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KATARZYNA ŁACH

Kraków University of Economics. Institute of Finance
ul. Rakowicka 27, 31-510 Kraków, Poland
lachk@uek.krakow.pl
ORCID ID: https://orcid.org/0000-0002-8403-339X

ANNA JASIŃSKA-BILICZAK

Wrocław University of Technology and Science. Faculty of Management
ul. Łukasiewicza 5, 50-371 Wrocław, Poland
anna.jasinska-biliczak@pwr.edu.pl
ORCID ID: https://orcid.org/0000-0002-1923-7345

Profitability of Investment in Photovoltaic Panels with Energy Storage for Households: A Case Study

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Abstract

Theoretical background: Poland, committed to an energy transition and to increasing the share of renewable energy sources (RES), has experienced dynamic growth in photovoltaics (PV), particularly within the sector of prosumer micro-installations. This development is driven by declining technology costs, rising energy prices, increased consumer awareness, and supportive government programs. Self-consumption has become a critical factor in determining investment profitability, especially under the net-billing system. There is growing interest in energy storage solutions, whose falling prices have made it possible to further increase self-consumption. The profitability of individual investments depends on installation costs, electricity prices, and the applicable settlement system.

Purpose of the article: The aim of this article is to conduct an economic analysis of the profitability of a prosumer photovoltaic installation combined with an energy storage system. The study focuses on current conditions in Poland, including the net-billing system and available support programs (e.g., "Mój Prąd"). The objective is to provide a detailed evaluation of costs, benefits, and profitability indicators (Payback Period, Discounted Payback Period, Net Present Value, and Internal Rate of Return). The analysis is based on a case study, with the goal of delivering a reliable economic assessment for potential individual investors.
Research methods: The study was conducted as a case study of a two-story residential house in Kraków (approx. 220 m²), heated electrically with a heat pump. In 2023, a 9.96 kWp PV installation and a 9.2 kWh energy storage unit were installed. The investment was financed with own funds, with a grant covering 50% of the capital expenditures. The household operates under the net-billing system. The profitability analysis uses actual production and consumption data from 2024, assuming the start of system operation in 2025. Savings were calculated as the difference in energy costs with and without PV, plus 30% of the value of electricity fed into the grid at wholesale prices. The assessment of profitability employed the discounted payback period method, Net Present Value (NPV), and Internal Rate of Return (IRR).
Main findings: The analysis demonstrated that the investment in a PV system with energy storage is economically viable for the examined case. The discounted payback period is approx. seven years. The NPV is positive, amounting to PLN 49,580, while the IRR stands at 13%, significantly exceeding the assumed opportunity cost of capital. The investment generates profits after the payback period. The study suggests that such a solution is particularly advantageous for households with higher electricity consumption, such as those using heat pumps. The results are subject to uncertainty regarding future electricity prices and regulatory changes, highlighting the need for ongoing analysis.

Introduction

In recent years, global and European energy policies have undergone significant transformations, primarily driven by rising energy carrier prices and the urgent need to combat climate change. The pursuit of a climate-neutral economy and the reduction of pollutant emissions – particularly those arising from the combustion of fossil fuels – necessitate an energy transition. As a member of the European Union, Poland has also committed to increasing the share of renewable energy sources (RES) in its energy mix, which is essential for achieving the EU's climate objectives.

In this context, photovoltaics (PV) have been developing particularly dynamically, being recognized as one of the most promising renewable energy sources. In Poland, this growth is predominantly fueled by the prosumer micro-installation sector. PV have become a modern solution for improving the energy efficiency of single-family buildings and are often integrated as part of comprehensive thermal modernization projects.

Despite the clear environmental benefits and the enhancement of energy independence, the key factor for individual investors remains the economic viability of investing in photovoltaic panels for households. Such investments are primarily aimed at reducing electricity consumption from the grid and lowering energy bills, which translates into direct financial savings. However, profitability is shaped by numerous variables, including initial installation costs, fluctuations in electricity prices, and, above all, the energy settlement system governing energy fed into and drawn from the grid. The introduction of the so-called net-billing system has made the level of self-consumption of energy produced during the day a crucial factor influencing profitability. In response to these changes, there is a growing interest in electricity storage systems, which enable increased self-consumption. Moreover, the availability of financial support programs, such as "Mój Prąd" and the thermomodernization tax relief, significantly reduces the initial investment cost and shortens the payback period, thereby enhancing the investment's attractiveness.

The aim of this article is to conduct an economic analysis of the profitability of investing in a prosumer photovoltaic installation with energy storage, with particular consideration of the current market and regulatory conditions in Poland. Based on a case study of a selected single-family household building, this study presents a detailed assessment of the costs and benefits influencing the investment payback period (both simple and discounted), along with other tools for evaluating investment profitability. The analysis will consider factors such as the amount of energy produced, stored, and consumed, which determines the level of self-consumption. The use of financial support in the form of investment grants has also been taken into account. The purpose of this study is to provide a reliable economic assessment for potential individual investors.

The article is divided into several sections. Following the introduction, a literature review is presented, followed by the research methodology, the characteristics of the selected case study, the results, and the conclusions drawn from the analysis.

Literature review

The development of renewable energy sources (RES) in Poland and worldwide is an undeniable fact. This process results from multiple factors, which can be categorized into three main groups: environmental and climatic, economic, as well as social and technological

1. *Environmental and climatic* aspects (López & Steininger, 2018; Vögele & Rübbelke, 2013; https://www.rymar.com.pl/sc/fotowoltaika-i-energia-sloneczna; https://globenergia.pl/dzisiaj-mial-skonczyc-sie-moj-prad-6-0-ile-pozostalo-z-pierwotnego-budzetu/; https://mojprad.gov.pl/)

The reduction of greenhouse gas emissions constitutes one of the key rationales for the expansion of RES. Investments in PV and other renewable technologies reduce CO_2 emissions and other air pollutants. The implementation of PV systems in enterprises contributes to the realization of the European Union's climate policy, including the "Fit for 55" package and the European Green Deal, whose strategic goal is climate neutrality by 2050.

The development of RES also contributes to the improvement of air quality by reducing the demand for coal-based electricity, thereby limiting emissions of particulate matter and sulfur oxides. This is particularly significant in Poland, where a considerable share of electricity generation still relies on coal.

Another important element is the protection of natural resources. Solar energy, unlike fossil fuels, is renewable and practically inexhaustible. PV micro-installations enable efficient utilization of locally available natural resources without the need for exploiting non-renewable raw materials. Furthermore, electricity production from PV systems does not entail negative impacts on ecosystems, such as water pollution or soil degradation, which are characteristic of conventional energy production.

2. *Economic* aspects (Bajor, 2024; Escobar et al., 2020; Filipiak et al., 2022; Jarosiński et al., 2021; Klein & Deissenroth, 2017; Pomorski et al., 2022; Pstraś, 2014; Schanz, 2012; Talavera et al., 2013; https://enerad.pl/oplacalnosc-fotowoltaiki/; https://www.otovo.pl/locator/fotowoltaika-krakow/; https://www.rymar.com.pl/leasing-fotowoltaiki-komu-sie-oplaca.htm; https://www.rymar.com.pl/mikroinstalacja-a-prosument-definicje-i-prawa.htm; https://www.rymar.com.pl/jak-rozliczac-fotowoltaike-po-zmianach-prawa-energetycznego.htm; https://akademia-fotowoltaiki.pl/net-billing-zasady-rozliczania/)

One of the crucial drivers of RES development is the continuous decline in technology costs. Prices of photovoltaic panels have been steadily decreasing, making them increasingly affordable for both households and enterprises. In recent years, the costs of PV installations in Poland have dropped by several dozen percent, which significantly shortens the payback period of investments.

PV installations are also characterized by stable operating costs, as they do not require fuel purchases, and their maintenance is relatively inexpensive. As noted by Drzymała and Korzeniewska (2020), in the case of enterprises, the operational costs of PV installations are both predictable and low, which facilitates long-term financial planning.

The development of RES also strengthens energy independence and security of supply. On a macroeconomic scale, this implies reducing dependence on fossil fuel imports, while on a microeconomic scale it enables households and companies to become more resilient to rising grid electricity prices. RES expansion also supports job creation and economic growth, particularly in the installation, servicing, and manufacturing sectors. Moreover, it fosters the emergence of new business models, such as PV leasing schemes.

Finally, PV installations generate cost savings for consumers. Self-consumption of electricity produced for own use reduces energy bills. Analyses by Chmieliński (2015) demonstrate that PV micro-installations were economically viable even before the introduction of the net-billing system, especially in cases of high levels of self-consumption. At present, savings stem not only from reduced electricity purchases but also from competitive financing options available for such investments.

3. *Social and technological* aspects (Ciesielka, 2021; Filipiak et al., 2022; Jarosiński et al., 2021; Kula, 2024; Pomorski et al., 2022; Talavera et al., 2013; https://www.rymar.com.pl/sc/fotowoltaika-i-energia-sloneczna; https://mojprad.gov.pl/)

The growing ecological awareness of society constitutes one of the driving forces behind renewable energy development. For enterprises, investments in RES are perceived not only as a means of cost reduction but also as an element of building a socially responsible image. Technological progress also plays a significant role. The advancement of bifacial panels, energy storage systems, and intelligent management solutions increases the efficiency and lifespan of PV installations. Consequently, micro-installations are becoming increasingly accessible and profitable.

Another advantage of PV lies in their availability and versatility. PV installations can be mounted both on residential buildings and within enterprises or agricultural holdings, which makes this technology one of the most flexible within the RES sector. Finally, PV installations require lower maintenance inputs compared to conventional power plants, as they are limited mainly to periodic inspections and module cleaning.

In Poland, an additional critical factor is the necessity of transitioning to low-emission energy sources, in light of European Union commitments and the urgent need to modernize an outdated, coal-based energy infrastructure. The development of RES is a key component of this energy transition.

According to experts, PV are expected to represent the fastest-growing segment within the renewable energy sector. This reflects a global and European trend driven by rising energy prices and the imperative to address climate change. In Poland, this growth is particularly evident in the prosumer micro-installation sector, where both the number of installations and the total installed capacity have increased significantly in recent years, as demonstrated in the following section (Bajor, 2024; Ciesielka, 2021; Filipiak et al., 2022; Jarosiński et al., 2021; Kula, 2024; Pomorski et al., 2022) (Figure 1).

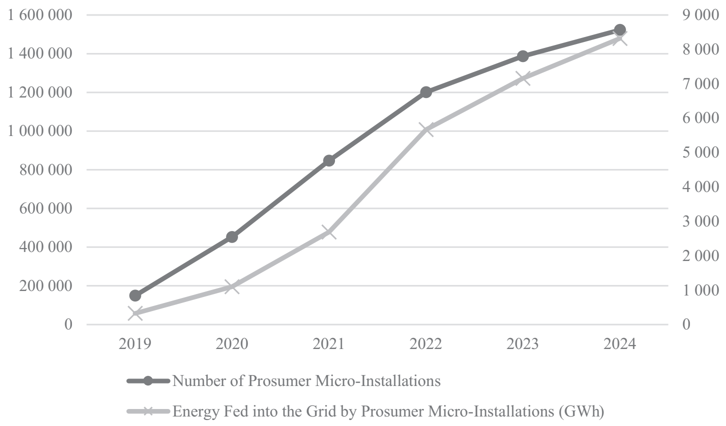

Figure 1. Development of photovoltaic micro-installations in Poland in the years 2019–2024

Source: (Energy Regulatory Office, 2025).

In 2024, Poland had over 1.5 million prosumers, and the installed capacity of micro-installations reached 8.3 GWh. This development was primarily driven by (https://mojprad.gov.pl/; https://akademia-fotowoltaiki.pl/net-billing-zasady-rozliczania/; https://globenergia.pl/dzisiaj-mial-skonczyc-sie-moj-prad-6-0-ile-pozostalo-z-pierwotnego-budzetu/; https://www.rymar.com.pl/mikroinstalacja-a-prosument-definicje-i-prawa.htm; https://www.rymar.com.pl/jak-rozliczac-fotowoltaike-po-zmianach-prawa-energetycznego.htm; https://enerad.pl/oplacalnosc-fotowoltaiki/):

- declining costs of photovoltaic panels and energy storage systems;
- rising electricity prices;
- increasing ecological and economic awareness among consumers; and
- the availability of government support programs for the purchase and installation of equipment.

The profitability of PV investments for households is shaped by numerous variables. The most important of these include (Bajor, 2024; Klein & Deissenroth, 2017; Pstraś, 2014; Talavera et al., 2013; https://www.otovo.pl/locator/fotowoltaika-krakow/; https://enerad.pl/oplacalnosc-fotowoltaiki/):

- Initial installation costs (CAPEX): A key factor that has decreased significantly in recent years. These costs include modules (panels), inverters, potentially energy storage units, mounting structures, wiring, labour, etc.
- Location and solar exposure of the building: The level of sunlight exposure affects the amount of energy produced. However, regional differences in solar irradiation across Poland are not particularly large.
- Electricity consumption and consumption profile: Annual energy consumption and the alignment of daily and seasonal demand with the PV production profile are critical for maximizing self-consumption.
- Electricity and distribution prices: Current and projected electricity and distribution prices directly impact savings (i.e., reduced costs). An increase in energy prices enhances investment profitability.
- Settlement system (net-metering, net-billing): The evolution of prosumer billing systems in Poland has had a substantial influence on profitability. The previously used net-metering system allowed for surplus energy to be returned to the grid and later withdrawn at a ratio of 70% or 80%, depending on the system's capacity. The energy grid effectively functioned as a seasonal energy storage system. Currently, the net-billing model has been introduced, significantly altering the regulatory framework. Under this model, energy fed into the grid is sold at market (wholesale) prices, while electricity drawn from the grid is purchased at retail prices. As a result, if a large portion of energy is fed into the grid, the profitability is reduced compared to net-metering. Therefore, under net-billing, maximizing self-consumption of the generated electricity during the day becomes crucial. Net-billing is also intended to discourage the oversizing of installations.
- Use of energy storage systems: These can increase self-consumption. Until recently, such solutions were largely inaccessible due to the high cost of energy storage devices. Many previous studies on the profitability of PV investments did not consider installations including storage. However, in recent years, the price of lithium-ion batteries has decreased significantly, prompting more prosumers to consider this option. Nonetheless, due to the still relatively high cost of storage

systems, it is vital to ensure proper matching in terms of both energy capacity and investment scale. Both undersized and oversized storage negatively affect the profitability of a PV system.
- Financial support programs and tax incentives: Programs such as "Mój Prąd" and "Czyste Powietrze," as well as the thermomodernization tax relief, significantly reduce the initial investment cost and shorten the payback period. The current editions of the "Mój Prąd" program encourage increased self-consumption by subsidizing energy storage systems and energy management solutions. Legal frameworks for energy storage have also been introduced.

Previous research on the profitability of PV micro-installations has focused on identifying the economic viability of PV systems for individual consumers in different regions of Poland, often assuming full on-site consumption of the generated electricity. The objective was to determine when and where achieving grid parity – i.e., when the cost of self-generated PV electricity is no higher than the cost of purchasing electricity from the grid without support mechanisms – is feasible. These studies indicated that, under full self-consumption assumptions, investments in PV micro-installations could be profitable in most regions of Poland, particularly for larger single-family homes with above-average electricity consumption and a demand profile aligned with PV production. However, achieving full self-consumption remains a difficult condition for the average household. One way to increase the level of self-consumption is through the integration of PV panels with battery storage systems.

Despite the existence of numerous publications analyzing profitability, most earlier studies were based on net-metering assumptions and installations without storage systems. The transition to net-billing, which alters energy settlement methods and elevates the role of self-consumption, has created a need for updated analyses that reflect the current legal and market environment in Poland. Although some studies have begun to address the role of energy storage under the new system, these are often model-based simulations. There remains a lack of detailed case studies based on real consumption data and specific building characteristics, conducted within the context of current support mechanisms (e.g., "Mój Prąd," thermomodernization tax relief) and the net-billing system. Such studies – based on concrete household examples – are essential to provide a reliable economic assessment for potential individual investors, accounting for local conditions, actual energy use profiles, and the impact of available support programs and the additional costs associated with storage systems.

Various financial analysis methods are employed to assess the profitability of PV investments (Bajor, 2024; Pstraś, 2014; Talavera et al., 2013). A basic and commonly used tool for preliminary evaluation is the simple payback period (PP), which determines the time it takes for the investment costs to be offset by the accumulated savings. Although easy to apply, this method has significant limitations, as it does not account for the time value of money. Much more reliable are dynamic methods, which consider the decreasing value of money over time. These are based on discounted cash flow (DCF) analysis. The key methods in this category include:

- Net Present Value (NPV) – the sum of the discounted cash flows generated by the investment:

$$NPV = \sum_{t=0}^{n} \frac{CF_t}{(1+r)^n}$$

where:
CF_t – cash flow generated in year t;
n – project lifespan;
r – discount rate (cost of capital financing the project).

A positive NPV indicates that the investment is profitable. A higher NPV reflects greater profitability; however, this indicator is not suitable for comparing projects of different scales.

- Internal Rate of Return (IRR) – the discount rate at which the NPV of the project equals zero:

$$\sum_{t=0}^{n} \frac{CF_t}{(1+IRR)^n} = 0$$

The investment is considered profitable if the IRR exceeds the cost of capital used to finance the project.

- Discounted Payback Period (DPP) – the number of years required for the present value of investment expenditures to be offset by the discounted net positive cash flows generated during the operational phase of the project.

Estimating the profitability of a PV investment is a complex task, as such investments are influenced by numerous factors, some of which – particularly key ones such as future electricity prices – are subject to change over time and are unknown at the time of the financial assessment. Moreover, regulations concerning renewable energy prosumers in Poland are frequently amended, which means that certain elements of the profitability assessment may change during the investment's lifetime. However, it can generally be assumed that regulatory changes are not made to the detriment of prosumers. If new, more favourable measures are introduced, the prosumer has the right to adopt them. In contrast, if the changes are unfavourable, the prosumer retains the right to remain under the terms of the original agreement signed with the energy provider.

Research methods

The subject of this study is the economic analysis of the profitability of an investment in a PV installation integrated with an energy storage system, using the example of a two-story residential building located in Kraków. The building has approx. 220 m^2 of usable floor space, is equipped with a heat pump, and is entirely heated with electricity via underfloor heating. The installation includes a 16 kW air-source heat pump manufactured by Kaisai and a 400-liter tank for domestic hot water.

In 2023, 24 photovoltaic panels were installed on the roof of the building, arranged in an east-west orientation, with 12 panels on each side. To increase the degree of self-consumption, the installation was equipped with an energy storage unit with a capacity of 9.2 kWh.

The investment was financed with the household's own funds, and financial support from the "Mój Prąd 5.0" government program was utilized, which reduced the total investment cost by half. The analyzed household settles the surplus energy produced under the net-billing scheme. Table 1 presents the individual components of the PV installation along with their associated costs.

Table 1. Components of the PV installation with associated costs

Component	Specification	Price, incl. 8% VAT (PLN)
Panels	Risen 415 W monocrystalline modules, 9.96 kWp (24 units)	15,000
Inverter	SolarEdge 8 kW hybrid inverter	9,000
Battery storage	9.2 kWh energy storage system	20,000
Mounting system	Mounting structure and installation	2,000
Total		**46,000**
Less	"Mój Prąd 5.0" subsidy (50% of capital expenditures)	−23,000
Own capital	Investor's contribution	23,000

Source: Authors' own study.

Given that the distribution of electricity generation from the analyzed PV installation does not fully coincide with the household's electricity demand pattern, varying levels of so-called self-consumption occur throughout the year. Self-consumption refers to the ratio of electricity produced on-site by the PV system to the total electricity consumption of the household. The data on electricity production and consumption for the analyzed case are presented below (Table 2).

Table 2. Electricity production and consumption in the analyzed household in 2024 (in kWh)

Month	Production				Consumption				Self-consumption (%)
	Total	To grid	To battery	To home	**Total**	From grid	From battery	From PV	
January	**87**	10	22	55	**701**	636	20	45	**9.3**
February	**265**	29	114	121	**541**	309	111	121	**42.9**
March	**619**	268	196	154	**529**	197	178	154	**62.8**
April	**928**	628	161	138	**294**	19	137	138	**93.5**
May	**1,400**	1,190	90	120	**210**	30	60	120	**85.7**
June	**1,260**	730	190	330	**630**	120	180	330	**81.0**
July	**1,280**	380	250	640	**1,410**	530	240	640	**62.4**
August	**1,270**	600	250	420	**800**	160	220	420	**80.0**
September	**916**	431	230	256	**543**	73	214	256	**86.6**
October	**560**	145	220	194	**657**	256	207	194	**61.0**
November	**220**	10	60	150	**1,140**	920	70	150	**19.3**
December	**160**	0	20	140	**1,360**	1,190	30	140	**12.5**
Total 2024	**8,965**	**4,421**	**1,803**	**2,718**	**8,815**	**4,440**	**1,667**	**2,708**	**49.6**

Source: Authors' own study.

As previously noted, a major challenge in the economic efficiency analysis of PV investments lies in the fact that many factors directly affecting their performance are unknown at the time of calculation (such as future electricity prices, potential changes in the surplus settlement system, etc.). Moreover, although the PV installation in the analyzed building was commissioned in 2023, the profitability calculations are based on current data, assuming that the operational start of the investment effectively begins in 2025, under the prevailing energy prices and billing regulations applicable at that time. The following set of assumptions was also adopted for the analysis:

- the level of electricity consumption in the analyzed household will remain at the 2024 level;
- the retail purchase price of 1 kWh of electricity in 2025 is assumed to be PLN 0.90;
- the average market price (wholesale market) of 1 kWh in 2025 is assumed to be PLN 0.40;
- electricity prices will increase by 3% annually;
- the operational lifespan of the installation is 25 years;
- the efficiency of the PV system will decrease by 20% over 25 years, which implies an average annual decline in energy production of 0.9%, leading to a corresponding yearly increase in the volume of energy drawn from the grid;
- PV panels require cleaning at least once per year, which incurs a cost of PLN 920 annually (PLN 20/m^2 × area of 24 modules ≈ 46.08 m^2);
- since the PV installation was financed with own funds, the discount rate for discounted cash flow methods is set at the opportunity cost in the form of the average interest rate on 12-month bank deposits, i.e. 3.8%.

The research hypothesis of this study is that a photovoltaic installation combined with an energy storage system constitutes a profitable investment for a household.

The profitability analysis of the PV investment presented in this paper was conducted using methods for assessing the economic efficiency of investments, which were briefly discussed in the previous section. A crucial issue in the investment profitability analysis is the accurate estimation of investment cash flows, which are subsequently applied to the evaluation formulas. In the context of PV investment assessment, investment cash flows include:

- expenditures for the purchase and installation of panels and all additional components;
- savings on electricity bills achieved thanks to the PV installation.

These savings, in turn, are defined as the difference between the cost of electricity consumption without PV and the cost when PV are in use. Additionally, surplus electricity generated by the PV system and fed into the grid is accounted for as revenue. Under the net-billing system, as regulated in 2025, the prosumer may recover the value of 30% of the electricity fed into the grid each month, albeit at wholesale market prices. Conversely, when the prosumer draws electricity from the grid (e.g., at night or during overcast days), it is billed at the retail electricity prices applicable to the consumer.

Results

In the first stage of the analysis, the savings achievable through the use of the PV installation in the first year of operation, i.e., in 2025, were calculated. As previously mentioned, the basis for these calculations was the actual data on electricity production and consumption from 2024 (Table 3).

Table 3. Forecast of savings achieved in 2025

Without PV	Cost (PLN)	With PV	Cost (PLN)
Consumption from the grid: 8,815 kWh	7,934	Consumption from the grid: 4,440 kWh	3,996
		Energy "fed into" the grid: 4,421 kWh (settlement covers 30%)	-531
		Total savings	4,469

Source: Authors' own study.

In the forecast of savings, and thus the cash flows (CF) for the subsequent years, the assumptions mentioned above were applied. Additionally, for year 0, investment expenditures related to the purchase and installation of the system in the amount of PLN 23,000 were assumed. Table 4 presents these values along with the calculated DCF, NPV, IRR.

Table 4. Projected cash flows related to the investment in a PV system over 25 years of operation (in PLN)

Year	Energy cost without PV	Energy cost with PV	Value of energy supplied to the grid	Cleaning cost	CF	DCF	Cumulative DCF
0					-23,000	-23,000	-23,000
1	7,934	3,996	531	920	3,548	3,418	-19,582
2	8,172	4,153	542	920	3,640	3,378	-16,203
3	8,417	4,316	553	920	3,733	3,338	-12,865
4	8,669	4,485	564	920	3,828	3,297	-9,568
5	8,929	4,662	576	920	3,923	3,256	-6,312
6	9,197	4,845	588	920	4,020	3,214	-3,098
7	9,473	5,035	600	920	4,118	3,172	74
8	9,757	5,233	612	920	4,217	3,129	3,203
9	10,050	5,438	625	920	4,317	3,086	6,289
10	10,351	5,652	638	920	4,418	3,043	9,332
11	10,662	5,874	651	920	4,520	2,999	12,330
12	10,982	6,104	665	920	4,622	2,955	15,285
13	11,311	6,344	679	920	4,726	2,910	18,195
14	11,651	6,593	693	920	4,830	2,865	21,061
15	12,000	6,852	707	920	4,935	2,821	23,881
16	12,360	7,121	722	920	5,041	2,775	26,657
17	12,731	7,401	737	920	5,147	2,730	29,387
18	13,113	7,691	752	920	5,253	2,685	32,071

Year	Energy cost without PV	Energy cost with PV	Value of energy supplied to the grid	Cleaning cost	CF	DCF	Cumulative DCF
19	13,506	7,993	768	920	5,360	2,639	34,710
20	13,911	8,307	783	920	5,467	2,593	37,304
21	14,329	8,634	800	920	5,575	2,547	39,851
22	14,759	8,973	816	920	5,682	2,501	42,352
23	15,201	9,325	833	920	5,790	2,455	44,808
24	15,657	9,691	850	920	5,897	2,409	47,217
25	16,127	10,072	868	920	6,003	2,363	49,580
					NPV =	**49,580**	
					IRR =	**13%**	

Source: Authors' own study.

From the above table, it follows that, considering the time value of money, the investment in a PV system for the studied case will pay off in approx. 7 years. The NPV is positive, amounting to PLN 49,580, and the IRR is 13%, which is significantly higher than the assumed alternative cost of 3.8%.

Discussion

As the study shows, a household investment in a PV system with energy storage is financially viable. The results obtained are in line with similar studies conducted in previous years. The assessment methods in most of these studies were based on the payback period, either simple or discounted. The payback period in different studies ranged from 5 to even 15 years. However, considering that the operational lifespan of the panels is a minimum of 25 years, the payback will occur much earlier, and after this period, the investment will generate a net profit. It should be noted, though, that nearly every year factors affecting profitability change: photovoltaic equipment prices decrease, energy prices fluctuate, and public support mechanisms and methods of surplus energy settlement evolve. Therefore, it is difficult to directly compare the results of different studies. This also supports the argument that such studies and analyses are continuously needed, given the changing economic and technological conditions.

When drawing conclusions from the conducted analysis, the specific nature of the studied case must also be taken into account. The building considered is heated by a heat pump, which results in above-average electricity consumption, as heat pumps are powered by electricity. Buildings heated by other methods, such as gas boilers, will not consume as much electricity, and the level of self-consumption in these buildings will be lower. However, the results of the research may still be useful when making decisions about heating methods. Combining a heat pump and PV will be a very cost-effective solution.

Additionally, it is worth emphasizing that the assumed operational period of the installation is not a limiting factor. Panel manufacturers offer a guarantee of 80% performance after 25 years, which means that the system can still operate and provide economic benefits beyond that period.

Conclusions

This case study analyzed the financial viability of investing in a household photovoltaic system with energy storage in Poland, considering the net-billing system and subsidies from the "Mój Prąd" program. The results confirmed the research hypothesis, indicating that the investment is profitable, with a discounted payback period of about 7 years, a positive NPV (PLN 49,580), and a high IRR (13%). This suggests the financial attractiveness of such solutions for households, especially those with higher energy consumption, e.g., with a heat pump. The study has limitations related to the uncertainty of future energy prices and regulatory changes. The need for continuous analyses reflecting evolving market and legal conditions is emphasized.

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