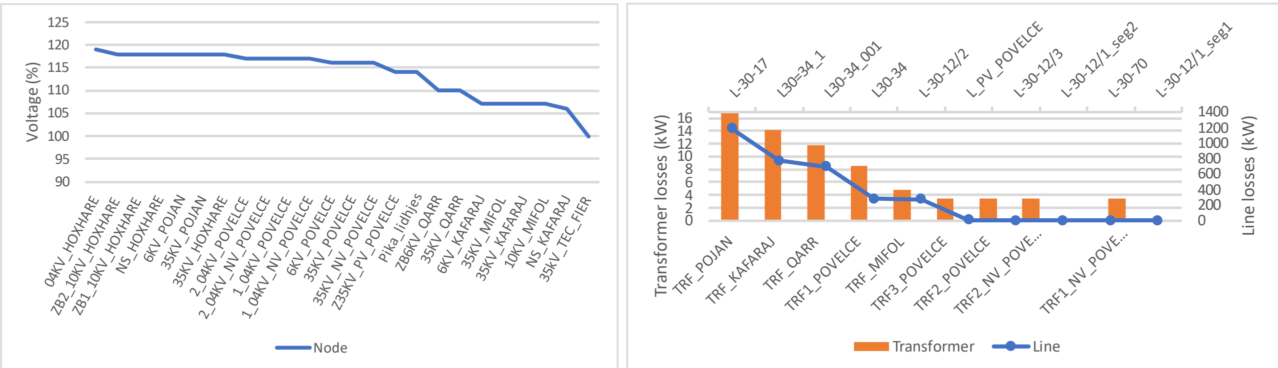

Figure 3. Voltage nodes & losses of lines and transformers of the distribution system

While an improvement is seen in the voltage levels of the nodes, some of the lines and transformers show technical losses due to their loading. However, these network parameters are expected.

Conclusion

This paper performs techno-economic feasibility analysis of a Single-Axis Tracked Bifacial PV Plant. Optimizing this 10MWp PV system, results in an annual energy production of 17950 MWh/Year. This amount of energy is expected to be sold in the energy exchange. This would bring in an internal rate of return of 20.6% IRR is, as well as a 4.8 years payback period of the investment. These values are quite attractive for investors. On the other hand, this paper analyses the impact of the photovoltaic system on the parameters of the distribution system, connected to its most suitable point. In this context, an improvement is been seen in the voltage levels of the nodes. Meanwhile, some of the lines and transformers show technical losses due to their loading. The future work will perform a comparison between a Single-Axis Tracked Bifacial PV Plant and a static Monofacial PV Plant.

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