

# PESTEL Analysis of the Photovoltaic Market in Poland—A Systematic Review of Opportunities and Threats

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**Abstract:** In recent years, Poland has implemented substantial changes to its energy mix, resulting in an increased proportion of energy production from photovoltaics (PV). However, the photovoltaic energy market's development is determined by several factors, and still requires further analysis. Therefore, the study's main objective was to comprehensively understand the PV phenomenon and its development in Poland. Furthermore, a PESTEL analysis was undertaken to assess the macroeconomic context of the photovoltaic industry in Poland. A systematic literature review methodology was employed to achieve this. The study's principal findings identified a number of pivotal opportunities and barriers to PV development. The environmental benefits of CO<sub>2</sub> reduction and the economic advantages, including cost savings and subsidies, were identified as significant opportunities, as were social acceptance and enhanced energy security. However, obstacles to progress include outdated grid infrastructure, high investment costs, environmental concerns during the PV lifecycle, and political uncertainties. Technical challenges like grid stability and high battery costs also impede growth. Potential strategies for improvement involve better public awareness campaigns, enhanced self-consumption through storage systems, and optimised system placement. Addressing these factors could transform current neutral aspects into either opportunities or threats for PV deployment.

**Keywords:** photovoltaics (PV); renewable energy sources (RESs); PESTEL analysis; systematic literature review



**Citation:** Hysa, B.; Mularczyk, A. PESTEL Analysis of the Photovoltaic Market in Poland—A Systematic Review of Opportunities and Threats. *Resources* **2024**, *13*, 136. <https://doi.org/10.3390/resources13100136>

Academic Editor: Benjamin McLellan

Received: 19 August 2024

Revised: 19 September 2024

Accepted: 20 September 2024

Published: 27 September 2024



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## 1. Introduction

There is no longer any doubt that the world should focus on replacing energy from traditional sources with energy from renewable sources (RESs). The reason is air pollution, which causes the greenhouse effect, and the finite nature of fossil fuels. The solutions to these problems are green energy sources that are considered infinite—do not deplete in the long term—and do not pollute the environment. In support of this change, the European Commission has prepared a set of proposals for reviewing and updating EU legislation in a package: 'Fit for 55' [1]. Under this package, European climate law set a legal obligation on the EU to meet its climate target of reducing EU emissions by at least 55% by 2030 and increasing the share of renewable energy in gross final energy consumption to 40%. EU countries were supposed to work on new legislation to meet this target and make the EU climate-neutral by 2050. Consequently, in February 2021, the Council of Ministers approved Poland's 'Energy Policy until 2040' [2] with its assumptions to be updated [3] (published in March 2022) as part of its national strategies. According to PEP2040, Poland's Energy Policy 2040 aims for energy security. It should be achieved, considering the optimal use of the country's energy resources—while ensuring the economy's competitiveness and energy efficiency and reducing the energy sector's environmental impact. The main objective has been clarified by eight specific objectives termed policy directions. Among them, the sixth specific objective refers to the development of renewable energy sources. Considering

the national potential for renewable resources, the competitiveness of RES technology, its technical feasibility and development challenges, the planned share of RES was estimated to be at least 28.5% by 2040. However, following Russia's aggression against Ukraine, the necessity arose to modify the approach in European countries and, consequently, Poland [4]. It highlighted the need to revise the approach to ensuring energy security towards greater diversification and independence. The assumptions mentioned above of the March 2022 update of PEP2040 emphasise the importance of RESs in diversifying the electricity mix. Therefore, by 2040, around half of the electricity generated should come from renewable sources.

The article focuses on photovoltaics (PV), one of the renewable sources. Photovoltaics have grown rapidly in Poland in recent years [5–9]. It was due, among other things, to government programmes such as “My Electricity” encouraging citizens to make such investments [10]. According to [11], Asia, specifically China, is the most active region regarding new grid connections. Given the total grid-connected solar capacity in 2023, Asia accounted for 59.5% of the total, Europe 20.2%, North America 10.9%, and the rest of the world 9.4%. As per [11], in terms of the growth of installed PV capacity in the European Union, in 2023, Poland was ranked in fourth place with a volume of 4 886.7 MW, after Germany (146,127.0), Spain (7301.2), and Italy (5236.0). In this way, Poland maintained sixth place in the cumulated photovoltaic capacity of EU countries at the end of 2023, achieving cumulated solar photovoltaic capacity at 17,057.1 MW. The highest volume of cumulative PV energy production belonged to Germany. They achieved it at a level as high as 82,191.0. Then came Spain and Italy (30,612.5 and 30,300.0). Next, the Netherlands were ranked (23,904.0) and, closest to Poland, France (20,541.3).

To take a more in-depth look at the PV phenomenon, some factors influencing the development and prospects of this renewable energy source in Poland were analysed. These factors were divided into political, economic, social, technical, environmental, and legal, and are included in the PESTEL analysis. For this purpose, a systematic literature review methodology was used.

The study aimed to comprehend the phenomenon of photovoltaics and its development in Poland. Furthermore, a PESTEL analysis was conducted to evaluate the macroeconomic environment of the photovoltaic sector in Poland. As far as we are concerned, this is the first study to conduct a comprehensive PESTEL analysis of photovoltaics through a systematic review methodology. It provides a holistic view of the photovoltaics sector in Poland, which has significant potential but is currently only marginally utilised. This study undoubtedly contributes to filling the research gap in this area. Furthermore, the PESTEL analysis can be a valuable decision-making tool for investors.

Therefore, the article intends to answer the following research questions:

RQ1: What are the main opportunities in the political, economic, social, environmental and legislative fields associated with the development of PV in Poland?

RQ2: What are the main barriers in the political, economic, social, environmental and legislative fields related to PV development in Poland?

RQ3: Are there factors in the political, economic, social, environmental and legislative fields to pay attention to that could become opportunities or threats for PV technology?

## 2. Materials and Methods

A systemic literature review (SLR) technique was chosen in this research to achieve the aim and answer the formulated questions [12]. Research advancement relies on systematic analysis and presentation of existing research [13,14]. Systematic literature reviews are a well-established method for achieving this goal [15,16]. They provide a verifiable and rigorous presentation of the existing literature and synthesise prior studies to strengthen the foundation of knowledge. They allow the identification of relevant research gaps and the setting of further research directions.

A systematic review is a comprehensive, transparent search of multiple databases that other researchers can replicate and reproduce. It should follow a clearly defined

protocol or plan, in which the criteria are clearly stated before the review is carried out. Therefore, following the methodology described in the literature [13,15–18], we conducted a systematic review following the Preferred Reporting Items for Systematic Reviews and Meta-Analyses guidelines (PRISMA) to adopt and propose our own stages of procedure. The five-step procedure (as shown in Figure 1) ensures the robustness and rigour of the study, eliminating subjectivity in data collection and analysis.

These five steps include the following:

- (1) Problem formulation:
  - the identification of the primary purpose;
  - the definition of the research questions;
  - preliminary research and idea validation.
- (2) Literature selection:
  - defining keywords;
  - search techniques and strategy;
  - searching the database.
- (3) Inclusion and exclusion criteria:
  - screening and selection;
  - coarse-sieve stage (first screening, second screening);
  - manual search.
- (4) Data and information synthesis:
  - data extraction;
  - content analysis.
- (5) Documenting and reporting:
  - PESTEL analysis.

#### Step 1. Problem formulation.

In the beginning, we conducted preliminary research to validate the idea. It involved a preliminary search to identify articles and ensure the validity of the proposed topic. Furthermore, we wanted to avoid duplicating the idea and previously discussed questions and ensure that we had enough articles to conduct the analysis.

#### Step 2. Literature selection.

The flow diagram of study screening and selection based on [16,18] for the methodology is presented in Figure 2. A set of keywords was defined using truncation symbols and Boolean operators, as follows: ‘photovoltaic’ OR ‘photovoltaics’ AND ‘Poland’. The basic search strategy was built, based on the formulation of the research questions. Search strategies were constructed to include text terms (e.g., in the title, abstract and keywords) and any appropriate subject indexing expected to retrieve eligible studies. The literature on photovoltaic solar energy in Poland was analysed between April and June 2024.

The analysis was conducted using the scientific publications repository from the Scopus bibliographic database, which indexes high-impact journal articles. Recent studies recommend using Scopus and/or Web of Science for literature searches [13,14]. However, scholars often choose to use only one of these databases. WoS is preferred for a more selective approach [15], while Scopus is better for a broader selection, due to its more comprehensive coverage [12,13]. The Scopus database contains published scientific literature, including journal articles, conference proceedings, patents, and books. The text includes descriptions of subjects in the form of keywords, authors, subject classification terms, and abstracts. An additional advantage of the Scopus database is undoubtedly its timeliness. It focuses on modern sources, which is what we were looking for.

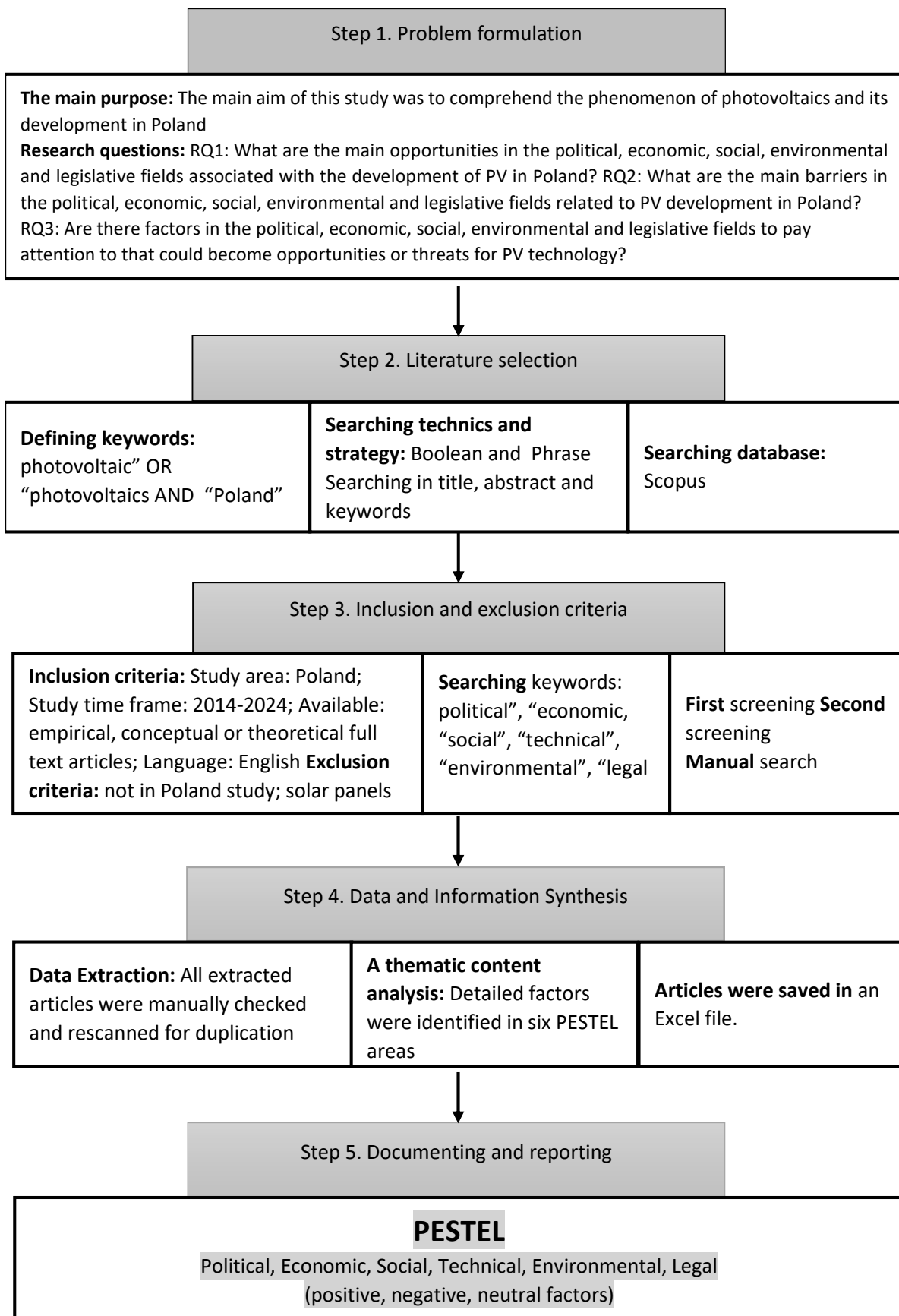


**Figure 1.** A systemic literature review (SLR) procedure. Source: own work, based on [13,15–18] and PRISMA guideline.

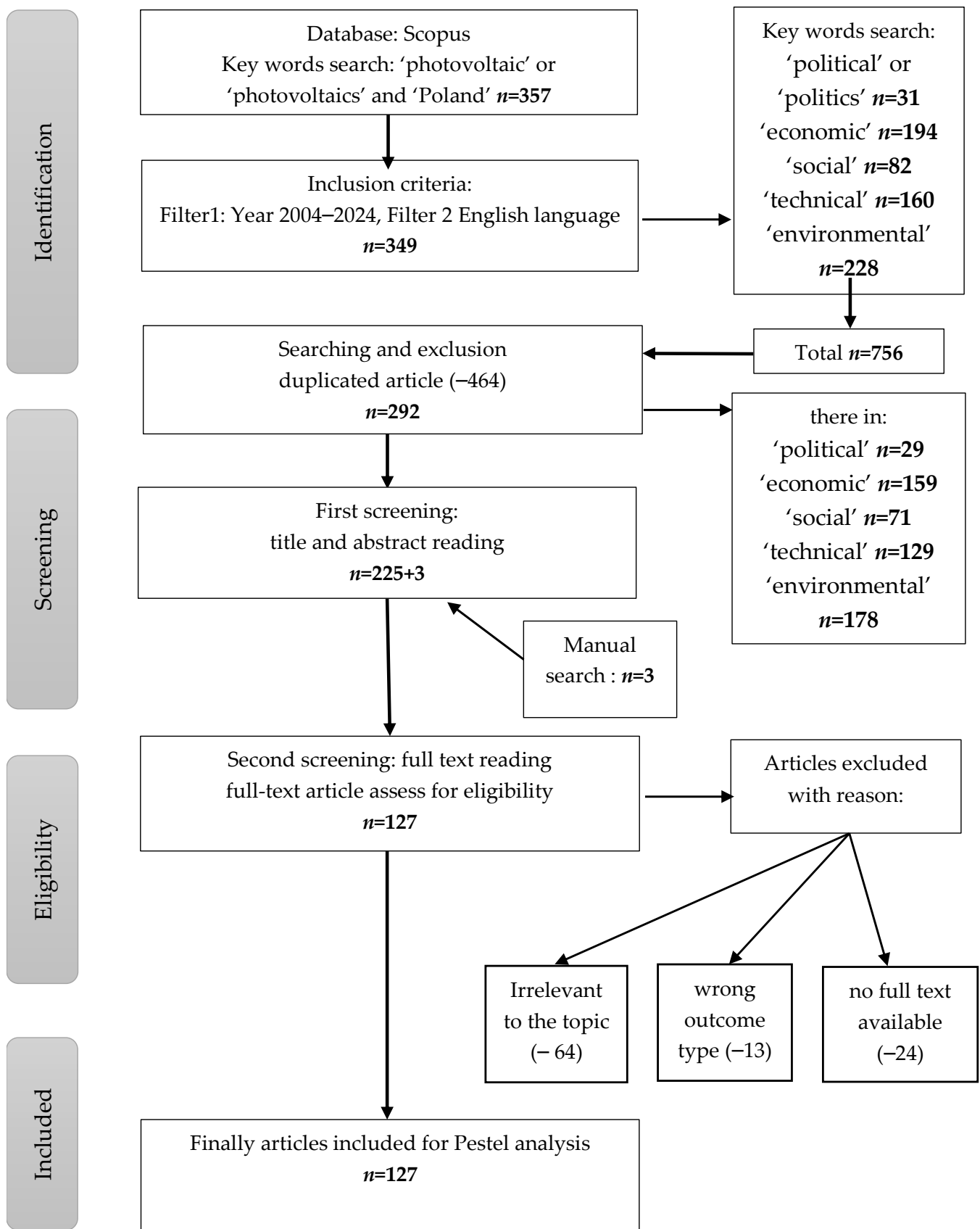


**Figure 2.** Flow diagram of studies' screening and selection. Source: own work, based on [13,15–18] and PRISMA guidelines.

### Step 3. Inclusion and exclusion criteria.

The key inclusion criteria were studies focusing on Poland-area insights in the past decade (10 years). At this stage, 357 articles were selected. The additional inclusion criteria were journal articles, full text, and those available in English. Although this search strategy is not without potential limitations—namely, the possibility of failing to identify relevant publications in languages other than English—we are confident that most valuable contributions to Polish photovoltaics published over the past ten years can be found in English. The exclusion criteria were studies from non-Polish countries and those focused on solar thermal panels. Many search engines provide free access to the full text of articles. However, if no article could be located, an alternative approach was taken, whereby other research sites, such as ResearchGate, were consulted. That enabled the direct request of full-text articles from the authors in question. After consideration of the exclusion criteria, the number of articles was 349.

The articles were once again searched using keywords corresponding to the Pestel factors. The results were as follows: political” or “politics” (31), “economic” (194), “social” (82), “technical” (160), “environmental” (228), and “legal” (61). A total of 756 articles were obtained. It should be noted that some articles appeared multiple times in the search results, as they fell into two, three, or more factor categories. Therefore, the next step was to reduce the number of duplicate articles (−464) and assign each of them the occurrence of a given factor. After reducing the number of duplicate articles, 292 were selected for further analysis.

The main goal of the stage, called first screening (early screening or practice screening), was to eliminate articles with weak thematic relevance to the research questions and to use a list of predefined inclusion/inclusion criteria. The first screening title, keywords and abstracts were read. All articles that were unrelated or did not address the topics of photovoltaics and Poland were ruled out. Only articles related to the scope of this study were selected. Thus, after title and abstract screening, 225 articles remained. Additionally, three articles were added from manual searches, which were revealed during source checking and validation.

In the text stage, called the second screening (full reading), the full text of all 228 remaining articles was read, and the articles that did not contribute to the present study were excluded. Articles were excluded for reasons like being irrelevant to the topic (−64), having the wrong outcome type (−13), and having no full text available (−24). Hence, only 127 remained, comprising this study’s final analysis.

### Step 4. Data and information synthesis.

The articles were subjected to a thematic content analysis to integrate the conceptual framework and extract the necessary information from the texts. Detailed factors were identified in six PESTEL areas that demonstrated conditions affecting the development of the photovoltaic energy market in Poland. All extracted articles were manually checked and scanned again for duplication and relevance of information, and documents relevant to achieving the objectives were saved in an Excel file.

### Step 5 Documenting and reporting.

The results of the analyses were grouped into factors that can be considered positive (referring to RQ1), negative (referring to RQ2), and neutral (referring to RQ3) when it comes to the development of photovoltaics in Poland.

## 3. Results and Discussion

In order to assess the development of photovoltaic energy in Poland, a PESTEL analysis was conducted. It described six key groups of factors: political, economic, social, technological, environmental and legal. The main objective of the PESTEL analysis is to discuss and consider each factor in detail, so that rapid future action can be taken. Every subsection contains factors regarding its area.

### 3.1. Political Factors

The adoption and success of renewable energy depend largely on the country's existing policy framework. Government policies are essential for creating an enabling environment to mobilise resources and encourage private-sector investment.

Ten articles found references to factors within the political area. Four factors were identified: P1: "International and national targets on renewable energy" was mentioned three times [5,19,20], P2: "Government strategy/policy about the production of photovoltaic panels" was mentioned six times [19,21–25], and P3: "Subsidy (decrease/increase) in energy" and P4: "Frequent changes in central administration" were each mentioned once [26]. Table 1 provides a summary of the analysis of these factors.

**Table 1.** Political factors.

| ID | Factor                                                                 | Positive                                                                                                                                                                                                                                                                                                                                                                | Negative                                                                                                                                                                                                                                                                  |
|----|------------------------------------------------------------------------|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| P1 | International and national targets on renewable energy                 | <ul style="list-style-type: none"> <li>EU law regulations and pro-climate policy [7,20]</li> </ul>                                                                                                                                                                                                                                                                      | -                                                                                                                                                                                                                                                                         |
| P2 | Government strategy/policy about the production of photovoltaic panels | <div>Positive</div> <ul style="list-style-type: none"> <li>Beneficial actions resulting from the government's economic policy in the form of incentives [25]</li> </ul> <div>Neutral</div> <ul style="list-style-type: none"> <li>The need for more widespread public campaigns aimed at promoting the benefits of RES and pro-ecological behaviours [24,27]</li> </ul> | <div>Negative</div> <ul style="list-style-type: none"> <li>A strong coal energy lobby [19];</li> <li>Lack of clear and long-term policy concerning RES development [23];</li> <li>Promotion of RES, including government incentives, is not so important [22].</li> </ul> |
| P3 | Subsidy (decrease/increase) in energy                                  | <div>Positive</div> <ul style="list-style-type: none"> <li>Electricity costs can be reduced with PV, provided there is support from the state or other institutions (e.g., subsidies/agricultural tax exemption) [26]</li> </ul>                                                                                                                                        | -                                                                                                                                                                                                                                                                         |
| P4 | Frequent changes in central administration                             | -                                                                                                                                                                                                                                                                                                                                                                       | <div>Negative</div> <ul style="list-style-type: none"> <li>Political unpredictability: the low level of citizens' trust in the state's policy and administration [28].</li> </ul>                                                                                         |

Several significant positive factors influencing the development of Poland's photovoltaic technology were identified in the literature. These included favourable measures resulting from the government's economic policy, such as incentives [25] and various forms of support from the state or other institutions that lower energy costs [26]. Additionally, the EU legal framework and regulations [20] and a pro-climate policy [7] have been necessary in promoting the adoption of PV technology.

The Polish energy mix is predominantly coal, accounting for 80% of the country's energy production. As [19] noted, a powerful coal energy lobby was a negative factor in developing renewable energy sources. The abandonment of coal has led to the closure of coal mines and associated distribution structures, resulting in substantial job losses. Thus, there is a deficient long-term policy concerning RES development [23]. That is why some studies stressed that the promotion of RES, including government incentives, was not so important [22].

As noticed by [21,24], the government should consider more widespread public campaigns to promote the benefits of RES and pro-ecological behaviours [21,24]. The authors classified this as a neutral factor.

To conclude, the advancement of photovoltaic technology in Poland still faces considerable challenges, particularly considering the prevailing dominance of coal in the energy mix and the influence of the coal lobby. Addressing these challenges through enhanced policy commitments and public engagement could facilitate the adoption and efficacy of photovoltaic systems in Poland.

### 3.2. Economic Factors

As many as 66 articles dealt with economic issues related to PV. Six factors were identified: E1: “PV system cost”—in 28 units [7,24,29–47], E2: “Guaranteed return on investment”—in 17 [7,10,22–24,30,34,44,45,48–56] E3: “Sell surplus electricity (profitable or not)”—in 8 [21,31,34,52,57–59] E4: “Higher cost of fuel”—in 9 [7,10,28,39,41,60–62], E5: “Disposable income of consumers and businesses”—in 6 [19,63–65] and E6: “Subsidy programs” in 18 [7,10,26,34,36,46,50,56,61,63,66–71]. These factors were characterised and summarised in Table 2.

**Table 2.** Economic factors.

| ID | Factor                          | Positive                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                      | Negative                                                                                                                                                                                                        |
|----|---------------------------------|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| E1 | PV system cost                  | <ul style="list-style-type: none"> <li>The PV costs are gradually falling [41];</li> <li>The positive financial result is growing, due to the “economy of scale” [42];</li> <li>Low maintenance cost [36,44].</li> </ul>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                      | <ul style="list-style-type: none"> <li>High investment costs—the main barrier [7,29,31,36,44,45,47]</li> </ul>                                                                                                  |
|    |                                 | Neutral                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                       |                                                                                                                                                                                                                 |
|    |                                 | <ul style="list-style-type: none"> <li>Analysis of net-metering and net-billing [46,72];</li> <li>PV profitability depends on the price of electricity, installation price, discount rate, the ratio of electricity utilisation transferred to the grid, and the ratio of panel degradation [73].</li> </ul>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                  |                                                                                                                                                                                                                 |
| E2 | Guaranteed return on investment | Positive                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                      | Negative                                                                                                                                                                                                        |
|    |                                 | <ul style="list-style-type: none"> <li>The will to have PV installations is motivated by economic, rather than environmental benefits [24];</li> <li>Good capital investment [7];</li> <li>The discounted rate on return of investment does not exceed the mortgage length [54];</li> <li>Increasing the scope of investments in PV leads to improved economic efficiency of macro- and microeconomic energy production [34];</li> <li>The calculated Discounted Payback Period equals 5.4 to 10 years [34];</li> <li>Investment is profitable, and pays off within 15 years [55];</li> <li>Reduction in electricity costs, use of energy for heating, and capital investment [22,69];</li> <li>The photovoltaic farms studied proved to be economically viable investments (NPV &gt; 0) [49];</li> <li>The return on investment for a hybrid photovoltaic solution with a heat pump is 5 years [50];</li> <li>The payback period was below 8 years [74];</li> <li>Profitability of investments in photovoltaics, even without state support [44].</li> </ul> | <ul style="list-style-type: none"> <li>Due to the high-price systems connected to the network, the investment payback time is now long [56];</li> <li>Extended periods of return on investment [45].</li> </ul> |
|    |                                 | Neutral                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                       |                                                                                                                                                                                                                 |
|    |                                 | <ul style="list-style-type: none"> <li>Having a battery or hydrogen system with a PEM fuel cell stack affects the return on investment differently [53];</li> <li>Indirect benefits—difficult or impossible to monetise [52,75].</li> </ul>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                   |                                                                                                                                                                                                                 |

Table 2. Cont.

| ID | Factor                                        | Positive                                                                                                                                                                                                                                                | Negative                                                                                                                                                                                                |
|----|-----------------------------------------------|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| E3 |                                               | Positive                                                                                                                                                                                                                                                | Negative                                                                                                                                                                                                |
|    | Sell surplus electricity (profitable or not)  | <ul style="list-style-type: none"> <li>The vital value of self-consumption for lowering costs [57];</li> <li>Generating one's own energy can lead to significant cost savings [21].</li> </ul>                                                          | <ul style="list-style-type: none"> <li>Main obstacles: inadequate economic (tax) mechanisms [31];</li> <li>Battery costs can increase dramatically as raw material prices rise [75].</li> </ul>         |
|    |                                               | Neutral                                                                                                                                                                                                                                                 |                                                                                                                                                                                                         |
|    |                                               | <ul style="list-style-type: none"> <li>Dependence on the cost of grid electricity purchase [20];</li> <li>Analysis of the economic role of energy storage in the context of photovoltaic farms [58].</li> </ul>                                         |                                                                                                                                                                                                         |
| E4 |                                               | Positive                                                                                                                                                                                                                                                | Negative                                                                                                                                                                                                |
|    | Higher cost of fuel                           | <ul style="list-style-type: none"> <li>Protection against the observed increase in electricity prices and fossil fuel costs [7,28,39,41,60–62,69]</li> </ul>                                                                                            | -                                                                                                                                                                                                       |
| E5 |                                               | Neutral                                                                                                                                                                                                                                                 |                                                                                                                                                                                                         |
|    | Disposable income of consumers and businesses | <ul style="list-style-type: none"> <li>The development of PV energy is correlated with the wealth of countries (GDP) [9,63];</li> <li>The development of prosumer photovoltaics depends more on individual income than regional income [65].</li> </ul> |                                                                                                                                                                                                         |
| E6 |                                               | Positive                                                                                                                                                                                                                                                | Negative                                                                                                                                                                                                |
|    | Subsidy programs                              | <ul style="list-style-type: none"> <li>Way to intensify the investments made by households in RES [7,34,36,50,61,63,66–69,71,76].</li> </ul>                                                                                                            | <ul style="list-style-type: none"> <li>The lack of subsidies [56];</li> <li>Without state support for an auction system, PV will not play a significant role in the electricity sector [77].</li> </ul> |

The economic factors influencing the development of energy efficiency in photovoltaic installations included, first of all, investment costs [71], which, despite a downward trend [41], were still high [7,29,31,36,44,45,47]. Other significant factors included the cost of maintenance [36,44] and the method of billing [72], in addition to the cost of purchasing energy from the grid [73].

In terms of guaranteed return on investment, researchers expressed differing opinions. Some believed that the payback time was relatively short [34,74], did not exceed the length of the mortgage loan [54], and was profitable [55]. In particular, Ref. [49] indicated that photovoltaic farms have been demonstrated as an economically profitable investment. The return on investment in a hybrid photovoltaic solution with a heat pump was said to be 5 years [78]. Nevertheless, other researchers identified a lengthy payback period [45], due to the high cost of grid-connected systems [56].

Furthermore, as [34] observed, expanding the scope of investments in PV led to enhanced economic efficiency of macro- and microeconomic energy production. It represented a good capital investment [7]. Investing in photovoltaics was considered profitable, despite the lack of state support [44]. Therefore, as [24] pointed out, the primary motivation for installing photovoltaic systems was economic, not environmental [24]. It was also described as reducing the costs of investment in electricity and capital by [22,69].

Authors in [23,52,53] presented neutral opinions regarding the return on investment in their research, indicating that there could also be indirect benefits that are difficult or impossible to monetise [52,53,75].

Furthermore, the existing literature contains opposing views on the profitability of selling surplus electricity. Thus, Ref. [21] pointed out that people's own energy production can lead to significant cost savings [27], which was the crucial value of one's own consumption for cost reduction [57]. On the other hand, Ref. [31] indicated tax mechanisms as the main obstacles, and [75] noticed that battery costs could increase dramatically as raw material prices rise. In their research, Refs. [20,58] represented, in turn, a neutral opinion regarding energy sales [20,58].

Many researchers agreed that a positive economic factor for using photovoltaic panels was protection against the observed increase in electricity prices and fossil fuel costs [7,28,39,41,60–62,69,71]. Especially as noticed by [9,63], the development of PV energy was correlated with the wealth of countries (GDP) [9,63] and depended more on individual income than regional income [65].

There was also a divide among researchers in their opinions about subsidy programs. Some viewed them as a positive way to intensify household investments in renewable energy sources [7,34,36,63,66,67,76,78]. In contrast, others, such as [56,77], believed there was a lack of significant subsidies from the state. Also, without state support for the auction system, photovoltaics will not play an important role in the electricity sector [56,77].

### 3.3. Social Factors

Social factors were mentioned in 25 articles. Four types of them were identified: S1: “Society’s inclination to use PV”—mentioned 7 times [20,27,33,46,66,77,79], S2: “Customer buying trends”—4 times [29,67,80,81], S3: “The lifestyle and behaviour of people”—10 times [7,19,20,25,31,36,39,75,76,82] and S4: “Independence, energy security”—4 times [4,19,83,84]. Table 3 provides a summary.

**Table 3.** Social factors.

| ID | Factor                                | Positive                                                                                                                                                                                                                                                                                                                                                                                                                                                            | Negative                                                                                                                                                                                                                                  |
|----|---------------------------------------|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| S1 | Society’s inclination to use PV       | <ul style="list-style-type: none"> <li>• EU law regulations [20];</li> <li>• Environmental sustainability [27,46,77,79];</li> <li>• The idea of corporate social responsibility [33].</li> </ul>                                                                                                                                                                                                                                                                    | <ul style="list-style-type: none"> <li>• Only wealthy people can afford PV without subsidies. A total of 10% of the population is affected by energy poverty [66].</li> </ul>                                                             |
| S2 | Customer buying trends                | <div>Positive</div> <ul style="list-style-type: none"> <li>• Consumer innovativeness has the most substantial impact on the intention to purchase [29];</li> <li>• The benefits of PV were linked to the green purchasing behaviour of the majority [81].</li> </ul> <div>Neutral</div> <ul style="list-style-type: none"> <li>• The choice of RES technology under the subsidy scheme depends on the prosumer’s income level or place of residence [67]</li> </ul> | <div>Negative</div> <p>-</p>                                                                                                                                                                                                              |
| S3 | The lifestyle and behaviour of people | <div>Positive</div> <ul style="list-style-type: none"> <li>• RES perceived by society as environmentally friendly [19,20,39];</li> <li>• Accepted by local communities [31,36,76];</li> <li>• The growing level of social awareness is encouraging potential customers [25].</li> </ul> <div>Neutral</div> <ul style="list-style-type: none"> <li>• Existence of peer effects [82]</li> </ul>                                                                       | <div>Negative</div> <ul style="list-style-type: none"> <li>• Often uncertain acceptance by owners of photovoltaic installations on roofs [75];</li> <li>• Social factors do not influence attitudes towards PV technology [7].</li> </ul> |
| S4 | Independence, energy security         | <div>Positive</div> <ul style="list-style-type: none"> <li>• One of the most significant issues of the 21st century is energy security [84];</li> <li>• The ability to become at least partially independent of energy suppliers and to diversify energy sources is crucial [19,22,83].</li> </ul>                                                                                                                                                                  | <div>Negative</div> <p>-</p>                                                                                                                                                                                                              |

According to the articles analysed, the level of investment in photovoltaics was influenced not only by political and economic conditions but also by social factors. These included the level of environmental and energy consciousness of society, its approach to energy saving, and the development of renewable energies [66]. This form of energy's ecological and renewable nature shaped societies' approach to photovoltaics. It was accepted by local communities [31,36,76] as a form of clean energy whose use on regional and global dimensions brings several social and environmental benefits.

Society's inclination to use PV resulted mainly from EU law regulations [20], environmental sustainability [27,46,77,79] and corporate social responsibility [33]. The cost of photovoltaic installations remained a significant barrier to their implementation, with only wealthy individuals able to afford them without subsidies. This trend will probably intensify, due to the energy transition in a society, with approximately 10% of the population currently affected by energy poverty [66]. Thus, social programmes could play a role in mitigating this impact. Still, a more comprehensive solution would be to develop a secondary market for affordable PV systems. Moreover, the choice of renewable energy technology also depended on the prosumer's income level or place of residence [67].

The lifestyle and behaviour of people were valuable for the development of solar energy, as well. Both positive and negative factors have been identified in this area. Renewable energy sources were viewed positively by society for their environmental benefits. This perception was supported by various studies [19,20,39]. Photovoltaic technology has gained acceptance among local communities, making its implementation smoother and more feasible [31,36,76]. Increasing social awareness about renewable energy and its benefits drove potential customers to adopt photovoltaic solutions [25]. However, some studies indicated that social factors did not significantly influence attitudes towards photovoltaic technology, suggesting that other factors might be more critical [7]. Moreover, there was often uncertainty regarding acceptance by owners of photovoltaic installations on roofs, which could hinder the spread of this technology [75].

The presence of peer effects, where individuals were influenced by the behaviours and decisions of their peers, existed, but did not strongly sway the overall attitude towards photovoltaic technology [82], so it could be classified as a neutral factor.

Social acceptance of photovoltaic energy largely depended on the level of knowledge about energy security and independence. Ref. [84] indicated that energy security was one of the most significant issues of the 21st century. Other researchers also emphasised the crucial role of diversifying energy sources and the ability to become at least partially independent of energy suppliers [19,22,83].

### 3.4. Technical Factors

The 55 articles addressed issues related to technical areas. The factors were divided into six groups: T1: "Experience in operating PV systems" (15 items) [5,10,25,31,36,69,73,85–89], T2: "Energy storage solutions need" (10), [31,46,47,74,75,83,90,91] T3: "Lack of grid study and upgrades to absorb all PV energy efficiently (self-consumption)" (20) [24,27,31,46,57,80,85,92–100], T4: "The type of photovoltaic panels" (7) [66,74,101–104], T5: "The angle of slope and geographical direction of installation orientation" (7) [27,74,98,101,105–107] and T6: "Other applications" (3) [21,108,109]. The most important results are in Table 4.

Table 4. Technical factors.

| ID | Factor                                                                                 | Positive                                                                                                                                                                                                                                                                                                                                                                                                                                                        | Negative                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                            |
|----|----------------------------------------------------------------------------------------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| T1 | Experience in operating PV systems.                                                    | <ul style="list-style-type: none"> <li>Low maintenance needs and low failure rate of PV systems [7,36,69]</li> </ul>                                                                                                                                                                                                                                                                                                                                            | <ul style="list-style-type: none"> <li>Problems with system stability [31];</li> <li>Particles in the air in urban areas negatively affect the performance of photovoltaic modules [86,87,110];</li> <li>The ratio of panel degradation [73];</li> <li>Breakdowns may occur due to damage to the inverter, cables, photovoltaic panels or their manufacturing defects [89];</li> <li>Need for quality control of PV micro-installations: risk of fire and electric shock in emergencies or in the case of incorrect installation [10,69,88];</li> <li>Information asymmetry, which results from a lack of sufficiently accurate information on system performance for the customer [25].</li> </ul> |
|    |                                                                                        | Neutral                                                                                                                                                                                                                                                                                                                                                                                                                                                         |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                     |
|    |                                                                                        | <ul style="list-style-type: none"> <li>Smart PV monitoring equipment would provide a rapid response to any faults in the PV system [89]</li> </ul>                                                                                                                                                                                                                                                                                                              |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                     |
| T2 | Energy storage solutions need                                                          | Positive                                                                                                                                                                                                                                                                                                                                                                                                                                                        | Negative                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                            |
|    |                                                                                        | <ul style="list-style-type: none"> <li>High reliability of the hybrid system is essential in some instances, such as powering medical equipment or costly production processes [47];</li> <li>The positive impact of solar energy storage on city self-sufficiency [75];</li> <li>The use of even small batteries leads to a noticeable increase in PV energy consumption [74].</li> </ul>                                                                      | <ul style="list-style-type: none"> <li>The development of storage systems has not been accompanied the rapid development of micro-installation [31,46];</li> <li>High cost is a significant barrier to the mass deployment of batteries [83,91];</li> <li>A complete reduction in fossil fuel power plants in favour of photovoltaics is not possible, due to the lack of efficient energy storage [90].</li> </ul>                                                                                                                                                                                                                                                                                 |
| T3 | Lack of grid study and upgrades to absorb all PV energy efficiently (self-consumption) | Positive                                                                                                                                                                                                                                                                                                                                                                                                                                                        | Negative                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                            |
|    |                                                                                        | <ul style="list-style-type: none"> <li>Increased innovation in the energy sector, including improving the efficiency and effectiveness of RES generation [111]</li> </ul>                                                                                                                                                                                                                                                                                       | <ul style="list-style-type: none"> <li>Power grids have not been upgraded for many years—they are not designed to transmit large amounts of energy quickly, resulting in constraints on energy production and grid interruptions [24,27,46,80,85,93,95–100];</li> <li>Insufficient growth rates of smart meters [31].</li> </ul>                                                                                                                                                                                                                                                                                                                                                                    |
|    |                                                                                        | Neutral                                                                                                                                                                                                                                                                                                                                                                                                                                                         |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                     |
| T4 | The type of photovoltaic panels                                                        | <ul style="list-style-type: none"> <li>There is a need for research on simulations and their comparisons with measurement data [94];</li> <li>The best way to enhance the profitability of a photovoltaic investment in every aspect is to increase the energy self-consumption [92];</li> <li>A way to increase efficiency by increasing self-consumption is to have an air-source heat pump or an air-source heat pump with a control system [57].</li> </ul> |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                     |
|    |                                                                                        | Positive                                                                                                                                                                                                                                                                                                                                                                                                                                                        | Negative                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                            |
|    |                                                                                        | <ul style="list-style-type: none"> <li>Utility of a tracking photovoltaic installation containing polycrystalline silicon cells [103];</li> <li>Highest annual energy production rate: bifacial monocrystalline silicon module system with 20.3% efficiency [74].</li> </ul>                                                                                                                                                                                    | <ul style="list-style-type: none"> <li>The low energy efficiency of perovskite photovoltaic panels [102];</li> <li>The consumer is usually unable to determine the importance of the various criteria for evaluating photovoltaic panels [104].</li> </ul>                                                                                                                                                                                                                                                                                                                                                                                                                                          |
|    |                                                                                        | Neutral                                                                                                                                                                                                                                                                                                                                                                                                                                                         |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                     |
|    |                                                                                        | <ul style="list-style-type: none"> <li>It is vital to develop a cost-efficient technology to produce PV cells which can be implemented in a short time [66]</li> </ul>                                                                                                                                                                                                                                                                                          |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                     |

Table 4. Cont.

| ID | Factor                                                                    | Positive                                                                                                                                                                                                                                                                                                                                                                                                                                 | Negative |
|----|---------------------------------------------------------------------------|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|----------|
| T5 | The angle of slope and geographical direction of installation orientation | Positive                                                                                                                                                                                                                                                                                                                                                                                                                                 | Negative |
|    |                                                                           | <ul style="list-style-type: none"> <li>The use of different areas, such as west- or east-facing slopes, for photovoltaic panels can be more beneficial to the electricity system network, e.g., in terms of peak-load reduction [98];</li> <li>GIS tools and information from open geospatial data on the potential of solar energy can help plan new PV installations [101].</li> </ul>                                                 | -        |
|    |                                                                           | Neutral                                                                                                                                                                                                                                                                                                                                                                                                                                  |          |
|    |                                                                           | <ul style="list-style-type: none"> <li>There is a relationship between the angle of inclination of photovoltaic modules and the amount of dirt that accumulates on them [107];</li> <li>The need to conceptually predict the correct position of the building regarding the orientation, as well as the roof structure [56,105,106];</li> <li>Dependence of PV efficiency on system orientation or inclination angle [74,94].</li> </ul> |          |
| T6 | Other applications                                                        | Positive                                                                                                                                                                                                                                                                                                                                                                                                                                 | Negative |
|    |                                                                           | <ul style="list-style-type: none"> <li>To be the only source of electricity for Poland, a large solar farm should have an area of about 6460 km<sup>2</sup>. Its construction and energy storage costs would probably be lower than those of a nuclear power plant [109];</li> <li>PV could charge electricity sources of varying power for soldiers and command posts (concept) [108].</li> </ul>                                       | -        |
|    |                                                                           | Neutral                                                                                                                                                                                                                                                                                                                                                                                                                                  |          |
|    |                                                                           | <ul style="list-style-type: none"> <li>PV within an energy cooperative can be more cost-effective than a home PV installation [21,27]</li> </ul>                                                                                                                                                                                                                                                                                         |          |

Negative factors prevailed regarding the technical aspects of experience in operating PV systems. Only [7,10,69] expressed low maintenance needs and low failure rates of PV systems. As a neutral factor, we classified [89], indicating that smart PV monitoring equipment would respond rapidly to any faults in the PV system [89].

The stability of photovoltaic systems remains a significant challenge in their development and widespread adoption. Ref. [31] highlighted the fact that system stability issues could undermine the reliability and efficiency of PV installations [31]. This instability might arise from fluctuations in power output and solar variability, necessitating robust system designs and advanced management strategies to ensure consistent performance.

In urban environments, airborne particles pose a notable threat to the performance of photovoltaic modules. Studies by [86,87,110] indicated that particulate matter could accumulate on PV surfaces, reducing light absorption and lowering energy output. This finding underscored the need for effective maintenance and cleaning protocols to mitigate the adverse effects of urban pollution on PV efficiency [86,87,112].

The degradation rate of PV panels was another critical factor influencing the long-term viability of solar energy systems. Ref. [73] had documented that panel degradation could significantly diminish the energy output over time, affecting the overall cost-effectiveness of PV installations. Understanding the mechanisms of degradation and developing more durable materials should be essential for enhancing the longevity and reliability of PV systems [73].

Breakdowns in PV systems, often due to damage to inverters, cables, and photovoltaic panels or manufacturing defects, could pose a severe risk to continuous energy production. Ref. [89] discussed the frequency and impact of these technical failures, emphasising

the importance of high-quality components and rigorous testing procedures during the manufacturing process, to prevent such occurrences.

The necessity for stringent quality control of PV micro-installations was paramount to ensure safety and performance. Refs. [10,69,88] highlighted the risks associated with inadequate quality control, such as fire hazards and electric shocks, particularly in emergencies or due to incorrect installation. Implementing comprehensive quality-assurance protocols could mitigate these risks and enhance the safety of PV systems [10,69,88].

Information asymmetry between PV system providers and customers remained a barrier to knowledgeable decision-making. According to [25], the lack of accurate information on system performance could lead to customer dissatisfaction and suboptimal choices. Addressing this issue through transparent communication and detailed performance data could empower consumers and foster greater trust in PV technology [25].

Some positive and negative factors concerning energy storage solutions were identified. One of the most crucial benefits was the high reliability of hybrid systems, particularly in critical applications such as powering medical equipment and supporting costly production processes. Ref. [47] emphasised the fact that the reliability provided by hybrid systems was essential, ensuring uninterrupted power supply and enhancing the feasibility of PV systems in sensitive and high-stakes environments [47]. Additionally, the ability to store solar energy positively impacted urban self-sufficiency. Ref. [75] highlighted the fact that solar energy storage could significantly enhance a city's energy independence, reducing reliance on external power sources and improving resilience against grid disruptions [75]. This self-sufficiency was particularly important in the context of increasing energy demands and the need for sustainable urban development. Furthermore, even the use of small-scale batteries could lead to a noticeable increase in the consumption of PV energy. Ref. [74] noted that incorporating batteries, regardless of their size, optimised energy usage by storing excess solar power for later use, thus maximising the efficiency and benefits of PV installations [74]. This increased consumption of stored solar energy can contribute to higher energy savings and a more sustainable energy consumption pattern.

Despite these advantages, several negative factors hindered the development of effective energy storage solutions for PV systems in Poland. One major issue was the disparity between the rapid growth of PV micro-installations and the slower development of storage systems. Refs. [31,46] pointed out that this imbalance limited the overall effectiveness of PV systems, as the lack of adequate storage solutions meant that excess generated energy could not be efficiently stored and utilised [31,46]. Another significant barrier was the high cost associated with energy storage technologies. The financial burden of large-scale battery deployment remained a substantial obstacle to their mass adoption. This cost factor affected individual consumers and posed challenges for broader implementation at the community and national levels, slowing the transition to renewable energy sources [83,91]. Additionally, the current limitations of energy storage technology prevented the complete replacement of fossil fuel power plants with photovoltaics. The authors of [90] argued that without efficient and scalable energy storage solutions, relying solely on PV systems to meet energy demands was not feasible, especially during periods of low solar output. This limitation underscored the need for continued research and development to enhance the capacity and efficiency of energy storage systems, enabling a more comprehensive shift towards renewable energy.

The most frequently identified negative factor influencing the development of photovoltaics in Poland was the lack of grid study and upgrades to absorb all PV energy efficiently. Even though, as [111] pointed out, there was an increase in innovation in the energy sector, including improved efficiency and production of renewable energy sources [111], power grids have not been modernised for many years. As many researchers highlighted [24,27,46,80,85,93,95–100], these grids were not designed to facilitate the rapid transmission of substantial quantities of energy, which gave rise to constraints in energy production and network disruptions. Moreover, smart meters had insufficient growth rates [31]. In addition, several factors that could be classified as neutral in the lack of grid

study have been identified: Ref. [94] indicated a need for research on simulations and their comparison with measurement data. In turn, Ref. [101] proposed that increasing self-generated energy consumption was optimal for enhancing a photovoltaic investment's profitability. Furthermore, Ref. [57] demonstrated that an air heat pump could be profitable with increased self-consumption.

Researchers had different views on the type of photovoltaic panels. We classified statements in [104] as negative factors, as the author pointed out that consumers usually could not determine the importance of the various criteria for evaluating photovoltaic panels. Similarly, the low energy efficiency of perovskite photovoltaic panels could also have a negative effect [102]. For positive factors, we included a [103] study on utilising a tracking photovoltaic installation containing polycrystalline silicon cells. The authors of [74] also studied the efficiency of a bifacial monocrystalline silicon module system, which we also classified as a positive factor. Ref. [66] emphasised the importance of developing a cost-efficient technology to produce PV cells that could be implemented in a short time. We classified this factor as neutral.

There were many studies on the technical aspects related to the slope angle and the installation orientation's geographical direction. We classified most of these studies as neutral factors. For example, Ref. [107] indicated the relationship between the angle of inclination of photovoltaic modules and the amount of dirt accumulating on them. Refs. [74,94] showed the dependence of PV efficiency on system orientation or inclination angle. In addition, Refs. [56,105,106] showed the need for conceptual prediction to correct the position of the building concerning the orientation, as well as the roof structure.

We included the [98,101] research as positive factors. The first one pointed out that using different areas for photovoltaic panels could benefit the electricity system network [98]. The second one indicated that GIS tools and information from open geospatial data could help plan new PV installations [101].

Finally, the remaining technical factors in the literature were identified and classified as other applications. First, the potential for PV systems to serve as Poland's sole electricity source was significant, and we classified this as a positive factor. Ref. [109] estimated that a large solar farm covering an area of approximately 6460 km<sup>2</sup> would be required to meet the entire country's electricity needs. They argued that such a large-scale solar farm's construction and energy storage costs would likely be lower than those associated with a nuclear power plant [109]. This finding highlighted solar energy's economic viability and scalability as a major power source, provided that sufficient land area and storage solutions were available. Second, the versatility of PV systems extended to military applications. Ref. [108] proposed the concept of using photovoltaic technology to charge electricity sources of varying power for soldiers and command posts. This application underscored the potential of PV systems to provide reliable and portable energy solutions in remote or tactical environments, enhancing operational efficiency and energy independence in the field.

These additional applications illustrated the broad potential of photovoltaic technology beyond traditional energy generation. The ability to extend to meet national energy demands and provide portable power solutions for specialised uses underscored the versatility and strategic importance of continued investment and innovation in PV technology. Moreover, Ref. [21,27] emphasised the fact that PV within an energy cooperative could be more cost-effective than a home PV installation.

### 3.5. Environmental Factors

In 47 articles, references to the environmental area were found. Seven factors were identified: En1: "Atmospheric air quality (Pollution and green gas house emissions)" was mentioned four times [43,112–114], En2: "Ability to reduce fossil fuel consumption and greenhouse gas emissions" was mentioned seven times [7,42,69,71,115–117], En3: "Geographical location of the country (region)" [24,32,41,43,94,105,114,116,118–124] fourteen times, En4: "Weather conditions", eight [36,45,46,48,101,112,120,125], En5: "Reduction of

carbon footprint”, seven [21,27,62,90,115,120,126], En6: “Meeting climate objectives, including reduced emissions, use of RES”, five [4,45,46,84,127] and En7: “Production and utilisation of PV”, nine [20,29,83,128–133]. Table 5 provides a summary of the analysis of these factors.

**Table 5.** Environmental factors.

| ID  | Factor                                                                 | Positive                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                           | Negative      |
|-----|------------------------------------------------------------------------|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|---------------|
| En1 | Atmospheric air quality (pollution and green gas house emissions)      | <ul style="list-style-type: none"> <li>Reduction in atmospheric emissions [43,112–114]</li> </ul>                                                                                                                                                                                                                                                                                                                                                                                                                                                                  | -             |
| En2 | Ability to reduce fossil fuel consumption and greenhouse gas emissions | Positive <ul style="list-style-type: none"> <li>Reduction in greenhouse gas emissions, conservation of natural resources, and ecological behaviour [7,60,69,83,115];</li> <li>PV systems with an average installed capacity (5.6 kWp) contribute to the most considerable reduction in CO<sub>2</sub> emissions due to the most significant number of installations; 10 kWp systems are the most efficient regarding environmental impact indicators [60];</li> <li>Significant reduction in CO<sub>2</sub> emission and other gaseous pollutants [94].</li> </ul> | Negative<br>- |
| En3 | Geographical location of the country (region)                          | Neutral <ul style="list-style-type: none"> <li>The efficiency of the installation depends on climatic conditions strongly correlated with the location [41,56,94,119,122];</li> <li>The choice of location for the installation of photovoltaic systems requires detailed information on solar radiation and meteorological conditions in the region [24,32,105,124];</li> <li>One of the main factors determining the amount of energy generated in a PV plant is Solar Global Horizontal Irradiation (SGH-I) [41].</li> </ul>                                    |               |
| En4 | Weather conditions                                                     | Positive <ul style="list-style-type: none"> <li>Problem: the dependence of power plant operation on changing weather conditions [41,46];</li> <li>Significant differences between energy generation in the summer and winter months [36,125,134];</li> <li>A significant drop in photovoltaic performance when temperatures rise [110];</li> <li>Climate change [36].</li> </ul>                                                                                                                                                                                   | Negative      |
|     |                                                                        | Neutral <ul style="list-style-type: none"> <li>One of the main factors determining the amount of energy generated by a photovoltaic installation is the hours of sunshine [41,123];</li> <li>The performance of PV is highly dependent on weather and insolation conditions [90],</li> </ul>                                                                                                                                                                                                                                                                       |               |

Table 5. Cont.

| ID  | Factor                                                              | Positive                                                                                                                                                                                                                                                                                                                                                             | Negative                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                            |
|-----|---------------------------------------------------------------------|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| En5 |                                                                     | Positive                                                                                                                                                                                                                                                                                                                                                             | Negative                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                            |
|     | Reduction of carbon footprint                                       | <ul style="list-style-type: none"> <li>Renewable energy helps reduce carbon footprint and mitigate the effects of climate change [21,27,60,90,115,126,135].</li> </ul>                                                                                                                                                                                               | <ul style="list-style-type: none"> <li>During production, CO<sub>2</sub> emissions occur [62].</li> </ul>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                           |
| En6 |                                                                     | Positive                                                                                                                                                                                                                                                                                                                                                             | Negative                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                            |
|     | Meeting climate objectives, including reduced emissions, use of RES | <ul style="list-style-type: none"> <li>The ‘green energy’ production can be significantly increased through the creation of large-scale self-sustaining housing estates, with appropriate stimulation at government and local levels [84];</li> <li>Energy transformation positively impacts the environment and air quality [45].</li> </ul>                        | <ul style="list-style-type: none"> <li>Ecological motivation and promotion of RES are far less important [22]</li> </ul>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                            |
| En7 |                                                                     | Positive                                                                                                                                                                                                                                                                                                                                                             | Negative                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                            |
|     | Production and utilisation of PV                                    | <ul style="list-style-type: none"> <li>Actual case studies show that the life cycle of a solar power plant is sustainable [133];</li> <li>The most favourable solution for environmental reasons is to use RES [126].</li> </ul>                                                                                                                                     | <ul style="list-style-type: none"> <li>The market for the repair, reuse and recycling of photovoltaic installations in Poland is practically non-existent [131];</li> <li>Potential negative environmental impacts throughout the life cycle of a PV plant, especially during PV production processes [129,130,136];</li> <li>Photovoltaic modules are the element causing the most harmful environmental repercussions in terms of the release of hazardous compounds into the atmosphere [128];</li> <li>Disposal of photovoltaic panels can be an essential issue—the life span of panels is relatively short [29];</li> <li>A wide range of negative externalities during the recycling/disposal of panels and associated equipment, currently [83].</li> </ul> |
|     |                                                                     | Neutral                                                                                                                                                                                                                                                                                                                                                              |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                     |
|     |                                                                     | <ul style="list-style-type: none"> <li>Environmental awareness regarding RES utilisation [20];</li> <li>If the annual electricity production of a PV is around 2000 MWh, the installation needs to operate for about 5.5 years to produce an amount of electricity equal to its total life-cycle consumption (with recycling of about 3 years) [128,133].</li> </ul> |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                     |

Regarding environmental factors, it would be essential to emphasise that photovoltaic installations do not release greenhouse gases into the atmosphere, nor do they cause noise or vibration. According to [43,112–114], reducing gases emitted into the atmosphere improved atmospheric air quality.

The literature analysis on reducing fossil fuel consumption and greenhouse gas emissions through photovoltaic (PV) systems revealed three significant positive factors. Firstly, adopting PV systems was strongly associated with reducing greenhouse gas emissions, conserving natural resources, and promoting ecological behaviour. Multiple studies supported this assertion, highlighting the environmental benefits of transitioning to solar energy [7,60,69,83,115]. By decreasing reliance on fossil fuels, PV systems would help

mitigate the adverse effects of climate change and preserve ecosystems, reinforcing the sustainability of renewable energy sources. Secondly, PV systems with an average installed capacity of 5.6 kWp were particularly effective in reducing CO<sub>2</sub> emissions, primarily due to the high number of installations of this size. The authors of [60] identified that while larger systems, such as those with a 10 kWp capacity, were more efficient regarding environmental impact indicators, the widespread adoption of 5.6 kWp systems resulted in the most significant overall reduction in CO<sub>2</sub> emissions [42,60]. This finding underscored the importance of promoting and supporting the installation of PV systems across various capacities, to maximise their environmental benefits. Thirdly, PV systems contributed to a significant reduction in CO<sub>2</sub> emissions and other gaseous pollutants. Ref. [94] emphasised that deploying solar energy systems could substantially decrease the emission of harmful gases, contributing to improved air quality and public health. This reduction in pollutants not only addressed environmental concerns, but also aligned with broader public health objectives, showcasing the multifaceted advantages of PV technology.

Various factors, including the country's geographical location and prevailing weather conditions, significantly influenced the operational performance of photovoltaic power plants. For example, Refs. [41,56,94,119,122] indicated that the efficiency of PV installations was highly dependent on climatic conditions, which were strongly correlated with their geographic location [41,94,119,121,122]. Furthermore, meteorological conditions in the region played a crucial role in determining the optimal location for installing photovoltaic systems. Studies by [24,32,105,124] supported this statement, emphasising that regional weather patterns and solar potential were critical considerations for site selection [24,32,105,124]. Moreover, Ref. [123] demonstrated that one of the primary factors influencing the amount of energy generated in a PV plant was Solar Global Horizontal Irradiation (SGHI). This parameter was essential for assessing the potential solar energy that can be harnessed at a specific location [123]. Understanding and optimising SGHI was vital for maximising the efficiency and output of PV installations.

In Poland, the prevailing weather conditions were the principal challenge to advancing photovoltaic technology. Consequently, in analysing the pertinent literature, we categorised most of the identified factors as negative or neutral. The dynamic nature of weather conditions, particularly the significant contrasts between summer and winter sunlight [36,101,125], presented a significant challenge to the profitability of photovoltaics. Ref. [110] noted a significant drop in photovoltaic performance when temperatures rise [112]. Climate change [36] and fluctuating weather conditions also influenced power plant operations [41,46].

These factors highlighted the critical need for developing adaptive strategies and technologies to mitigate the impacts of adverse weather conditions and enhance the resilience and efficiency of photovoltaic systems in Poland.

Many researchers agreed that renewable energy, including photovoltaics, helped reduce carbon footprint and mitigate climate change's effects [21,27,42,90,115,126,135]. However, Ref. [62] implied that CO<sub>2</sub> emissions occur during the production process [62].

The literature analysis on meeting climate objectives through the use of renewable energy sources (RES) revealed both positive and negative factors impacting the adoption and effectiveness of photovoltaic technology in Poland. One significant positive factor identified was the potential for substantially increasing 'green energy' production by developing large-scale self-sustaining housing estates. Ref. [84] emphasised the fact that, with proper stimulation and support at both government and local levels, these housing estates could significantly contribute to the production of renewable energy. This approach would not only enhance energy independence, but also align with broader climate objectives by reducing greenhouse gas emissions and promoting sustainable living. Additionally, the ongoing energy transformation positively impacted the environment and air quality. Ref. [45] highlighted the fact that the shift towards renewable energy sources, including PV systems, led to a noticeable improvement in environmental conditions. Despite these positive aspects, the literature also identified meaningful negative factors. One notable issue

was that some stakeholders considered ecological motivation and the promotion of RES as far less important. Ref. [22] pointed out that the lack of solid environmental motivation and inadequate promotion of renewable energy could hinder progress towards achieving climate objectives. That indicated a need for more robust educational and promotional campaigns to raise awareness about RES's environmental and economic benefits and to foster greater public and institutional support for renewable energy initiatives.

The literature analysis on producing and utilising photovoltaic (PV) systems in Poland revealed a complex situation, characterised by a predominance of negative factors. One significant challenge was Poland's underdeveloped market for repairing, reusing, and recycling photovoltaic installations. Ref. [131] highlighted the fact that this market was practically non-existent, posing a major barrier to the sustainable lifecycle management of PV systems. Additionally, the production processes associated with PV systems had potential negative environmental impacts. Studies by [129,130,136] emphasised the fact that these impacts were particularly concerning during the manufacturing phase, where the emission of hazardous compounds occurred [129,130,136]. Therefore, photovoltaic modules could be assessed as a significant source of environmental harm. Ref. [128] pointed out that these modules were the most harmful element of the PV system in terms of ecological repercussions. The disposal of photovoltaic panels also presented a critical issue. Ref. [29] noted that the relatively short lifespan of panels necessitated frequent disposal, which was not managed effectively at this time. This issue was compounded by the wide range of negative externalities associated with the recycling and disposal of panels and related equipment, as discussed by [83].

Despite these challenges, there were positive aspects to consider. Actual case studies indicated that the life cycle of a solar power plant could be sustainable. Ref. [133] provided evidence that, when appropriately managed, PV systems could offer a sustainable solution over their operational life. Moreover, Ref. [126] argued that the most favourable environmental solution was to use renewable energy sources, including PV systems. Their findings supported the broader environmental benefits of transitioning to solar energy, which aligned with global sustainability goals.

There were also neutral factors that neither heavily favoured nor significantly hindered the adoption of PV systems. Environmental awareness regarding the utilisation of RES was one such factor. The author of [20] noted that, while awareness was growing, it had not impacted PV adoption rates so far. Additionally, the energy payback time of PV installations was a crucial consideration. Ref. [128,133] highlighted the fact that a PV system with an annual electricity production of around 2000 MWh must operate for approximately 5.5 years to produce electricity equal to its total life-cycle consumption. This included about 3 years for recycling, indicating a relatively long period before the system's environmental benefits were fully realised [128,133].

### 3.6. Legal Factors

Legal issues were addressed in the 19 articles found. Five factors were identified. Regarding the first one, L1: "The renewable energy law" was mentioned by four authors [31, 121,137,138], L2: "The electricity law number" by three [20,31,66], L3: "PV net-metering and net-billing regulation" by four [85,101,111,139], L4: "Frequent changes in legislation" by eight [20,25,31,46,75,96,138,139], and L5: "Environmental policy" by five [31,66,130,131, 140]. The results are shown in Table 6.

Table 6. Legal factors.

| ID | Factor                                     | Positive                                                                                                                                                                                                                                                                                                                                                         | Negative                                                                                                                                                                                                                                                       |
|----|--------------------------------------------|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| L1 | The renewable energy law                   | <ul style="list-style-type: none"> <li>Prosumer financing and support programmes [138];</li> <li>Law on energy efficiency, law on electromobility: local authorities will be protagonists in the development of environmentally friendly solutions [137].</li> </ul>                                                                                             | <ul style="list-style-type: none"> <li>Too slow and unoptimized approval process for RES [31];</li> <li>Lack of applicable legal requirements [121].</li> </ul>                                                                                                |
| L2 | The electricity law number                 | Positive                                                                                                                                                                                                                                                                                                                                                         | Negative                                                                                                                                                                                                                                                       |
|    |                                            | <ul style="list-style-type: none"> <li>EU law regulations and pro-climate policy [20]</li> </ul>                                                                                                                                                                                                                                                                 | <ul style="list-style-type: none"> <li>Installation safety regulations require more detail [66]</li> </ul>                                                                                                                                                     |
|    |                                            | Neutral                                                                                                                                                                                                                                                                                                                                                          |                                                                                                                                                                                                                                                                |
|    |                                            | <ul style="list-style-type: none"> <li>Household energy price regulation in Poland [31]</li> </ul>                                                                                                                                                                                                                                                               |                                                                                                                                                                                                                                                                |
| L3 | PV net-metering and net-billing regulation | Positive                                                                                                                                                                                                                                                                                                                                                         | Negative                                                                                                                                                                                                                                                       |
|    |                                            | -                                                                                                                                                                                                                                                                                                                                                                | <ul style="list-style-type: none"> <li>Negative consequences of billing changes for further PV development, as ‘net-billing’ is less profitable [46,85,101,111,139];</li> <li>Lack of solutions supporting investments in home energy storage [85].</li> </ul> |
|    |                                            | Neutral                                                                                                                                                                                                                                                                                                                                                          |                                                                                                                                                                                                                                                                |
|    |                                            | <ul style="list-style-type: none"> <li>The main modes of photovoltaic installations in Poland are on-grid, off-grid and hybrid systems [139]</li> </ul>                                                                                                                                                                                                          |                                                                                                                                                                                                                                                                |
| L4 | Frequent changes in legislation            | Positive                                                                                                                                                                                                                                                                                                                                                         | Negative                                                                                                                                                                                                                                                       |
|    |                                            | -                                                                                                                                                                                                                                                                                                                                                                | <ul style="list-style-type: none"> <li>Unstable law and frequently changing legislative solutions [25,31,138];</li> <li>Lack of adequate support mechanisms and legislation [75,96].</li> </ul>                                                                |
|    |                                            | Neutral                                                                                                                                                                                                                                                                                                                                                          |                                                                                                                                                                                                                                                                |
|    |                                            | <ul style="list-style-type: none"> <li>The activities of conventional and renewable energy producers in legislative energy processes [20]</li> </ul>                                                                                                                                                                                                             |                                                                                                                                                                                                                                                                |
| L5 | Environmental policy                       | Positive                                                                                                                                                                                                                                                                                                                                                         | Negative                                                                                                                                                                                                                                                       |
|    |                                            | <ul style="list-style-type: none"> <li>PV is a perfect solution for the development of post-mining areas for large-scale renewable energy generation [130]</li> </ul>                                                                                                                                                                                            | <ul style="list-style-type: none"> <li>Standards for safely and reliably reusing PV modules have not yet been formulated [131]</li> </ul>                                                                                                                      |
|    |                                            | Neutral                                                                                                                                                                                                                                                                                                                                                          |                                                                                                                                                                                                                                                                |
|    |                                            | <ul style="list-style-type: none"> <li>Long-term environmental impact assessment and land use plan [31];</li> <li>Regulations on environmental protection and recycling of modules and batteries [66];</li> <li>Formulating effective economic, social and marketing policies is necessary to motivate consumers to be active energy producers [140].</li> </ul> |                                                                                                                                                                                                                                                                |

The instability and lack of clarity in Poland’s regulatory framework for renewable energy sources represented a significant obstacle to the growth of the photovoltaic industry. Many provisions and solutions included in the relevant legislation were ad hoc, and introduced in response to the evolving challenges posed by the dynamic renewable

energy market. Therefore, the legal area was dominated by negative factors identified by the authors.

One of the most pressing issues was the unstable legal environment, characterised by frequent changes in legislative solutions and the number of electricity laws. Refs. [25,31,138] all highlighted the detrimental impact of this instability on the PV industry. The frequent modifications in laws created uncertainty, making it difficult for investors and businesses to plan long-term projects and investments in PV technology. As [66] emphasised, there was a necessity for more comprehensive guidelines regarding the safety of installation procedures. Moreover, there was a notable lack of adequate support mechanisms and legislation tailored to the needs of the renewable energy sector. Studies by [75,96] emphasised the fact that the absence of solid legislative backing and support structures significantly hampered the industry's growth. They stated that without a stable and supportive regulatory framework, fostering confidence among stakeholders and attracting the necessary investments for large-scale PV projects would be challenging.

The recent changes in billing regulations, particularly the shift from net-metering to net-billing, negatively affected further PV development. As [46,85,101,111,139] noted, net-billing was less profitable than the previous net-metering system. This reduction in profitability discouraged new investments in PV systems, as potential investors perceived lower financial returns. Furthermore, there was a lack of solutions supporting investments in home energy storage. Ref. [85] pointed out that the absence of incentives and regulatory frameworks for energy storage systems prevented the effective integration of PV installations with storage solutions. Addressing these issues through a more stable and supportive regulatory framework will be crucial for fostering the sustainable development of PV technology in Poland. However, we included as neutral statements those of [139], who pointed out that Poland's main types of photovoltaic installations were on-grid, off-grid and hybrid systems.

The literature analysis revealed both positive and negative factors regarding renewable energy law (general view). Ref. [138] highlighted the significant impact of financing and support programs for prosumers. These initiatives provided financial assistance and incentives to individuals and businesses that generated their renewable energy, promoting the adoption of PV systems. Ref. [137] discussed the importance of laws focused on energy efficiency and electromobility. These laws positioned local authorities as key players in developing environmentally friendly solutions, including integrating PV technology. However, Ref. [31] identified the negative aspect, the approval process for renewable energy sources (RESs), as being too slow and unoptimized. The bureaucratic hurdles and lengthy procedures delayed the implementation of PV projects, discouraging potential investors and slowing the industry's growth. Ref. [121] pointed out the absence of specific legal requirements for deploying RESs. This lack of clear guidelines and standards created uncertainty and inconsistency in the regulatory environment, making it difficult for developers to navigate the legal landscape and comply with necessary regulations.

One of the significant positive factors identified in the context of environmental policy was the potential for PV technology to be exploited in developing post-mining areas for large-scale renewable energy generation [130]. Repurposing these areas would not only provide an effective use of otherwise abandoned land, but also contribute to the overall increase in renewable energy capacity. This approach aligned with the goal of sustainable development, which is to transform environmentally degraded sites into productive renewable energy hubs, thus addressing both land rehabilitation and energy generation needs.

A notable negative factor identified in the context of environmental policy was the lack of formulated standards for safely and reliably reusing PV modules [131]. This gap in regulatory frameworks posed significant risks, including potential environmental hazards and the loss of valuable materials that could otherwise be recycled.

Several factors fell into the neutral category, indicating that their potential impact depends mainly on how they were managed and implemented. For instance, long-term

environmental impact assessment and land use plans were essential for the sustainable integration of PV technology [31]. Regulations on environmental protection and the recycling of modules and batteries were also classified as neutral [66]. These regulations provided a framework for managing the environmental footprint of PV technology. Still, their impact would depend on how effectively industry stakeholders enforced and adhered to them. Proper implementation could mitigate negative environmental impacts, while lax enforcement might render these regulations ineffective. Formulating effective economic, social, and marketing policies was crucial to motivate consumers to become active energy producers [140]. These policies could significantly influence the adoption of PV technology by creating a favourable environment for consumers.

#### 4. Conclusions

The presented studies of the systematic literature analysis allowed us to answer RQ1: what are the main opportunities in the political, economic, social, environmental and legislative fields associated with the development of PV in Poland? When searching the literature for answers to this research question, the most common statements were those related to the environmental aspects of PV investment. Reducing CO<sub>2</sub> and other gaseous pollutants was emphasised, thereby reducing the carbon footprint and mitigating the effects of climate change. Economic factors also appeared frequently in the works analysed. The deployment of photovoltaics was usually seen as an economically viable investment with significant cost savings (also highlighting the importance of self-consumption). Subsidies played a substantial role in many articles here. PV investment was often understood as protection against rising electricity prices and fossil fuel costs. As far as social factors were concerned, there were almost only benefits. Generally, society perceived RES as environmentally friendly and accepted by local communities. It was also stressed that energy security and the ability to become at least partially independent of energy suppliers and to diversify energy sources was crucial. In terms of technical factors, attention was drawn, among others, to the high reliability of the hybrid system resulting from the attachment of energy storage to PV. Political and legal factors focused on maintaining a direction aligned with the EU in supporting RES.

Thereafter, we addressed RQ2: what are the main barriers in the political, economic, social, environmental and legislative fields related to PV development in Poland? Regarding this research question, most obstacles appeared to be those concerning technological factors. First of all, there were problems with system stability, because power grids had not been upgraded for many years, and consequently, grid interruptions occurred often. Unfortunately, this reduced the efficiency of the system. The outages were most often caused by inadequate network parameters and, in particular, transformers unsuitable for drawing power from such a large number of photovoltaic installations in their area of operation. Therefore, the energy supplier should upgrade the electricity grid as soon as possible, to accommodate the new conditions. Furthermore, some articles mentioned that particles in the air in urban areas negatively affected the performance of photovoltaic modules. Another weakness—as far as the environment was concerned—was the dependence on weather conditions, which are difficult to predict for the long term. The authors of the analysed articles also claimed that PV would not be so ecological regarding the whole-life cycle. Negative environmental impacts were to occur during PV production processes and the recycling/disposal of panels. Economic barriers also emerged during the analysis. High investment costs were in first place. At these costs, subsidies lost their power, according to some studies. Some authors also claimed that the investment payback time was too long. Moreover, as the development of storage systems had not gone hand in hand with the rapid growth of micro-installation, the main barrier here was the high cost of batteries. Many authors likewise stressed the negative consequences of recent billing changes for further PV development, seeing ‘net-billing’ as less profitable. The main political and legal barriers were the deficiency of clear and long-term policy, the influence of the coal lobby, and political unpredictability. Therefore, we think that solving this problem through more

structured, stable and user-friendly legislation would contribute to the development of PV. Above all, it would be worth reviewing how prosumers are billed and, if possible, reverting to the previous one, which the authors felt was more equitable.

Finally, we examined the neutral ratings of the factors studied to answer RQ3: are there factors in the political, economic, social, environmental and legislative fields to pay attention to that could become opportunities or threats for PV technology? Undoubtedly, there was a need for more widespread public campaigns aimed at promoting the benefits of RESs and pro-ecological behaviours, which was noticed. Also, Smart PV monitoring equipment would provide a rapid response to any faults in the PV system, in terms of system stability. The best way to enhance the profitability of a photovoltaic investment in every aspect was to increase the energy self-consumption. And that could be achieved by having a battery or an air-source heat pump (preferably with a control system). Legislative facilitation and increased battery-purchase subsidies would help solve this problem. Another way to develop PV efficiency was the system's orientation or the inclination angle. There was also a correlation between the angle of inclination of photovoltaic modules and the amount of dirt accumulating on them. So, a need emerged to conceptually predict the correct position of the building regarding the orientation and the roof structure. The location for installing photovoltaic systems would require detailed information on solar radiation and meteorological conditions in the region. In addition, PV within an energy cooperative could be more cost-effective than a home PV installation. Moreover, the development of photovoltaic power depended on individual income and was also correlated with the wealth of countries. Therefore, developing a more cost-effective photovoltaic production technology, which would allow for a reduction in investment expenditure, would contribute to the significant development of this technology. This provides a competitive challenge for researchers and justification for intensifying research.

It is essential not to overlook the fact that the above factors included in the PESTEL analysis are interrelated. For example, legislative changes regarding how PV installations are billed have significantly affected the economic evaluation of investments in this technology. An active campaign to promote PV concerning environmental protection could still increase public acceptance.

A systematic review of the literature has enabled the organisation and categorisation of knowledge on the development of photovoltaics in Poland over the last 10 years, in the form of a PESTEL analysis of macroeconomic factors. In addition, it seems valuable to provide a significant amount of synthesised and aggregated knowledge. It is easily verifiable, due to the possibility of replicating the review process. A comparison of our studies with PESTEL analyses in other countries [19,141–145] reveals significant differences, for example, in location [19,141] or environmental conditions [142,143]. Similarly, in EU countries, common directives and guidelines on green energy may cause comparable difficulties regarding legal factors [144]. In Australia, the fact that the economy is based on coal and export, similarly to Poland, may present an economic barrier [145]. Nevertheless, the authors intend to conduct further studies to enable a more comprehensive comparison of PESTEL in other countries.

Based on a PESTEL analysis, we provide specific recommendations that could benefit policymakers, industry stakeholders, and researchers. These include the following:

- The establishment of favourable, stable and legal regulations;
- The allocation of more significant financial subsidies for photovoltaic systems;
- The advancement of domestic producers of renewable energy systems (RESs);
- The dissemination of knowledge and the enhancement of public awareness;
- The provision of incentives for the utilisation of photovoltaic systems;
- The undertaking of grid studies and upgrades to ensure the efficient integration of all renewable energy;
- Increased funding for research into innovations related to photovoltaic systems.

A limitation of the present analysis was that only selected articles were collected using the method described. More than that, as the articles were in English, relevant publications

in other languages could be excluded. We cannot guarantee that nothing significant has been omitted. However, we trust that the number of papers read and analysed will reduce this constraint. Consideration could only be given to a different selection of words used to search the database. It is also important to emphasise that the PESTEL analysis is subject to subjectivity. Consequently, it is recommended that such a study should be repeated, given that some of the factors discussed in different sections may change over time. It is, therefore, advised that these factors be periodically evaluated and compared with other countries. Thus, in the future, the authors intend to integrate the PESTEL approach with multi-criteria decision-making tools, such as the Analytical Hierarchical Process, to assist in assigning weights to the identified factors. This will facilitate the formulation of target decisions for the photovoltaic sector.

**Author Contributions:** Conceptualisation B.H. and A.M.; methodology B.H.; validation, formal analysis B.H.; investigation B.H. and A.M.; resources B.H., data curation A.M.; writing—original draft preparation B.H. and A.M.; writing—review and editing B.H. and A.M.; visualisation B.H.; supervision A.M. All authors have read and agreed to the published version of the manuscript.

**Funding:** This research was partly financed from the statutory funds of the Faculty of Management and Organization at the Silesian University of Technology in Gliwice, Poland.

**Data Availability Statement:** The original contributions presented in the study are included in the article, further inquiries can be directed to the corresponding authors.

**Conflicts of Interest:** The authors declare no conflicts of interest. The funders had no role in the study's design, in the collection, analyses, or interpretation of data, in the writing of the manuscript, or in the decision to publish the results.

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