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Energy Transition of Poland Supports the Dynamic Development of Photovoltaics - Quantitative Analysis

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Abstract
This study analyzes the rapid development of photovoltaic (PV) energy production in Poland, highlighting its growing importance in the country's energy transition and its efforts to meet EU climate and energy targets. Over the past two decades, Poland has undergone a significant transition from reliance on fossil fuels, such as coal, to the use of renewable energy sources, with photovoltaic (PV) energy becoming one of the most dynamic and transformative sources. The study identifies the key drivers of this growth, including a favorable regulatory framework, technological advances in photovoltaic systems, and financial incentives such as the "My Current" program, which has significantly accelerated the deployment of home solar installations. In addition to analyzing the historical growth of the sector, the study examines the structural and systemic challenges that will hinder further PV expansion, including limited grid infrastructure capacity, the need for more efficient energy storage solutions, and regulatory complexities that impede large-scale deployment. The article also compares the development of PV in Poland with leading European countries in the field, such as Germany, Spain, and Italy, as well as with Central and Eastern European countries, such as Slovakia, the Czech Republic, and Hungary, offering valuable insight into Poland's position in the European renewable energy sector and its future prospects. The results presented in the article not only illustrate the remarkable growth of photovoltaic capacity in Poland over the past two decades but also shed light on challenges such as grid infrastructure constraints, regulatory barriers, and the need for investment in energy storage.

Keywords
Photovoltaics, renewable energy, solar energy, sustainability, energy transition.

Introduction

Energy, which is the foundation of modern economies, is undergoing dynamic changes catalyzed by both technological advances and changing political conditions and social expectations. In an era of global warming and increased environmental awareness, the direction of energy development is beginning to depend more and more on renewable sources (Hassan et al., 2024). In Poland, a country long dominated by traditional energy sources such as coal and lignite (Widera et al., 2024), these challenges take on a special dimension due to the need to redefine the energy future in the context of climate and energy commitments to the European Union (Jorge-Vazquez et al., 2024).

The energy industry is currently undergoing a period of significant change in response to a number of global challenges (Xu et al., 2024). First and foremost, climate change and the growing environmental awareness of societies are putting pressure on the energy sector to seek and implement sustainable solutions (Joel & Oguanobi, 2024). Technological advances, particularly in areas such as photovoltaics, wind turbines, and energy storage technologies, are creating new opportunities for the generation and utilization of renewable energy (Nwokediegwu et al., 2024).

However, Poland, as a country dependent on coal and lignite for many years, the energy transition process is particularly complicated. Traditional dependence on coal not only shapes infrastructure and technology but also affects local economies, politics, and society (Černoch et al., 2024; Sinaga et al., 2024). The introduction of renewable technologies requires not only capital investment but also structural change, education, and social support (Hashemizadeh et al., 2024; Pavláková Dočekalová et al., 2024). Meanwhile, European Union membership obligations, such as reducing emissions of harmful gases, impose on Poland the need to accelerate energy sector reform measures (Szulecki et al., 2024).

Energy transitions are also affecting public perceptions and expectations (Al-Humairi et al., 2024; Parente et al., 2024). Growing environmental awareness is translating into greater support and acceptance for investments in renewable energy sources, such as solar and wind, which are seen as key to a sustainable future (Jabbour Al Maalouf et al., 2024).

Redefining Poland's energy future in the context of its commitments to the European Union and global environmental imperatives is, therefore, a task that requires an integrated approach, taking into account both the latest technological developments and broader socioeconomic interests.

The article highlights the key role of photovoltaic (PV) energy as a dynamic component of Poland's renewable energy sector, reflecting a broader global shift toward sustainable energy production. This transformation is being driven by technological innovations, such as high-efficiency solar panels and advanced energy storage solutions, which have increased the feasibility of solar energy even in regions with moderate sunlight, such as Poland. Despite its initial reliance on coal, Poland's adoption of photovoltaic technologies shows its potential to transition to cleaner energy systems and align with international targets.

The study aims to analyze the historical and current development of the photovoltaic sector in Poland, identify the factors driving this growth, and assess the role of government programs, such as "My Current," and EU directives, such as RED II, in shaping the country's energy transition. Objectives include assessing the contribution of PV installations to Poland's renewable energy mix and overall energy system, as well as comparing the country's progress with leading PV markets in Europe.

To achieve its objectives, the paper employs a comprehensive methodology that incorporates quantitative analysis of statistical data and qualitative assessment of the regulatory framework, technological progress, and economic conditions. The study analyzed key trends in installed photovoltaic (PV) capacity, number of installations, and financial and policy instruments supporting the development of the sector, such as support programs in Poland, Germany, Spain, Italy, France and also Slovakia, the Czech Republic and Hungary.

Literature review

Solar energy and photovoltaic technologies play a crucial role in the global energy transition, which addresses growing climate and environmental challenges (Adelekan et al., 2024; Adanma & Ogunbiyi, 2024). This transformation is essential in the face of climate change, the depletion of fossil fuel resources, and the need to reduce greenhouse gas emissions (Dilanchiev et al., 2024; Wang & Azam, 2024; Straka et al., 2021). In particular, solar energy, as one of the cleanest and most abundantly available energy sources, can play a fundamental role in achieving the Sustainable Development Goals (Adebayo & Ullah, 2024; Lyulyov et al., 2024).

Since the Industrial Revolution, humanity has based industrial development, infrastructure, and improved living standards on fossil fuels such as coal, oil, and natural gas (Zhironkin & Abu-Abed, 2024). These energy sources, although they enabled global progress, had serious side effects, including environmental degradation, increased greenhouse gas emissions, and health problems from air pollution (Acheampong & Opoku, 2023). In recent decades, however, it has been understood that it is necessary to move away from these traditional energy sources to more sustainable solutions (Surya et al., 2024) that not only protect the environment but also provide stability and energy independence (Li et al., 2024).

Photovoltaics, which uses solar radiation to generate electricity, is one of the most rapidly growing renewable energy sectors in Poland (Iglinski et al., 2023). Although insolation in Poland does not match the levels of southern European countries such as Spain or Italy, the development of modern technologies has enabled photovoltaic panels to operate efficiently even with moderate insolation (Kuczynski & Chliszcz, 2023). As a result, Poland has the necessary conditions for the large-scale deployment of these technologies, and solar energy is becoming increasingly cost-effective for both households and businesses (Witkowska-Dąbrowska et al., 2023).

The development of photovoltaics in Poland started relatively late, and the first investments in this sector were limited mainly due to the lack of adequate legal regulations and financial support (Bórawski et al., 2023). Following Poland's accession to the European Union in 2004, the situation began to change gradually. The implementation of EU climate and energy requirements, such as the Renewable Energy Directives (for instance, RED I and RED II), created a legal and financial framework for the development of solar power (Mazurek-Czarnecka et al., 2022). Commitments to increase the share of renewable energy sources (RES) in the energy mix accelerated the sector's development, although the real breakthrough did not come until 2015 with the enactment of the Renewable Energy Sources Act (Ciepielewska, 2016; Olejarczyk, 2016).

One of the key elements supporting the development of photovoltaics in Poland has been financial support mechanisms, such as the "My Current" program. This program, launched in 2019, enabled households to obtain subsidies for PV installations, which significantly increased interest in PV technologies (Burzynska, 2023). Between 2019 and 2023, the number of PV micro-installations increased from 150,000 to over 1.4 million, making Poland one of the leading growth countries in the PV sector in Europe (Ministry of Climate and Environment, Poland, 2024).

Against the background of Europe, the development of photovoltaics in Poland stands out for its high dynamics, although in total terms, it is still inferior to the largest producers in the PV market, such as Germany, Spain, and Italy (Hysa & Mularczyk, 2024). Germany, which has been at the forefront of the photovoltaic (PV) sector for years, reached more than 65 GW of installed PV capacity in 2024, representing the largest share in Europe (Silveira et al., 2024). Spain, on the other hand, is rapidly developing large-scale PV farms, making solar power about 20% of the energy mix there (SolarPower Europe, 2025). Italy, due to its favorable climatic conditions and long-standing public support, is maintaining steady growth in the sector, reaching nearly 30 GW of installed capacity in 2024 (Eurostat, 2025).

In Central and Eastern Europe, countries such as Slovakia, the Czech Republic, and Hungary are also experiencing dynamic growth in the PV sector, although they still lag behind the leaders. Hungary, thanks to heavy investment in PV infrastructure, has reached 5.8 GW of installed capacity by 2024, which translates into 32.1% of PV's share of RES and 10.2% of the total energy mix (Magyar Energetikai Hivatal, 2025). The Czech Republic, which has invested in stable support programs and grid modernization, saw 4.5 GW of installed PV capacity in 2024, representing a 36.5% share of RES and 8.4% of the total energy mix (Energetický regulační úřad, 2025). Slovakia, with less potential and slower development, has reached 1.3 GW of PV capacity, which translates into a 28.3% share of PV in RES and 6.2% in the mix (Slovenská energetická agentúra, 2025).

Photovoltaics in Poland, although growing rapidly, reached approximately 20 GW of installed capacity by 2024, accounting for more than 62.7% of the country's installed RES capacity (Energy Regulatory Office, 2025). This is an impressive result in the context of a short period of intensive investment, but it still represents a smaller share compared to European leaders (Nawrocki et al., 2024). Poland, however, comes close to the performance of the Czech Republic and Hungary, and in many aspects surpasses Slovakia. At the same time, Poland, like other countries in the region, faces challenges, including insufficient transmission grid capacity and the need to modernize its energy infrastructure and simplify procedures for connecting new installations (Barwińska-Małajowicz et al., 2023).

EU regulations, such as the RED II Directive, require all member states, including Poland, the Czech Republic, Hungary, and Slovakia, to achieve at least a 32% share of RES in final energy consumption by 2030 (Jankowska-Karpa & Wnuk, 2024). By comparison, in 2023, the share of renewable energy in Germany was about 42% (Pata et al., 2023), in Spain 46% (Auguadra et al., 2023), while in Poland the result was about 16.9%, in the Czech Republic 19%, in Hungary 22% and in Slovakia 18.5% (Eurostat, 2025). The development of photovoltaics in these countries demonstrates that, despite regional differences, all countries are moving toward increasing their share of renewable energy, with photovoltaics playing a key role in the energy transition.

In the context of sustainable development and decision-making support, several studies highlight the potential of intelligent models based on fuzzy logic in addressing complex socio-economic challenges. For example, Gavurova et al. (2023) presented a fuzzy decision support model for evaluating and selecting healthcare projects in a competitive environment, which could be adapted to energy-related initiatives. Similarly, a model for travel planning for people with disabilities demonstrates how fuzzy logic can support inclusivity in urban and infrastructure planning (Gavurova & Polishchuk, 2025). Studies focused on managing patient trust in medical staff (Gavurova et al., 2024) and the integration of IT in healthcare institutions (Smolanka et al., 2024) further confirm the effectiveness of intelligent solutions in complex systems. These approaches could be transferred to the energy domain, especially in decision-making on PV site selection and renewable infrastructure development. In addition, the works by Skare et al. (2023a, 2023b) explore large-scale decision-making models for financing start-up and tourism infrastructure projects, which is highly relevant for stimulating investments in the solar energy sector. Finally, Moravec et al. (2025) analyze algorithmic personalization and digital media literacy, which is crucial for public engagement and promoting environmentally friendly energy solutions. Thus, interdisciplinary approaches based on AI and fuzzy set theory can serve as a foundation for comprehensive management models in the energy transition.

Photovoltaics in Europe have a diverse set of conditions driven by local policies, natural resources, and government support (Hilker et al., 2024). Countries such as Denmark, Austria, and the Netherlands, despite their smaller areas, are achieving significant successes in integrating solar power into national energy systems, thanks to effective regulation and investment in storage technologies (Breyer et al., 2023; Wohlfart, 2024; Zhang, 2023). Poland can draw inspiration from these experiences to increase the efficiency of the solar PV sector while supporting the energy transition and meeting EU climate goals (Brodny et al., 2024).

Despite barriers such as a changing regulatory environment and infrastructure constraints, solar energy remains one of the most important elements of the energy transition in Europe and Poland (Kryszk et a., 2023). Supported by EU programs and national initiatives, solar PV has the potential to become a cornerstone of modern energy, contributing to sustainable development, improved quality of life, and increased local and international energy security.

Methodology

The research method used was based on trend analysis and empirical data, the purpose of which is to gain a thorough understanding of the dynamics of photovoltaic development in Poland in the context of the energy transition. The method enables monitoring, comparing, and interpreting changes in installed capacity, the number of installations, and the average power of individual installations over time. It aims to identify key trends in the sector's development, identify factors accelerating this growth, such as supportive policies or technological development, and compare Poland's achievements with those of other European countries. In addition, the study aims to assess the role of photovoltaics in the Polish energy mix and its importance in the renewable energy sector, taking into account the changing regulatory and technological environment.

The study was based on a wide range of statistical data on the installed capacity of photovoltaics and the number of installations in Poland from 2005 to 2024, sourced from reliable institutions such as the CSO, the ERO, and Solar Power Europe. An important part of the analysis also involves a detailed assessment of policy documents and regulations, including EU directives such as RED II and national legislation, such as the Renewable Energy Sources Act. The study was enriched by an international comparison, which included data from countries with developed PV markets, such as Germany, Spain, Italy, and France, as well as countries in Central and Eastern Europe, including Slovakia, the Czech Republic, and Hungary. The addition of these countries allowed for a broader view of the development of the PV sector in the region and its characteristics. Data for Slovakia, the Czech Republic and Hungary came from reliable national sources, such as Slovenská energetická agentúra, Energetický regulační úřad and Magyar Energetikai és Közmű-szabályozási Hivatal. In this way, it was possible to compare the dynamics of the development of the photovoltaic market in Poland with other countries in the region that are also undergoing an energy transition.

The analysis also takes into account trend modeling, which enables the forecasting of further growth in installed PV capacity and its share in the Polish energy mix. The study also utilized historical data and considered key socioeconomic events, including the impact of the COVID-19 pandemic and the war in Ukraine, which were relevant to the development of the energy sector.

The result of this method is a detailed determination of the growth rate of installed photovoltaic capacity in Poland over almost two decades. It was possible to identify key moments in the development of this sector, such as the introduction of the "My Current" program in 2019 and the sharp increase in the number of installations from 2020 to 2023. Comparing Poland's position with European leaders in photovoltaics makes it possible to illustrate the dynamics of change and the challenges facing the country. The method also enables the identification of barriers to the further development of photovoltaics. The survey results provide a comprehensive picture of the current state of photovoltaics in Poland and its growing importance in the context of the European energy transition.

Results and Discussion

Historical data on the development of photovoltaics in Poland between 2005 and 2024 reveal significant changes in installed capacity, the number of installations, the average power of a single installation, and key events that impacted the sector. This information makes it possible to trace how photovoltaics has gone from a marginal energy source to one of the pillars of Poland's energy mix. The analysis of the data presented illustrates the impact of technological, economic, and regulatory factors on the sector's growth dynamics and its role in Poland's energy transition (Table 1).

Table 1. Development of photovoltaics in Poland from 2005 to 2024

Year	Installed capacity (MW)	Number of photovoltaic installations	Average installation power (kW)	Comments
2005	0,3	< 100	5,0	First micro-installations in Poland.
2010	2,0	~500	6,7	Initial surge of interest in PV.
2015	110,9	~10 000	7,4	Start of major investments in RES.
2018	486,0	~55 000	8,8	The beginning of a boom in microinstallations.
2019	1500,0	~150 000	6,5	The "My Current" program is accelerating development.
2020	3960,0	~450 000	6,7	Photovoltaics as the RES leader in Poland.
2021	7670,0	~850 000	6,8	Record growth in the number of installations.
2022	12 189,0	~1 200 000	9,7	Further development of micro and PV farms.
2023	17 057,0	~1 400 000	10,1	Poland is one of the leaders in the EU.
2024	20 555,4	~1 500 000	13,7	Large photovoltaic farms are beginning to play a larger role.

Source: Own compilation based on data: https://stat.gov.pl/energia/ (accessed January 9, 2025); https://ieo.pl/ (accessed January 9, 2025); https://ure.gov.pl/ (accessed January 9, 2025)

Between 2005 and 2018, photovoltaics in Poland underwent dynamic development, from a marginal share in the energy mix to a key segment of RES. In 2005, the installed capacity was 0.3 MW (60 installations), and by 2018, it had reached 486 MW (55,000 installations). This growth was made possible by support programs such as "My Current" and RES auctions, which increased interest in both micro-installations and photovoltaic farms.

Data on the growth of photovoltaic installed capacity in relation to total energy capacity and renewable energy sources (RES) in Poland from 2010 to 2024 helps illustrate the changing share of photovoltaics in the national energy structure. This information highlights the growing importance of photovoltaics in the context of the energy transition, considering both Poland's total energy capacity and the installed capacity of renewable energy sources (RES). The analysis of these data enables an understanding of the long-term trends and dynamics of the country's renewable energy sector (Table 2).

Table 2. Share of photovoltaics in total energy and RES energy in Poland (2010-2024)

Year	**Total energy capacity in Poland (MW)**	**Installed capacity of RES (MW)**	**Installed photovoltaic capacity (MW)**	**Share of photovoltaics in RES (%)**	**Share of photovoltaics in total power (%)**
2010	35 000,0	2 200,0	2,0	0,1	0,006
2015	41 000,0	6 700,0	110,9	1,7	0,27
2018	44 000,0	8 500,0	486,0	5,7	1,1
2020	47 000,0	10 800,0	3 960,0	36,7	8,4
2022	51 500,0	14 300,0	12 189,0	85,2	23,7
2024	71 981,8	32 762,2	20 555,4	62,7	28,6

Source: own compilation based on: https://solarpowereurope.org/ (accessed January 10, 2025); https://stat.gov.pl/ (accessed January 10, 2025); https://ieo.pl/ (accessed January 10, 2025).

In 2010, the share of photovoltaics in both RES and the country's total energy capacity was marginal, at 0.1% and 0.006%, respectively. However, the rapid development of the photovoltaic sector has caused significant changes in the structure of energy production.

In 2024, the installed capacity of photovoltaics was 20,555.4 MW, accounting for 62.7% of the country's total RES capacity and 28.6% of its total energy capacity. These figures underscore the growing importance of photovoltaics as a key component of Poland's energy transition.

Since 2005, the development of photovoltaics in Poland has been extremely dynamic, as reflected in the data on installed capacity, including micro-installations, medium-capacity installations, and large photovoltaic farms (Table 3).

Table 3. Increase in installed capacity in Poland by category of installation (2005-2024)

Year	**Installed capacity (MW)**	**Microinstallations <50 kW (MW)**	**51-999 kW installations (MW)**	**Installations ≥ 1000 kW (MW)**	**Energy production (GWh)**	**Share of PV in total energy production (%)**
2005	0,3	0,2	0,1	0,0	0,2	0,001
2010	2,0	1,2	0,5	0,3	1,2	0,007
2015	110,9	55,8	35,1	20,0	80,1	0,05
2018	486,0	250,5	150,6	84,9	410,0	0,3
2019	1500,0	825,0	475,5	199,5	1200,0	0,8
2020	3960,0	2178,6	1095,7	685,7	3950,0	2,6
2021	7670,0	4385,4	2209,6	1075,0	7600,0	5,0
2022	12 189,0	7119,4	3180,3	1889,3	12 000,0	7,5
2023	17 057,0	9805,2	4180,4	3071,4	16 700,0	10,1
2024	20 555,4	11859,9	4738,1	3957,4	20 000,0	12,5

Source: Own compilation based on: https://stat.gov.pl/energia (accessed January 9, 2025); https://ieo.pl/ (accessed January 10, 2025); SolarPower Europe https://solarpowereurope.org (accessed January 11, 2025); https://www.gov.pl/web/klimat accessed January 10, 2025)

At the beginning of the analyzed period, in 2005, photovoltaics was a marginal source of energy, with only 0.3 MW of installed capacity and energy production of 0.2 GWh, which accounted for only 0.001% of Poland's total energy production. Growth in the first decade was very slow due to the lack of regulatory and technological support.

The breakthrough came after 2015, when installed capacity increased to 110.9 MW and energy production reached 80.1 GWh. This was thanks to the introduction of regulations supporting renewable energy sources and greater interest in prosumer installations. In the following years, the sector experienced rapid growth, particularly in 2019, when the "My Current" program and a decline in installation costs significantly accelerated the development of micro-installations. This year, installed capacity increased to 1,500 MW, and energy production reached 1,200 GWh, which already accounted for 0.8% of total energy production.

Between 2020 and 2024, Poland's photovoltaics sector experienced its highest growth in history. In 2020, installed capacity reached 3960 MW, and energy production reached 3950 GWh, accounting for 2.6% of total energy production. By 2024, the installed capacity had increased to 20,555.4 MW, and energy production had reached 20,000 GWh, translating into a 12.5% share of the national energy mix. This growth was driven by the development of micro-installations, which accounted for more than 11,800 MW of capacity in 2024, as well as the growing share of medium-sized installations and large-scale photovoltaic farms.

An important part of the table is to show the structure of installed capacity. Microinstallations accounted for the largest share, indicating the dominant role of prosumers such as households and small businesses. However, the importance of medium-sized installations and large PV farms has also increased in recent years, indicating the interest of larger investors and the development of professional photovoltaic projects.

The table's conclusions underscore the key role of photovoltaics in Poland's energy transition. Its share of total energy production has risen from almost zero in 2005 to more than 12% in 2024. This shows how effectively the sector has responded to the needs of decarbonization, technological development, and the growing environmental awareness of society. Further growth, however, requires investment in grid infrastructure and energy storage to realize the full potential of solar PV.

Key financial and organizational data related to the development of photovoltaics in Poland in 2015-2024 include indicators such as the average cost of installation per 1 kW, the average amount of subsidies under support programs, the number of beneficiaries (e.g., participants in the "My Current" program), and the payback time for an average 5 kW installation. In addition, the data takes into account the percentage of households and businesses in new installations. Analysis of these indicators allows a better understanding of the dynamics of PV sector development and the structure of beneficiaries, reflecting the changing costs of the technology and the growing popularity of PV installations among prosumers (Table 4).

Table 4. Financial and organizational data for photovoltaics in Poland (2015-2024)

Year	**Average cost of installation (PLN/kW)**	**Average amount of funding (PLN)**	**Number of program beneficiaries (thousands).**	**Payback time (years)**	**Share of households in installations (%)**	**Share of companies in installations (%)**
2015	6000	0	0	12	80.0	20.0
2018	4500	0	0	10	85.0	15.0
2020	4000	5000	500	8	90.0	10.0
2022	3800	3000	900	7	92.0	8.0
2024	3600	2000	1200	6	94.0	6.0

Source: Own compilation based on: https://www.ure.gov.pl/ (accessed January 13, 2025); https://ieo.pl/ (accessed January 13, 2025)

The average cost of installation per kW has been decreasing successively, from 6,000 PLN in 2015 to 3,600 PLN in 2024, indicating a reduction in the cost of photovoltaic technologies. Subsidies, such as the "My Current" program, were introduced in 2020 and significantly contributed to the increase in the number of beneficiaries. In 2024, approximately 1.2 million households and companies received support through various programs.

The payback time for investments shrinks from 12 years in 2015 to 6 years in 2024, making solar PV more economically attractive. The share of households in new installations increased from 80% in 2015 to 94% in 2024, while the share of businesses decreased from 20% to 6%.

Photovoltaics accounted for 62.74% of the installed capacity in the Polish RES sector (20,555.4 MW), ahead of wind power (30.14%) (Fig. 1).

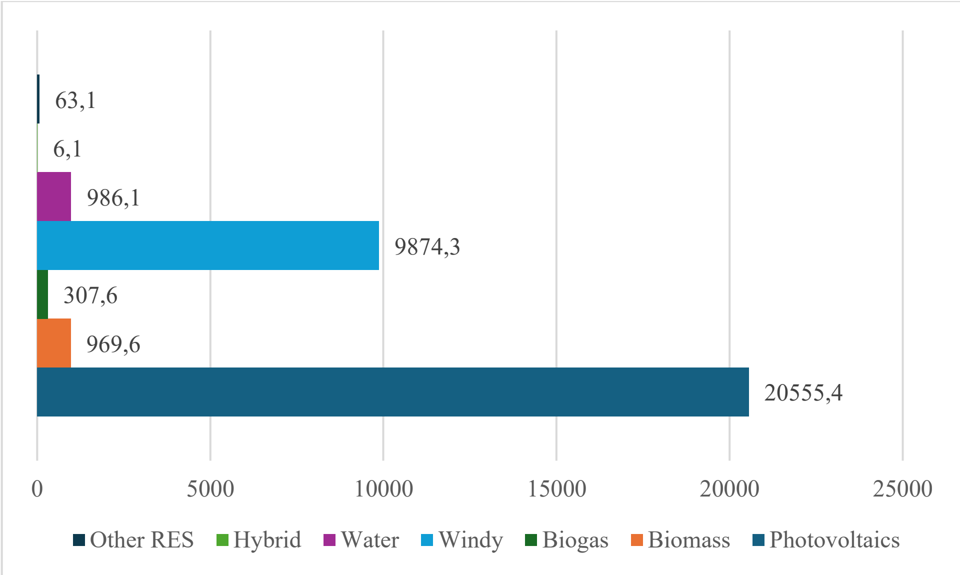

Fig. 1. Installed photovoltaic capacity (MW) vs. RES in 2024

Poland's total RES capacity amounted to 32,762.2 MW, accounting for 45.5% of the country's energy mix. These figures underscore the dominant role of photovoltaics, which has become a pillar of the energy transition and a key element in meeting climate goals.

The dynamics of the development of installed PV capacity in Poland against the background of selected PV market leaders in Europe, such as Germany, Spain, Italy, and France, as well as countries in Central and Eastern Europe, such as Slovakia, the Czech Republic, and Hungary, makes it possible to see both Poland's achievements and the differences in the advancement of technology and development strategies of the PV sector in each country. An analysis of the data reveals the extent to which Poland is keeping up with leading European markets and what challenges and opportunities the sector faces in the context of further energy transition (Table 5).

Table 5. Development of photovoltaics in Poland and selected EU countries (2010-2024)

Year	Poland (MW)	Germany (MW)	Spain (MW)	Italy (MW)	France (MW)	Slovakia (MW)	Czech Republic (MW)	Hungary (MW)
2010	2	17 000	4 000	3 500	1 000	0	50	0
2015	110	39 700	5 400	18 900	6 600	500	2 120	200
2018	486	45 930	5 600	20 120	8 500	600	2 300	800
2019	1500	49 000	8 700	20 800	9 400	700	2 400	1 500
2020	3960	53 000	10 000	21 600	10 600	800	2 500	1 800
2021	7670	59 000	13 000	22 500	12 000	900	2 600	2 500
2022	12 189	66 500	19 000	24 000	14 000	1 100	3 400	3 700
2023	17 057	82 200	26 300	28 000	16 000	1 200	4 000	4 700
2024	20 555	90 000	32 000	30 000	18 000	1 300	4 500	5 800

Source: Own compilation based on: https://solarpowereurope.org/ (accessed January 11, 2025); https://irena.org/ (accessed January 10, 2025); https://www.ise.fraunhofer.de/ (accessed January 10, 2025); https://www.mpo.cz (accessed January 10, 2025); http://www.sea.gov.sk (accessed January 12, 2025); https://www.mekh.hu (accessed January 14, 2025);

At the beginning of the period under review, Germany clearly dominated with an installed capacity of 17 GW, while Poland started practically from scratch, just 2 MW in 2010. Western European countries, such as Spain, Italy, and France, also achieved significant milestones during this period, reaching 4 GW, 3.5 GW, and 1 GW, respectively. In Poland, a significant breakthrough occurred after 2015, when installed capacity increased from 110.9 MW to 486 MW in 2018 and then to 12.2 GW in 2022, reaching a projected 20.6 GW by 2024. This growth was driven by several key factors, including the introduction of support programs such as "My Electricity" and feed-in tariff schemes, falling technology costs, and growing public awareness of environmental issues. Countries in the region experienced similarly rapid growth, such as Hungary, which increased its capacity from 0 MW in 2010 to a projected 5.8 GW by 2024, and the Czech Republic, which expanded its PV systems, increasing capacity from 50 MW in 2010 to 4.5 GW by 2024. Slovakia grew more slowly, reaching 1.3 GW by 2024, exhibiting a more stable growth rate compared to Poland and Hungary. Spain and Italy, as countries with more experience in the PV sector, also saw significant growth, reaching 32 GW and 30 GW, respectively, in 2024. Germany, Europe's leading PV market, has increased its capacity from 17 GW in 2010 to an impressive 90 GW by 2024, underscoring its long-term commitment to renewable energy development. France, although growing more slowly than other Western countries, has also seen solid growth, from 1 GW in 2010 to 18 GW by 2024.

A comparison of growth rates in different countries reveals that Poland, despite starting from a very low level, has one of the highest growth rates in the PV sector in Europe. Poland's growth rate is particularly evident between 2018 and 2024, during which installed capacity increased by an average of several gigawatts per year, making it one of the fastest-growing PV markets in the CEE region. Hungary and the Czech Republic also stand out for their dynamic growth, demonstrating the growing interest in renewable energy in this part of Europe.

Data on installed photovoltaic capacity and its percentage share of renewable energy sources (RES) and the total energy mix in selected European countries - Poland, Germany, Spain, Italy, France, Slovakia, the Czech Republic, and Hungary - allow us to illustrate the development of the PV sector in different parts of Europe. The information takes into account country-specific factors, such as available natural resources and energy policies, which shape growth dynamics. The analysis enables a comprehensive comparison of trends and the significance of PV in the energy structure of the analyzed countries from 2020 to 2024 (Table 6).

Table 6. Installed capacity of photovoltaics and percentage share in RES and energy mix in selected European countries (2020-2024)

Year	**Country**	**Installed PV capacity (MW)**	**Share of PV in RES (%)**	**Share of PV in the energy mix (%)**
2020	**Poland**	**3 960**	**36,7**	**8,4**
	Germany	54 000	41,2	18,0
	Spain	15 000	33,0	13,5
	Italy	22 000	30,5	15,0
	France	11 000	25,0	8,0
	Slovakia	700	20,3	4,5
	Czech Republic	2 200	25,0	5,8
	Hungary	1 800	23,1	6,1
2021	**Poland**	**7 670**	**47,5**	**14,0**
	Germany	59 000	42,5	19,5
	Spain	21 000	37,5	17,0
	Italy	25 000	33,0	16,5
	France	14 000	28,5	9,5
	Slovakia	900	22,5	5,4
	Czech Republic	2 600	26,7	6,9
	Hungary	2 500	28,0	8,3
2022	**Poland**	**12 189**	**55,2**	**18,7**
	Germany	65 000	44,0	21,0
	Spain	26 000	42,0	20,5
	Italy	27 000	35,0	17,5
	France	16 000	31,0	10,5
	Slovakia	1 100	25,8	6,5
	Czech Republic	3 400	31,0	8,5

	Hungary	3 700	30,5	9,8
2023	**Poland**	**17 057**	**60,2**	**23,7**
	Germany	75 000	45,5	23,5
	Spain	30 000	45,0	23,0
	Italy	29 000	37,0	18,5
	France	17 000	33,0	11,5
	Slovakia	1 200	27,1	7,3
	Czech Republic	4 000	34,0	9,7
	Hungary	4 700	31,7	10,9
2024	**Poland**	**20 555**	**62,7**	**28,6**
	Germany	90 000	47,0	26,0
	Spain	32 000	47,5	25,5
	Italy	30 000	38,5	19,0
	France	18 000	34,5	12,0
	Slovakia	1 300	28,3	6,2
	Czech Republic	4 500	36,5	8,4
	Hungary	5 800	32,1	10,2

Source: Compiled from: https://ec.europa.eu/eurostat (accessed January 14, 2025); https://iea.org (accessed January 13, 2025); https://ure.gov.pl (accessed January 10, 2025); Slovenská energetická agentúra - http://www.sea.gov.sk (accessed January 15, 2025); Energetický regulační úřad - https://www.eru.cz (accessed January 16, 2025); Magyar Energetikai és Közmű-szabályozási Hivatal - https://www.mekh.hu (accessed January 16, 2025)

As of 2020, solar PV in Europe was experiencing strong growth, with Germany, Spain, Italy, Poland, and France being key players in the sector. Additionally, Central and Eastern European countries such as Slovakia, the Czech Republic, and Hungary should also be noted. Each of these countries pursued its own solar deployment strategy, which was determined by local resources, regulations, and energy policies.

In 2020, Germany was the leader in photovoltaics in Europe, with 54,000 MW of installed PV capacity. At the time, PV accounted for 41.2% of RES capacity and 18.0% of the total energy mix, highlighting the importance of the technology in Germany's energy transition strategy. In second place was Italy, with 22,000 MW, which accounted for 30.5% of RES and 15.0% of the total energy mix. Spain, with 15,000 MW (33.0% in RES, 13.5% in the mix), focused mainly on developing large PV farms, while France, with 11,000 MW (25.0% in RES, 8.0% in the mix), was still in the early stages of developing PV technologies. Poland, with 3,960 MW of installed capacity, ranked last on the list but was already attracting attention due to its dynamic growth, reaching 36.7% of PV's share in RES and 8.4% in the overall mix. Slovakia, the Czech Republic, and Hungary, while still developing their PV sectors, installed 700 MW, 2,200 MW and 1,800 MW, respectively, in 2020. The share of PV in RES in these countries was 20.3% for Slovakia, 25.0% for the Czech Republic, and 23.1% for Hungary, highlighting their more early-stage development.

The year 2021 saw continued strong growth in PV capacity. Germany strengthened its leadership position, increasing its PV capacity to 59,000 MW (43.5% from renewable sources, 19.5% in the mix). Spain also made significant progress, increasing capacity to 21,000 MW, which accounted for 37.5% of RES capacity and 17.0% of the total mix. Italy and France also saw increases, reaching 25,000 MW and 14,000 MW, respectively, with PV's share of RES reaching 33.0% in Italy and 28.5% in France. Poland, on the other hand, increased its PV capacity to 7,670 MW, giving it a 47.5% share of RES and 14.0% of the energy mix, clearly approaching the levels of Western European countries. In Central and Eastern Europe, Slovakia installed 900 MW, the Czech Republic 2,600 MW, and Hungary 2,500 MW, with respective PV shares in RES of 22.5%, 26.7%, and 28.0%.

The year 2022 saw rapid growth in the PV sector across Europe. Germany maintained its leadership position with 65,000 MW (44.0% in RES, 21.0% in the mix). Spain increased capacity to 26,000 MW and Italy to 27,000 MW, reaching 42.0% and 35.0% of PV's RES share, respectively. France, with 16,000 MW of PV capacity, moved closer to its climate goals, reaching 31.0% of PV's RES share and 10.5% in the mix. Poland, meanwhile, saw record growth, reaching 12,189 MW of PV capacity, corresponding to a 55.2% share of RES and 18.7% of the total energy mix. Central and Eastern European countries also experienced significant growth, with Slovakia reaching 1,100 MW, the Czech Republic 3,400 MW, and Hungary 3,700 MW, corresponding to PV shares in RES of 25.8%, 31.0%, and 30.5%, respectively.

Germany installed as much as 75,000 MW of PV capacity in 2023, accounting for 45.5% of RES capacity and 23.5% of the mix. Spain, with 30,000 MW (45.0% in RES, 23.0% in the mix), and Italy, with 29,000 MW (37.0% in RES, 18.5% in the mix), continued the sector's steady growth. France increased its capacity to 17,000 MW (33.0% from renewable sources, 11.5% in the mix), but the Polish market attracted the most interest, with PV capacity reaching 17,080 MW. The share of PV in the Polish RES increased to 60.2% and in the total mix to 23.7%. Regionally, Slovakia reached 1,200 MW, the Czech Republic 4,000 MW, and Hungary 4,700 MW, reflecting PV's RES shares of 27.1%, 34.0%, and 31.7%.

In 2024, Germany remained the leader with 90,000 MW (47.0% in RES, 26.0% in the mix), but Poland, with 20,555 MW, approached countries such as Spain (32,000 MW) and Italy (30,000 MW). The share of photovoltaics in Poland's RES reached 62.7% and 28.6% in the mix. France, with 18,000 MW, also increased its shares in RES (34.5%) and the mix (12.0%). Central and Eastern European countries continued to grow, with Slovakia reaching 1,300 MW, the Czech Republic 4,500 MW, and Hungary 5,800 MW, with PV shares in RES at 28.3%, 36.5%, and 32.1%, respectively.

Conclusion and policy implications

The primary objective of the study was to present the dynamics of photovoltaic development in Poland from 2005 to 2024 and to identify the factors that influenced this process. The goal was also to assess the role of photovoltaics in the energy transition and its comparison with other European countries. The paper fully met the stated goal, presenting comprehensive data on installed capacity, the number of installations, and support programs that contributed to the sector's development. Conclusions from the analysis made it possible to identify both Poland's achievements in the field of solar energy and the challenges facing further development. Additionally, a comparison with European countries, such as Germany and Spain, provided context for assessing Poland's international position.

The development of the photovoltaic sector in Poland has been driven by a number of factors, both internal and external. The introduction of EU energy directives, such as RED I and RED II, mobilized Poland to increase the share of renewable energy sources in the energy mix. At the same time, national regulations, such as the Renewable Energy Sources Act of 2015, established a legal framework for the sector's development. Financial support programs, especially "My Current," which accelerated the development of solar PV micro-installations, enabling households to reduce their energy costs and participate in the energy transition, also proved crucial.

The beginnings of photovoltaics in Poland date back to 2005, when the installed capacity was only 0.3 MW, and the number of installations was marginal. In the following years, the sector developed slowly, with key changes introduced after Poland's accession to the European Union in 2004. Dynamic growth did not occur until 2015-2024, when installed photovoltaic capacity increased from 110.9 MW to 20,555 MW. The rapid growth from 2019 to 2023 was the result of both financial support and a shift in societal environmental awareness. The number of micro-installations increased from 150,000 to more than 1.5 million during this period, making Poland one of the leaders in photovoltaic development in Europe.

A key element of this success has been not only investment in solar technology but also the gradual reduction in installation costs. The average installation cost per kW dropped from PLN 6,000 in 2015 to PLN 3,600 in 2024, making solar PV more accessible to households and businesses. Support programs, such as "My Electricity," have helped finance more than one million installations, and the payback time has decreased from 12 years in 2015 to six years in 2024.

Against the background of Europe, the development of photovoltaics in Poland stands out for its dynamism, although in terms of total installed capacity, Poland is still behind leaders such as Germany, Spain, and Italy. Germany, the European leader, reached 90 GW of installed PV capacity in 2024, accounting for 47% of renewable energy sources and 26% of the total energy mix. Poland, with 20,555 MW, ranks high among countries in the region, but its share of renewables (62.7%) is one of the highest in Europe.

Analyzing the structure of photovoltaic development, it is worth noting that micro-installations dominate in Poland, accounting for more than half of the installed capacity. At the same time, large photovoltaic farms are playing an increasingly important role, with a capacity of nearly 4 GW in 2024. Their development is crucial for further growth and to enable the EU's climate goals, including achieving a 32% share of RES in the total energy mix by 2030.

The development of photovoltaics in Poland faces significant challenges that require urgent solutions. One of the key problems is the limited capacity of the transmission grid, which hinders the effective integration of new installations into the national power system. According to data provided by the Energy Regulatory Office (ERO) (2025), about 30% of applications for connection of new RES installations in Poland are rejected due to insufficient transmission capacity in the existing infrastructure. As a result, investors face high technical costs and delays in project implementation. The lack of adequate energy storage infrastructure is another barrier that significantly limits the energy system's flexibility and ability to manage surplus solar generation. The IEA (2025) report indicates that Poland has only 1% of the energy storage required to meet the needs generated by the booming PV sector.

Volatile regulations have also hindered the sector's development. Frequent changes to prosumer billing rules, such as the switch from discount to net billing in 2022, have created uncertainty among investors and slowed the growth rate of new micro-installations in some regions of the country. Data from SolarPower Europe (2024) shows that the change in these rules caused a temporary reduction in the number of household installations of around 15% in the first quarter of 2023 compared to the same period last year.

To meet the growing demand for renewable energy, Poland needs to increase its investment in upgrading its transmission and storage infrastructure. It is estimated that by 2030, expenditures on transmission grid expansion will amount to at least 40 billion zlotys to ensure system stability and enable further development of the renewable energy sector (ERO, 2025).

The analysis' conclusions unequivocally underscore that solar PV in Poland has the potential to become a pillar of the energy transition. With financial and regulatory support, as well as technological investments, solar energy can significantly contribute to reducing CO_2 emissions, improving air quality, and increasing the country's energy security. For example, the share of photovoltaics in Poland's energy mix increased from 8.4% in 2020 to 28.6% in 2024, demonstrating its dynamic development (Eurostat, 2025). At the same time, the experience of other European countries, such as Germany and Spain, shows that stability in energy policy and a long-term development strategy are key to fully realizing the potential of PV. Germany, with a 47% share of photovoltaics in its RES, has been investing in grid expansion and energy storage for years, allowing it to efficiently manage energy production and consumption (Fraunhofer ISE, 2025).

Against the backdrop of global climate challenges and rising energy costs, investment in solar energy is the foundation of Poland's sustainable energy future. Taking inspiration from the best practices of Western, Central, and Eastern European countries, Poland can not only modernize its energy infrastructure but also strengthen its position as one of the leaders of the energy transition in the region.

The survey results indicate important areas for future analysis. First and foremost, it is worth focusing on the development of energy storage technologies, which are crucial to the stability of the energy system in the event of a growing share of photovoltaics in the energy mix. Analysis of the efficiency and cost of deploying energy storage technologies, such as lithium-ion batteries or hydrogen, could provide valuable information for planning the further expansion of PV photovoltaics.

Another direction of research could be to model the impact of further legal regulations and support programs on the dynamics of photovoltaic energy production development. Such analyses could consider various energy policy development scenarios and their potential impact on the rate of installing new photovoltaic systems. It would also be important to study the possibility of increasing the share of photovoltaic farms in the market structure, which would allow for increasing generation capacity while relieving the burden on transmission grids.

It is also worthwhile to conduct research on the socioeconomic impact of photovoltaics, including its effects on local economies, job creation, and increased environmental awareness in society. The potential for utilizing photovoltaics in rural areas, combined with biogas production or the development of agrophotovoltaics, offers additional research opportunities.

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