European Research Studies Journal
Volume XXV, Issue 2, 2022

pp. 316-332

Impact of the Self-Consumption of Electricity on the Profitability of the Investment into a Photovoltaic Installation: The Case of a Company in Poland

Submitted 01/05/22, 1st revision 24/05/22, 2nd revision 10/06/22, accepted 25/06/22

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Abstract:

Purpose: *The main aim of this paper is an attempt to calculate the impact of the self-consumption of electricity in an exemplary enterprise with the annual electricity demand 42.2 MWh on the profitability of investments in a photovoltaic installation from the point of view of the law introduced in Poland in 2021 - 2022.*
Approach/Methodology/Design: *The analysis of the profitability of the photovoltaic power plant was carried out on the basis of the method of assessing the economic efficiency of an investment using the DCF method with the assumed discount rate.*
Findings: *The obtained results can estimate the future value of the investment, capitalization, discounted value, i.e., the present capital value, which is derived from future income.*
Practical Implications: *The obtained results will help to indicate what is the optimal (maximum) selection of the size of the photovoltaic installation based on the company's electricity demand in the Net-billing system applicable in Poland.*
Originality/Value: *The obtained results may indicate that investing more capital in photovoltaics allows for the construction of an installation with greater power, but at the same time leads to a reduction in the self-consumption of electricity during its production and significantly affects the profitability of such an investment. Profitability estimation was carried out with reference to an alternative investment in relatively low-risk treasury bonds. The economic net present value assumes that the future buying or selling value of money will not be the same as it is today. Factors that significantly affect the investment profitability assessment are given.*

Keywords: *Renewable energy, photovoltaic power, cost-effectiveness of photovoltaic.*

JEL codes: *O130, Q420.*

Paper Type: *Research article.*

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1. Introduction

The years 2019-2022 are characterized by dynamic, even revolutionary (unpredictable) changes in the demand for raw materials (including energy raw materials) and changes in energy prices (including electricity). This is initially due to the transition through the Covid19 pandemic period, which drastically reduced the demand for raw materials and energy, and then to a period of rebound in demand in world economies, which led to even greater dynamics of demand growth and an increase in the prices of energy resources and energy itself.

This period is characterized by anomalies in the commodity and energy markets that were not captured by any predictive model. For example, in 2020, during the Covid 19 pandemic, energy demand decreased by 4.5%, which is the highest value since the Second World War, and oil demand fell by 9 million barrels a day! (Approximately 3.2 billion barrels per year). At that time, the prices of futures contracts for crude oil supplies listed on the US stock exchanges had to be paid extra because there was no place and resources to store it, and it was not possible to stop production in oil wells because it was associated with their irretrievable loss. Paradoxically, the oil tanker lease prices went up significantly at that time.

In the years 2021-2022, there was an economic rebound, leading to an increase in demand for raw materials, and this demand was further intensified by ongoing conflicts (including the war in Ukraine). War, uncertainty, and fear drive up prices, which translates not only into an increase in energy itself, but also in fertilizers and food, and indirectly in an increase in the prices of goods and services in the entire world economy (Gatto, 2022). It also causes fluctuations in share prices on capital markets, especially in the energy and fuel sectors (Bieszk-Stolorz, 2021)

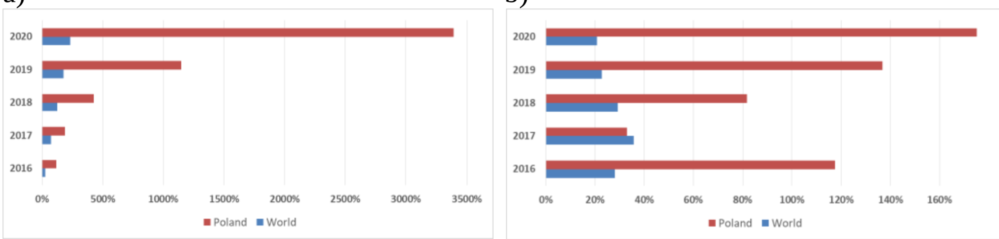
Energy obtained directly from renewable natural resources, which can include energy obtained from wind, sun, water, is largely free and independent of geopolitical situations. The geopolitical situation changed by the war, with a simultaneous increase in energy demand, will thus contribute to new investments in renewable energy in various regions of the world. Renewable energy has a stabilizing effect on the market and contributes to the restoration of the market equilibrium of energy commodity prices, and investments, although initially costly, contribute to accelerating the transition to cleaner energy sources, so needed by the global economy and humanity (BP Statistical World Energy Review, 2021).

It requires the use of support mechanisms in the form of wise policy for the needs of the sustainable development economy. It is also important that the combustion of fossil fuels leads to the emission of greenhouse gases (GHG) (Sreenath, 2022). In opposition to fossil resources, in the same period 2019-2022, wind and solar energy increases significantly in production. This is due to the reduction in the cost of mass production of photovoltaic panels, which has led to a decline in their prices on world markets throughout the decade. This enabled the expansion of renewable energy based on solar and wind resources (Allouhi, 2022). Figure 1 shows the cumulative increase (dynamic changes) in the world and Poland since 2015 in the generation of electricity in particular years (2015 = 100%) and percentages of solar energy production growth in the world and Poland (year on year) (Nęcka, 2016; Tomasik, 2018). The values given in the plots are relative ones (in relation to 2015).

The Figure shows that in the years 2016-2020 the dynamics of the increase in the production of renewable energy from the sum is 234% (OECD, 2022) which is (together with the production of energy from wind) over 55% of the total increase in energy production at that time (BP Statistical World Energy Review, 2021). For example, only in 2020 year (the year of the pandemic), the power of sources based on solar and wind energy was increased by as much as 238 GW and this increase was 50% higher in comparison to the previous year. Poland, which according to forecasts will not reach the EU target of 15% share of renewable energy sources by 2030, is nevertheless a leader in the EU in terms of the growth dynamics of the photovoltaic market (Rataj, 2022).

Figure 1. *a) Solar energy production growth dynamics in the world and Poland (2015 = 100%). b) Percentages of solar energy production growth in the world and Poland (year on year)*

a) b)



Source: *Own study based on BP Statistical World Energy Review 2021.*

It leads to the much-desired reduction of the demand for alternative energy resources and favors the energy transition. As the consequence it leads to the stabilization of the economy and its sustainable development.

2. Literature Review

2.1 Theoretical Framework and Previous Studies

The European Union countries have set the goal of significantly increasing the share of renewable energy sources in energy consumption, to achieve the assumed percentage share of renewable energy sources in energy production (European Parliament, 2021). All future energy scenarios developed in the EU to meet the 2050 climate goals provide for a key role for solar energy (Institute of Renewable Energy, 2020).

At the COP26 climate conference in Glasgow in 2021 a Climate Pact has been agreed, which calls on the parties to take a series of steps to reduce greenhouse gas emissions and achieve net zero by 2050. India at COP-26 in Glasgow in 2021 announced that the net-zero will be in 2070, but in 2030 it will already have 50 % share of renewable energy in country (COP26, 2021). According to World Energy Outlook forecasts, energy demand will grow (BP Statistical World Energy Review, 2021) and global energy consumption will increase by about a third by 2040 year. According to the Report of the Intergovernmental Panel on Climate Change - Intergovernmental Panel on Climate Change, entitled: Climate Change 2022: impacts, adaptation and vulnerability, climate change caused by the emission of greenhouse gases by human activity, is already causing suffering and death to people all over the world. They disrupt food production, devastate nature and limit economic growth (Climate Change, 2022).

According to the agreement of the European Union countries in 2009, the share of renewable energy sources in energy consumption was to be 20% by 2020. In 2018, as much as 32% share of renewable sources by the end of 2030 was agreed. EU Member States have been obliged to propose a national energy target and establish ten-year national energy and climate plans under the Horizon 2030 program. Subsequently, under the directive, Member States were required to report on their progress every two years. The Commission is expected to evaluate these plans and may take measures at EU level to ensure that the plans are consistent with the overall EU objectives.

However, the latest agreement on this topic in July 2021 includes increasing the share of renewable sources in energy consumption to 40% by the end of 2030. Of course, the EU continues to discuss new, even more restrictive arrangements and the future policy framework (European Parliament, 2022). In May 2022, the European Commission presented the details of the REPowerEU plan, which is related to the current situation in eastern Europe and, at the same time, a response to the attack by Russia to Ukraine. It was created in response to problems in the energy market and the strong dependence on supplies of fossil fuels from Russia, as the EU currently pays almost EUR 100 billion a year for them. At the same time, the EU wants to accelerate the energy transformation through REPowerEU, including the development of renewable energy sources.

The Commission proposes to increase the target for the share of renewable energy in the energy sector in 2030 from 40% to 45%. This is to be supported by initiatives such as:

- a special EU strategy for solar energy, thanks to which the installed RES capacity will reach over 320 GW in 2025 (doubling compared to 2021), and in 2030 - almost 600 GW;
- Solar Rooftop Initiative, which provides for a legal obligation to install solar panels on public, commercial and residential buildings; The photovoltaic panels will cover the roofs of new public and commercial buildings over 250

m^2 (by 2026), existing public and commercial buildings over 250 m2 (by 2027) and all new residential buildings (by 2029) (Bujalski, 2022).

In 2021, 173.6 TWh of electricity was produced in Poland, while consuming 174.4 TWh - according to the preliminary data of Polskie Sieci Elektroenergetyczne (PSE, 2022; Derski, 2022). In the latest report, Energia Forum defines the role of distributed energy, formulates recommendations regarding the support system and measures necessary for distribution grids to play a supporting role, and not inhibiting the development of community energy.

The benefits of the dynamic growth of renewable energy installations are large: distributed energy supports the transformation of the Polish energy sector towards climate neutrality, strengthens the security of energy supply in summer and helps in the fight against smog when electrification of heating occurs. In addition, it engages society in the transformation of the energy sector and is also an effective way to avoid sudden increases in electricity or heating prices, especially when the household uses a heat pump (Adamczewski, 2021).

If we strive for the energy transformation, it is crucial to use rooftop solar photovoltaic (Bugała, 2017; Bódis, 2019) and modernize buildings in Poland as soon as possible. Replacement of lighting with energy-saving lighting (Sikora 2010; 2020) and it also requires the development of appropriate algorithms for electricity billing (Rymarczyk, 2017a; 2017b). Research is also conducted on the use of photovoltaic panels in various shapes, which is aimed at increasing the attractiveness of their use (Pawlak, 2013; Tomczyk, 2014). As part of the implementation of climate goals, Poland should double the pace of their modernization. Buildings in Poland are responsible for 40% energy consumption which mainly comes from coal. Also, mostly fossil fuels are used for individual heating. In Poland, 70 % of public and residential buildings (4.6 million) are energy inefficient, and 16 % of them (about 1 million) have the worst energy standard (Strzałkowski, 2022).

The dynamic development of RES in recent years in Poland, as a result of the introduction of a very favorable discount system for prosumers, has led to a situation in which Polish low and medium voltage power grids are not ready to transmit excess power of photovoltaic installations during their peak production periods. In the period of 2019 to 2022, there was an increase in the share of solar energy production by over 5.2 GW, i.e. from 0.5%. to almost 3 % of general energy production in Poland (OECD, 2022).

2.2 Applicable Legal Standards in Poland under the Act on Renewable Energy Sources

The requirements of the EU Renewable Energy Directive II Directive (RED II, 2021) impose an obligation on the Member States, from the date 1 January 2024, to introduce a system enabling separate accounting for electricity fed into the grid and electricity collected from the grid. These principles rely on Net-metering, which promotes local self-consumption and is a pursuit of energy self-sufficiency of consumers (Smith, 2021; Soto, 2022). Considering the above-mentioned reasons, the legislator decided to change the discount rules which have been applicable to prosumers so far. They allow to produce electricity, surplus to the energy system and with a specific consumption ratio in periods of greater demand.

On October 29, 2021, the Act on Renewable Energy Sources (ISAP, 2021) was amended in Poland, which with its update of January 27, 2022 (ISAP, 2022) significantly changes the rules of the billing system for new prosumers who joined the system after April 1, 2022. Pursuant to the amendment to the Act, the discount system is replaced by the Net-billing system. The system is implemented in several stages:

- in the first stage, which is actual from April 1 to June 30, 2022, the legislator gave energy companies time to adapt to the new regulations. At this stage, new prosumers will be charged on a discounted basis until June 30, 2022. The discount system assumes that the owner of the installation can collect a part of the energy fed into the grid. Depending on the power of the photovoltaic system, the factor is different. For installations up to 10 kWp it is 80%, and for installations with a capacity of 10-50 kWp it is 70%. In the rebate system, the prosumer does not pay any charges for the received energy from the grid (collection is proportional to its production), and any other additional distribution charges. This is a big advantage for the prosumer.
- in the second stage, actual from July 1, 2022, to June 30, 2024, prosumers will settle accounts on the basis of Net-billing. In this period, the value of electricity is determined for each calendar month, and it is the product of: the sum of the amount of electricity introduced to the distribution network by a prosumer and the monthly market price of electricity for a given calendar month. Thus, the price of electricity introduced by the prosumer to the grid during this period will be determined as the monthly market price (ISAP, 2021) (ISAP, 2022).

The market price of electricity (*RCE*) is calculated according to formula 1:

$$RCE = \frac{\sum_{s \subset S} CG_s \cdot EG_s}{\sum_{s \subset S} EG_s} \tag{1}$$

where:

CGs – electricity price specified in the single-price auction system at the day-next day's trading session on the Polish Power Exchange (POLPX) [PLN / MWh],

EGs – the amount of electricity constituting the trading volume on the day-next day's trading session on the POLPX market, with the determination of the energy price in the single-price auction system [MWh],

S–a set of day-ahead market quotation sessions with the determination of the energy price in the single-price auction system conducted by the POLPX commodity exchange or under the single day-ahead market coupling run by designated electricity market operators.

The monthly market price of electricity is determined for each calendar month as weighted by the volume of electricity introduced to the power grid by prosumers. The monthly market price of electricity (*RCEm*) is calculated according to formula 2.

$$RCEm = \frac{\sum t \in T (E_t \cdot RCE_t)}{\sum_{t \in T} E_t} \quad (2)$$

where:
Et - the total volume of electricity introduced to the power grid during the imbalance settlement period t by renewable energy prosumers producing electricity in micro-installations,
RCEt - market price of electricity in the imbalance settlement period t, in the case when RCEt is negative for a given period t, then RCEt is assumed to be zero for this period t [PLN / MWh],
T - set of imbalance settlement periods in the month.

— in the third stage, active from July 1, 2024, the electricity price settlements between the seller and the prosumer of renewable energy will be carried out on the basis of the total amount of balanced energy (from all phases of the three-phase system) in each hour and expressed in kWh. Thus, the billing process is very similar to the second step, except that it is done in hourly intervals instead of monthly.

Additionally, it should be noted that the settlement in the net-billing system is carried out with the use of the so-called a prosumer deposit, in which the charges for energy downloaded from the network by a prosumer can be reduced. However, this occurs at medium-term market rates depending on the settlement stage described above. The value of the prosumer deposit for a given calendar month is determined and assigned to the prosumer account in the next calendar month. The funds with the oldest date of being assigned to the account are to be allocated first for settlement with the seller. The amount of funds constituting the prosumer deposit will be able to be settled on the prosumer account for 12 months from the date of assigning the amount as a deposit. If it is not used within that time, it is to be redeemed.

3. Research Methodology

3.1 Adopted Boundary Conditions and Assumptions

Bearing in mind the above provisions of the Act, it is necessary to simulate the legitimacy of investments in renewable energy installations from a business point of view. As this system assumes many variable input parameters, the estimation of profitability is burdened with a high risk of uncertainty.

For example, the developed model must take into account the following parameters:

- future electricity price on the Polish Power Exchange POLPX in given time intervals (De, 2022),
- demand for it (the investor has to anticipate the demand for electricity in his own enterprise at the very beginning of the investment),
- index of changes in prices of goods and services (inflation),
- self-consumption levels in given time intervals (summer and winter periods),
- interest rates for alternative investments, e.g., in treasury bonds of the EDO type.

The following exemplary simulation variants for estimating the profitability of a photovoltaic installation, total costs, capitalization, and rates of return were adopted:

A) under dimensioned installation - this is the case in which the investor decides to make an investment of relatively low capacity to his own self-consumption of electricity, bearing the conscious risk of losing the benefits of having it. In other words, the demand for electricity of the enterprise significantly exceeds the production capacity of the photovoltaic installation and the possibility of self-consumption, and the installation supports the supply of electricity for the enterprise to some extent. In this case, the payback time for the installation will be comparable to the payback time for the variant of the fitted installation. However, the investor consciously loses the lost profits from the possibility of having a larger installation. This case may take place when the rates of return on other alternative capital investment possibilities are much higher than for the owned installation.

B) installation adjusted to the production of electricity to the company's average annual demand for electricity. In this case, it was assumed that in the spring and summer period there is a surplus in the electricity production of the installation in relation to the company's electricity demand, resulting only from calendar restrictions and company holidays introduced by law by the regulator. However, it was assumed that in the autumn and winter period the company will use the so-called a prosumer deposit, in which the charges for energy downloaded from the network by a prosumer can be reduced.

C) oversized installation - a case in which the possibilities of self-consumption during production periods are so small that the cost of the installation is much bigger than the prize of produced energy and it there is little probability of not only profit from generated energy, but also a return-on-investment costs in the expected, e.g., 7-10 years of its operation.

The estimation of the adjustment of the installation capacity to the average annual electricity demand of the enterprise can be made on the basis of the calculation of its annual production (which depends on the location zone), which should be reduced to the daily average electricity production and the daily average electricity demand in the company. At this stage, it is not possible to use the monthly production and the monthly demand due to the necessity to overlap the production periods with the demand periods. From this estimation, the maximum real level of self-consumption for the company can be determined

For example:
Let's suppose the company's annual electricity demand is 42,168 kWh (42.2 MWh). Additionally, let us assume the average number of working days per year of 250 days, excluding Saturdays, Sundays, and national holidays. Therefore, for such assumptions, the average daily energy demand on a working day is 168.67 kWh per day. The ratio of working days to non-working days is 0.68.

The calculated coefficient determines the maximum possible value of the self-consumption of electricity from the installation, which is even lower due to the daily work schedule of the enterprise and the afternoon production of electricity outside the company's working hours.

Further, let us assume for the purposes of estimating that the enterprise works in a one-shift mode, i.e., the working hours of the enterprise cover the time period coinciding with the daily production time of the enterprise, which is between 7:00 and 17:00. In Poland, higher energy production occurs in the summer months, when days are much longer than nights and energy production exceed the daily possibility of one-shift work in the company. For this reason, the self-consumption enumerated above is even smaller.

For the purposes of further analysis and the given case of the company, the maximum average possible self-consumption in Polish realities was assumed at the level of 60% (although other exceptions are possible, e.g., during multi-shift work 24/7 days a week).

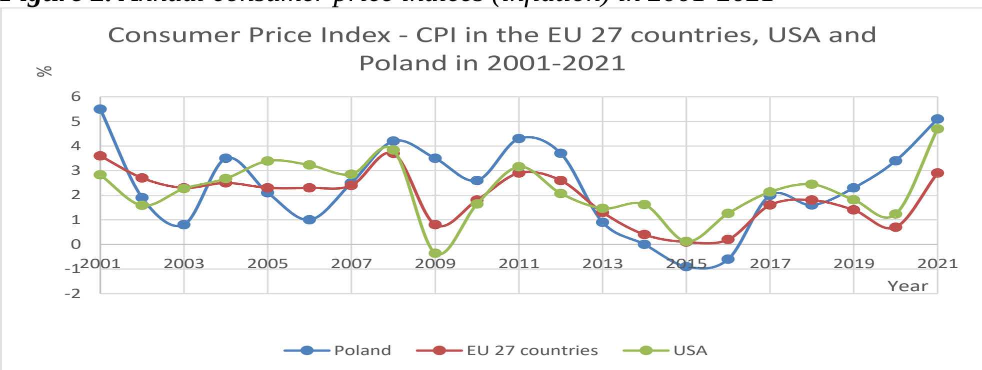
Assumptions adopted to assess the profitability of investments in a photovoltaic micro-installation referred to in the newly introduced act:

- It is possible to depreciate a fixed asset in the form of an installation in a photovoltaic micro power plant. The entrepreneur is included in the group of "small taxpayers" and is a VAT payer. The investment will be located on the company's own premises, without costs of land purchase, fencing, monitoring. Insurance cost is calculated as 0.5% of the investment value per year. No operating costs, such as: maintenance and service costs, including estimated costs of repairing damages, etc. during the operation period for 10 years are taken into account;
- No overproduction of energy in 12-month billing periods. It means that production of electricity of the PV system throughout its operation period is

entirely used for the company's own needs, regardless of the adopted simulation variant for the degree of self-consumption, i.e. there is no case in which the electricity produced in the photovoltaic installation is lost unused in 12 monthly settlement periods.

- Electricity costs for the tariff applicable to business customers - C11 and for customers - branch: Łódź-City. Therefore, energy is billed at a single-zone tariff up to a contracted capacity of 40 kW;
- Average price for active energy: 0.3194 EUR / kWh net due to the possibility of VAT deduction by the company, variable component of the network rate: Euro 0.0375 EUR / kWh net, quality rate: Euro 0.002 EUR / kWh net;
- Installation costs were determined on the basis of the offer of the 14.4 kWp Longi LR4-72HIH-450M / SolarEdge set (Maximum power P_{max} = 450Wp, 20.6% efficiency, 25-year power warranty, where 90% of the power is guaranteed after 12 years of operation) and after 25 years 80% of the module power). The expected energy yield from the installation in a given region is 15.18 MWh / year (considering losses and a decrease in the efficiency of the cells themselves). Estimated losses (cables, converter, etc.) in the system are at about 20%. The installation is purchased with own funds, without any credit facilities;
- The forecast revenues from the increase in the price of energy itself were taken into account, which can be indexed by the inflation rate on the basis of historical data;
- The forecast price index of consumer goods and services at the level of 4.54% annually. This indicator was calculated for the period of the last 25 years of inflation in Poland, i.e., from 1996 to 2021 (GUS, 2022). Changes in the price index of consumer goods and services in the years 2001-2021 in Poland, the EU and the USA are presented in Figure 2.
- Discounted cash flows and IRR will be related to the alternative investment of financial resources in 10-year treasury bonds for the series valid from 01/06/2022 to 30/06/2022 EDO0632, which give an alternative interest rate of 5.75% in the first annual interest period, in subsequent annual interest periods: 1.25% margin + inflation, with annual interest capitalization.

Figure 2. *Annual consumer price indices (inflation) in 2001-2021*



Source: *Own study, the data based on GUS, (2022), OECD, (2022), Eurostat, (2022).*

3.2 Analysis and Model Development

The profitability analysis of a 14.4kWp (it results from the adopted model assumptions) photovoltaic power plant was carried out based on the method of assessing the economic efficiency of an investment using the DCF (discounted cash flow) method at the assumed discount rate (Oosterom, 2022; Drzymala, 2018; 2019; Syafii, 2018; Chiaroni, 2016).

A simplified version of the DCF equation in time n discount periods is presented as follows:

$$DPV = \sum_{nt=0}^{N} \left(\frac{FV_{\mathrm{t}}}{(1+d)^{\mathrm{t}}} \right) \qquad (3)$$

where:
DPV - the discounted present value of the future cash flow (FV), adjusted for the cost of lost benefits for an alternative cash investment,
FV - (future value) - nominal value of the future cash flow,
d - the discount rate, which is equal to the amount of the lost benefits of an alternative investment of money,
t - time in years before the future cash flow,
N - number of flows.

The investment assesment should include an analysis of the project based on dependencies, which can include: discounted payback period (DPP), net present value (NPV), internal rate of return (IRR), break-even point (BEP).

Table 1. *Estimated installation costs and parameters*

Description		***Value***
1.	Initial and total costs of entry into the RES installation (without operating costs) of the installed peak power	11935.48 EUR (without TAX)
2.	Total losses in the system	19.6%
3.	Average annual initial energy production	15180.6 kWh
4.	Forecasted average annual decrease in energy production	1%
5.	Average annual price index of consumer goods and services (inflation)	4.54%
6.	Average price for active energy 1 kWh of energy (including VAT)	0.32 EUR
7.	Variable component of the grid rate of 1 kWh of energy (including VAT)	0.04 EUR
8.	Qualitative rate of 1 kWh of energy (with VAT)	0.002 EUR
9.	Interest rate on 10-year bonds EDO0632	1.25% + inflation

Source: *Own study.*

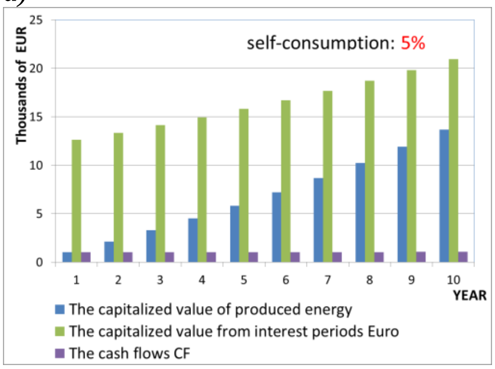
The basic design study methods also include the Modified Internal Rate of Return (MIRR). The MIRR is the discount rate for which the (discounted) residual value of the investment equals the updated value of the capital expenditure for the project. The residual value is the future value of the net financial surplus generated by the PV system, folded using a rate equal to the cost of capital. Compared to the IRR, the modification consists in the fact that positive cash flows are not discounted immediately, but their future value is calculated according to cost of capital, which value (as a sum) is still being discounted up to the present moment.

4. Research Results and Discussion

Figure 3 (a-f) and Figure 4 present a comparison of the return of capital invested in RES with an alternative form of investing funds in treasury bonds depending on the adopted degree of self-consumption and assuming that energy surpluses from the periods of summer overproduction will be sold on the Polish Power Exchange, which provides the average monthly values 1MWh of energy produced in RES installations. The figures show the value of the return on capital in the given annual time intervals.

Figure 3. *Comparison of the return on invested capital with self-consumption ranging from 5 to 50%. with an alternative form of investing funds in 10-year treasury bonds.*

a)



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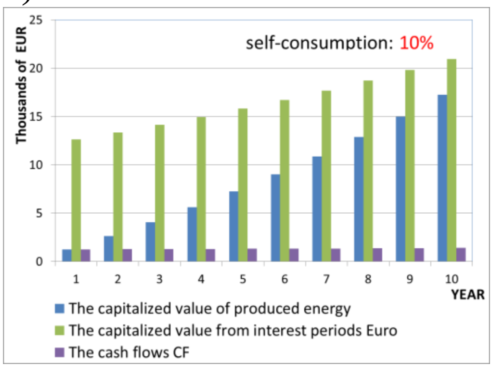

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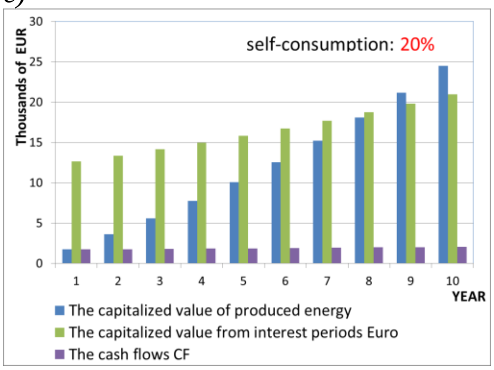

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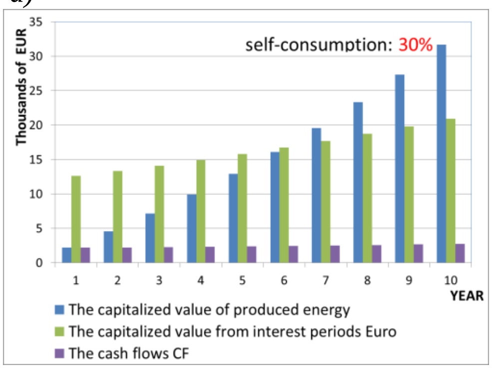
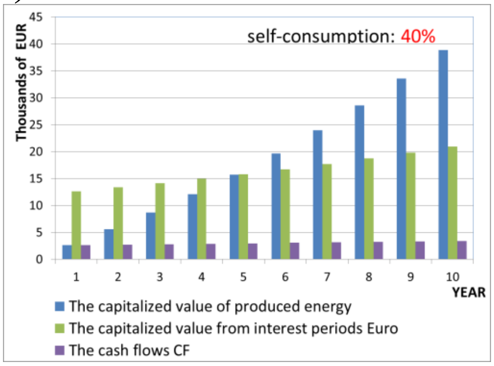
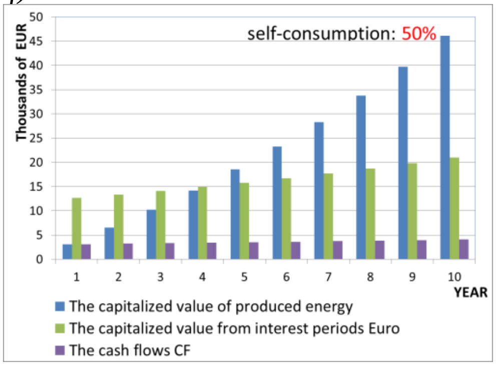


e)

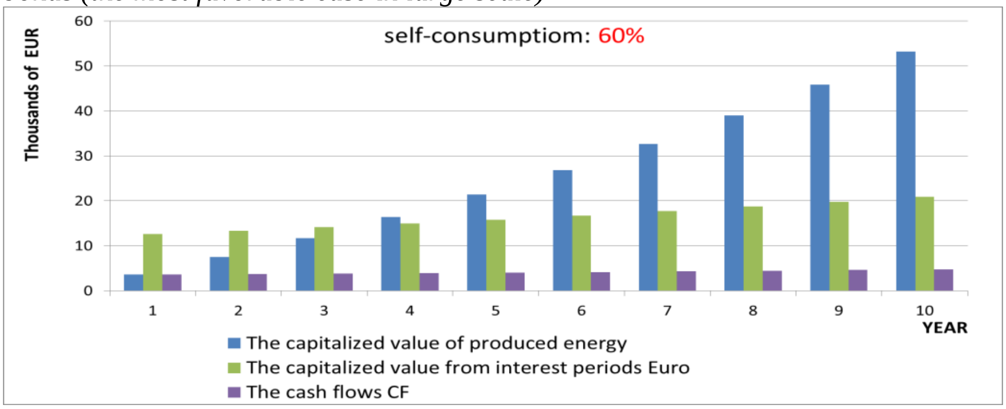


f)



Source: *Own study.*

Figure 4. *Comparison of 60% return on invested capital with self-consumption (ROI) on invested capital with an alternative form of investing funds in 10-year treasury bonds (the most favorable case in large scale)*



Source: *Own study.*

In the analysis, the price of energy produced in individual periods was calculated from the product of the production forecast in a given year (falling due to the decrease in cell efficiency) and the price of 1 kWh of energy updated by the value of inflation. In addition, it was adopted for investments in renewable energy, for each period the generated return on capital/profit will also be reinvested once a year in long-term treasury bonds with the same rate of return as the adopted alternative form of safe investment.

The analysis does not include the estimation of the project's risk margin, which is not insignificant from the investor's point of view. The obtained investment ratios are presented in Table 2. All conclusions are made considering 10 years of PV installation operation. For a self-consumption of 5% (Figure 3a), the capitalized value of the return on produced energy will not achieve the return on alternative investment in treasury bonds but will not be equal to the costs of entering this investment.

Table 2. *The Net present value (NPV) and Internal rate of return (IRR) depending on the percentage of self-consumption for the 10-year investment period*

Sefl-consumption:	5%	10%	20%	30%	40%	50%	60%
NPV10 Year: EUR	-4029.8	-2098.6	2222.5	6390.8	22494.6	26662.9	30831.1
IRR(10 Year):	-2.3%	2.0%	9.1%	15.1%	20.5%	25.5%	30.3%

Source: *Own study.*

If the self-consumption is 10% (Figure 3b), the capitalized value of the return on produced energy will not reach the levels of return on an alternative investment in treasury bonds, but after about 9 years it will be equal to the costs of entering this investment. Considering the value of the loss of capital due to inflation, in real terms this investment will also not pay off in a 10-year period.

With a self-consumption of 20% (Figure 3c), the capitalized value of the return on energy produced already reaches the levels of return on an alternative investment in treasury bonds and it is already beginning to exceed the costs of entering this investment. From the point of view of the entrepreneur, considering the risk of uncertainty, this investment does not seem to be profitable enough to enter it.

For a self-consumption of 30% (Figure 3d), the capitalized value of the return on energy produced already reaches the levels of return on an alternative investment in treasury bonds and even more than exceeds the costs of entering this investment. From the point of view of the entrepreneur, considering the risk of uncertainty, the investment can only be considered at the level of stabilization of ensuring the price of energy in the event of its intensive growth in this period, exceeding the level of interest rates.

In the case of self-consumption equal to 40% (Figure 3e), the capitalized value of the return on produced energy already reaches the levels of return on an alternative investment in treasury bonds, and from the point of view of the entrepreneur, taking into account the risk of uncertainty, the investment seems attractive because it pays off after 5 years.

If the self-consumption is 50% ÷ 60% (Figure 5f and Figure 6), the capitalized value of the return on energy produced very quickly reaches the levels of return on an alternative investment in treasury bonds. From the point of view of the entrepreneur, considering the risk of uncertainty, the investment seems to be very profitable and returns after 4.5 years (for self-consumption 50%) or even a period of 3 years (for self-consumption up to 60%) from its commencement.

5. Conclusions

Estimating the return on investment in renewable energy sources is relatively difficult because the investment is influenced by many factors that are not always specified at the investment planning stage. For this reason, the investment carries a high risk of uncertainty considering the expected return on capital. The risk can only be taken by the investor with the expected high rate of return on capital.

The analysis of the profitability of the company's investment in photovoltaics, with auto-consumption of 60%, indicates that in the period of high inflation (in which the rate of return on capital on bonds does not cover the value of money changes over time), it is a very interesting alternative method to investing funds in long-term treasury bonds. The payback period in this case is very short and amounts to approximately 3.6 years, and the rate of return IRR is approximately 30% over 10 years of operation of the installation. Such a high IRR value and a relatively short payback period are due to several reasons:

- high prices of energy resources and, consequently, electricity produced from fossil fuels. The cost of electricity for enterprises in Poland is almost twice as high as for households. This results in an extremely favorable and short payback time with an auto-consumption of 60%. This results in a faster discounting of the incurred expenditure and, consequently, significantly shortens the payback time.

- making a one-off depreciation as a fixed asset and deduction of VAT at the beginning of the investment, which makes such an investment cheaper in advance in relation to a similar investment by an individual investor.

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