

## Article

# Review of Regional Renewable Energy Investment Projects: The Example of EU Cohesion Funds Dispersal

Wojciech J. Florkowski <sup>1,\*</sup>  and Joanna Rakowska <sup>2,\*</sup> 

<sup>1</sup> Department of Agricultural and Applied Economics, University of Georgia, Griffin, GA 30223-1797, USA

<sup>2</sup> Department of Development Policy and Marketing, Institute of Economics and Finance, Warsaw University of Life Sciences, 02-787 Warsaw, Poland

\* Correspondence: wojciech@uga.edu (W.J.F.); joanna\_rakowska@sggw.edu.pl (J.R.)

**Abstract:** The study aimed at reviewing the European Union funds' distribution mechanism supporting investments in renewable energy deployment in Poland, its effects and the relationship between the value of each investment and its location, location area characteristics, the type of investing entity, and the type of RE to be utilized once the investment is completed. The study fills a gap in the literature on the regional dispersal of cohesion funds. The presented findings are novel and contribute to a better understanding of the use of funds to support local investment projects and improve planning and implementation of evidence-based policies aimed at increasing renewable energy utilization in the European Union. The applied methods included multiple linear regression and cartograms. The data on the renewable energy investments were obtained from the SIMIK database for the years 2007–2015, while the characteristics of counties were gathered from Statistics Poland. The results show that the European Union cohesion funding was essential in overcoming the major barrier to solar renewable energy utilization, which was the cost of the initial investment. There were significant differences in the dispersal of the analyzed investments—most of them cumulated in north-eastern and eastern Poland. Although the funding distributed through operational programs was accessed by a variety of applicants, the municipality self-governments and small and medium-sized enterprise contributed most to the increased share of energy generated from solar renewable energy. The largest number of projects involved solar and wind energy, allowing applicants to lower operating costs by reducing energy bills.

**Keywords:** renewable energy; investment; European Union cohesion funds; solar energy; wind energy; air quality; Poland



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## 1. Introduction

The 1997 European Union (EU) policy on increasing renewable energy (RE) utilization predates the accession of Poland and nine other countries into the EU in May 2004. The European Commission (EC) and European Parliament adopted the “White Paper for the Community Strategy and Action Plan” on expanding the share of RE in gross energy consumption [1]. Simultaneously, similar laws were adopted in Poland and the country passed another law corresponding to the European Parliament Directive 2001/77/EC in August 2001 [2]. Several weeks prior to the 2004 accession to the EU, Poland amended the energy law creating additional incentives to develop renewable energy sources (RES). Subsequently, Poland implemented provisions of Directive 2009/28/EC to promote RE use in 2010. The increased utilization of RES was intended to reduce dependence on fossil fuels, especially coal, contribute to EU climate policy through the reduction in CO<sub>2</sub> and other GHG emissions, and comply with the Kyoto Protocol and the United Nations Framework Convention on Climate Change [3,4]. RE has also become a factor relevant for EU energy security [5]. Furthermore, the utilization of RE is consistent with the policy of sustainable development and increased investment in RE in Central and East European countries between 2004 and 2013 [6].

Between 2007 and 2013, the EU invested 347.4 billion euros, or more than one-third of its total budget, in regional and cohesion policies [7] and Poland together with the other new (as of May 2004) EU member countries received a large portion of those funds. The program was based on Community Strategic Guidelines of the EU Council and the National Strategic Reference Framework of each member-country [8]. The main goal of the program was the strengthening of economic and social cohesion by reducing the disparities between development levels across member countries [9] through, among other things, the increased use of RES mandated by the EC [10].

There have been a number of studies examining the goals of the EU energy policy [11,12] at the onset of the 2007–2013 funding period including RE generation and its links to food security [13,14]. Another set of studies focused on the anticipated climate change policy and EU goals with regard to GHG emissions, for example [15–18]. However, there is a complete lack of studies examining how the funds were spent on RE utilization projects at the regional level in the recipient country and knowledge is lacking regarding factors driving local investment in such projects (receiving funding through 2013 and completion date at the end of 2015) since the conditions for accessing EU funds required matching contributions. Moreover, the flexibility in spending was left to each member-country, which could apply the funds to enhance air quality improvement and implement the goals of the EU carbon reduction and climate change policies. The outcomes of this flexibility need to be determined and explained.

The current study fills this gap by reviewing the funds' distribution mechanism using the example of Poland. Rationale of choosing Poland as the case study stems from the fact that Poland has been the largest recipient of the EU cohesion funds and has been heavily dependent on fossil fuels, especially hard coal, for space heating [19] and electricity generation [20]. The case of Poland illustrates a middle-size country, where the level of energy generation from RE was relatively small, air pollution was seasonally high [21], and the general public viewed RE favorably. Furthermore, RE use fits an important goal of Poland's policy of developing energy mix [22,23]. Poland's total investment in all RE utilization projects was valued at 8.194 billion Polish zloty, which raises questions concerning the regional dispersal of the effects. Specifically, the current study examines the investment in RES utilization using EU cohesion funds for the funding period 2007–2013, which permitted the project's completion by the end of 2015. The difference in the timespan listed in the name of the financial perspective 2007–2013 and dataset range 2007–2015 results from the so-called "N+2" principle [24] allowing member states to issue payments from the 2007–2013 cohesion funds over the next 2 years after the nominal perspective expired, i.e., through 2015. Thus, the dataset for the financial perspective 2007–2013 was available in 2016. A similar rule applies to the financial perspective of 2014–2020, though the data on RE investment supported by the EU cohesion funds for that period are not yet available. Only the data for the period 2007–2015, the most recent completed financing cycle were released.

The main focus of this study is to investigate how the funds were used to support RE utilization for implementing the EU energy and climate change policy. The study aims to show the location of counties where the solar and wind energy projects were funded using the cohesion funds in terms of solar radiation, wind conditions, and biomass availability and describes the system guiding the allocation of funds to all 16 regions in the country. Using a unique dataset pertaining to the funds' distribution, the study also attempts to quantify the relationship between the value of an investment project utilizing solar, wind, and biomass energy and project location, location area characteristics, the type of investing entity, the program contributing to the project, and the type of RE to be utilized once the investment is completed. Such detailed analysis at the project level cannot be found in the existing literature, and this contributes to the novelty of the study.

The applied hypothesis is:

**Hypothesis 1.** *The value of the absorbed EU funding for RE investments depended on selected social and economic characteristics of municipalities where the solar renewable energy investments were located, on the type of investor and the region.*

## 2. Literature Review

The continuous progress in RE use in the EU has been viewed as too slow [25]. The unsatisfying pace in the individual EU member states results from different technical, administrative, legal, financial and social barriers [26–31]. However, financial barriers are recognized as the most crucial and it has been commonly acknowledged that the use of RES needs to be supported by public funds [32–39].

The EU provides such support to its member states under the cohesion and regional policy rules through funds allocated through the so-called financial perspectives (such as those for the perspective 2007–2013). Although the EU has supported the utilization of all kinds of renewable energy, the use of specific RES may vary across countries. Different types of RE also have different attributes, e.g., solar and wind energy produce a minimal amount of on-site emissions contributing to cleaner air [40,41], while biomass energy use is consistent with sustainable development [42]. The differences in natural endowment are the reason why the use of funds allocated under the cohesion policy umbrella [8] is guided by national policy priorities formulated in National Renewable Energy Action Plans [43]. The EU principles governing the financial support allocated under cohesion and regional policy require that they are evidence-based [44]. The term “evidence-based” implies that decisions must be based on a scientific framework.

The design and implementation of an effective RE policy requires understanding the past trends and defining their implications for the future [45]. The current study recognizes the importance of these trends and their implications and examines the outcome of the 2007–2013 financial perspective and its contribution to RE utilization.

## 3. Materials and Methods

### 3.1. Data

The data on the RE projects are from the SIMIK database for the years 2007–2015 managed by the Ministry of Regional Development (the name of the ministry as of 31 January 2016, when the data were obtained). The data reflect the status of projects on 31 December 2015, which was the project completion deadline [24,46]. The database contained about 150,000 entries and this study uses the data involving RE investment. The specific RE investment project data included their total value, share of EU funds for each project, RE source, county location, and applicant category.

The study also uses information about the county where the RE project was located. The characteristics of the county were obtained from Statistics Poland [47]. County classification followed the system DEGURBA defining three categories according to the degree of urbanization: cities or densely populated areas, towns and suburbs; intermediate density areas; and rural areas or thinly populated areas [48]. Using the DEGRUBA classification assures a consistent classification across the domestic and EU systems. The current study identifies urban counties because urban county governments tend to have more resources and every RE project requires investor contribution before qualifying for a contribution from EU-sponsored programs.

To further account for local characteristics and the RE investment, the current study included population density and gross per capita income per county resident. Less populated counties encourage RE investments that require space (solar power plants) or safe locations (wind turbines). Additionally, less populated counties may benefit from increased energy security and accessibility as grid lines are likely less dense there. The gross annual income per county is a measure of relative strength of the local economy. Per capita income is an implicit measure of a county’s ability to make the required contribution of funds to finance projects since none of the projects could be fully funded through the regional or national

programs. The income data for the period 2007–2015 are from Statistics Poland. To identify a possible effect of the national I&EOP, the study included a binary variable to link a project to that source of funding. The national program was receptive to larger, more costly projects or projects involving applicants located in a given county but of supra-regional importance.

A variety of public and private investors could apply for support of RE utilization projects. To distinguish two particular groups, the study identified private firms and NGOs. Private firms motivated by profits could have implemented large projects. NGOs are likely to invest in smaller projects, but may utilize a greater variety of RES. Three separate indicators categorize RES that were most often the focus of an investment project, namely wind, sun, and biomass.

The location of a particular investment in an RE-using facility is important as natural conditions for the availability of solar and wind energy vary. Those two RE sources can only be used on-site. Biomass must be transported and needs some degree of processing before it can be used, and its nature tends to require regions with relatively large forest areas. Each voivodship has been distinguished using binary variables, which account for the diverse economies and natural conditions influencing the availability of various RE types.

The value of EU funding obtained for the RE investments was a dependent variable, while other data described were predictors, as explained in the Section 3.2.

### 3.2. Estimation Approach

To verify the hypothesis ‘The value of the absorbed EU funding for RE investments depended on selected social and economic characteristics of municipalities where the solar renewable energy investments were located and on the type of investor’, the applied estimation technique used multiple linear regression. The relationship between the amount of subsidies from programs supported by EU cohesion funds was expected to identify statistically significant explanatory variables, which acting as predictors, provide insights into the factors that the funds’ managers and policy makers may use in selecting the amount of subsidy for specific future RE projects.

The general form of the multiple linear regression was:

$$Y_i = b_0 + b_1x_{1i} + b_2x_{2i} + \dots + b_nx_{ni} + \varepsilon_i$$

in which  $b_0$  is the Y intercept,  $b_1$  is the gradient for the straight line,  $X_1$  is the value of the predictor, and  $\varepsilon$  is a residual term. The qualitative predictors describing the county where the RE project was located were expressed as variables in logarithmic form. These were:

$x_1$ —population density;

$x_2$ —the county per capita revenues.

The latter is a proxy for the local government’s ability to match the subsidy of investment projects realized by the public sector. The qualitative predictors were expressed as binary variables:

$x_3$ —binary variable to differentiate between regional and national operational programs as the funding source;

$x_4$ —a binary variable to distinguish different types of investors;

$x_5$ —a binary variable to distinguish three specific RE sources, i.e., wind, solar radiation, and biomass, from other RE sources;

$x_6$ —a binary variable to separate urban counties from rural counties.

Results of the estimation are presented in Section 4.5 Multiple Linear Regression Results.

## 4. Results

### 4.1. Overview of the EU Funding for Investment in RE Utilization in Poland

The EU has promoted RE for energy generation in its directive of September 2001 [49]. During the period 2007–2013, the umbrella term of Cohesion Fund applied to two structural funds: European Regional Development Fund and European Social Fund [50]. The funds

were allocated to eligible member states and distributed through numerous operational programs organized and implemented in individual countries with the completion date no later than 31 December 2015.

In the period 2007–2013, Poland was granted 67 billion euro, which was the biggest (19%) share of total EU cohesion policy funding allocated to any eligible member state [7] (Table A1). Poland, Spain, and Italy were the top three recipients followed by Czechia, Germany, and Hungary. However, the calculation of per capita allocation shows that the three top recipients were Estonia, the Czech Republic, and Hungary followed by Malta, Slovakia, and Slovenia, placing Poland 11th by that measure (Table A1). The three countries with the lowest per capita allocation in the period 2007–2013 were Denmark, the Netherlands, and Luxembourg.

Each EU recipient country was obligated to use the funds for projects within the scope of the cohesion fund goals and according to the EU legal requirements. In Poland, the EU funds co-financed, among others, the nationwide Infrastructure and Environment Operational Program (I&EOP) and 16 regional operational programs [51] (Table A2). Thus, the EU funding became an instrument to achieve the RE utilization target of a 15% share of energy from RES in gross final energy consumption in Poland by 2020 [52] and subsequently increased [10].

To qualify for a subsidy, the investor was also required to invest their own funds. Applicants including local and provincial governments, companies, and civic organizations could submit RE-relevant projects and obtain EU subsidies under the condition that they assumed a portion of each project's cost. In Poland, as in all member states, the upper limit a project could receive from the EU funds was generally 85% of eligible expenditures [9]. However, the principle of cross-financing and/or rules of granting public assistance could raise this threshold to 100%. Thus, the granted subsidies for individual projects could vary in size. The operational programs in all 16 voivodships distributed a total of nearly 8.2 billion PLN (2.282 billion euro) at the exchange rate of 31 December 2007 [53] and funded 716 investment projects utilizing RES between 2007 and 2015.

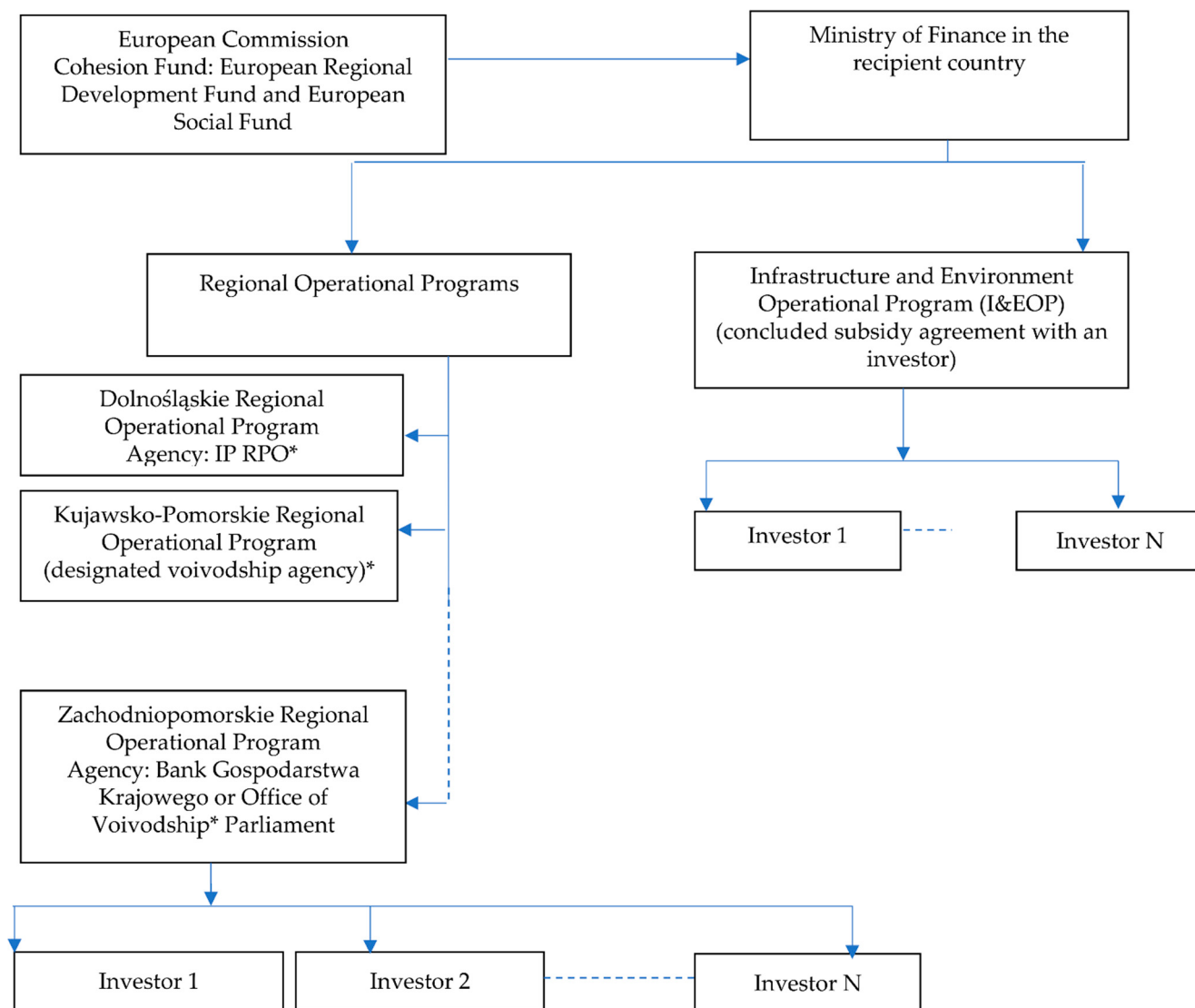
RE utilization offers an opportunity at the local level to change dependence on fossil fuels through the EU funds distributed by voivodship government programs, i.e., the regional operational program and the I&EOP. Of particular relevance is investment in rural areas, which have less dense grids and where residents suffer larger losses from power outages than those in urban areas [54]. The program encourages multi-level governance by involving all levels of the administrative structure from the central to county governments. The investment in local RE utilization projects in the period 2007–2013 seemed to be recognized by the public, as 31% of surveyed adults in Poland agreed that the development of RE should have been a priority of EU policy [55].

Figure 1 illustrates the flow of funds from the European Commission to an investor. The distribution of funds was managed by the Ministry of Finance and, in the case of a voivodship, resources were transferred to the regional agency in charge of investment project approval and fund dispensation. There were differences across voivodships in designating the regional agency in charge of the program (Figure 1).

In the period 2007–2013, regional operational programs funded 645 projects and infrastructure and environment programs funded 71 projects allowing the completion by the end of 2015 (Table 1).

Table 1 shows the location of RE investment projects in 16 voivodships of Poland that received EU funding distributed through Regional Operational Programs and the I&EOP. Out of 716 RE investment projects, Podlaskie Voivodship implemented 122 projects accounting for 17% of all projects, while Lubelskie and Warmińsko-Mazurskie realized 107 and 106 projects, respectively. All four regions offer opportunities for the utilization of wind, solar, and biomass energy. All are located in eastern or southeastern Poland, and Podlaskie and Lubelskie are among the least developed EU regions according to the NUTS2 system and part of the eastern border of the EU. Except for Małopolskie, with 95 projects, the remaining 12 regions reported at most 38 projects (Table 1). The four

mentioned regions had all or nearly all projects funded through their regional operation programs. Investments supported through the national I&EO shows a different geographical distribution. Zachodniopomorskie (12 projects), Łódzkie (10 projects), Pomorskie (9 projects), and Kujawsko-Pomorskie (8 projects) implemented the largest number of funded projects (Table 1).



**Figure 1.** Illustration of the flow of funding from the European Commission to the RE investment project. Notes: \* Each voivodship selected its own intermediary institution to conclude the subsidy agreement with an investor. Specific examples for selected voivodships are shown above.

However, the size of the RE utilizing facilities is implied by their value. Table 2 shows that by far the highest value of RE projects was located in Lubelskie and amounted to about 340 million Polish zloty. The value of the 122 projects in Podlaskie was less than one half of that and reached almost 167 million Polish zloty. Among the remaining regions, only in Małopolskie and Łódzkie did the value of the projects exceed 100 million Polish zloty (133.5 and 102.5 million Polish zloty, respectively). The comparison of the value of funded projects through the national I&EOP to those funded through the regional programs shows that the former investment applied to larger-scale RE utilizing facilities (Table 2). The total value of 90 projects funded by I&EOP was valued at 1.6 billion Polish zloty vs. slightly more than 1.2 billion Polish zloty supporting 645 projects from the regional programs.

Łódzkie, Zachodniopomorskie, and Pomorskie were the highest funding recipients from the national I&EOP. The latter two regions have relatively suitable conditions for wind and solar energy as well as biomass potential.

**Table 1.** Number of RE projects and their share by RES funding in 16 voivodships by regional operational programs and the Infrastructure and Environment OP in the period 2007–2013.

| Voivodship          | Number of Projects | Voivodships' Share in the Number of Projects, % | Regional Operational Program | Project Number and Funding Source |                                           |                                             |
|---------------------|--------------------|-------------------------------------------------|------------------------------|-----------------------------------|-------------------------------------------|---------------------------------------------|
|                     |                    |                                                 |                              | Infrastructure and Environment    | Regional Operational Program <sup>a</sup> | Infrastructure and Environment <sup>a</sup> |
| Dolnośląskie        | 20                 | 2.8                                             | 14                           | 6                                 | 70                                        | 30                                          |
| Kujawsko-Pomorskie  | 17                 | 2.4                                             | 9                            | 8                                 | 53                                        | 47                                          |
| Lubelskie           | 107                | 14.9                                            | 106                          | 1                                 | 99                                        | 1                                           |
| Lubuskie            | 14                 | 2.0                                             | 9                            | 5                                 | 64                                        | 36                                          |
| Łódzkie             | 33                 | 4.6                                             | 23                           | 10                                | 70                                        | 30                                          |
| Małopolskie         | 95                 | 13.3                                            | 95                           | 0                                 | 100                                       | 0                                           |
| Mazowieckie         | 26                 | 3.6                                             | 25                           | 1                                 | 96                                        | 4                                           |
| Opolskie            | 16                 | 2.2                                             | 15                           | 1                                 | 94                                        | 6                                           |
| Podkarpackie        | 38                 | 5.3                                             | 35                           | 3                                 | 92                                        | 8                                           |
| Podlaskie           | 122                | 17.0                                            | 121                          | 1                                 | 99                                        | 1                                           |
| Pomorskie           | 35                 | 4.9                                             | 26                           | 9                                 | 74                                        | 26                                          |
| Śląskie             | 16                 | 2.2                                             | 14                           | 2                                 | 88                                        | 13                                          |
| Świętokrzyskie      | 5                  | 0.7                                             | 4                            | 1                                 | 80                                        | 20                                          |
| Warmińsko-Mazurskie | 106                | 14.8                                            | 102                          | 4                                 | 96                                        | 4                                           |
| Wielkopolskie       | 28                 | 3.9                                             | 21                           | 7                                 | 75                                        | 25                                          |
| Zachodniopomorskie  | 38                 | 5.3                                             | 26                           | 12                                | 68                                        | 32                                          |
| Poland total        | 716                | 100.0                                           | 645                          | 71                                | 90                                        | 10                                          |

<sup>a</sup> Note: Share of project per funding source in the number of voivodship projects.

**Table 2.** Value and percent of EU funding in the total value of RE projects under Regional Operational Programs and the Infrastructure and Environment Operational Program, 2007–2013.

| Voivodship          | Total Value<br>mln PLN | Amount and Share of Funding from EU Supported Programs |          |                                   |          |
|---------------------|------------------------|--------------------------------------------------------|----------|-----------------------------------|----------|
|                     |                        | Regional Operational Programs                          |          | Infrastructure and Environment OP |          |
|                     |                        | mln PLN                                                | Share, % | mln PLN                           | Share, % |
| Dolnośląskie        | 203.9                  | 22.7                                                   | 11       | 181.2                             | 89       |
| Kujawsko-Pomorskie  | 145.9                  | 18.3                                                   | 13       | 127.6                             | 87       |
| Lubelskie           | 347.2                  | 339.4                                                  | 98       | 7.9                               | 2        |
| Lubuskie            | 121.5                  | 16.9                                                   | 14       | 104.6                             | 86       |
| Łódzkie             | 382.0                  | 102.5                                                  | 27       | 279.5                             | 73       |
| Małopolskie         | 133.5                  | 133.5                                                  | 100      | 0.0                               | 0        |
| Mazowieckie         | 85.7                   | 65.2                                                   | 76       | 20.5                              | 24       |
| Opolskie            | 36.2                   | 18.5                                                   | 51       | 17.7                              | 49       |
| Podkarpackie        | 163.3                  | 62.8                                                   | 38       | 100.5                             | 62       |
| Podlaskie           | 174.9                  | 166.9                                                  | 95       | 8.0                               | 5        |
| Pomorskie           | 252.3                  | 37.5                                                   | 15       | 214.8                             | 85       |
| Śląskie             | 113.3                  | 50.1                                                   | 44       | 63.2                              | 56       |
| Świętokrzyskie      | 15.4                   | 3.4                                                    | 22       | 12.0                              | 78       |
| Warmińsko-Mazurskie | 165.0                  | 89.2                                                   | 54       | 75.8                              | 46       |
| Wielkopolskie       | 158.9                  | 60.9                                                   | 38       | 97.9                              | 62       |
| Zachodniopomorskie  | 282.5                  | 49.6                                                   | 18       | 232.9                             | 82       |
| Total               | 2781.5                 | 1237.4                                                 | 44       | 1544.0                            | 56       |

Note: PLN = Polish zloty; 1 PLN = USD 3.012 or 1 PLN = 4.1472 euro on 31 December 2013 [53].

The number of funded RE projects shows large spatial variation across voivodships, some likely related to local natural conditions. Examples of the county governments implementing solar energy utilization projects by rural households include Lubelskie Voivodship [56]. The largest number of RE investment projects were located in three voivodships: Podlaskie, Lubelskie, and Warmińsko-Mazurskie (Table 1), which are among the least developed regions in the EU according to the classification NUTS2 [57]. All three regions have a rural character and the use of coal as a source of energy is common. However, not all NUTS2 regions lagging in development in Poland showed a strong interest in RE investment projects. For example, Świętokrzyskie Voivodship reported only five projects representing 0.7% of all RE projects supported by EU funds. It is possible that the region received funds from other sources for RE projects. Overall, the majority of projects were funded through regional operational programs (in Polish: Regionalny Program Operacyjny). Only about 10% of all projects received funding from the I&EOP.

The large number of projects did not translate into the highest total value of RE projects in a given region (Table 2).

RE projects received funds from the regional operational program as well as the national I&EOP. However, the portion of the investment value funded with the regional operational program dominated in the lesser developed regions. For example, in the Lubelskie and Podlaskie Voivodships, the subsidies from those programs covered 98% and 95% of the total value of the projects, respectively (Table 2). EU funding from the regional operational program covered 100% of the RE project value in Małopolskie Voivodship. Funding from the regional operational programs in several voivodships was relatively small, but those regions received the needed funding from the national I&EOP. Dolnośląskie, Kujawsko-Pomorskie, Lubuskie, Pomorskie, and Zachodniopomorskie obtained, respectively, 89%, 87%, 86%, 85%, and 82% of the RE investment value from the I&EOP (Table 2). Both the regional and national programs were critical in funding RE utilization projects in Poland in the period 2007–2013.

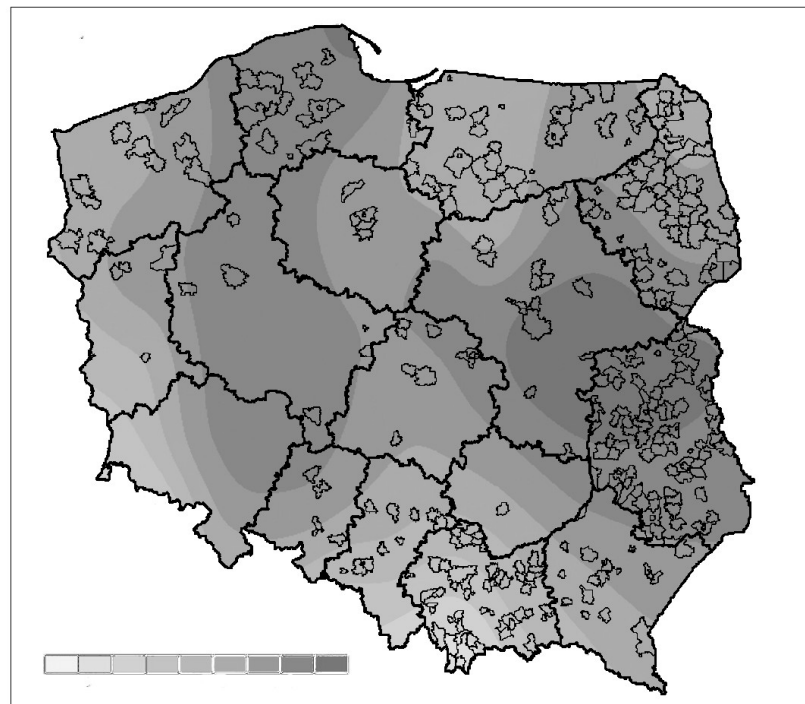
#### 4.2. Regional Availability of Selected RE Types in Poland

Spatial availability maps are helpful in identifying areas for locating specific RE utilization projects [58] and reduce the logistic needs associated with special conditions (e.g., for hydro-energy generation) or threatening food supplies (e.g., bioethanol from grains, biodiesel from oilseed crops). Regional differences in the availability of RES are quite pronounced in Poland.

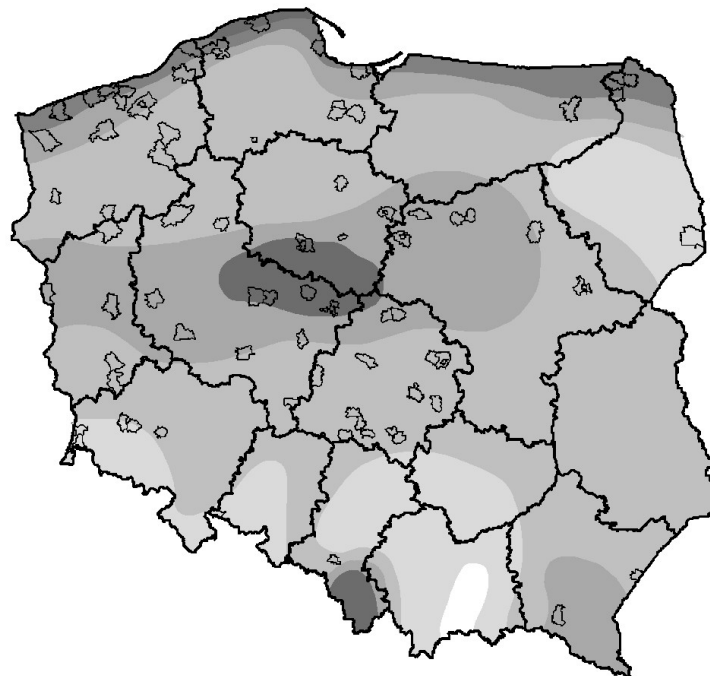
Figure 2 shows the distribution of solar radiation in Poland. There is substantial spatial variation. Eastern Poland, the narrow path along the Baltic Sea coast, and an area in central Poland receive the highest amount of solar energy. The counties marked on the map indicate that at least one solar energy utilization project was located there and supported by one of the two types (regional or national) of operational programs. The vast majority of counties are located in the three peripheral EU NUTS2 regions, namely Lubelskie, Podlaskie, and Warmińsko-Mazurskie Voivodships. Another large cluster of solar energy utilization projects was funded in counties in Małopolskie Voivodship in southern Poland and a cluster near the Baltic Sea coast.

In the case of wind patterns, location matters [59]. The prevailing winds are from the west in Poland (Figure 3).

Such orientation makes the western, west-central, and coastal regions of Poland particularly suitable for the placement of windmills. Those areas were historically the location of windmills used for grain milling, and nowadays, they have seen an expansion of windmills used to generate electric energy. Southern Poland, where the main mountain ranges are located, is less suitable for the construction of windmills due to the topography. Finally, the northeastern tip of the country has favorable wind conditions from the standpoint of power generation, but the prevailing winds are of a northeast direction.

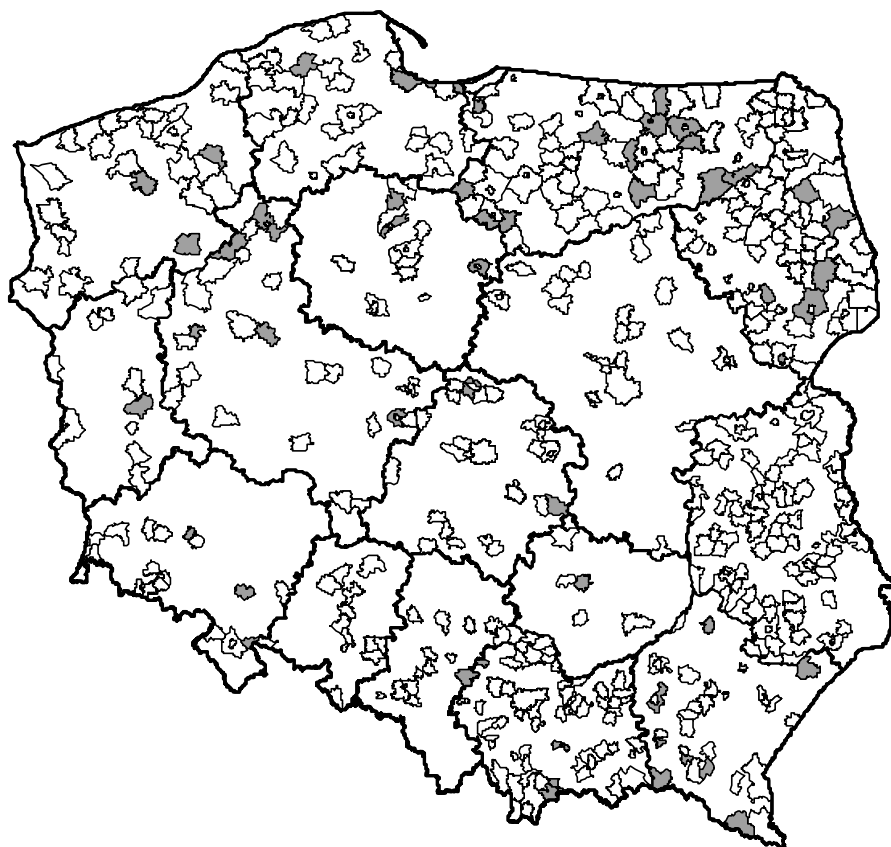


**Figure 2.** Location of investment projects utilizing solar energy co-funded during the 2007–2013 EU funding period in counties in 16 voivodships and the solar radiation ( $\text{MJ}/\text{m}^2$ ) distribution in Poland. Source: County location placed by the authors on the solar radiation map elaborated based on [60] (darker shaded area indicates more intense solar radiation).



**Figure 3.** Location of investment projects utilizing wind energy co-funded during the 2007–2013 EU funding period in counties in 16 voivodships in Poland (wind energy in  $\text{kW}/\text{h}/\text{m}^2/\text{year}$ ). Source: County location placed by the authors on the accessibility of wind energy distribution map elaborated based on [60] (darker shaded areas indicate increasingly favorable wind conditions for energy generation).

Biomass is another source of RE and is widely available in Poland. The biomass used to generate energy is regulated [61]. Availability of raw material for wood biomass led to the expansion of wood pellet production in Poland and the private forest area has been expanding the potential supply. Biomass, including firewood, used in scaled-back cogeneration boilers yields more energy than in large power plants [62] and such small-scale investment projects were eligible for funding from the regional programs considered in the current study. Figure 4 shows counties where the biomass investment projects were located in the funding period 2007–2013.



**Figure 4.** Location of investment projects utilizing biomass co-funded during the 2007–2013 EU funding period in counties in 16 voivodships in Poland.

The projects were located primarily in Podlaskie, Warmińsko-Mazurskie, Podkarpackie, and Zachodniopomorskie Voivodships that have forest cover of 30.8%, 31.4%, 38.2%, and 35.5%, respectively, which is above the national average of 29.6% (as of 31 December 2015). In addition, other voivodships reporting investment in biomass energy projects, located in the west and south of the country, were in regions with forest cover above the national average. The biomass projects located in voivodships were located near large forests, even if the region's forested area was below the national average. Overall, the biomass investments were in relative proximity to potential sources of firewood supplies, thus reducing transportation cost.

#### 4.3. The Number of RE Projects and Value of EU Funding in a Region

RE projects invested in a variety of energy sources (Table 3). Nearly 60% of all projects involved the use of solar radiation. Installations using wind energy were the second most common projects and represented about 13% or 88 projects. Slightly fewer projects (82, or 11%) involved the use of biomass.

**Table 3.** Percent of investment projects, project total value, funding from EU, and investor contribution by renewable energy source.

| Renewable Energy Source (RES) | Number of Projects | Share in Total Project Number | Total Value mln PLN | EU Funds mln PLN | Investor Contribution mln PLN |
|-------------------------------|--------------------|-------------------------------|---------------------|------------------|-------------------------------|
| Wind                          | 88                 | 12.3                          | 4989.6              | 1360.3           | 3629.2                        |
| Solar                         | 427                | 59.6                          | 1388.1              | 821.1            | 567.0                         |
| Biomass                       | 82                 | 11.5                          | 1566.4              | 482.8            | 1083.6                        |
| Hydro                         | 24                 | 3.4                           | 70.2                | 25.9             | 44.3                          |
| Geothermal                    | 10                 | 1.4                           | 39.6                | 17.3             | 21.7                          |
| Other                         | 85                 | 11.9                          | 144.8               | 73.3             | 71.5                          |

Note: PLN = Polish zloty; 1 PLN = USD 3.012 or 1 PLN = 4.1472 euro on 31 December 2013 [53].

These three RES are readily accessible in Poland, although some regional variation occurs as described. Table A3 lists the RE projects by voivodship, including the EU subsidy and investor contribution.

#### 4.4. Investment Projects by RE Source

Among the supported RE projects, those utilizing solar energy accounted for 59.6% of all projects receiving EU funding (Table 3). Among the 427 projects in solar energy, 171 projects applied to thermal solar facilities and 256 were PV systems. Thermal solar panels typically heat water for space heating and are used by schools, indoor pools, and other public institutions. The relatively large number of PV projects during the funding period involved small solar power plants or off-grid systems. Projects utilizing wind energy were less frequent (88 projects). Those projects represented the highest investment value of nearly 5 billion Polish zloty, but were associated with the highest investor contribution, surpassing 3.6 billion Polish zloty. The average value of a wind utilizing project was 56.7 million Polish zloty (Table 4).

**Table 4.** Descriptive statistics of utilizing renewable energy sources projects (RES) co-funded by the EU structural funds in Poland during the period 2007–2013.

| RES              | Mean Value, in PLN | Std. Dev. | Min  | Max   |
|------------------|--------------------|-----------|------|-------|
| Total Value      | 56.7               | 72.1      | 0.1  | 289.2 |
| Wind             |                    |           |      |       |
| Solar            | 3.3                | 3.3       | 0.03 | 18.1  |
| Biomass          | 19.1               | 47.0      | 0.2  | 282.5 |
| Hydro            | 2.9                | 2.7       | 0.4  | 10.4  |
| Geothermal       | 4.0                | 5.6       | 0.1  | 17.6  |
| Other            | 1.7                | 2.8       | 0.05 | 23.4  |
| EU subsidized    |                    |           |      |       |
| Wind             | 15.5               | 13.6      | 0.04 | 40.0  |
| Solar            | 1.9                | 2.1       | 0.02 | 11.8  |
| Biomass          | 5.9                | 8.9       | 0.05 | 40.0  |
| Hydro            | 1.1                | 0.2       | 4.6  | 25.9  |
| Geothermal       | 1.8                | 2.4       | 0.04 | 7.9   |
| Other            | 0.9                | 0.8       | 0.03 | 3.5   |
| Domestic subsidy |                    |           |      |       |
| Wind             | 41.2               | 60.7      | 0.03 | 251.0 |
| Solar            | 1.3                | 1.7       | 0.01 | 11.9  |
| Biomass          | 13.2               | 39.2      | 0.07 | 242.5 |
| Hydro            | 1.9                | 1.8       | 0.2  | 6.0   |
| Geothermal       | 2.2                | 3.4       | 0.07 | 9.8   |
| Other            | 0.9                | 2.3       | 0.01 | 20.2  |

The average value of an investment prohibited almost all public agencies or local governments from undertaking such projects. The total value of investment in biomass-utilizing projects was larger than that in solar energy projects and amounted to almost 1.6 billion Polish zloty. However, as in the case of wind energy, the share of investor contribution was considerably larger than the funding received from EU funds, 1.084 billion Polish zloty vs. 483 million Polish zloty (right column in Table 3).

Biomass-utilizing facilities with an average investment value of 19.1 million Polish zloty (Table 4) stretch the financing ability of a majority of local governments or other public institutions. Hydro-energy and geothermal projects were very few during the period 2007–2013. The average value of a hydro-energy project was 2.9 million Polish zloty and that of a geothermal project 4 million Polish zloty (Table 4). The highest average contribution of EU funds was to solar energy investment projects valued at 1.9 million Polish zloty with the average total project value of 3.3 million Polish zloty.

The cost of some facilities utilizing RE receiving EU funding from regional or national programs was high and beyond the ability of the vast majority of local governments or local public institutions. Yet the number of those entities accounted for the majority of investors (Table 5).

**Table 5.** Number and share of RE projects by investor category, 2007–2013.

| Investor Category                       | Number of Projects | Share in Total Project Number |
|-----------------------------------------|--------------------|-------------------------------|
| County, county consortium, poviats      | 296                | 41.3                          |
| Large enterprise                        | 68                 | 9.5                           |
| Medium-sized enterprise                 | 47                 | 6.6                           |
| Small enterprise                        | 70                 | 9.8                           |
| Micro enterprise                        | 147                | 20.5                          |
| Private and public health care provider | 61                 | 8.5                           |
| Other                                   | 55                 | 7.8                           |

Notes: A county consortium is a group of neighboring counties investing in a single project located in one of them, but serving all consortium members. “Poviat” is a territorial administrative unit that encompasses several counties with self-government, but are part of a voivodship. Category “other” includes: foundations, associations, higher education institutions, churches, voivodship governments, government agencies.

County governments or county-based institutions represented 41.3% of investors using EU funding provided in the period 2007–2013. Micro enterprises’ share was 20.5%, while small firms represented another 9.8%. The share of large enterprises was 9.5% (Table 5). Public and private healthcare providers and “other investors” implemented an additional 116 projects, or 16.3% of all projects. The domination of small and micro enterprises and local governments reflects the local interest in RE utilization, especially since each project required that the investor contributes to the total cost of the RE installation. Since some of the regions with conditions favoring solar or wind energy use are lagging in development within Poland and the EU, the reported participation of local entities is remarkable.

Table 6 shows the descriptive statistics of the variables used in the specific empirical relationship. The values of three variables were expressed as logs, i.e., the value of the EU subsidy from the cohesion funds, the population density of the county where the project was located, and the per capita revenues to the county treasury.

#### 4.5. Multiple Linear Regression Results

The overall goodness of fit measures of the estimated empirical relationship are reasonable as indicated by the F-test value 21.689 with a significance level of  $p = 0.00$ . The adjusted  $R^2$  value is 0.407, which conforms to the panel nature of the data, but tends to be lower than using time-series data.

Results stress the relevance of the average county resident's per capita income and indicate that for every 1000 Polish zloty increase, the value of subsidies for the RE investment project increased by 2.11% (Table 7).

**Table 6.** Descriptive statistics of explanatory variables and voivodship indicators.

| Variable Name       | Units                       | Mean   | Std. Deviation | Min | Max |
|---------------------|-----------------------------|--------|----------------|-----|-----|
| LogEUfund           | Value in Polish PLN         | 6.0892 | 0.62276        | 0   | 1   |
| Logpopuldensity     | Population per sq.km        | 2.0730 | 0.67591        | 0   | 1   |
| Logincomegross      | Gross income in PLN         | 4.3410 | 0.04166        | 0   | 1   |
| I&EOP               | 1 if funded by this program | 0.0706 | 0.25635        | 0   | 1   |
| Inventerp           | 1 if investor a firm        | 0.4510 | 0.49795        | 0   | 1   |
| InvNGO              | 1 if investor NGO           | 0.0476 | 0.21297        | 0   | 1   |
| Sourcewind          | 1 if RE is wind             | 0.1009 | 0.30137        | 0   | 1   |
| Sourcesun           | 1 if RE is solar rad.       | 0.6153 | 0.48688        | 0   | 1   |
| Sourcebiom          | 1 if RE is biomass          | 0.1124 | 0.31608        | 0   | 1   |
| Dolnośląskie        | 1 if located there          | 0.0231 | 0.15019        | 0   | 1   |
| Kujawsko-Pomorskie  | 1 if located there          | 0.0259 | 0.15906        | 0   | 1   |
|                     | 1 if located there          | 0.1542 | 0.36138        | 0   | 1   |
| Lubuskie            | 1 if located there          | 0.0187 | 0.13567        | 0   | 1   |
| Łódzkie             | 1 if located there          | 0.0403 | 0.19691        | 0   | 1   |
| Małopolskie         | 1 if located there          | 0.1369 | 0.34398        | 0   | 1   |
| Opolskie            | 1 if located there          | 0.0231 | 0.15019        | 0   | 1   |
| Podkarpackie        | 1 if located there          | 0.0519 | 0.22193        | 0   | 1   |
| Podlaskie           | 1 if located there          | 0.1758 | 0.38092        | 0   | 1   |
| Pomorskie           | 1 if located there          | 0.0432 | 0.20352        | 0   | 1   |
| Śląskie             | 1 if located there          | 0.0216 | 0.14552        | 0   | 1   |
| Świętokrzyskie      | 1 if located there          | 0.0072 | 0.08463        | 0   | 1   |
| Warmińsko-Mazurskie | 1 if located there          | 0.1513 | 0.35860        | 0   | 1   |
| Wielkopolskie       | 1 if located there          | 0.0403 | 0.19691        | 0   | 1   |
| Zachodniopomorskie  | 1 if located there          | 0.0504 | 0.21899        | 0   | 1   |
| Urban               | 1 if urban investor         | 0.3718 | 0.48362        | 0   | 1   |

**Table 7.** Results of the relationship between the amount of subsidy from EU to RE instrument percent and a set of explanatory variables.

| Variable Name       | Coefficient | Std. Error | t-Value | p-Value  |
|---------------------|-------------|------------|---------|----------|
| Constant            | −3.179      | 3.009      | −1.06   | 0.29     |
| Logpopuldensity     | −0.44       | 0.041      | −1.06   | 0.29     |
| Logincomegross      | 2.119       | 0.695      | 3.05    | 0.00 *** |
| IEOP                | 0.724       | 0.094      | 7.73    | 0.00 *** |
| Inventerp           | −0.124      | 0.044      | −2.84   | 0.01 *** |
| InvNGO              | −0.021      | 0.091      | −0.23   | 0.82     |
| Sourcewind          | 0.530       | 0.096      | 5.52    | 0.00 *** |
| Sourcesun           | 0.054       | 0.056      | 0.96    | 0.34     |
| Sourcebiom          | 0.409       | 0.074      | 5.52    | 0.00 *** |
| Dolnośląskie        | −0.081      | 0.141      | −0.58   | 0.57     |
| Kujawsko-Pomorskie  | 0.201       | 0.125      | 1.61    | 0.11     |
| Lubelskie           | 0.534       | 0.064      | 8.36    | 0.00     |
| Lubuskie            | 0.241       | 0.144      | 1.68    | 0.09 *   |
| Łódzkie             | 0.221       | 0.109      | 2.02    | 0.04 **  |
| Małopolskie         | 0.027       | 0.067      | 0.40    | 0.69     |
| Opolskie            | 0.109       | 0.130      | 0.84    | 0.40     |
| Podkarpackie        | 0.185       | 0.099      | 1.88    | 0.06 *   |
| Pomorskie           | −0.263      | 0.103      | −2.56   | 0.01 **  |
| Śląskie             | 0.213       | 0.149      | 1.43    | 0.15     |
| Świętokrzyskie      | −0.064      | 0.222      | −0.29   | 0.77     |
| Warmińsko-Mazurskie | −0.253      | 0.064      | −3.94   | 0.00 *** |
| Wielkopolskie       | −0.022      | 0.112      | −0.19   | 0.85     |
| Zachodniopomorskie  | −0.117      | 0.098      | −1.20   | 0.23     |
| Urban               | −0.076      | 0.058      | −1.31   | 0.19     |

\* Significant at  $\alpha = 0.10$ . \*\* Significant at  $\alpha = 0.05$ . \*\*\* Significant at  $\alpha = 0.01$ .

A project associated with the national support program I&EOP could expect a 0.72% higher subsidy from the EU funds. The national support program is more likely to focus on relatively large projects and, possibly, those of wider importance, but the increase in subsidy is quite modest. However, if the project was initiated by a private enterprise, the amount of subsidy would decrease by 0.12% (Table 7). Private enterprises are profit-seeking entities and although they qualify for a subsidy for an RE project, their projects tend to be large and may be viewed as riskier than other types of investments. The regional projects administered by regional government staff tend to be risk averse and aware of the rigorous financial reporting required by the EC.

The type of RES used to generate energy by a proposed facility matters and the effect is consistent with expectations given the earlier described reports. The identified increases in the amount of subsidy for wind and biomass-utilizing projects are compared in this study to those RES that are omitted and undertaken by eligible applicants. Specifically, if a project was to use wind energy, the subsidy would have increased by 0.52% (Table 7). The costs of erecting a windmill are high and an investor was unlikely to limit the project to a single location, which implies relatively high investment and consequently a larger subsidy. Similarly, a biomass-utilizing investment project would receive a 0.42% higher subsidy from EU funding because it was likely a facility using a co-firing furnace that tends to be technically more complex and, therefore, more expensive.

The effects of the binary variables are measured against the projects located in the omitted Mazowieckie Voivodship. RE projects located in two voivodships, namely Lubuskie Voivodship and Łódzkie Voivodship could expect a higher subsidy from EU funds (Table 7).

The increase in the subsidy was similar and amounted to 0.22% and 0.24%, respectively. An applicant for an RE project from the Podkarpackie Voivodship received a 0.18% higher subsidy than a project in the Mazowieckie Voivodship. RE projects in two other regions received lower subsidies (Table 7). An investment project in the Pomorskie Voivodship received a 0.27% lower subsidy, while in the case of a project located in the Warmińsko-Mazurskie Voivodship, the subsidy was 0.26% lower than for a project located in the Mazowieckie Voivodship. Both voivodships may have lower investment costs because several RES (wind, biomass) are relatively abundant there and require less support.

The cohesion funding provided in the period 2007–2013 (with completion of all projects by the end of 2015) has definitely contributed to the increased RES use in Poland. Hektus and Kalbarczyk [63] reported that in 2015, the year after the program was terminated, wind energy was the most frequent source of RE and dominated all RES. Windmills generated most of the RE in voivodships in northwestern, northern, and northeastern Poland together with centrally located Wielkopolskie, Kujawsko-Pomorskie, Mazowieckie, and Łódzkie voivodships. Voivodships that reported the highest number of investment projects supported by EU funds was the region generating the smallest amount of energy from RES in 2015, but together with Podlaskie and Małopolskie Voivodships reported a perceptible share of solar energy.

## 5. Discussion

RES have a potential to improve Poland's energy security, which historically has been dependent on energy imports, especially oil [64,65]. The findings prove that two main types of investments supported by the EU cohesion funds in Poland include solar and wind renewable energy. Poland's geographical latitude, the prevailing weather patterns, and natural resources could have influenced the choice of investment using these two specific RE types, although they pose the risk of intermittent interruptions due to, among others, seasonal weather patterns [66].

The photovoltaic (PV) capacity installed in 2007 in Poland was 0.6 MW, while the solar thermal energy production capacity reached 254 MW in 2008, placing the country seventh among the 28 EU member countries [67]. Although solar renewable energy is commonly favored by the general public [68], not until 2015 did the regulations permit connecting

of small PV operations to the grid spurring the expansion of PV system installations by households [69,70].

Local projects focused on the use of solar energy for the purpose of heating water used to heat living spaces and for other household uses [56]. In Poland, due to climatic conditions requiring heating of public and private indoor spaces for much of the year, RE has the potential for reducing the volume of burnt coal and ash disposal as well as the risk of polluting surface water and soil. Heating accounts for a large portion of the final energy consumption in some countries in Europe (e.g., 46% in the United Kingdom [71], while heating living space accounted for 60–70% of household energy consumption in Poland [72]. The growth of the PV capacity in Poland was hampered by the absence of regulations permitting small producers, including households, to connect to the grid and sell the surplus electricity. The changes in regulations, completed in 2015 and implemented in July 2016, favored household PV panel installation, shifting the form of solar energy use, but solar thermal panels dominated installations during the funding period 2007–2013. However, solar energy projects were often small scale and the demand stimulated by EU funding kept solar panel prices almost unchanged [73].

In contrast, wind energy utilization projects encountered local opposition during the period 2007–2013, [74], but such opposition existed locally earlier in the EU [75]. Windmill investment projects were more expensive than the solar energy projects and the investor seldom was a farmer since farm households offered favorable locations for windmill installations. Regulations required that windmills are located a certain distance away from residential buildings.

Some counties have been encouraged to produce biomass as a RES [76]. Biomass investment projects likely involve co-firing by burning locally available biomass [77] with fossil fuels such as coal. The use of biomass reduces the emission of SO<sub>2</sub>, NO<sub>2</sub>, and CO<sub>2</sub> [78]. The added benefit is that money spent on biomass purchases stays with local businesses.

There are significant differences in regional dispersal of EU funding in Poland. Lubelskie Voivodship appeared to be the leader in the absorption of EU funds. It is possible that those projects increased the engagement of county governments in that voivodship, which was still perceived low in 2011 [79]. The differences across regions were indicated as important in RE investment in other countries and associated with the presence of specific RES [80]. However, solar, wind, or biomass energy are accessible across Polish regions similarly to other East European countries, such as Romania [81].

Another factor is the cost of installation and equipment that varies across RES, which influences the selection [66]. For example, during the period under consideration, only 10 projects (1.4%) involved geothermal energy and 24 were hydroelectric projects (3.4%). Both project types require larger outlays than the most common solar energy micro-installations (Table A3). Additionally, a hydroelectric project requires extensive environmental assessment, which can be a barrier to project approval [82]. Even though the cost of technology using wind to produce energy has been decreasing [83], wind energy projects are also viewed as costly.

EU funding eased the economic barriers to investing in RES, but each project still had to comply with environmental regulations and investors had to provide a domestic financial contribution.

## 6. Conclusions

The EU funding was essential in overcoming the major barrier to RES utilization, which was the cost of the initial investment. The funding distributed through regional programs and the I&EOP was accessed by applicants in all regions and included a variety of public institutions, local governments, healthcare providers, and businesses contributing to the increased share of energy generated from RES. The share of RE increased from 7.7% in gross final energy consumption in 2008 to 11.3% in 2013 and 11.4% in 2014 in Poland, advancing towards the goal of a 15% share in 2020 [84]. The RE production per capita increased by nearly 50% during that period.

This study analyzed only projects funded through the regional projects that qualified for a subsidy from the EU cohesion funds. A review of the number of projects shows their location in all voivodships, although in some of them the number of funded projects was particularly high, especially in those classified as lagging in development such as Podlaskie and Lubelskie. The lowest number of funded projects was located in Świętokrzyskie Voivodship and can be attributed to its relatively small area. A similar pattern was observed in Opolskie, Kujawsko-Pomorskie, and Lubuskie, which also cover a relatively small area.

The largest number of projects involved solar and wind energy. The largest number of solar energy projects was located in Lubelskie voivodship, which has particularly favorable conditions regarding annual solar radiation intensity. However, the small scale of such projects, as indicated by the average value, could have limited the efficiency of the investments. Projects utilizing wind energy were also popular, but their costs were higher because of high initial investment costs and strict site selection regulations. Still, the majority of wind energy projects were located in areas with suitable natural conditions supported by long-term meteorological observations. Biomass-utilizing investment projects likely involved co-firing furnaces, which, under Poland's climatic conditions, are used to heat space. In the case of the objectives of the programs subsidizing RE projects, biomass was typically used to heat space in public buildings. The advantage of solar and wind energy is that they do not require transportation, whereas biomass requires transportation over limited distances but offers continuity of supply. The use of local biomass also injects a stream of funds into local businesses, stimulating the local economy.

The importance of local government funding in relation to the amount of the subsidy from EU-supported programs has important implications. Economically stronger counties could undertake larger RE projects because of the requirement for matching funds and limiting subsidies to 85% of the investment value. Moreover, the subsidy was paid after the completion of the investment, which implied that either the applicant's resources were tied to financing the project during the investment period or required the applicant to finance the project using credit. The former approach could have restricted other activities during the funding period, while the latter approach increases investment costs by adding the cost of interest that depletes local resources.

The requirement of first spending own resources before releasing the subsidy likely limited the number of projects, their size, and the type of RES. Solar energy projects offered an opportunity for a relatively low-cost investment, whereas the projects using geothermal energy were few because they not only were considerably more expensive but the costs of rarely used technology implied greater cost unpredictability during the funding period. Another limitation was the two-year project completion condition that encouraged the use of readily available equipment using RES. The approach applied by regional program managers followed the regulations and was intended to assure that the RE project was completed within a two-year period. Since the efficiency of RE utilization varies in response to the scale, other methods of accessing the awarded subsidy may need to be considered.

The typical applicant was not motivated by expected profits to undertake investment in RE use. Rather, given the opportunity to receive a subsidy, the applicants sought ways to lower operating costs by reducing energy bills. Energy prices have been increasing in Poland at an annual rate exceeding 3% between 2002–2012 [85] and the need for space heating during the fall and winter months encourages efficient energy use. RES, especially solar and biomass energy, which are suitable for small installations, were often selected by applicants and contributed to a local reduction in emissions and improving air quality. Since local air quality is of concern in Poland, funds targeting local institutions with additional subsidies will continue to reduce emissions, increase RE use, and lower energy bills while demonstrating environmental benefits. In general, the RES production share in individual voivodeships concerning total electricity consumption in Poland was growing over the studied time span [85].

The findings and conclusions of this study provide insights for refining the policies supporting RE utilization relevant to the EU's climate, energy security, regional policies,

and air quality objectives. Although the relative importance of various RES varies across the EU countries, practical implications from this study can be relevant to countries that benefit from the cohesion funds supporting RE investments. The analysis can provide guidance for similar analyses of funds used in other EU countries, especially those that accessed the EU later, such as Romania and Bulgaria, or countries with a similar level of utilizing renewable energy in Central Europe (Slovakia, Hungary) and the Baltics. The results of this study can also be used as the basis for a comparative analysis of EU support for RE use in other member states.

## 7. Limitations

The current study limits its scope to RE investment projects supported by those two types of programs, but there were other programs that provided funding for RE investment in Poland. Although these provided much smaller funding amounts, they were significant for some areas. For example, the Swiss government supplied funds for the investment in solar panels [86], while the so-called Norway funds established by Norway, Iceland, and Lichtenstein helped fund RE investment in two interactions partially overlapping with the period considered in this study (2004–2009 and 2009–2014) [87].

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**Conflicts of Interest:** The authors declare no conflict of interest.

## Appendix A

**Table A1.** Allocation of EU funding by member-country, 2007–2013, mln euro.

| Country        | Million Euro | Share, in % | Per Capita, Euro |
|----------------|--------------|-------------|------------------|
| Belgium        | 2258         | 0.6         | 217.278          |
| Bulgaria       | 6853         | 2.0         | 935.837          |
| Czech Republic | 26,692       | 7.7         | 2609.509         |
| Denmark        | 613          | 0.2         | 112.104          |
| Germany        | 26,340       | 7.6         | 319.656          |
| Estonia        | 3456         | 1.0         | 2626.315         |
| Éire-Ireland   | 901          | 0.3         | 219.270          |
| Greece         | 20,420       | 5.9         | 1907.290         |
| Spain          | 35,217       | 10.1        | 870.669          |
| France         | 14,319       | 4.1         | 224.739          |
| Italy          | 28,812       | 8.3         | 495.497          |
| Cyprus         | 640          | 0.2         | 811.712          |
| Latvia         | 4620         | 1.3         | 2044.420         |
| Lithuania      | 6885         | 2.0         | 1925.638         |
| Luxemburg      | 65           | 0.0         | 135.354          |
| Hungary        | 25,307       | 7.3         | 2541.857         |
| Malta          | 855          | 0.2         | 2427.501         |
| Netherlands    | 1907         | 0.5         | 115.083          |

**Table A1.** *Cont.*

| Country                                | Million Euro | Share, in % | Per Capita, Euro |
|----------------------------------------|--------------|-------------|------------------|
| Austria                                | 1461         | 0.4         | 178.175          |
| Poland                                 | 67,284       | 19.4        | 1746.809         |
| Portugal                               | 21,511       | 6.2         | 2021.172         |
| Romania                                | 19,668       | 5.7         | 882.921          |
| Slovenia                               | 4205         | 1.2         | 2092.826         |
| Slovakia                               | 11,588       | 3.3         | 2127.214         |
| Finland                                | 1716         | 0.5         | 327.577          |
| Sweden                                 | 1891         | 0.5         | 209.388          |
| United Kingdom                         | 10,613       | 3.1         | 174.624          |
| Inter-regional/<br>Network cooperation | 445          | 0.1         | -                |
| Technical Assistance                   | 868          | 0.2         | -                |
| Total                                  | 347,410      | 100.0       | -                |

Note: Allocation figures rounded to the nearest million [7].

**Table A2.** Regional Operational Programs 2007–2013 in Poland.

| Voivodship          | Regional Operational Program<br>Name<br>(ROP)                     | % of the Total EU Money Invested in<br>Poland under Cohesion Policy<br>2007–2013 | EU Fund |
|---------------------|-------------------------------------------------------------------|----------------------------------------------------------------------------------|---------|
| Dolnośląskie        | Dolnoslaskie ROP for 2007–2013                                    | 1.8                                                                              | ERDF    |
| Kujawsko-Pomorskie  | Kujawsko-Pomorskie ROP for<br>2007–2013                           | 1.4                                                                              | ERDF    |
|                     | Regional Operational Programme<br>2007–2013                       | 1.7                                                                              | ERDF    |
| Lubuskie            | Lubuskie ROP for 2007–2013                                        | 0.7                                                                              | ERDF    |
| Łódzkie             | Łódzkie ROP 2007–2013                                             | 1.5                                                                              | ERDF    |
| Małopolskie         | Małopolskie ROP 2007–2013                                         | 1.9                                                                              | ERDF    |
| Mazowieckie         | Operational Programme for the<br>Mazowieckie Voivodship 2007–2013 | 2.7                                                                              | ERDF    |
| Opolskie            | Opolskie ROP for 2007–2013                                        | 0.6                                                                              | ERDF    |
| Podkarpackie        | Podkarpackie ROP 2007–2013                                        | 1.6                                                                              | ERDF    |
| Podlaskie           | Podlaskie ROP for 2007–2013                                       | 0.95                                                                             | ERDF    |
| Pomorskie           | Pomorskie ROP for 2007–2013                                       | 1.3                                                                              | ERDF    |
| Śląskie             | Śląskie ROP 2007–2013                                             | 2.5                                                                              | ERDF    |
| Świętokrzyskie      | Świętokrzyskie ROP 2007–2013                                      | 1.1                                                                              | ERDF    |
| Warmińsko-Mazurskie | Warmińsko-Mazurskie ROP<br>2007–2013                              | 1.6                                                                              | ERDF    |
| Wielkopolskie       | Wielkopolskie ROP for 2007–2013                                   | 1.8                                                                              | ERDF    |
| Zachodniopomorskie  | Zachodniopomorskie ROP for<br>2007–2013                           | 1.25                                                                             | ERDF    |

Note: ERDF—European Regional Development Fund.

**Table A3.** RE project total value, EU subsidy and investor contribution in percent and Polish zloty by voivodship and energy source.

| Voivodship/RE<br>type | Number of<br>Projects | Total Value of<br>Projects (mln<br>PLN) | Investor<br>Contribution<br>(mln PLN) | Total Value of<br>EU Funding<br>(mln PLN) | Investor<br>Contribution<br>as % of the<br>Project's Total<br>Value | Average<br>Investor<br>Contribution<br>per Project<br>(mln PLN) |
|-----------------------|-----------------------|-----------------------------------------|---------------------------------------|-------------------------------------------|---------------------------------------------------------------------|-----------------------------------------------------------------|
| Dolnośląskie          | 20                    | 960.0                                   | 204.0                                 | 756.0                                     | 21                                                                  | 10.2                                                            |
| Wind                  | 6                     | 906.4                                   | 725.1                                 | 181.2                                     | 80                                                                  | 120.9                                                           |
| Solar                 | -                     | -                                       | -                                     | -                                         | -                                                                   | -                                                               |
| Biomass               | 3                     | 20.6                                    | 9.8                                   | 10.8                                      | 48                                                                  | 3.3                                                             |

Table A3. Cont.

| Voivodship/RE type | Number of Projects | Total Value of Projects (mln PLN) | Investor Contribution (mln PLN) | Total Value of EU Funding (mln PLN) | Investor Contribution as % of the Project's Total Value | Average Investor Contribution per Project (mln PLN) |
|--------------------|--------------------|-----------------------------------|---------------------------------|-------------------------------------|---------------------------------------------------------|-----------------------------------------------------|
| Other              | 11                 | 33.0                              | 12.9                            | 20.1                                | 39                                                      | 1.2                                                 |
| Kujawsko-Pomorskie | 17                 | 263.9                             | 145.9                           | 118.1                               | 55                                                      | 8.6                                                 |
| Wind               | 5                  | 142.3                             | 60.7                            | 81.6                                | 43                                                      | 12.1                                                |
| Solar              | 5                  | 29.5                              | 13.6                            | 15.9                                | 46                                                      | 2.7                                                 |
| Biomass            | 3                  | 86.9                              | 40.9                            | 46.0                                | 47                                                      | 13.6                                                |
| Other              | 4                  | 5.2                               | 2.8                             | 2.4                                 | 54                                                      | 0.7                                                 |
| Lubelskie          | 107                | 584.3                             | 347.2                           | 237.0                               | 59                                                      | 3.2                                                 |
| Wind               | -                  | -                                 | -                               | -                                   | -                                                       | -                                                   |
| Solar              | 102                | 544.1                             | 216.3                           | 327.9                               | 40                                                      | 2.1                                                 |
| Biomass            | 3                  | 31.7                              | 16.3                            | 15.4                                | 52                                                      | 5.4                                                 |
| Other              | 2                  | 8.4                               | 3.4                             | 5.4                                 | 41                                                      | 1.7                                                 |
| Lubuskie           | 14                 | 389.9                             | 121.5                           | 268.4                               | 31                                                      | 8.7                                                 |
| Wind               | 5                  | 344.8                             | 246.1                           | 98.7                                | 71                                                      | 49.2                                                |
| Solar              | 5                  | 20.6                              | 11.5                            | 9.1                                 | 56                                                      | 2.3                                                 |
| Biomass            | 2                  | 21.9                              | 9.3                             | 12.6                                | 42                                                      | 4.7                                                 |
| Other              | 2                  | 2.6                               | 1.5                             | 1.1                                 | 57                                                      | 0.8                                                 |
| Łódzkie            | 33                 | 947.0                             | 382.0                           | 565.0                               | 40                                                      | 11.6                                                |
| Wind               | 11                 | 704.2                             | 438.2                           | 266.0                               | 62                                                      | 39.8                                                |
| Solar              | 17                 | 57.4                              | 43.0                            | 14.4                                | 75                                                      | 2.5                                                 |
| Biomass            | 3                  | 164.2                             | 63.7                            | 100.5                               | 39                                                      | 21.2                                                |
| Other              | 2                  | 21.1                              | 9.3                             | 11.9                                | 44                                                      | 4.6                                                 |
| Małopolskie        | 95                 | 260.2                             | 133.5                           | 126.7                               | 51                                                      | 1.4                                                 |
| Wind               | -                  | -                                 | -                               | -                                   | -                                                       | -                                                   |
| Solar              | 74                 | 196.7                             | 92.3                            | 104.5                               | 47                                                      | 1.2                                                 |
| Biomass            | 7                  | 24.8                              | 10.8                            | 14.0                                | 43                                                      | 1.5                                                 |
| Other              | 14                 | 38.7                              | 23.7                            | 15.0                                | 61                                                      | 1.7                                                 |
| Mazowieckie        | 26                 | 174.4                             | 85.7                            | 88.7                                | 49                                                      | 3.3                                                 |
| Wind               | 7                  | 108.2                             | 66.4                            | 41.8                                | 61                                                      | 9.5                                                 |
| Solar              | 18                 | 64.5                              | 21.2                            | 43.3                                | 33                                                      | 1.2                                                 |
| Biomass            | -                  | -                                 | -                               | -                                   | -                                                       | -                                                   |
| Other              | 1                  | 1.7                               | 1.1                             | 0.6                                 | 66                                                      | 1.1                                                 |
| Opolskie           | 16                 | 61.2                              | 36.1                            | 25.1                                | 59                                                      | 2.3                                                 |
| Wind               | 1                  | 31.2                              | 13.6                            | 17.7                                | 43                                                      | 13.6                                                |
| Solar              | 5                  | 3.3                               | 1.2                             | 2.1                                 | 37                                                      | 0.2                                                 |
| Biomass            | -                  | -                                 | -                               | -                                   | -                                                       | -                                                   |
| Other              | 10                 | 26.6                              | 10.3                            | 16.4                                | 39                                                      | 1.0                                                 |
| Podkarpackie       | 38                 | 509.3                             | 163.3                           | 345.9                               | 32                                                      | 4.3                                                 |
| Wind               | 2                  | 217.1                             | 156.6                           | 60.5                                | 72                                                      | 78.3                                                |
| Solar              | 22                 | 72.6                              | 29.5                            | 43.0                                | 41                                                      | 1.3                                                 |
| Biomass            | 9                  | 184.9                             | 135.0                           | 49.9                                | 73                                                      | 15.0                                                |
| Other              | 5                  | 34.7                              | 24.8                            | 9.9                                 | 72                                                      | 5.0                                                 |
| Podlaskie          | 122                | 356.9                             | 174.9                           | 182.0                               | 49                                                      | 1.4                                                 |
| Wind               | 5                  | 74.0                              | 54.1                            | 19.9                                | 73                                                      | 10.8                                                |
| Solar              | 85                 | 160.0                             | 64.7                            | 95.3                                | 40                                                      | 0.8                                                 |
| Biomass            | 10                 | 100.4                             | 57.3                            | 43.1                                | 57                                                      | 5.7                                                 |
| Other              | 22                 | 22.4                              | 5.9                             | 16.6                                | 26                                                      | 0.3                                                 |
| Pomorskie          | 35                 | 1145.7                            | 252.3                           | 893.4                               | 22                                                      | 7.2                                                 |
| Wind               | 9                  | 1039.5                            | 840.7                           | 198.8                               | 81                                                      | 93.4                                                |
| Solar              | 19                 | 38.2                              | 11.4                            | 26.8                                | 30                                                      | 0.6                                                 |
| Biomass            | 4                  | 66.1                              | 40.8                            | 25.3                                | 62                                                      | 10.2                                                |
| Other              | 3                  | 1.9                               | 0.5                             | 1.4                                 | 27                                                      | 0.2                                                 |
| Śląskie            | 16                 | 408.9                             | 113.3                           | 295.6                               | 28                                                      | 7.1                                                 |
| Wind               | 1                  | 59.3                              | 36.1                            | 23.2                                | 61                                                      | 36.1                                                |

Table A3. Cont.

| Voivodship/RE type  | Number of Projects | Total Value of Projects (mln PLN) | Investor Contribution (mln PLN) | Total Value of EU Funding (mln PLN) | Investor Contribution as % of the Project's Total Value | Average Investor Contribution per Project (mln PLN) |
|---------------------|--------------------|-----------------------------------|---------------------------------|-------------------------------------|---------------------------------------------------------|-----------------------------------------------------|
| Solar               | 12                 | 61.9                              | 13.7                            | 48.2                                | 22                                                      | 1.1                                                 |
| Biomass             | 1                  | 282.5                             | 242.5                           | 40.0                                | 86                                                      | 242.5                                               |
| Other               | 2                  | 5.2                               | 3.3                             | 1.9                                 | 63                                                      | 1.6                                                 |
| Świętokrzyskie      | 5                  | 57.1                              | 15.4                            | 41.7                                | 27                                                      | 3.1                                                 |
| Wind                | -                  | -                                 | -                               | -                                   | -                                                       | -                                                   |
| Solar               | 1                  | 3.0                               | 1.5                             | 1.5                                 | 50                                                      | 1.5                                                 |
| Biomass             | 1                  | 49.3                              | 37.3                            | 12.0                                | 76                                                      | 37.3                                                |
| Other               | 3                  | 4.8                               | 2.9                             | 1.9                                 | 60                                                      | 1.0                                                 |
| Warmińsko-Mazurskie | 106                | 550.3                             | 164.9                           | 385.4                               | 30                                                      | 1.6                                                 |
| Wind                | 1                  | 32.5                              | 15.0                            | 17.5                                | 46                                                      | 15.0                                                |
| Solar               | 46                 | 68.1                              | 41.0                            | 27.1                                | 60                                                      | 0.9                                                 |
| Biomass             | 26                 | 420.7                             | 315.9                           | 104.8                               | 75                                                      | 12.2                                                |
| Other               | 33                 | 29.0                              | 13.4                            | 15.6                                | 46                                                      | 0.4                                                 |
| Wielkopolskie       | 28                 | 438.5                             | 158.9                           | 279.6                               | 36                                                      | 5.7                                                 |
| Wind                | 12                 | 338.1                             | 218.9                           | 119.2                               | 65                                                      | 18.2                                                |
| Solar               | 7                  | 44.9                              | 23.4                            | 21.5                                | 52                                                      | 3.3                                                 |
| Biomass             | 6                  | 39.9                              | 28.6                            | 11.3                                | 72                                                      | 4.8                                                 |
| Other               | 3                  | 15.7                              | 8.7                             | 6.9                                 | 56                                                      | 2.9                                                 |
| Zachodniopomorskie  | 38                 | 1091.2                            | 282.4                           | 808.8                               | 26                                                      | 7.4                                                 |
| Wind                | 17                 | 992.1                             | 757.8                           | 234.3                               | 76                                                      | 44.6                                                |
| Solar               | 15                 | 23.2                              | 11.3                            | 12.0                                | 48                                                      | 0.8                                                 |
| Biomass             | 4                  | 72.4                              | 38.5                            | 33.9                                | 53                                                      | 9.6                                                 |
| Other               | 2                  | 3.5                               | 1.2                             | 2.3                                 | 34                                                      | 0.6                                                 |

Note: PLN = Polish zloty; 1 PLN = USD 3.012 or 1 PLN = 4.1472 euro on 31 December 2013 [53].

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