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IMPACT OF A PHOTOVOLTAIC INSTALLATION ON ECONOMIC EFFICIENCY ON THE EXAMPLE OF A COMPANY WITH HIGH ENERGY CONSUMPTION

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Purpose: The research objective of the work is to quantify the levels of profitability of a photovoltaic installation for a company from the clothing industry. The authors of the article answer the question of where and under what boundary conditions in Poland there is already economic justification for the construction of photovoltaic power plants producing energy for the needs of their own business activity.
Design/methodology/approach: The study was conducted using the methods of models of economic measures. These methods allowed the authors to calculate the market value of the investment with the assumed boundary criteria and to determine the economic efficiency of the investment. In addition, the authors made an analysis of the energy consumption of the company's implementation of individual manufacturing processes. The research was carried out in the period 2020-2022 on the example of a real PV installation.
Findings: Installing a photovoltaic system in production plants brings many benefits. It should be noted that each kWh produced in a PV installation makes the investor independent of the grid distributor, reduces the consumption of energy from conventional sources, minimizes the emission of pollutants into the atmosphere and favors economic development. In addition, investment in this type of installation allows for obtaining income from the sale of surplus energy produced.
Practical implications: The presented models have shown that the project of their implementation is fully economically justified and will allow investors to make a rational investment decision.
Originality/value: The contribution of this work is to obtain data that allowed the authors to indicate directions for improvement that may contribute to a more reliable assessment of the profitability of the tested installations. The proposed research can improve the planning of new industrial plants in terms of PV Installations as well as the redesign of existing ones.

Keywords: Profitability account, economic analysis, energy analysis, renewable energy sources, photovoltaic panels, energetic efficiency.

Category of the paper: Research paper.

1. Introduction

When planning an investment in a PV installation, an investor is mainly interested in both its energy efficiency and economic profitability (Niekurzak et al., 2022), (Höfer, Madlener, 2020). Investments in renewable energy sources (including photovoltaic panels) are not low-budget in Poland, but thanks to the possibility of taking advantage of non-repayable subsidies and favorable credit financing for the purchase and installation of photovoltaic panels, they may gain popularity in Poland (Derski, 2019) and (SolarPower Europe, 2023). The main reason for this is the profitability of the purchase and use of ecological systems for electricity production (Benalcazar et al., 2020). As part of the work, the authors characterized the general principles of operation of a photovoltaic system in an energy-intensive company and presented the practical application of this type of solution, based on the results of measurements made in an example company. The work is of a research and analytical nature, which is devoted to the assessment of the economic efficiency of renewable energy sources (RES) technologies and the assessment of ecological benefits from use of these technologies. The research nature of the work resulted from the need to obtain original, reliable and verified input data for the economic evaluation model. The main purpose of the work is to examine the efficiency of the photovoltaic installation in the company and to analyze the use of photovoltaics for the company from the economic point of view (Zimm et al., 2019). An additional goal is to conduct a study reflecting the actual impact of the PV installation on the company's electricity consumption, as well as to analyze the results generated by the photovoltaic system, on the basis of which the individual parameters related to electricity consumption in the described company are determined.

The conducted analysis allows for a summary of the amount of energy produced by the photovoltaic installation, energy taken from the distribution network for production purposes or the surplus of energy produced sent to the grid. It is also important to show how the system works in days when the company is not working. The last important aspect is to calculate the savings for the company on account of the electricity generated by photovoltaics and to simulate the payback period of the installation.

2. Materials and Methods

The subject of the research was a photovoltaic installation installed on the roof slopes of a manufacturing company, the diagram of which is shown in Figure 1.

Figure 1. Diagram of a photovoltaic installation.

Source: own.

In order to see the benefits of a photovoltaic installation, the authors analyzed the energy consumption of individual manufacturing processes in the company. The demand for electricity was divided into two areas. The first, requiring the most energy, was related to the textile technology, where the total demand is 1145.7 kWh. The second is for the leather technology, where the maximum demand for electricity is 327.75 kWh. In addition, the sector with the demand for electricity at the level of 207.2 kWh was specified, including other consumption (lighting, compressor, boiler room and others). In the final calculation, the total (maximum) demand for electricity, assuming that all installed devices work continuously, in the company is 1680.65 kWh. Photovoltaics in the company were created in three stages. The first installation was built with a capacity of 49.82 kWp, the second with a capacity of 309.32 kWp and the third 294.75 kWp. The installed modules made it possible to generate a total power of 653.89 kWp. As a result, all three installations have a total of 1,747 PV panels installed and have been integrated and connected so that all energy from all generators goes into production, and their total capacity is 653.89 kWp. Figure 2 shows the installed inverters.

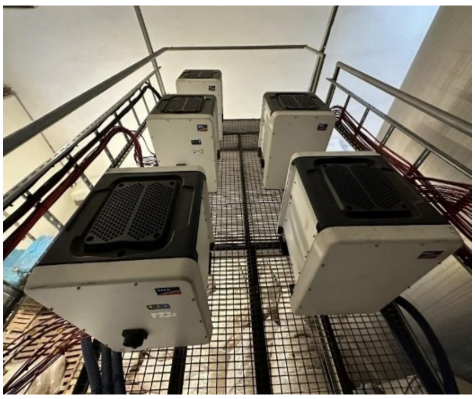

Figure 2. SolarEdge inverters.

Source: own.

The research carried out in the company consisted in collecting the results during the implementation of manufacturing processes, subjecting them to processing and analysis in order to issue recommendations on the efficiency of the operation of a given installation. Thanks to the integrated functions of the inverters, not only real-time results were obtained, but also a number of data on the history of the installation's operation from the beginning of its operation. The main two-way energy meter installed in the company's transformer station was also used for the study, from which the results of energy consumption and transmission to the grid were read. Thanks to this information, data was collected and analyzed in terms of energy production from photovoltaics, energy consumption from the grid, energy sent to the grid, and the amount of energy consumed by the company was presented, broken down into energy from photovoltaics and from the distribution grid (Niekurzak, 2021) and (Hayibo, 2019). Due to the three different PV installations, each with a different installed capacity and different operating time, all results were obtained by individual installations and for each group, individual analyzes were performed, and then a summary statement was made.

Economic investment aspects

In order to determine the full cost of the investment, in order to determine its profitability, it was necessary to take into account the individual stages of work not directly related to the photovoltaic installation. All costs are divided into direct and indirect costs. Indirect costs are mainly those related to the construction of infrastructure responsible for receiving and transmitting energy, which includes Fic, 2023; Zimm et al., 2019; Bhuiyan et al., 2021:

- development of design documentation for the electrical industry (transformer station, individual installations),
- construction of a transformer station equipped with appropriate devices (transformers, meters, protections with supervision and remote operation),
- construction of cable lines connecting the installations with the transformer station,
- preparation of space for installation.

Direct costs are those related to the construction of a specific installation, completed at the inverter stage, and they include:

- purchase of installation components (photovoltaic modules, inverters, roof mounting system),
- delivery and assembly,
- other connection elements (solar cable, wiring, assembly elements).

Indirect costs resulting from the division described above amounted to PLN 150,000. Direct costs are presented broken down into individual types of installations. For the first installation with a capacity of 49.82 kWp, the costs incurred for the purchase of installation components, delivery and assembly amounted to PLN 165,900. For the second installation with an installed capacity of 309.32 kWp, the costs amounted to PLN 624,200. They were related to the purchase of photovoltaic modules, inverters, roof mounting system as well as delivery and installation. For the third installation with a capacity of 294.75 kWp, the costs incurred were PLN 596,100. After comparing indirect and direct costs and their costs Summing up, the amount of PLN 1,536,200 was obtained for the entire installation with a capacity of 653.89 kWp, together with the entire infrastructure needed for the proper functioning of the mini power plant.

From the perspective of a company with a photovoltaic installation, the method of accounting for the surplus energy that goes to the grid is important. An entrepreneur who generates electricity only from renewable energy sources to use it for his own needs becomes a prosumer and has the option of transferring the surplus of energy produced to the power grid. One of the conditions for a company to become a prosumer is that the company has an agreement covering the sale of electricity and the provision of distribution services by the distribution network operator. Regulations in this matter are provided by the Act on Renewable Energy Sources and inspections are carried out by the Energy Regulatory Office. For installations defined as small installations, i.e. with a capacity of 50 kW to 1 MW, an entry in the register of energy producers in a small installation kept by the Energy Regulatory Office is required. In the described company, the method of accounting for the energy generated by the photovoltaic installation consists in selling surplus electricity to a distributor with whom the company has a contract, at a fixed price (at the moment it is PLN 360/MW) and buying energy when it is needed, also at a fixed price (currently PLN 974/MW including shipping fee). Payments are made both ways after each billing period (both for energy sold and purchased by the company). From the company's point of view, the profitability of owning a photovoltaic installation is justified only in the case of high self-consumption or in the case of having an energy storage facility. In the analyzed company, despite the fact that the degree of self-consumption is very high, there are times when surplus energy is sold, mainly on days off, which is later settled according to legal regulations.

3. Results and discussion

The research was conducted in the period from May 2020 to July. 2022. The data collected over this period made it possible to reflect the functioning and impact of the photovoltaic installation on the consumption of electricity taken from the grid. For the installation with a capacity of 49.82 kWp, data was recorded from May 2020, for the second installation with a capacity of 309.32 kWp, data was recorded from December 2020, while the results obtained by the third installation with a capacity of 294.75 kWp were recorded from July 2020. In the final statement, all the results obtained by each installation were combined to provide an overall statement of the energy production of the entire photovoltaic system in the company. The main purpose of the study and the presented results is their economic analysis.

The presented data for individual months made it possible to check in which periods photovoltaics are the most effective and have the greatest contribution to the company's economy, and when they are less efficient. The collected data give the opportunity to present the results from the entire lifetime of the photovoltaic installation in the company and allow you to calculate the payback period of this installation. Table 1 and Figure 3 present sample data obtained from the daily production of the analyzed installations for the period: September 5-26, 2022.

Table 1.
Results of the survey from September 5 to September 26, 2022

	Reading from the energy meter		Reading from the inverter
Examination day	**Energy taken from the grid (kWh)**	**Energy sent to the grid (kWh)**	**Energy produced by the installation PV (kWh)**
05.09.2022	678.8	0.0	2755.8
06.09.2022	821.5	0.0	2206.7
07.09.2022	551.9	0.9	2662.4
08.09.2022	720.8	0.0	2478.2
09.09.2022	962.0	0.0	2017.6
10.09.2022	286.2	309.1	1190.5
11.09.2022	93.1	918.2	1185.8
12.09.2022	356.2	0.1	2884.3
13.09.2022	1006.6	0.0	2327.6
14.09.2022	2285.8	0.0	829.8
15.09.2022	2406.9	0.7	754.4
16.09.2022	1191.5	0.6	2043.1
17.09.2022	186.7	94.1	1544.0
18.09.2022	83.1	1377.4	1658.5
19.09.2022	1696.9	97.1	1240.1
20.09.2022	1531.2	107.9	1455.0
21.09.2022	2050.6	9.6	1064.5
22.09.2022	1097.5	223.0	1894.8
23.09.2022	1693.6	43.4	1255.9
24.09.2022	113.7	594.0	1909.1
25.09.2022	49.2	1007.4	1274.6
26.09.2022	2187.8	25.0	803.5

Source: own.

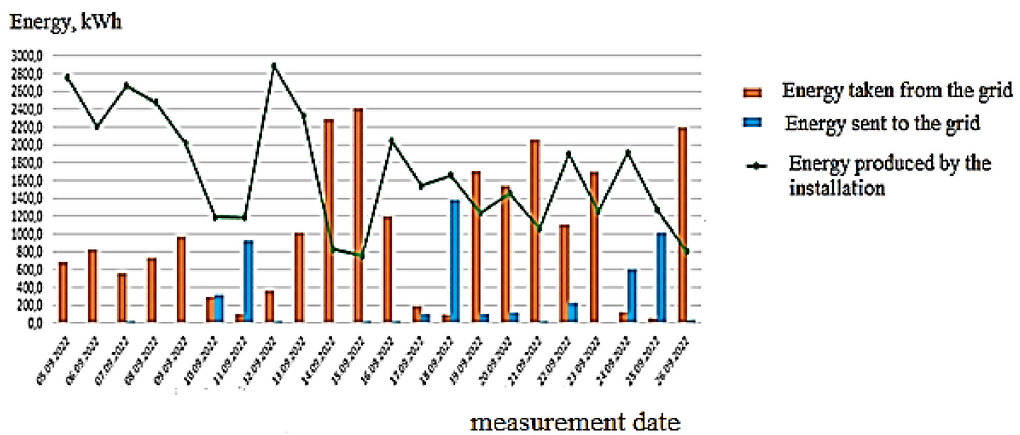

Figure 3. Distribution of energy consumption in the enterprise.
Source: own.

From the analysis of Figure 3, a downward trend in the energy produced by the PV installation should be noted. This decline is not sudden, but there are smaller and smaller peaks for individual days, there are also days when the production is significantly higher, but these are increasingly rare cases. The reason for this situation is the month in which the survey was conducted and the degree of insolation during this period. It can be observed that at the beginning of September the conditions are favorable and the results of the energy produced reach over 2500 kW, from the further course one can read one more day when the energy produced was at the level of over 2800 kWh, while later such results are no longer repeated, and the largest production for one day oscillates around 2000 kWh and is gradually decreasing. These results are a natural consequence of the arrival of a period of lower efficiency of PV modules, caused by less insolation, greater cloud cover and shorter insolation time. Another relationship, clearly visible on the chart, is in the case of energy taken from the grid and energy produced from photovoltaics. In a situation where there is a large production of energy from photovoltaics, energy consumption from the grid is lower, which is best seen in the first and at the beginning of the second week of the study (energy production of about 2500 kWh - consumption below 1000 kWh per day). On the other hand, the opposite situation is when the production from the modules is low, then the energy consumption from the grid is high (most visible on days 14 and 15, production of about 800 kWh - consumption from the grid over 2200 kWh, and from the 19th until the end of the study, where the green line intersects the orange). These relationships result from the fact that the electricity generated from PV panels first goes to production and is consumed there, and any shortage of energy is only obtained from the grid, so when there is little production from the PV installation, most of the electricity comes from the grid, and when there is a large that's more covered by photovoltaics. There is no such dependence on non-working days, in this case Saturday and Sunday, then further data on the energy transferred to the grid appear (blue). On Saturdays, production is limited, so you can see a small consumption of energy from the grid and a noticeable transfer of energy to the grid (produced energy is consumed first and the surplus is sent to the grid). On days such as Sunday, the company does not work, most of the energy produced is sent to the grid, and a small part is used for maintaining devices, lighting and other (in the graph, the blue bars approach the green line). It is also important to explain the situation shown in the graph, when on working days it happens that energy is sent to the grid and the consumption from the grid is higher than the production from photovoltaics. This situation occurs when the production of energy by the PV modules exceeds the current demand or when there is no consumption by the company, e.g. employees have a break and the machines are turned off. Including when the PV installation does not have an energy storage, it goes to the grid. Figure 4 also shows the company's total energy consumption on a given day.

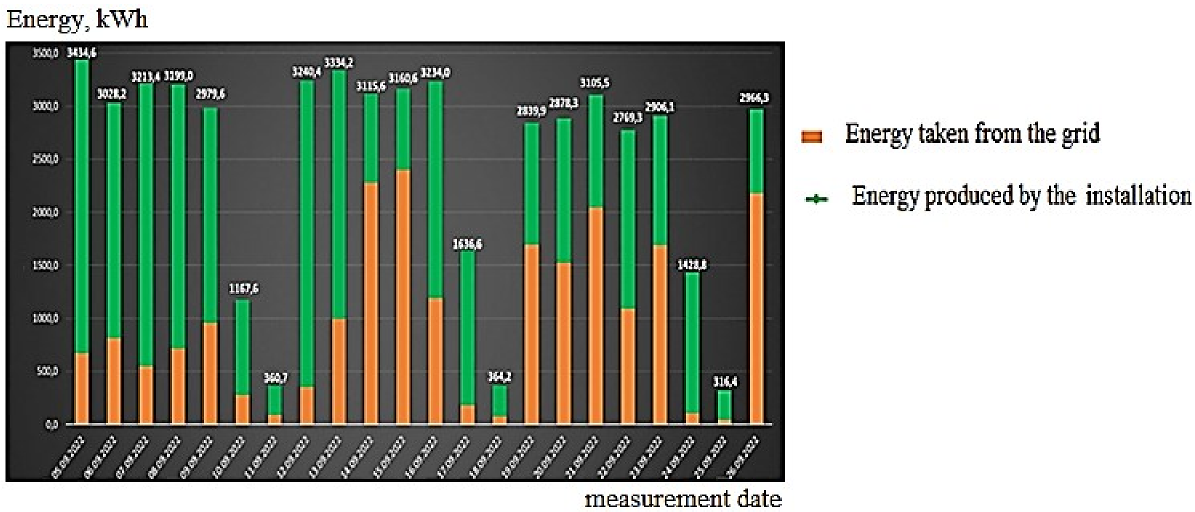

Figure 4. Annual daily energy consumption in the enterprise.
Source: own.

Figure 4 presents data that show the total energy consumption of the company on the analyzed day. They represent the cumulative value of the energy taken from the grid and the energy generated by the photovoltaic installation, reduced by the energy returned to the grid. In addition, it can be read that the daily energy consumption on working days oscillates around 3 MW. As noted, due to the decrease in production from photovoltaics caused by the season, in the first week most of the energy consumed in the company is covered by photovoltaics, in the second there are days with a mixed division, while in the rest the energy taken from the grid prevails. The exceptions are days with limited production or non-working days, when almost all the energy is covered by the photovoltaic installation and the share of energy consumed from the grid is marginal.

The analysis of the results obtained by individual installations made it possible to read in which months the modules produce the most energy, and when the production is low. In addition, the amount of energy generated by the installation, broken down by month and year, as well as the total production, since the beginning of operation, was recorded. The results for the first installed installation with a capacity of 49.82 kWp in 2020-2022 are shown in Figure 5.

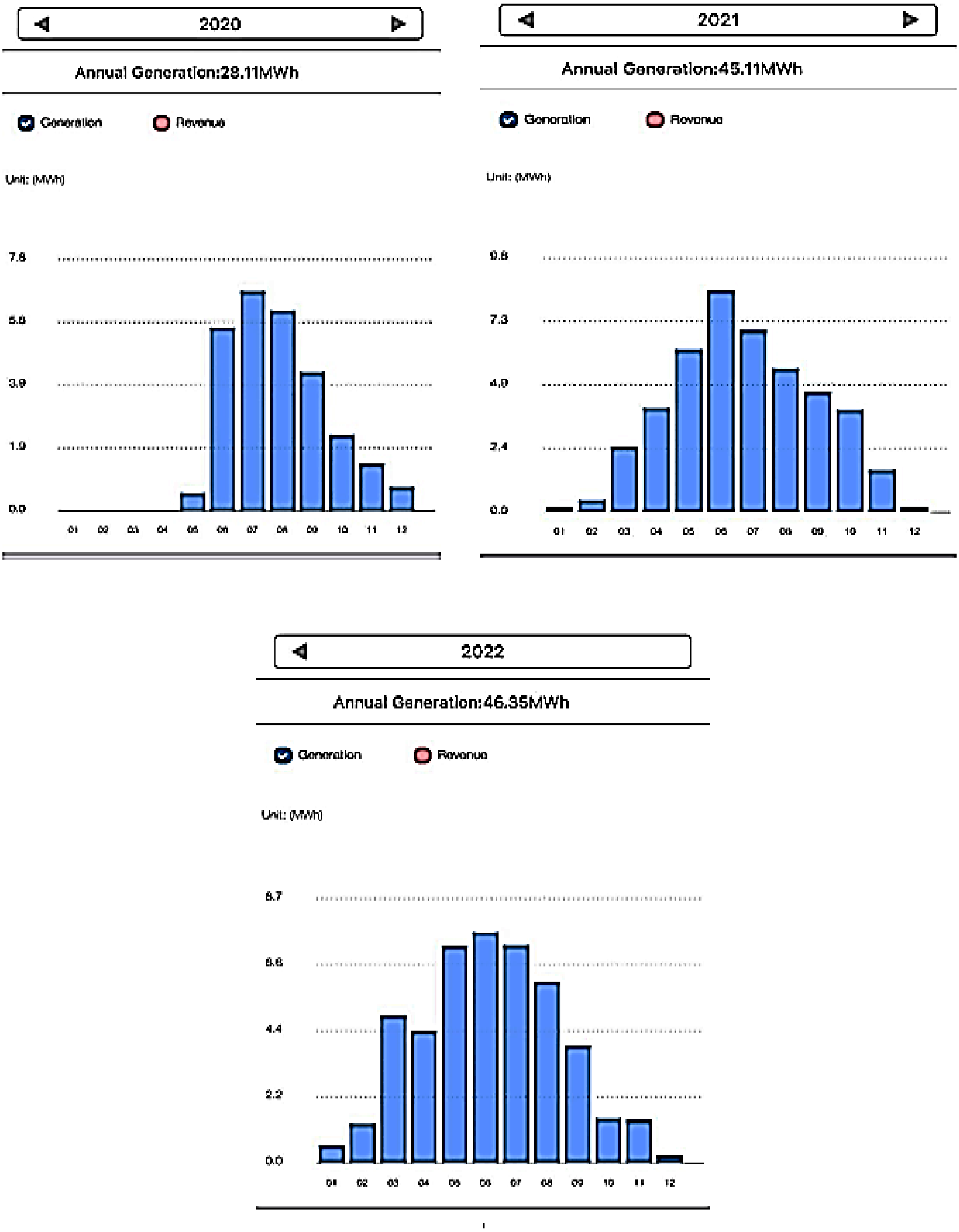

Figure 5. Energy generated by the first installation in 2020-2022.

Source: own.

The analysis of Figure 5 shows that the best efficiency of the installation is for the months of May, June, July and August, while the least effective installation is in January, February and December. The total result of the installation since the beginning of operation is shown in Figure 6.

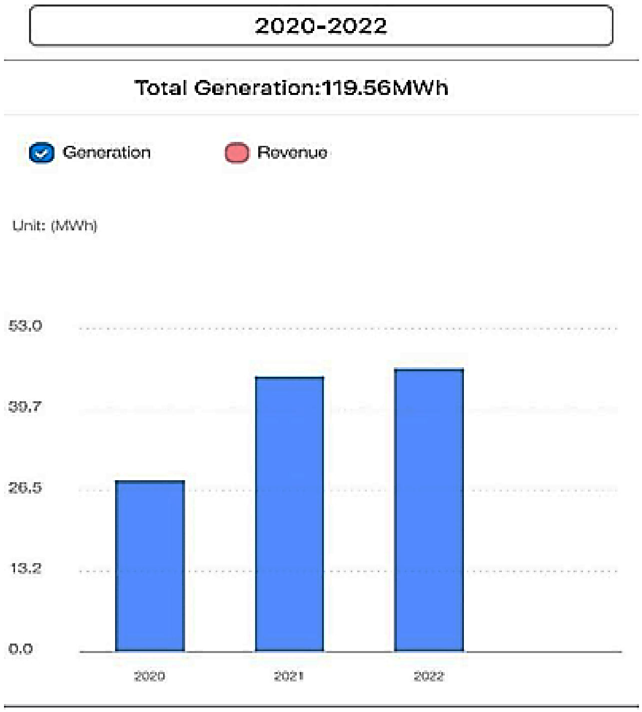

Figure 6. Energy generated over the entire lifetime of the first installation in 2020-2022.
Source: own.

The total production, as of May 2020 for the installation with a capacity of 49.82 kWp, is 119.56 MWh. The total production within one year oscillates around 46 MWh.

Figure 7 shows the results of the energy produced for the second installation, with a capacity of 309.32 kWp, operating since December 2020.

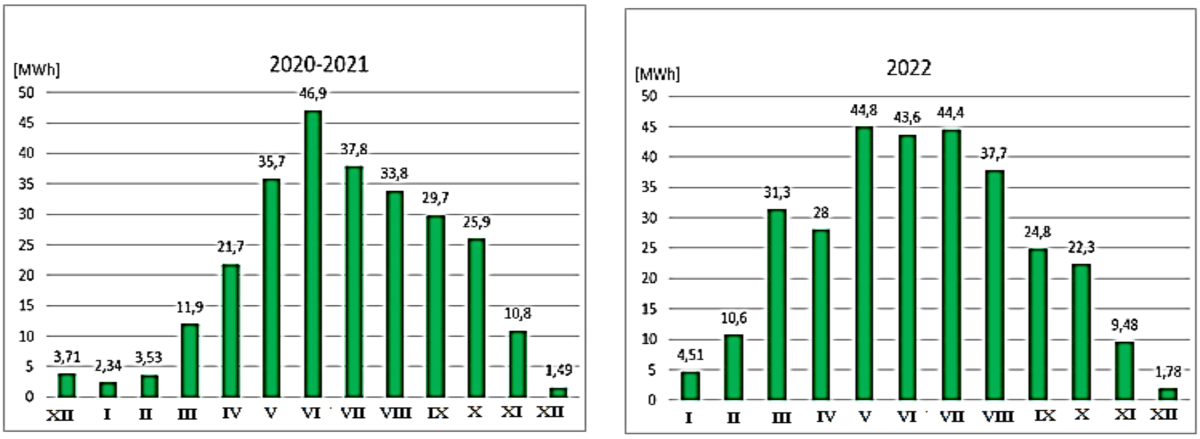

Figure 7. Energy generated over the entire period of operation by the second installation in 2020-2022 with a capacity of 309.32 kWp.
Source: own.

Figure 8 shows a significant difference in total energy production between 2020 and 2022, which is over 40 MWh. In turn, Figure 9 shows the monthly difference in the analyzed production, and Figure 10 shows the total production.

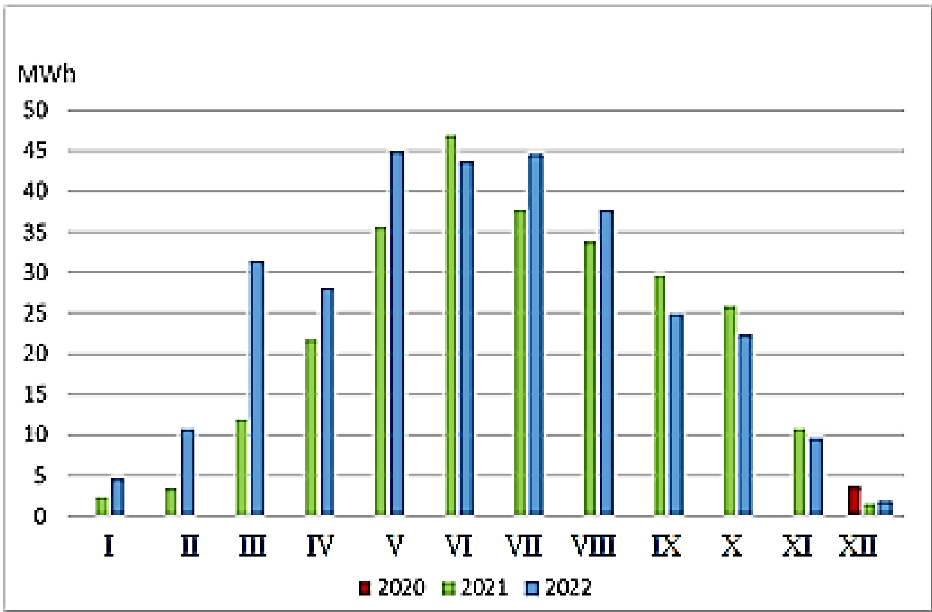

Figure 8. Comparison of production in 2020-2022 for PV installations 309.32 kWp.
Source: own.

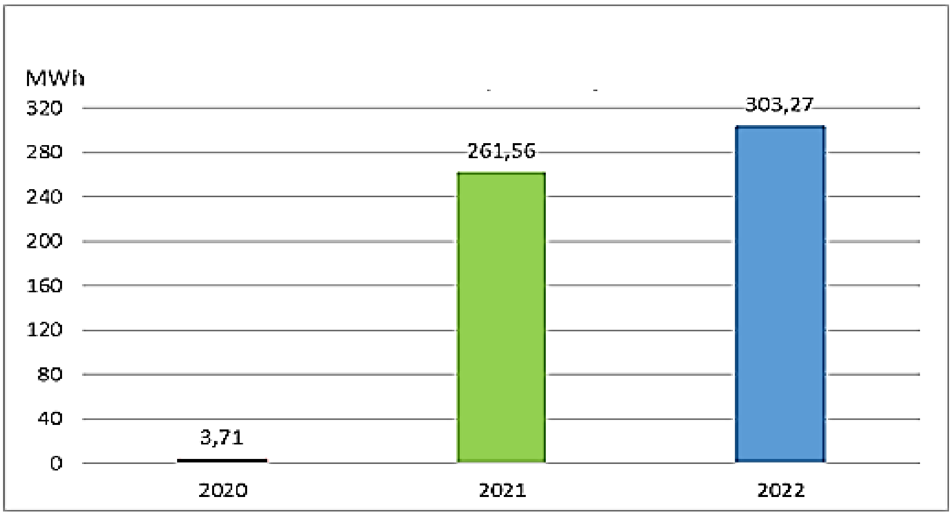

Figure 9. Total production for a PV installation of 309.32 kWp.
Source: own.

The installation with a capacity of 309.32 kWp produced 568,540 kWh of energy over the entire period of operation Figure 9. Considering the years 2021 and 2022, where the production was for all months, a large discrepancy in production can be noticed.

The last of the installed photovoltaic installations, with a capacity of 294.75 kWp, has been operating at the company since July 2021. The production results in particular years are presented in Figure 10.

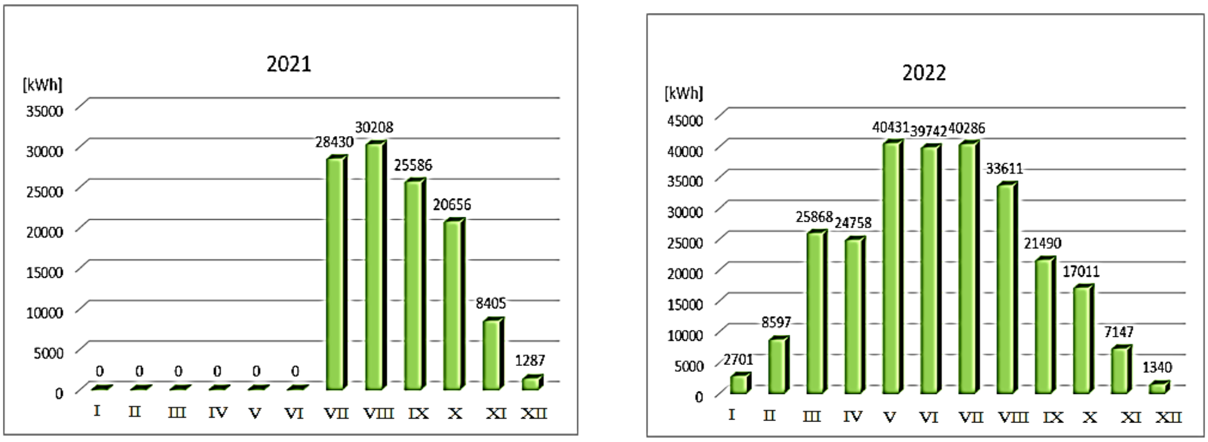

Figure 10. Energy generated over the entire period of operation by the second installation in 2020-2022 with a capacity of 294.75 kWp.

Source: own.

In turn, Figure 11 shows the monthly difference in the analyzed production, and Figure 12 shows the total production.

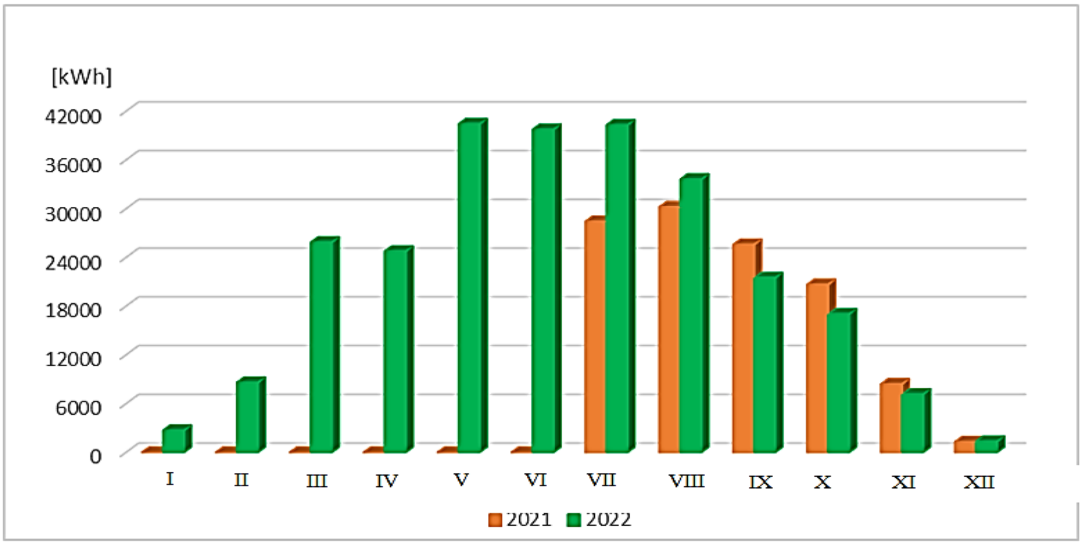

Figure 11. Comparison of production in 2020-2022 for PV installations of 294.75 kWp.
Source: own.

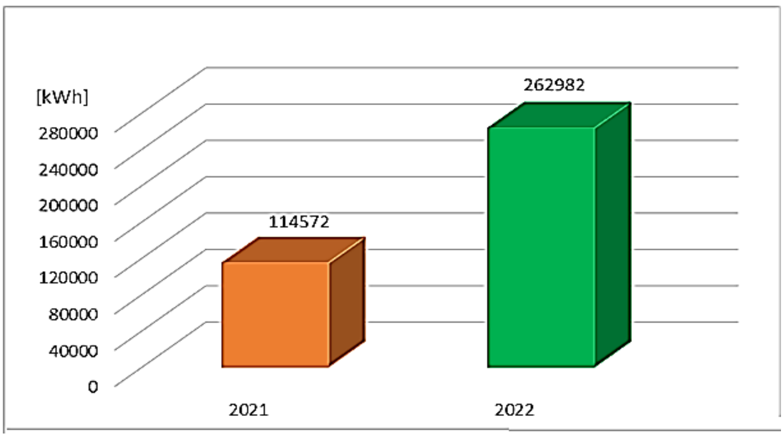

Figure 12. Total production for a 294.75 kWp PV installation.
Source: own.

The total amount of energy produced over the entire period of operation by the installation with a capacity of 294.75 kWp is 377,554 kWh. Disproportions in the results obtained, for individual months and years, in all installed installations show that the photovoltaic system is a highly unstable and difficult to forecast source of energy. Despite the very large amount of energy produced by the photovoltaic installation, it cannot become the sole power supply for the company, but it significantly reduces electricity costs. Figure 13 shows the total production of PV installations of 653.89 kWp for the analyzed period of 2020-2022.

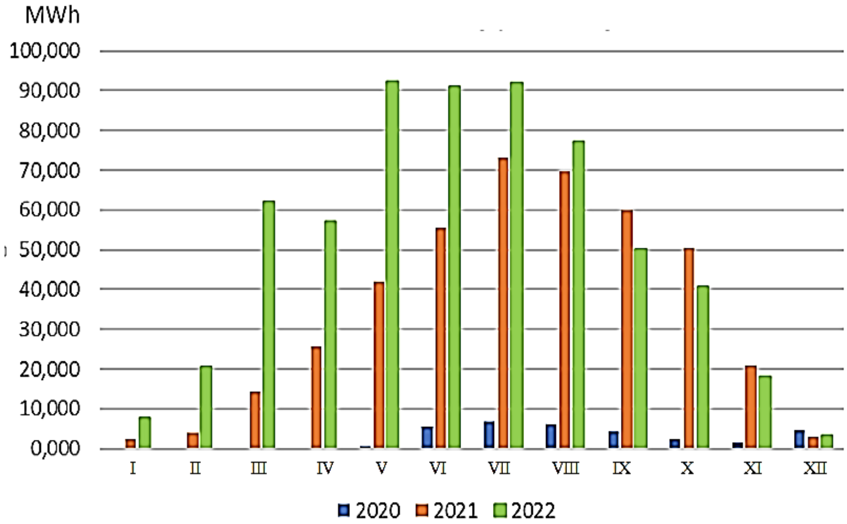

Figure 13. Comparison of total production from 2020-2022, PV installation 653.89 kWp.
Source: own.

Figure 13 shows a production comparison, showing the total energy produced by all installations. In order to read the data correctly, it should be noted that the installation with a total capacity of 653.89 kWp has been operating since July 2021. Earlier, from December 2020, two installations with a total capacity of 359.14 kWp were in operation, and data from May 2020 show the operation of one installation with a capacity of 49.82 kWp. For this reason, in 2020 the production is low, in 2021 it becomes much higher, and from July, when all installations are in operation, a large increase in energy production can be observed. We can only make a proper comparison in the period from July 2021, where we see that for July and August this year, production is lower than in this period in 2022. The only months in 2021 when the installation was more efficient than in 2022 are September, October and November. The sum of all results for individual years of operation of the entire photovoltaic system is shown in the Figure 14.

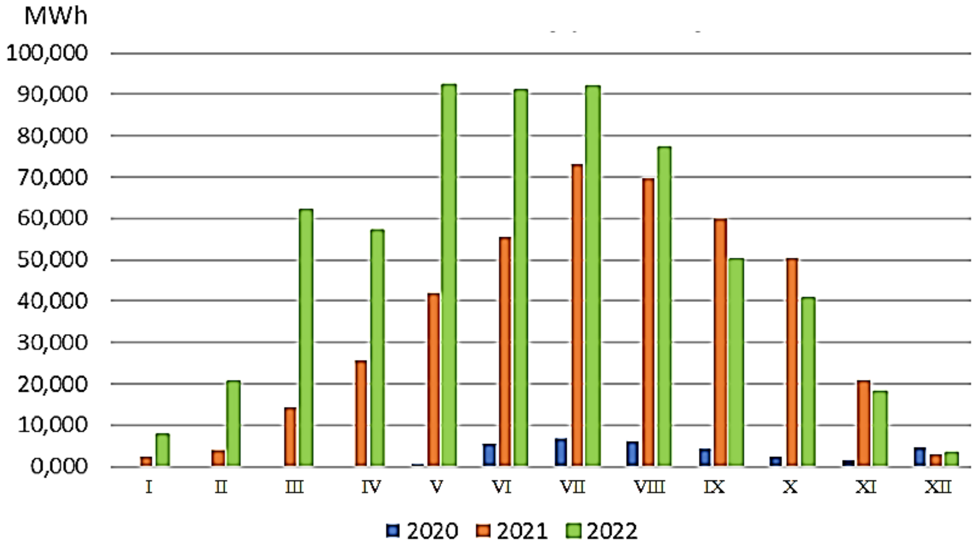

Figure 14. Total production in 2020-2022, PV installation 653.89 kWp.
Source: own.

Figure 14 shows the energy generated in a given year and the total amount of energy produced in the years 2020-2022 by the photovoltaic installation in the company. Thanks to the use of the potential for photovoltaics in the company and the construction of new installations, the capacity of the PV installations increased, which resulted in higher production every year. After summing up the results for individual years, over the entire period of operation, the photovoltaic installation with a capacity of 653.89 kWp produced 1065.624 MWh of electricity for the company, which was mostly used for the needs of the company's production. Figures 15 and 16 show the results of energy consumption from the grid and energy sent to the grid in the period from October 2021.

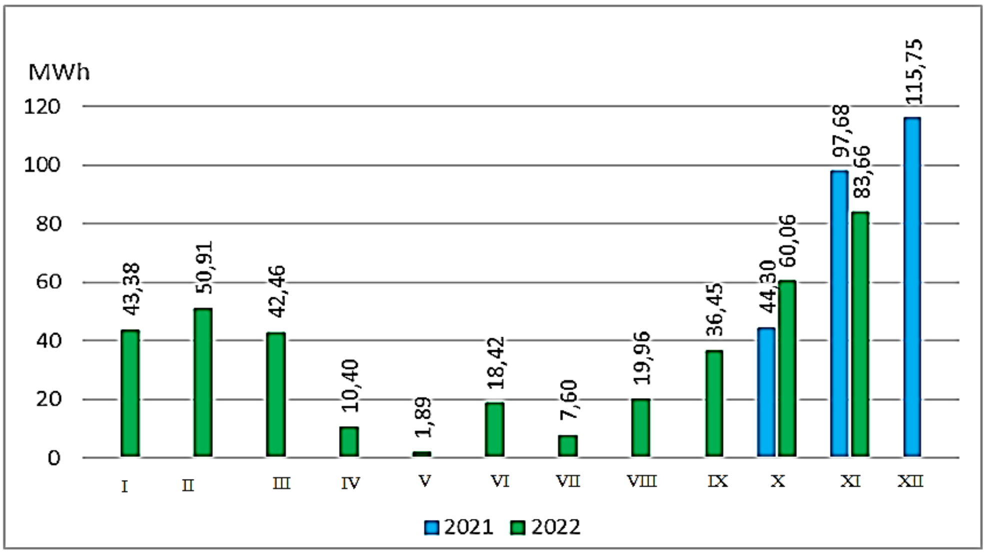

Figure 15. Energy taken from the distribution network by the company in 2021-2022, PV installation 632.91 kWp.
Source: own.

In 2022, the amount of energy taken from the grid for production purposes is over 375 MWh, which, with the production by PV installations for this year in the amount of over 612 MWh, means that the annual energy consumption in the company oscillates around 850 MWh, and the energy produced by the system photovoltaic covers more than 60% of the total consumption.

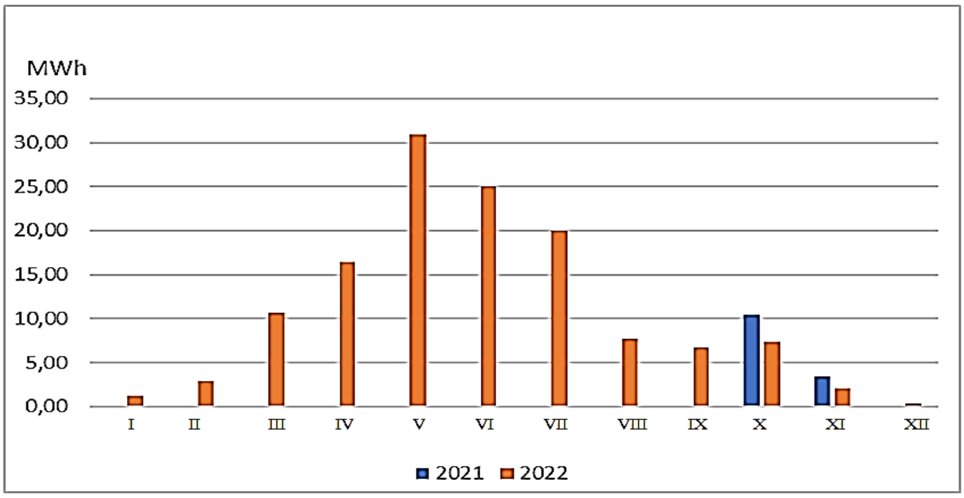

Figure 16. Energy sent to the distribution network by the company in 2021-2022, PV installation 632.91 kWp.

Source: own.

The data presented in Figure 16 shows that for the period from October 2021, the company sent over 145 MWh of energy to the distribution network. This surplus comes mainly from holidays and days when the company's production is lower.

The presented results provided comprehensive data on the functioning of the photovoltaic installation in the analyzed company and allowed to determine the proportions in which energy is consumed in the company, divided into energy from photovoltaics (over 60%) or from the distribution network (over 30%). Using the data from the entire study, as well as from the previous chapter, it is possible to calculate the payback period of the installation and the savings for the company in respect of the energy generated by individual installations of different capacity, over the entire period of operation. Presenting the savings obtained from each installation separately is important because each is different and works for a different period, therefore, first individual profits for each installation are presented, and then the payback period of the entire PV installation according to the formula, counting from 2022 and based on data from this year.

Savings generated by the 49.82 kWp PV installation:

- period of operation from May 2020 to the end of 2022,
- energy produced during operation: 119.56 MWh,
- rate for energy from the network: PLN 974/MWh, company savings due to energy produced in this period: PLN 116,451.

Savings generated by a 309.32 kWp PV installation:

- period of operation from December 2020 to the end of 2022,
- energy produced during operation: 568.54 MWh,
- rate for energy from the network: PLN 974/MWh,
- company savings thanks to the energy produced in this period: PLN 553,757.

Savings generated by a 294.75 kWp PV installation:

- operation period from July 2021 to the end of 2022,
- energy produced during operation: 377.55 MWh,
- rate for energy from the network: PLN 974/MWh,
- company savings thanks to the energy produced in this period: PLN 367,737.

Savings generated by the entire 653.89 kWp PV installation:

- period of operation from 2020 to 2022,
- energy produced during operation: 1065.624 MWh,
- rate for energy from the network: PLN 974/MWh,
- company savings thanks to the energy produced in this period: PLN 1,037,917.

The payback period of the entire installation was calculated for a PV installation with a capacity of 653.89 kWh. The base year for calculating the payback period of the installation is 2022, because this is the first full period in which all installations work together and are treated as one PV installation, all necessary data is also presented for this year to calculate the payback investment.

Cost of the photovoltaic installation: PLN 1,536,200:

- energy produced by PV installations in 2022: 612.583 MWh,
- energy produced, sent to the grid: 131.155 MWh,
- energy produced and consumed directly by the company: 481.423 MWh,
- total energy consumption in 2022: 856.603 MWh,

(energy taken from the grid + production from the PV installation - energy sent to the grid),

$$375.182\text{h} + 612.583 \text{ MWh} - 131.155 \text{ MWh} = 856.603 \text{ MWh}$$

- rate for energy taken from the grid: PLN 974/MWh,
- rate for energy sent to the grid: PLN 360/MWh,
- profit from energy used directly by the company: PLN 468,906,
- profit from energy sent to the grid: PLN 47,217,
- annual energy costs if there was no photovoltaic installation: PLN 834,331,
- annual energy costs with a PV installation: PLN 365,425,
- annual energy costs with a PV installation less the profit from energy sent to the grid: PLN 318,208.

Installation payback period:

$$\frac{\text{photovoltaic installation costs}}{\text{annual costs without a photovoltaic installation} - \text{annual costs with a photovoltaic installation}}$$

$$\frac{1536200}{834331-318208} = 2{,}98 \approx 3 \text{ years} \tag{1}$$

The payback period of the installation, assuming results and data for 2022, is 3 years. Thanks to these calculations, only a simplified calculation is presented, which does not take into account possible financing costs, operating costs, or financial ratios such as inflation or change in the value of money over time. The calculations do not take into account the operation time of individual installations, but the starting point is the first full period of operation of the entire installation. This does not change the fact that in the case of high self-consumption, which is in the described company, these results give an optimistic view of the company's photovoltaics, even if the calculated payback period, as a result of the above dependencies, was extended by up to half.

4. Summary and Conclusions

The conducted research concerned the use of a photovoltaic installation in the company and the impact of the results obtained by photovoltaics on the company's electricity consumption costs. From the point of view of a company focused on production, where energy consumption is high, this is an important issue, because the use of photovoltaics allows you to reduce electricity costs and become more competitive, which is not easy nowadays. The aim of the work was to examine the efficiency of the photovoltaic installation in the company and to check the economic aspect of such a solution. With an extensive database and results related to the described installation at our disposal, the research carried out on their basis allowed us to achieve the goal of the work (Hayibo et al., 2021) and (Chakraborty et al., 2019). Based on the conducted research and analysis of daily results, it can be concluded that the use of a photovoltaic installation in the company is justified in practice and allows you to reduce energy costs electricity costs borne by the company, in this case by about 60%. The analysis of daily results allowed to illustrate the characteristics of the installation's operation in synergy with the production carried out by the company. The presented data reflect the actual share of energy produced by the photovoltaic installation in the total energy consumption of the company on a given day. Thanks to the recorded results, it is possible to analyze the distribution of energy, divided into energy consumed and sent to the grid, as well as taking into account the amount of energy produced by the photovoltaic system, depending on the conditions (Niekurzak, Kubińska-Jabcoń, 2021; Kochanek, 2019; Niekurzak, Mikulik, 2021). The analysis of the results obtained by individual photovoltaic installations and the year-on-year comparison of the results made it possible to conclude that the photovoltaic system is a highly unstable and difficult to forecast source of energy (Rouzbahani et al., 2021). Despite the disproportion in the results obtained in all installations, for individual months and years, the photovoltaic installation still has a measurable impact on reducing costs electricity incurred by the company. The overall results related to electricity in the company show that the annual energy consumption oscillates around 850 MWh, and the photovoltaics installed in the company can cover over 60% of the entire demand. These data give a positive assessment of the use of photovoltaics for the purposes of the company. With the help of the presented graphs and results, savings for the company were calculated for the energy produced by photovoltaics (Burgio et al.,2020; Niekurzak, 2022; Shahzad et al., 2021). The savings generated in a relatively short period of time prove that a photovoltaic installation can significantly reduce electricity costs. Taking into account the result for the calculated payback period of the installation, which is 3 years, it shows that such an investment is very profitable for the company, which is also confirmed by the authors in their works (Dogan et al., 2020; Alvarado, et al., 2021; Isik et al., 2021; Ahmad et al., 2021; Kraan et al., 2021; Zimm et al., 2019). To assess the profitability of investments, it is recommended to conduct a discounted analysis and use dynamic indicators, i.e. taking into account the time factor. In the case of unusual nature of cash flows, it is recommended to use the ratios in a modified version, i.e. taking into account a separate income reinvestment rate. When comparing various investment projects, one should be consistent in the selection of individual financial and technical parameters and compare investments with the same implementation periods. Using renewable energy sources is certainly profitable, but you have to take into account a fairly large one-time expense when purchasing and installing equipment. Such an investment usually pays off after min. several years - depending on the solution we decide on (Wróblewski, Niekurzak, 2022).

Summing up, the conclusions resulting from all the studies allow us to conclude that the use of a photovoltaic installation in an enterprise has its practical justification. Taking into account both the work efficiency and the economic background, high energy yields can be noticed, and as a consequence, a significant reduction in the costs incurred by the company for electricity consumption.

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