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Analysis of Investments in RES Based on the Example of Photovoltaic Panels in Conditions of Uncertainty and Risk—A Case Study

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Abstract: The aim of this study is to examine the profitability of investment in a photovoltaic microinstallation, to analyze the impact of legal changes on its profitability, and to perform a sensitivity analysis of the investment profitability to energy price changes. The novelty of the research applies to the financial analysis of two legal systems of discount called net-metering and net-billing. The two systems and the change in energy prices present legal and macroeconomic risks. Climate neutrality strategy implementation is the analysis background. The authors formulate the hypothesis that, firstly, the solar panel installations in Poland are aimed at reducing the operating costs of the building; secondly, the investment motivation is environmental. The main research conclusion is that taking into consideration the solar panel 'boom' in Poland, the 'regulator' has achieved its intended goal connected with progress toward climate neutrality. This research used the method of logical design, experiment, and comparative analysis. The tools applied to calculate project profitability included the internal rate of return (IRR) and net present value (NPV). The case study method has been applied. The analysis uses real-world assumptions and is conducted for weather conditions in Gdańsk, Poland.

Keywords: sustainable development; investment profitability; climate neutrality; photovoltaic panels

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1. Introduction

Sustainable development has shaped ways of thinking about development and has gained high-level policy recognition both worldwide and locally [1]. The "triple bottom line" shows the interrelationship between and co-dependence of social, economic, and environmental dimensions. The determinants of sustainable development have become mainstream in research, policy, and practice [2]. A milestone in sustainable development is the 2030 agenda and a set of 17 sustainable development goals (SDGs) accepted by UNIDO in 2015. The 2030 agenda is linked to Global New Green Deal (presented in 2008) and the European Green Deal (approved in 2020), originating from the Kyoto protocol from 1997 and the global and European action plan for sustainable economy, focusing on climate neutrality and a modern, resource-efficient, and competitive economy. The goal of a sustainable development should then drive the decision making in the urban transformation strategy [3], as urban areas consume 75% of the natural resources and emit 60–80% of the global greenhouse gases and future population in the cities will increase [4–6].

On 14 July 2021, the European Union announced a new set of climate regulations "Fit for 55"—meaning a 55% reduction in emissions in the EU by 2030. The entire Union wants to become climate neutral by 2050. Is this realistic, especially in the context of recent geopolitical events and the interests of non-EU countries? Many indications suggest not. Is it necessary? Everything points to it being so. In practice, the actions will include a reform of the current emissions trading system (ETS), new carbon tariffs/duties, and stricter emission standards. The new renewable energy sources (RES) directive project provides for an increase in renewable energy in the energy mix [7,8]. As the example from Poland shows, both companies and individual consumers are willing to participate in this on a wide scale. There have been changes in the social awareness of the views of Poles on the current shape of the energy sector and the proposed changes in this sector [9–12]. The results of the EIB (European Investment Bank) research on climate change shows that 75% of Poles surveyed (compared to 78% of European Union average) are concerned about climate change and its consequences [13]. According to the report prepared by Energetyka24.com and IBRiS (Market and Social Research Institute), approximately 41% of respondents want to switch to renewable sources as soon as possible [14].

Concern for the environment increased social awareness, and the constant rise in electricity prices are causing interest in energy systems based on renewable energy sources to grow [15,16]. Among them, solar energy is particularly noteworthy. It is a renewable energy source with significant potential. There are many ways to convert solar energy [17]. One of the more common technologies for using solar energy is photovoltaics. It allows for the direct conversion of solar radiation energy into electrical energy. The generated electrical energy translates into savings in the form of reduced electricity bills. An investment in a photovoltaic installation may be interesting as a form of long-term investment.

The aim of this study is to examine the profitability of investment, the impact of legal changes on profitability, and the analysis of selected factors that affect the profitability of investing in a photovoltaic microinstallation for a typical single-family house in Poland. Poland is a parliamentary republic; it is a country on the coast of the Baltic Sea in Central Europe, a member of the European Union. The climate of Poland is temperate transitional and varies from oceanic in the north-west to continental in the south-east. Considerable day-to-day weather fluctuations, thermal anomalies, and the differences in the arrival of a particular season are present [18,19]. The time frame of the study covers 25 years, which is a typical period of the warranty for the installation's efficiency given by manufacturers. Case study research is an accepted form of social science research. It is a preferred method, compared to others, particularly in situations when the focus of the study is a contemporary phenomenon [20]. The case study approach has been applied in renewable energy resources related research (e.g., [21–25]). The novelty of research applies to financial analysis of two legal systems of discount called net-metering and net-billing, which present the legal and macroeconomic risk in the context of investor financial and non-financial motivation and implementation of the strategy of climate neutrality.

Authors formulate the hypothesis that, firstly, the solar panel installations in Poland are aimed at reducing the operating costs of the building; secondly, the investment motivation is environmental. The main research conclusion is that taking into consideration the solar panel "boom" in Poland, the "regulator" has achieved its intended goal—connected with progress toward climate neutrality.

The research used the method of logical design, experiment, and comparative analysis to discuss the motivation and profitability of photovoltaic microinstallation for a single-family house. The tools applied to calculate project profitability included the internal rate of return (IRR) and net present value (NPV). IRR and NPV are discounted cash flow (DCF) methods used to evaluate the economic profitability of investment (project) [26]. For instance, it has been used in research evaluating scenarios concerning photovoltaic panels and storage systems in a residential building in Italy [21]. The authors claim that the increase in the share of self-consumption is the main critical variable. The profitability of photovoltaic and battery systems was also calculated with DCF methods in the research based on Switzerland case study [27]. The authors proposed a machine learning algorithm which predicts optimal configuration, profitability, and self-sufficiency ratios with good accuracy. Another research shows that positive NPV of flexible storage photovoltaic investments due to the high electricity prices were confirmed in Germany and in Spain, but not in France and Italy [22]. Finally, the research over economic performance of photovoltaic panels in Iran shows that, even under subsidized prices, the cash generated by investment cannot cover the costs that the investment requires and the NPV is negative [23]. The mentioned research used the same methods, and they were all subordinated to the specified original research aims. They provide general conclusion that photovoltaic panels investment is sensitive to technical, natural, and legal conditions.

2. Materials and Methods

2.1. Specificity of Photovoltaics—Technical Conditions

Photovoltaics use a phenomenon that involves the direct conversion of solar radiation energy into electricity. It is not a source of energy adapted to power loads continuously. The use of solar radiation in the photovoltaic conversion process has a positive effect on the energy balance of the Earth; moreover, it is a renewable source. Photovoltaic panels, which are the basic element of a photovoltaic installation, are divided into three basic generations, but their presented efficiency in the literature differs. According to Dasari, Balaraman & Kohli (2018) [28], the first-generation panels, which currently dominate the market, are made of cells made of mono- and polycrystalline silicon. Their efficiency can reach up to 25.6%. Second-generation panels are characterized by a very thin semiconductor layer that absorbs light. The highest reported efficiency is 28%. Third generation panels are based on many technologies, e.g., non-toxic organic materials and graphene. The advantage of such cells is their low production cost and light absorption of up to 90%, while the main disadvantage is the efficiency (which was unsatisfactory), and no advances were reported (although theoretical calculations indicated efficiency over 80% [28]). Different ratios of efficiency are presented by other authors (e.g., [25]).

Frequently mentioned advantages of photovoltaic panels include: no contamination with products of incineration, redundancy of fuel, operator, transport, inexhaustible resources of solar energy, and direct conversion of radiation energy into electricity. Other features are as follows: cost-effectiveness of use, as they do not require overhauls and repairs; a relatively short investment period; low operating costs; energy independence (in the case of off-grid systems); and a determined dynamic increase in installed photovoltaic capacity in Poland. At the end of September 2021, the installed capacity in photovoltaics exceeded 6.3 GW. Prosumers (producers and consumers) [17,25] are responsible for such dynamic growth, whose share in the total capacity exceeds 70% [29]. The factors that revived the photovoltaic market were subsidy programs, an increase in electricity prices (Figure 1), and an expected change in the energy discount system.

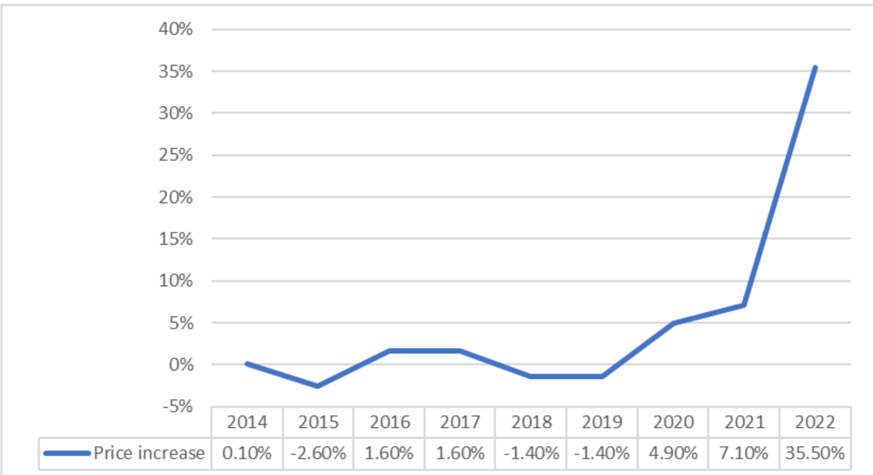

Figure 1. Increase in energy prices in Poland (2014–2022) [30].

At the same time, the disadvantages of the installation are their high price, the fact that the amount of energy produced depends on the season, and the toxic compounds used to build cells—cadmium, selenium, arsenic, and tellurium. Additionally, the panels do not produce energy at night, and it is difficult to store the energy produced. The issues of utilization of this multi-composite material after the period of operation have been also raised recently, showing both threats and possibilities (e.g., recovery of rare earth metals) [31].

The first step in designing a photovoltaic installation is to choose where to install the panels on the roof of the building. This must consider the surface, exposure to sunlight, and obstacles that can shade the installation. The next step is to determine the method of installation of photovoltaic panels and the selection of the supporting structure. Next, it is necessary to analyze the precise location of photovoltaic panels on the roof of the building and analyze the shading of the panels—this will allow for the determination of specific models of photovoltaic panels and inverters, energetically matched to the number of panels and their placement. Inverters are used to change current and DC voltage into current and AC voltage with grid parameters. They also keep statistics on energy production and perform a control function [32]. Photovoltaic installations do not require much attention from the investor during the period of operation, but they may be exposed to damage (galvanic, magnetic, and electrical couplings) [33].

The selection of the type and size of a photovoltaic installation consists of determining the demand for power and correlating it with the power of the generator. The energy needs of the building should be met as much as possible, and only surplus energy should be fed into the power grid to minimize losses related to possible transmission or storage of energy [34]. Another important factor is the way the installation works with the power grid. The following types of systems are distinguished [24]:

- On-grid system—the system returns the generated electricity to the public grid through a separate meter. The energy necessary for operation is taken by the second meter directly from the power grid. The settlement takes place with the energy company by issuing an invoice based on the measurements of both meters.
- Off-grid system (autonomous)—the system has no connection to the public grid, and the generated energy is usually stored in batteries. It produces energy for consumers assuming adequate energy demand. This system is used when energy consumption is low or when it is not possible to connect to the power grid.

2.2. Specificity of Photovoltaics—Economic and Legal Conditions

Capital expenditures (CAPEX) incurred for the photovoltaic installation include costs related to the purchase of photovoltaic panels, inverter, assembly accessories, and all electrical equipment and labor. The financial analysis is part of the documentation for the photovoltaic installation project. It should consider the financing structure, i.e., the share of equity, credit with subsequent repayment of installments, and possible subsidies. Each type of financing is associated with its specific costs. Basically, EU or government funds are non-repayable funds, but they may involve the costs of employing an adviser or preparing documentation. Typically, grants are implemented in the form of reimbursement of part of the costs incurred or repayment of a loan taken out and are therefore transferred to the investor at a later date, which requires securing other funds to cover part of the investment expenditures. According to the current provisions of the Personal Income Tax Act [35], subsidies and other free benefits received to cover costs or as reimbursement of expenses are included in other revenues from business activity and are therefore subject to income tax. It is also possible to use the thermo-modernization tax relief enabling the deduction of the costs of purchasing a photovoltaic installation up to a certain amount from the tax base. However, it does not cover the cost of funding under grants. Programs financed from EU funds offer co-financing at the level of about 60% to even 80% of CAPEX. When looking for a non-returnable subsidy or a low-interest loan, it is worth searching beyond popular, domestic supporting projects. There are co-financing programs for photovoltaic panels for entities from in selected region [25].

The discount system is also a key factor in photovoltaics investment decision-making [25]. The discount system allows to treat the power grid as a “virtual energy storage” in which surplus electricity produced by photovoltaic installations and not consumed as part of self-consumption is stored. The system is called net-metering. In Poland, a proconsumer who provides 1 kWh into the distribution network can collect 0.8 kWh (for installations up to 10 kW) or 0.7 kWh (when the size of the installation is from 10 kW to 50 kW). At the same time, the distribution system operator collects distribution fees from the prosumer for retransmission of energy [36]. The transparency of the net-billing system is beneficial for prosumers and the systematically increasing price of electricity has caused a significant increase in interest regarding photovoltaic installations. However, the amendment to the act on renewable energy sources of 29 October 2021 changed the existing rules for the energy discount [37]. The new system of discount, the so-called net-billing system, consists of a separate settlement of electricity introduced into the distribution network and electricity taken from the network based on the value of a unit of energy determined according to the exchange price on an hourly basis. The prosumer will receive a market price for electricity introduced into the network from its own photovoltaic installation, and it would pay for the energy consumed in the same way as other consumers. The amount for electricity introduced into the network goes to the "prosumer deposit," which is intended for the settlement of liabilities of the renewable energy prosumer for the purchase of electricity from the seller maintaining the prosumer's account. The unused surplus from the "prosumer deposit" is returned, but its amount may not exceed 20% of the value of electricity introduced by the prosumer into the network.

The net-billing model in Poland applies, in principle, to prosumer photovoltaic installations whose generation and introduction of electricity to the grid took place starting on 1 April 2022. In turn, photovoltaic installations that have started generating and introducing electricity into the distribution network through 31 March 2022 will still be able to use the system of net-metering. This is linked to the principle of protection of acquired rights, as changing the discount system may result in a change in the payback period. Changes to the discount system are important sources of legal risk for a photovoltaic installation project.

Installations up to 40 kW can be installed without any need to apply for a building permit—only a notification with the necessary attachments is needed. Large installations must apply for a building permit, which involves additional mapping for design purposes, mapping the micro-power plant, and an excerpt from the local spatial development plan [38]. A starting of the operation of photovoltaic microinstallation should be announced at least 30 days before the planned connection to the network of a given operator. The application must contain the relevant documents. After a positive substantive and formal assessment, the operator checks the technical condition of the microinstallation and sets up a security system and two-way remote reading meters, which are currently still free of charge [39].

2.3. Parameters of the Investment

The investment is a photovoltaic microinstallation with a capacity of 5.04 kWp, which was installed on a typical single-family house, whose average annual energy consumption was 4200 kWh. The price of a complete installation (12 IBC SOLAR solar panels, photovoltaic inverter, security cost, connection to the power grid, assembly) is 25,000 PLN (approx. 5500 €, 1 €~4.71 PLN, for 28 February 2023). In Polish climate conditions, an optimally located and constructed photovoltaic installation can produce 1000 kWh from each installed kWh of power [40]. The forecast of energy production from the panels considers the decrease in efficiency every year to be 0.5%. The analysis assumes a 25-year period of economically useful life of the panel system (Table 1). The analysis was carried out in variable prices for the purpose of real-life investment performed in 2022 just before the change in the law regarding the discount system to analyze the profitability before and after the changes, as well as under the conditions of an unstable political and economic situation representing legal and macroeconomic risk.

Table 1. Financial analysis assumptions.

Assumptions	Value
CAPEX	25,000 PLN
Installation power	5.04 kW
Increase of energy prices	2.5%
Decrease of effectiveness of the system	0.5%
Average energy price	0.401 PLN/kWh
Energy price	0.59 PLN/kWh
Daily system exploitation	30%
Discount rate	4%

This is not a typical income project, so the 4.0% discount rate recommended by the European Commission was used to discount cash flows [41]. The price of energy for a household customer included a fee for the provision of electricity distribution services. The analysis assumes an increase in electricity prices by an inflation rate of 2.5%, which is the formal inflation target of the National Bank of Poland [42].

In net-metering(Table A1), current consumption (daily system exploitation) is about 30% of the energy produced during the day. The remaining energy goes to the grid, where it is stored. The stored energy can be used within 12 months. In this system of discounts, knowing the amount of energy tariffs, the savings on bills that the investor will gain in individual years can be easily calculated. Regardless of the time of the day, year, or month the prosumer introduces energy to the grid, it will always have the same value, reduced by 20% for installations below 10 kW. Therefore, knowing the prices at which we can recover energy from our operator, we are able to determine the financial cash flows (Table A2) and the profitability of investments in the basic scenario in the net-metering system.

The second option is the settlement of produced energy using the net-billing system (Table A3). The surplus energy produced is sold at the price of the day and goes to the prosumer deposit. The amount from this deposit can be settled in the account for 12 months from the date it is credited as a deposit. From the purchase price of energy with all fees from the distributor, the amount from the deposit is deducted. Unused money within 12 months will be returned only up to 20% of the value of electricity fed into the grid. Thus, the net-billing system assumes a separate settlement of energy introduced into the electricity network and electricity taken from the power grid, based on a value determined according to the exchange price. In this system, the prosumer bears the costs of the distribution fee, because they buy the collected energy with all fees (including VAT), in accordance with the tariff of their seller. In this system, knowing the amount of energy tariffs, savings, financial cash flows (Table A4) and profitability of investments can also be calculated in the basic scenario in the net-billing system.

The tools applied to calculate project profitability in both discount systems were the payback period, the discounted payback period, the internal rate of return (IRR) and the net present value (NPV). The sensitivity analysis (taking into consideration the forecasted price increase of energy) was performed. The calculations were performed using Excel spreadsheets. The scenario analyzed included annual energy price increase of 2.5%, 5%, 10%, 20%, 30%, and 40% from the basic price (Table 1) and was performed for both discount systems—net-metering and net-billing. The other assumptions remained the same (Table 1).

3. Results

Installing a photovoltaic system on a building can bring many benefits, ranging from generating own energy (thereby becoming independent of the distributor) through reducing the pollutants emitted into the atmosphere and ending with the economic aspect, i.e., reducing electricity bills. Both methods of discount for the analyzed case are profitable. However, the net-billing system indicated lower values compared to the net-metering system. The payback period and the discounted payback period are longer for the "new" system. A profitability analysis for a 5.04 kW photovoltaic installation in conditions of higher energy price growth was also carried out. The price increase was simulated up to 40%, as the current prices of energy increased by about 45%, while inflation has been recorded officially as 14%. The results of analysis are presented for net-metering and net-billing system of discount (Tables 2 and 3).

Table 2. Financial analysis results for net metering.

Assumptions	Net-Metering					
Annual energy price increase	2.5%	5%	10%	20%	30%	40%
IRR	13.8%	16.3%	21.1%	30.8%	40.4%	50.0%
NPV (PLN)	28,837.52	44,681.21	101,015.31	487,272.24	2,325,227.34	10,760,467.76
Discount rate	4%	4%	4%	4%	4%	4%
Payback period	8	7	7	6	5	5
Discounted payback period	9	9	8	6	6	5

Table 3. Financial analysis results for net-billing.

Assumptions	Net-Billing					
Annual energy price increase	2.5%	5%	10%	20%	30%	40%
IRR	12.5%	15.0%	19.8%	29.4%	39.0%	48.5%
NPV (PLN)	24,298.03	38,600.46	89,439.64	437,916.48	2,095,909.44	9,704,996.16
Discount rate	4%	4%	4%	4%	4%	4%
Payback period	9	8	7	6	5	5
Discounted payback period	10	9	8	7	6	5

Comparing the profitability of investments in both settlement systems, net-billing is characterized by lower profitability under other unchanged conditions because the seller will return the money not used within 12 months only up to 20% of the value of electricity introduced into the network in the calendar month to which the refund of the overpayment relates to. It can be concluded that, from a financial point of view, it is not profitable to oversize the installation. In conditions of energy price increases higher than the NPB inflation target, the profitability of investments increases.

The change in the profitability of the investment (both because of the change in the assumptions of the project (change in the energy price growth rate) and changes in the method of discount) illustrates the risk of the project. The risk of an investment project is considered independently of other investment and financial decisions of the owners. It is caused by the degree of accuracy of the adopted technical, economic, and financial assumptions. The scope of risk depends mainly on the type of investment project, as well as the phase of its development. As the investor proceeds to the next phases of the project cycle, the degree of risk generally decreases. Greater risk accompanies the pre-investment phase and lowers in the operational phase, while the cost of risk mitigation increases over time. Risk may have positive or negative outcomes or may simply result in uncertainty. Therefore, risks may be related to an opportunity or a loss or the presence of uncertainty [43]. In the case study, the legal risk in the form of a change of law and the discount system decreases investment profitability, while the macroeconomic risk in the form of an increase in energy price results in profitability increases.

In the case study presented, the risk is related, among other factors, to meteorological conditions and technical issues such as the type of photovoltaic panels, but the analysis took the macroeconomic risk exemplified by the change of energy prices and the legal risk associated with a change in the method of discount under special consideration. The case study limitations relate to the fact that it is impossible to accurately predict the price level over the 25-year life of the investment. It is worth taking a safe level and correcting it for the trend of price increases as the case study showed. Finally, the situation of neutral profitability of the project was also assessed. It is a decrease in energy prices of about 7.55% for net-metering and about 6.3% for net-billing so that NPV = 0 and IRR equals the discount rate, which represents the neutral profitability of the investment.

4. Discussion and Conclusions

Investments in renewable energy sources increase the energy security of many regions of our country, and contribute to the improvement of energy supply in areas with poorly developed energy infrastructure. The development of RES also contributes to creating new jobs and, above all, reducing carbon dioxide emissions. The RES was installed as close as possible to the consumer results in the reduction of losses generated by energy transmission and allows for better control and improvement of network parameters in the vicinity of their connection.

One of the advantages of photovoltaic systems is decentralization—direct proximity to the consumer compared to other renewable energy sources. This is due to the relatively easy installation and operation of photovoltaic systems and the possibility of integration with other energy systems. Another argument in favor of photovoltaic systems refers to environmental aspects. This method of obtaining electricity is the most beneficial for the natural environment due to the lack of by-products in the form of waste, gases, or other pollutants. The main advantage of photovoltaics over other sources of renewable energy is its general availability. These systems can be installed in many sunny places. Unlike other RES, it does not need special conditions to function (such as a water or wind power plant). Low sound intensity also builds the advantage of these systems over other sources. Working panels are quiet, which makes them an ideal solution in built-up areas. Photovoltaic panels can be disposed of and, therefore, materials from the manufacturing process can be reused. These mean a positive impact on the environment and allow for a reduction in the amount of energy needed in the production process. All of the advantages mentioned above make photovoltaics an important element of renewable energy sources.

However, the rapid growth of micro-installations in Poland has not been accompanied by a modernization of electrical transmission networks or development of systems for storage of the produced energy. There are no systemic solutions (at the national level) regarding the storage of energy generated in this way, e.g., through the construction of new pumped-storage tanks, the appropriate stimulation of investments in energy storage facilities, etc. Experts also raise the problem of providing a stable or easy starting base source of energy (used instead of coil and/or gas). It is hoped that the announcements of the launch of the first nuclear power plant in Poland will not meet the same fate as the "Żarnowiec" in the 1990s (which was started but never completed) [44].

In the case of Poland, the new EU RES directive will reduce the importance of coal, but also biomass—in connection with which Poland, being largely forested, has had high hopes for in the past [45]. In general, experts weigh two parameters: the cost of energy transformation (and in the long term: generated savings) versus increased operating costs based on the current model. The latter was mercilessly revealed by the geopolitical situation of the last year and associated with increases in energy prices. Somewhere in the background, the cost of non-measurable changes in climate, its impact on our health, and more and more frequent extreme weather events are rarely mentioned.

The emission of greenhouse gases in energy (electricity and heat production together) is the largest part of pollution—25%. In second place is widely understood to be "Agricultural" (24%). According to a 2014 EPA and IPCC/USA report, 14% of pollution comes from transportation [46]. According to other sources and different approach to pollution calculation, livestock (including, among others, farming, feeding, transportation, and slaughtering) accounts for 37% of gas emissions. In terms of the type of pollutants, methane is the primary sources of greenhouse gases [47] and more than half of the greenhouse gases are carbon emission. Fossil fuels and industry are responsible for 89% of carbon emission.

The development of micro-installations, aimed at reducing emissions concerns the construction industry, which, according to the report, is responsible for only 6% of greenhouse gas emissions. Polish cities are still developing "outwards". Reducing emissions related to transportation and construction will be a big challenge as a significant portion of houses are energy inefficient, the weather is not favorable to bicycles or public transport users for approximately half a year, and every third car is 20 years old. Moreover, the purchasing power in Poland is still one of the lowest in the EU. Probably, all of those factors are also responsible for the scale of investment in photovoltaic installations in Poland. The cost of the installation is still lower than the cost of building thermal modernization or buying a new, more efficient, and cleaner car, and temporarily helps to reduce current living costs. However, does such a sequence/order of support make sense?

All large-scale investments in macroeconomics have a sinusoidal character over time—whether we are talking about energy or biotechnology. Fuel crisis? Development of alternative fuels. Lack of rare earth metals? Bio-metallurgy/Bioleaching. Expensive gas and oil . . . Will the answer be renewable energy sources (RES)?

Fit 55 is ambitious—that's true. In the case of Poland, it is difficult to achieve and is definitely too expensive to bear without pain at the assumed pace of change, but above all, it is a change in the economic model and lifestyle. The European Union has always tried to "introduce innovative solutions with a human face" in contrast to strongly capitalist, liberal economies. Will "running/escape forward" be good for the EU this time? Time will show.

For now, the authors conclude that, regardless of the degree of incentives (e.g., in the form of subsidies) or changes in regulations to less favorable methods, installed photovoltaic installations in Poland are motivated by reducing the costs of exploitation of the building—and environmental benefits are forced into the background. The main research conclusion shows that the "boom" for photovoltaics in Poland suggests that the "regulator" is achieving its intended goal relating the implementation of solutions supporting sustainable development and a triple bottom line. Sustainable development and the climate neutrality created a starting point for the research, while the triple helix could be also a research context [48]. The triple helix model of university–industry–government interaction (which refers to innovation-driven development and knowledge-based economies) might be a concept to develop the research focused on social returns on RES projects funded by government decision-makers.

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Appendix A

Table A1. The energy settlement with the net-metering system.

Year	Annual Energy Production from Panels Taking into Account the Decrease in Efficiency (kWh)	Estimated Annual Energy Coverage of Panels During the Day (kWh)	Annual Surplus Production to be Used (for Installations below 10 kWp 0.8)	Energy Purchased from the Energy Company (kWh)	Annual Cost of Purchase of Purchased Energy (PLN)	Annual Cost of Purchasing Energy without Panels (PLN)	Difference between Bills (Savings) (PLN)
1	5040	1512	2822	-	-	2478	2478
2	5015	1504	2808	-	-	2540	2540
3	4990	1497	2794	-	-	2603	2603
4	4965	1489	2780	-	-	2669	2669
5	4940	1482	2766	-	-	2735	2735
6	4915	1475	2753	-	-	2804	2804
7	4891	1467	2739	-	-	2874	2874
8	4866	1460	2725	15	11	2946	2935
9	4842	1453	2711	36	26	3019	2993
10	4818	1445	2698	57	42	3095	3053
11	4794	1438	2684	78	59	3172	3114
12	4770	1431	2671	98	76	3251	3175
13	4746	1424	2658	119	94	3333	3239
14	4722	1417	2644	139	113	3416	3303
15	4698	1410	2631	159	133	3501	3369
16	4675	1402	2618	180	153	3589	3435
17	4652	1395	2605	200	175	3679	3504
18	4628	1388	2592	220	197	3771	3573
19	4605	1382	2579	240	220	3865	3644
20	4582	1375	2566	259	245	3961	3717
21	4559	1368	2553	279	270	4060	3791
22	4536	1361	2540	299	296	4162	3866
23	4514	1354	2528	318	323	4266	3943
24	4491	1347	2515	338	351	4373	4021
25	4469	1341	2502	357	381	4482	4101

Table A2. Cash flows for net-metering system.

Year	Difference between Bills (Savings) (PLN)	CAPEX (PLN)	Subsidy	Cash Flow	Discounted Cash Flow	Cumulated Cash Flow	Cumulated Discounted Cash Flow
0		−25,000	5000	−20,000	−20,000	−20,000	−20,000
1	2478			2478	2383	−17,522	−17,617
2	2540			2540	2348	−14,982	−15,269
3	2603			2603	2314	−12,379	−12,955
4	2669			2669	2281	−9710	−10,673
5	2735			2735	2248	−6975	−8425
6	2804			2804	2216	−4171	−6210
7	2874			2874	2184	−1297	−4026
8	2935			2935	2145	1638	−1881
9	2993			2993	2103	4631	222
10	3053			3053	2062	7684	2284
11	3114			3114	2022	10,797	4307
12	3175			3175	1983	13,973	6290
13	3239			3239	1945	17,211	8235
14	3303			3303	1907	20,514	10,142
15	3369			3369	1870	23,883	12,013
16	3435			3435	1834	27,318	13,847
17	3504			3504	1799	30,822	15,646
18	3573			3573	1764	34,395	17,410
19	3644			3644	1730	38,039	19,139
20	3717			3717	1696	41,756	20,836
21	3791			3791	1663	45,547	22,499
22	3866			3866	1631	49,413	24,131
23	3943			3943	1600	53,356	25,730
24	4021			4021	1569	57,377	27,299
25	4101			4101	1538	61,478	28,838

Table A3. The energy settlement with the net-billing system.

Year	Annual Energy Production from Panels Taking into Account the Decrease in Efficiency (kWh)	Estimated Annual Energy Coverage of Panels during the Day (kWh)	Annual Surplus Production (kWh)	Sale of Surplus (PLN)	Energy Demand not Covered by Panels (kWh)	The Purchase Price of Energy not Covered by Panels (PLN)	Energy Purchase Price—Sales Surplus (PLN)	Annual Cost of Purchasing Energy without Having Panels (PLN)	Difference between Bills (Savings) (PLN)
1	5040	1512	3528	1415	2688	1586	171	2478	2307
2	5015	1504	3510	1443	2696	1630	187	2540	2353
3	4990	1497	3493	1472	2703	1676	204	2603	2399
4	4965	1489	3475	1501	2711	1722	221	2669	2447
5	4940	1482	3458	1531	2718	1770	240	2735	2496
6	4915	1475	3441	1561	2725	1819	258	2804	2545
7	4891	1467	3423	1592	2733	1870	278	2874	2596
8	4866	1460	3406	1624	2740	1922	298	2946	2648
9	4842	1453	3389	1656	2747	1975	319	3019	2700
10	4818	1445	3372	1689	2755	2030	341	3095	2754
11	4794	1438	3356	1722	2762	2086	364	3172	2809
12	4770	1431	3339	1757	2769	2144	387	3251	2864
13	4746	1424	3322	1792	2776	2203	411	3333	2921
14	4722	1417	3305	1827	2783	2264	437	3416	2979
15	4698	1410	3289	1864	2790	2326	463	3501	3039
16	4675	1402	3272	1901	2798	2390	490	3589	3099
17	4652	1395	3256	1938	2805	2456	518	3679	3161
18	4628	1388	3240	1977	2812	2524	547	3771	3223
19	4605	1382	3224	2016	2818	2594	577	3865	3287
20	4582	1375	3208	2056	2825	2665	609	3961	3353
21	4559	1368	3191	2097	2832	2738	641	4060	3419
22	4536	1361	3176	2139	2839	2813	675	4162	3487
23	4514	1354	3160	2181	2846	2891	709	4266	3557
24	4491	1347	3144	2225	2853	2970	745	4373	3627
25	4469	1341	3128	2269	2859	3051	783	4482	3699

Table A4. Cash flows for net-billing system.

Year	Difference between Bills (Savings) (PLN)	CAPEX (PLN)	Subsidy	Cash Flow	Discounted Cash Flow	Cumulated Cash Flow	Cumulated Discounted Cash Flow
0		−25,000	5000	−20,000	−20,000	−20,000	−20,000
1	2307			2307	2218	−17,693	−17,782
2	2353			2353	2175	−15,341	−15,607
3	2399			2399	2133	−12,941	−13,474
4	2447			2447	2092	−10,494	−11,382
5	2496			2496	2051	−7998	−9331
6	2545			2545	2012	−5453	−7319
7	2596			2596	1973	−2857	−5346
8	2648			2648	1935	−209	−3412
9	2700			2700	1897	2491	−1515
10	2754			2754	1860	5244	346
11	2809			2809	1824	8053	2170
12	2864			2864	1789	10,917	3959
13	2921			2921	1754	13,839	5714
14	2979			2979	1721	16,818	7434
15	3039			3039	1687	19,857	9121
16	3099			3099	1655	22,956	10,776
17	3161			3161	1623	26,116	12,398
18	3223			3223	1591	29,339	13,990
19	3287			3287	1560	32,627	15,550
20	3353			3353	1530	35,980	17,080
21	3419			3419	1501	39,399	18,581
22	3487			3487	1472	42,886	20,052
23	3557			3557	1443	46,443	21,495
24	3627			3627	1415	50,070	22,910
25	3699			3699	1388	53,770	24,298

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