Assessment of the economic efficiency of a photovoltaic plant for a small and medium-sized production facility

Borislav Boychev
Technical University of Sofia
Sofia, Bulgaria
bojchev@tu-sofia.bg

Polina Petkova
Technical University of Sofia
Sofia, Bulgaria
ppetkova@tu-sofia.bg

Abstract— In the present paper, the economic efficiency of a photovoltaic installation for a small and medium-sized manufacturing company is evaluated. It considers the location and size of the analyzed facility. The maximum capacity that can be built into the developed system is determined. The energy needs of the company are assessed. The optimum capacity of the photovoltaic installation is calculated. Overall, an economic analysis is made and the payback period of the investment is obtained.

Keywords—electricity costs, photovoltaic systems, photovoltaic plants, manufacturing company, energy efficiency.

I. Introduction

Within the European Union (EU), micro, small and medium-sized enterprises employ over 100 million people and produce more than half of Europe's GDP. In Bulgaria, SMEs account for 75.7% of total employment and 65.3% of value added in the economy. 50% of the country's total exports are made by SMEs, which represent 98% of all exporting firms in Bulgaria.

In the last few years, a large number of small and medium-sized enterprises (SMEs) have been moving towards the installation of photovoltaic (PV) systems in order to reduce production costs and better compete in the market. At the same time, the cost of production is easier to predict. [1, 2, 3].

In the last few years, several European grant programs have been launched for PV energy.

In this paper, a designed and physically implemented working PV installation, mounted on the roof of a small enterprise in Southern Bulgaria, is presented. The structure of the work is organized in the following way. In the next section, the design of the developed photovoltaic plant is described. An economic analysis of the effect of the proposed solution is made in Section III. The manuscript ends with a conclusion on the financial benefit of the renovations and improvements made by implementing new photovoltaic plant for a small and medium-sized energy production.

II. Design Solution of the Photovoltaic Plant

The purpose of the PV plant placement is for electricity generation, storage, and use only for self-consumption with a limitation to return instantaneous excess electricity to the grid. [4, 5, 6].

It is planned to build a photovoltaic installation on the roof of an existing building with identifier 77476.505.4.7, in the village Hrishteni, Stara Zagora municipality, Stara Zagora region, Bulgaria. The sketch of the renovated object is shown in Fig. 1.

The current situation of the installation consists of a hall producing energy from pipelines, metal structures, assembly of machinery, construction of hydroelectric power plants, and some gas stations. Mechanical processing of ferrous and non-ferrous metals. Manufacture of non-standard equipment.

Fig. 1. Sketch of the facility.

In order to assess the efficiency of the PV installation, the load profile of the plant was requested from the electricity distribution company. The variation of power (in kWh) during the day is shown in Fig. 2. Obviously, that the largest amount of electrical energy by PV plant is generated between 10 and 18. Obviously, the greatest amount of electrical energy from PV system is generated in the hour range, as the sun shines most strongly during that time.
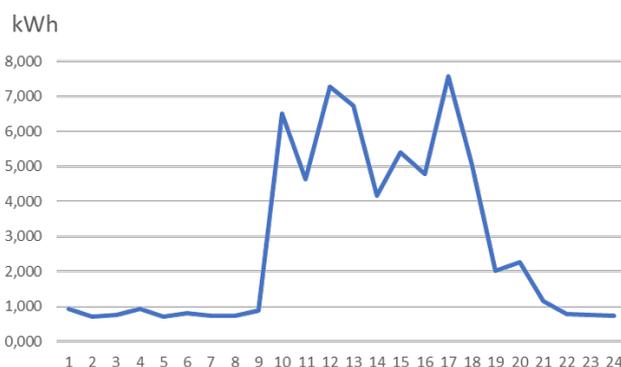
The connected power of the enterprise to the electricity distribution network is 38 kW.

This means that it is entitled to install a 76 kWp captive PV plant.

The roof of the building is gable with a pitch of 12° facing east-west.

The location of the PV modules on both slopes directly on the roof structure is suitable.

The appearance of the roof of the building, where the PV modules are mounted, is shown in Fig. 3. The maximum power that can be deployed from these modules is 124.3kWp.

Fig. 3.   In the design, photovoltaic modules with a capacity of 550kWp from the company DAH Solar were used.

From the load schedule of the plant it is evident that the installed capacity required need not exceed 30kWp (see Fig. 4).

Fig. 4.   Placement of panels at power 30 kWp.

III. ECONOMIC ANALYSIS OF THE PROPOSED SOLUTION

The production of the electrical energy from the photovoltaic plant and the energy consumption of the plant are shown in Fig. 5 with green and red bars, respectively. The self-consumption is marked with blue, but clipped energy – with cut-off blue.

Fig. 5.   Production of the photovoltaic plant and the energy consumption.

For the installation, storage systems (rechargeable batteries) are foreseen to store the energy produced, which is not consumed, at the moment of its production. For this purpose, 6 solar lithium batteries, 30 kWh are used. The local

energy storage facilities (batteries) shall have a total minimum capacity in kWh equivalent to storage of 1 (one) hour for 100% of the installed capacity of the developed PV plant.

The connection will be accomplished by means of a dedicated PV system plug-in, non-return voltage to the main power source Power meter, which shall be mounted in the low voltage panel feeding the building equipment, located on the façade of a substation located within the property boundary.

The connection to the electricity generated by the photovoltaic system is to the building's internal electrical wiring, thereby providing the ability to provide electricity to the consumers. The photovoltaic installation is not connected to the electricity grid and the connection to the internal electricity grid on site is downstream of the electricity distribution company's meter.

The construction of the photovoltaic installation amounts to 59 400 Bulgarian leva.

The Net Present Value (NPV) method is used to determine the economic efficiency of the investment.

The lifetime of the PV plant is assumed to be 10 years. The results of the economic evaluation in this case are presented in Table I.

TABLE I.   ECONOMIC EVALUATION FOR THE PROPOSED PHOTOVOLTAIC SYSTEM
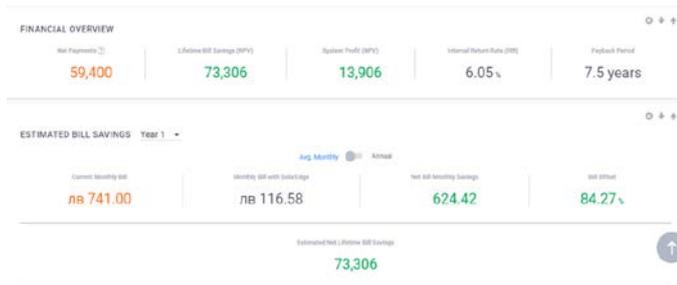
The respective returns by years in the next 10 years by bar graphs are equitably distributed over the years (see Fig. 6). This distribution in tabular form is shown in Table II.
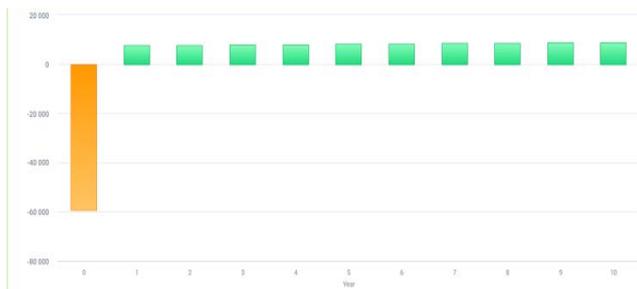

Fig. 6.   Returns by year in graphical form.

Fig. 7.   Returns by year in tabular form.

IV. CONCLUSIONS

From all mentioned above, it is evident that the payback period of the PV installation is seven and a half years. In view of this, the project is found to be economically viable. On the other hand, it has been approved under the procedure "Construction of new RES for own consumption in combination with local energy storage facilities in enterprises". In this case, 50 % of the costs are covered by the procedure. Consequently, the payback period of the plant will be reduced to less than 4 years.

Investing in small captive photovoltaic plants, when tailored to the needs of the enterprise, is an economically viable investment that, in addition to reducing the energy costs of enterprises, also ensures their energy independence.

REFERENCES

[1]   V. Atanasov, D. Stoilov, "Determining the Places for Installation of Remote Power Disconnectors in Overhead Power Lines," 22nd International Symposium on Electrical Apparatus and Technologies (SIELA), Bourgas, Bulgaria, 2022, pp. 1-4, DOI: 10.1109/SIELA54794.2022.9845755

[2]   G. Cherneva, S. Filipova-Petrakieva, "Modeling and analysis of an autonomous photovoltaic system for laboratory research", XIV International Conference BulEF'2022, 14-17.09.2022, Varna, Bulgaria, ISBN: 978-166549026-9, IEEE Catalog Number CFP22BUL-ART, 2022, Conference ID in IEEE Xplore: 56479X, DOI: 10.1109/BulEF56479.2022.10021202

[3]   V. Atanasov, D. Stoilov, "Technical Economic Analysis of Utilization of Transformers Along a Long Low Voltage Overhead Power Line," 18th Conference on Electrical Machines, Drives and Power Systems (ELMA), Varna, Bulgaria, 2023, pp. 1-4, DOI: 10.1109/ELMA58392.2023.10202422

[4]   P. I. Tsvetkova, "Problems and influencing factors in short-term planning of the development of distribution electric networks", News of TU-Sliven, ISSN: 1312-3920, N 4, 2022.

[5]   P. I. Tsvetkova, "Determination of the optimum power from decentralized sources in long connecting branches in distribution networks", News of TU-Sliven, ISSN: 1312-3920, N 3, 2023.

[6]   P. I. Tsvetkova, "Calculation of the optimum power from decentralized sources in short connecting branches in distribution networks", News of TU-Sliven, ISSN: 1312-3920, N 3, 2023.