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ENERGY INDEPENDENT CITIES? INVESTMENT ACTIVITY OF CITIES IN THE IMPLEMENTATION OF EU CO-FINANCED PROJECTS IN RENEWABLE ENERGY SOURCES AND ITS CONDITIONS IN POLAND

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ABSTRACT

Aim: The main objective of the paper is to evaluate the scale, scope, and significance of investments in renewable energy sources by cities in Poland, which were co-financed from EU funds. This assessment will focus on the last two multiannual financial frameworks, namely for the years 2007–2013 and 2014–2020. **Methods:** Empirical studies were conducted based on data from the database of the Ministry of Development Funds and Regional Policy in Poland, the Local Data Bank, and the Ministry of Finance. When investigating the investment activity of towns and cities related to renewable energy sources, basic descriptive statistics methods were applied. Logistic regression was used to identify the primary socio-economic, financial, and environmental conditions. **Results:** In the analyzed period, the role of towns and cities in the realization of renewable energy projects increased, although it is still relatively limited compared to other types of administrative communes. In the multiannual financial framework for 2007–2013, less than one in ten cities executed at least one project, while in the years 2014–2020, more than one in four cities realized at least one project related to the development of renewable energy sources supported by EU funds. The disparity in activity between towns and cities on a regional scale was huge. These investments were more often realized by towns and cities with a lower level of development, serving tourist functions, and experienced in carrying out such investments. Their lower investment activity was influenced by their level of indebtedness. **Conclusions:** So far, one of the main drivers behind the development of renewable energy in urban areas has been the ecological aspect, particularly the improvement of air quality. However, there is now a growing recognition of the importance of energy security.

Key words: green energy, city decarbonization, local investments, municipal management, EU funds, urban commune

JEL codes: H72, O18, R51, R58, Q42

INTRODUCTION

Over 70% population of Europe, while in Poland over 60% population live in cities [Eurostat]. Urbanization influences all areas of development, including economic, social, and environmental aspects. [Neirotti et al. 2014, Hoppe et al. 2015]. The environmental impact of cities is related to considerable energy consumption and high CO_2 emissions, which manifest in air and water pollution [Bibri and Krogstie 2017]. Expansion of cities also leads to the loss of green areas designated for housing development or economic activity. Energy is

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essential for the smooth operation of cities across various sectors, including schools, kindergartens, care centers, offices, and other municipal institutions. Energy is used to run water supply systems, provide street lighting, and power tramways. Power outages can completely paralyze a city's functions. The condition of the energy supply infrastructure and the infrastructure dependent on it also plays a crucial role, not only because urbanization increases the demand for energy [Birbi 2013]. Thus, cities undertake an increasing number of actions aimed at modernizing infrastructure and public utilities to improve the quality of life for their residents, as well as enhancing their competitive advantage [Rogerson 1999, Senlier 2009, De Jong et al. 2015, Zhan et al. 2018, Ferro De Guimarães et al. 2020, Standar et al. 2022]. These actions are in line with the low-emission urban development in view of the pressing need for transition towards low-emission European[1] and – specifically – the Polish economy [Hoppe et al. 2015, Burchard-Dziubińska 2016, Xing et al. 2019, Kozera et al. 2022]. Issues connected with improved energy efficiency, air quality, and the transition to cleaner, locally available renewable energy sources are becoming priorities for local government units, including cities [Bulkeley 2013, Geels 2013]. To date, a major driver for the development of renewable energy sources in urban areas has been connected to environmental protection, specifically the improvement of air quality [see Chen et al. 2023]. At present, energy security is increasingly being considered essential due to the depletion of natural resources and as a solution to the EU energy crisis, which has been worsened by Russia's invasion in Ukraine. In addition to the environmental impacts of generating energy from renewable sources, such as reduced atmospheric CO_2 emissions, the solutions that have been adopted aim to rationalize the costs of purchasing and consuming electricity. Developing the city's own energy sources makes it possible to stabilize energy prices, gain independence from external factors, and ensure energy security and a reliable energy supply for the city. Consequently, the rising energy prices are forcing local governments to search for savings, which can be provided by renewable energy sources. Moreover, the use of renewable energy aligns with the concept of a so-called smart city. It is a multifaceted term and the smart environment is one its six dimensions [Giffinger et al. 2007, 2014]. This segment is frequently mentioned as one of the key features of smart cities. It involves the application of state-of-the-art technologies to ensure the more efficient utilization of energy resources and the reduction of CO_2 emissions [Stawasz and Sikora-Fernandez 2015]. Such cities minimize their environmental impact through infrastructure and urban management, primarily by developing and utilizing renewable energy sources. Local investments, carried out by the local government sector (including cities), play a crucial role in decarbonizing cities and promoting green energy. This is supported by the Polska Net-Zero 2050 report [CKE 2021], which emphasizes the importance of local community involvement in transitioning to renewable energy sources. Given this, local government units, including cities, must assume a key role in this process as they are closest to the residents and have a deep understanding of their needs. They can implement various investments at the local level to support the development of green energy, thereby accelerating sustainable development in the region. These investments can be financed through various EU funds.

The primary aim of this paper is to assess the scale, scope, and importance of investments made by cities in renewable energy sources and co-financed from EU funds, as well as to identify their conditions in Poland in the last two multiannual financial frameworks (i.e., in the years 2007–2013 and 2014–2020). This paper presents several research questions: What is the role of cities in the realization of investment in the development of renewable energy sources? What role is played by regional city centers in the acquisition of EU funds for these investments? What are the primary socio-economic and environmental factors determining the absorption of EU funds for the development of renewable energy sources?

[1] With each successive multiannual financial framework the EU increasingly focuses on the implementation of measures aimed at the development of low-emission economy, including those related to the development of renewable energy sources. Climate neutrality is to be reached by 2050 [Parlament Europejski 2024]. As early as 2030, greenhouse gas emissions are to be reduced by min. 40% (in relation to the levels in 1990), the share of renewable energy in total energy consumption is to reach min. 32%, and energy efficiency is to be increased by min. 32.5% [2030 Climate & Energy].

The results of the conducted empirical research are both cognitive and applied. Firstly, they fill the cognitive gap regarding the implementation by urban local governments of investments co-financed by EU funds in the field of RES and the conditions of this activity. Secondly, the results of the conducted research are significant for the implementation of future programs in the field of low-carbon economy development, such as the National Reconstruction Plan.

SOURCE MATERIALS AND RESEARCH METHODS

In order to realize the research aim the Ministry of Development Funds and Regional Policy database was searched to identify projects meeting renewable energy criteria in low-carbon economy (priorities: 41 Renewable energy: biomass, 39 Renewable energy: wind, 40 Renewable energy: solar, 42 Renewable energy: hydroelectric, geothermal, and other)[2] within two EU multiannual financial frameworks covering the years 2007–2013 and 2014–2020. Overall, from both of these databases comprising almost 160 thousand projects, a total of 157 were selected. The beneficiaries of these projects were communes with town rights, including towns with county rights. To assess the investment activity of these entities and the conditions determining such activity, a study was designed and divided into two stages. The first stage consisted of assessing the investment activity of towns, focusing on renewable energy sources. This analysis was conducted using basic descriptive statistical methods. The second stage investigated the conditions determining this investment activity using the logit model. In the first stage, the number and total value of realized projects were analyzed both in absolute and relative terms (per 10 000 inhabitants and per 1 km^2 area). Additionally, the percentage of towns acquiring the investigated financial support was estimated for both studied EU financial frameworks. A significance test for dependent variables was applied to verify whether the size of the local government body and the location of the administrative unit have a significant effect on investment activity addressing renewable energy projects. The non-parametric one-way ANOVA on ranks (the Kruskal-Wallis test by ranks) was used because the investigated variables within the distinguished groups did not have a normal distribution, as verified by the Shapiro-Wilk test.

In the second stage of the study, logistic regression was used to identify the primary socio-economic, financial, and environmental conditions that affect investment activity in towns acquiring EU funds for the development of renewable energy sources. Data for analyses in this stage of the study was collected from the Local Data Bank[3] and the Ministry of Finance, which was mainly from 2020. A total of nearly 50 different variables were considered in the research, including 19 variables representing the socio-economic situation, 19 variables representing the financial situation, and 8 environmental variables. The selection of replacement variables for the study was conducted on the basis of merit – a review of the literature and studies by other authors, as well as the authors' research experience. Statistical criteria (i.e., the degree of correlation between variables) were also taken into account. The models that were highly correlated with each other were eliminated. Finally, only the models that formed statistically significant variables were discussed.

Logistic regression is used when the dependent variable is dychotomic (i.e., it takes two values), where value 1 denotes the presence of a given characteristic, while 0 denotes a lack of a given characteristic [Hosmer and Lemenshow 2000]. Investigated local government units (i.e., communes with town rights) were divided into two separate classes:

$$y_{i}= \begin{cases} 0 & \text{communes with town rights, which did not realize EU projects related with development of renewable energy sources 51 communes with town rights, which realized EU projects related with development of renewable energy sources}^{4} \\ 1 & \text{communes with town rights, which realized EU projects related with development of renewable energy sources} \end{cases}$$

[2] The projects concerning renewable energy sources were identified based on the so-called Priority Themes in the years 2007–2013 and Areas of support in the years 2014–2020.

[3] A major barrier to conducting this type of research is the availability of data at the municipal level. There is a particular lack of information on the level and sources of environmental pollution in Polish public statistics.

[4] Considering the two investigated EU financial frameworks jointly.

The logistic function, on which the logistic regression model is based, takes the following form [Hilbe 2009]:

$$f(z) = \frac{e^z}{1 + e^z}$$

This method is applied, for example, in modelling probability of finding the investigated entity (e.g., a town) in a certain state ($Y = 1$, i.e., realizing projects related with development of renewable energy sources), while it also identifies statistically significant factors influencing this probability. Logistic regression makes it possible to calculate probability of such an event (the so-called "probability of success") [Hilbe 2009]:

$$P(y_i = 1/X) = \frac{e^{\beta_0 + \beta_1 x_1 + \ldots + \beta_K x_K}}{1 + e^{\beta_0 + \beta_1 x_1 + \ldots + \beta_K x_K}},$$

where:

y_i-th ($i = 1,\ldots, n$) observation in the dychotomic explained variable, which takes value 1 or 0,

$k = 1, 2,\ldots, K$

$X_{i1},\ldots, X_{iK}$ – explanatory variables (socio-economic, financial and environmental conditions, respectively),

$P(y_i = 1/X)$ – probability that variable Y takes value 1 for values of explanatory variables,

$X = [X_{iK}, \ldots, X_{iK}]$, i = 1,…, n; $k = 1,\ldots, K$;

$\beta_0, \beta_1, \ldots, \beta_K$ – structural parameters of the model.

Formally, the logistic regression model is a generalized linear model (GLM) in which the logit is a link function. However, the interpretation of a given model differs from that of the linear model. The sign of the parameter at variable X_k defines the direction of the effect of a given variable on Y. Its plus sign indicates that together with an increase in X_k the odds for $Y = 1$ increase, whereas negative values indicate a decrease in the odds for $Y = 1$. In order to interpret values of model parameters, the odds ratio is estimated [Kleinbaum and Klein 2002]:

$$\Psi = \frac{P_i}{1 - P_i}.$$

The odds ratio determines the relative odds for the occurrence of a given event. In the logit regression model, the level of odds may be estimated as a function of independent variables by modeling values of probability. This ratio is simplified to the following form [Kleinbaum and Klein 2002]:

$$\Psi = e^{\beta_0 + \beta_1 x_{1s} + \ldots + \beta_K x_K}.$$

The expression is a relative change in the odds for the occurrence of an event as a result of the action of a factor described by variable X_k, assuming stability of the other variables included in the model. This value is interpreted by comparing it with the value of 1 and expressing the obtained difference in percent. For example, if , then it is stated that the factor described by variable X_k has a stimulating effect on probability of occurrence of a given phenomenon at a stable effect of the other variables included in the model [Cramer 2011].

The fit of the logit model is evaluated based on the *chi*-square statistic and the so-called "pseudo-R^2 measures" [Maddala 2001], while statistical significance of variables is verified based on the Wald test. Additionally, the predictive power of the models is also assessed. This is done using the measure of the predictive power of the model established based on the validity table (general validity of the model) [Hosmer and Lemeshow 2000].

RESULTS

Assessment of the investment activity of communes with town rights, dedicated to investment projects co-financed from EU funds and allocated to the development of renewable energy sources

Conducted analyses showed that out of the 302 towns investigated within the first financial framework, less than one out of ten towns acquired UE funds allocated to the development of renewable energy sources. However, in the next financial framework, it was more than a quarter of the investigated local government units. Between the years 2007–2014, towns realized a total of 34 projects, amounting to a joint sum of 95 million PLN. In the years 2014–2020, there were as many as 123 projects, totaling over five times the previous amount (PLN 521 million). The negative result for the years 2007–2014 was caused by the fact that only seven out of 16 provinces managed to acquire EU subsidies. There was a huge disparity in the investment activity of towns depending on the region. During the first analyzed financial framework period in the Podlaskie province, 62% of towns realized projects dedicated to the development of renewable energy sources, co-financed by EU funds. In the Podkarpackie, Opolskie, and Lubelskie provinces, it ranged from 30 to 44% of the investigated local government units. In the other regions, very limited activity was observed for the analyzed beneficiaries. In terms of the number of projects, the towns of the Podlaskie province were particularly successful, as they implemented one-third of all projects. A similar percentage was recorded for this province in terms of the value of these investments. However, the highest amount of EU funds allocated to the development of renewable energy sources was absorbed by communes with town rights from the Lubuskie province. Here, only 6 projects jointly amounted to a record PLN 46 million. In relation to the size of the commune, measured both by the number of inhabitants and area, the greatest funds were also acquired by towns from the Lubelskie province (Table 1).

In the successive financial framework (i.e., in the years 2014–2020), the level of investment activity dedicated to renewable energy increased considerably and only in three provinces no towns implemented such

Table 1. Characteristics of projects co-financed from EU funds, realized by communes with town rights and allocated to renewable energy sources in Poland within the financial frameworks for 2007–2013 and 2014–2020

Provinces	2007-2013					2014–2020				
	number of projects	total value (in thous. PLN)	value per 10 thous. inhabitants (in thous. PLN)	value per 1 km^2 (in thous. pln)	% of towns acquiring projects	number of projects	total value (in thous. PLN)	value per 10 thous. inhabitants (in thous. PLN)	value per 1 km^2 (in thous. PLN)	% of towns acquiring projects
Dolnośląskie	0	0	0	0	0	0	0	0	0	0.0
Kujawsko--pomorskie	0	0	0	0	0	9	7 578.3	79.5	12.9	41.2
Lubelskie	6	46 048.8	527.6	71.2	30.0	22	91 050.8	1 104.3	140.7	85.0
Lubuskie	0	0	0	0	0	1	639.6	16.1	1.1	11.1
Łódzkie	0	0	0	0	0	3	16 507.0	126.1	19.7	16.7
Małopolskie	0	0	0	0	0	0	0	0	0	0.0
Mazowieckie	1	1 816.0	3.9	0.9	2.9	2	20 941.4	42.4	10.6	5.7
Opolskie	2	1 954.9	88.7	6.8	33.3	0	0	0	0	0.0
Podkarpackie	8	7 511.8	107.2	10.7	43.8	7	62 400.3	919.6	88.9	31.3
Podlaskie	10	29 270.3	492.0	61.0	61.5	12	15 412.8	264.1	32.1	61.5
Pomorskie	4	613.4	4.6	0.7	18.2	2	7 937.6	59.2	8.9	4.6
Śląskie	3	8 048.9	23.9	2.5	4.1	54	263 719.5	830.5	81.4	55.1
Świętokrzyskie	0	0	0	0	0	1	4 366.1	119.8	15.5	20.0
Warmińsko--mazurskie	0	0	0	0	0	5	2 421.9	39.7	6.8	31.3
Wielkopolskie	0	0	0	0	0	3	19 473.1	163.8	24.5	15.8
Zachodniopomorskie	0	0	0	0	0	2	8 620.9	110.3	10.2	9.1
Total for towns	34	95 264	46.7	6.5	9.6	123	521 069.1	258.6	35.4	26.8
Total for communes	237	791 891.4	205.7	2.5	×	926	3 533 985.4	927.8	11.3	×
Share of towns in absorption of EU support (%)	14.35	12.03	×	×	×	13.3	14.7	×	×	×

Source: the authors’ study based on data [Zasady działania…, GUS and BDL].

support. However, in this case, the concentration of EU aid allocated to the development of green energy was even higher. Towns in the Śląskie province had the highest activity indicators in absolute terms, absorbing as much as 43% of the total number of investment projects, which is equivalent to almost half of the town projects in that period. Once again, local government units from the Lubelskie province took a leading position among the most active entities. This province accumulated the highest number of such investments, considering the number of inhabitants or unit area (Table 1).

The results presented above suggest that there may be statistically significant differences between the EU aid acquired by towns allocated to renewable energy sources in individual provinces. The non-parametric analysis of variance confirmed this thesis (Table 2). Further post-hoc analysis revealed that the significance of these differences was influenced by the results recorded for towns from the Lubelskie, Podlaskie, and Śląskie provinces. The local government units from the Śląskie province, namely Zawiercie and Tarnowskie Góry, were the most effective beneficiaries, with each receiving as much as PLN 70 million for renewable energy sources.

Compared to other types of administrative communes, towns realized approximately 13% of projects aimed at developing renewable energy sources, absorbing 14% of EU funds allocated for that purpose. Although these percentages are relatively small, it is important to note that the number of towns is also relatively small compared to other types of administrative communes. Furthermore, towns themselves are not a homogeneous group of local government units in terms of their population. There are towns with several thousand inhabitants and others with populations 100 or even 1000 times larger, such as the capital, Warsaw. Interestingly, regional centers, which are the capitals of Polish regions (called *województwa* in Polish), received relatively small EU funds for projects related to renewable energy sources. Their share of projects in the total number was as low as 5%, and the funds they received accounted for only 2%. Studies conducted by Standar et al. [2022] have shown that the largest cities, which are regional centers, are leaders in implementing projects related to transitioning to low-emission in Poland. Therefore, the study investigated whether the size of a town is reflected in the EU funds acquired for investments in renewable energy sources. It was found that the results were not statistically significant, indicating that every town, regardless of its size, was an effective beneficiary. Therefore, other factors may influence this type of activity (Table 2). Based on the above, the second part of the study focused on identifying these conditions.

Modelling the investment activity of communes with town rights in the realization of investment projects co-financed by EU funds, allocated to the development of renewable energy sources

The process of acquiring EU projects dedicated to the development of renewable energy sources by towns

Table 2. Results of ANOVA on ranks (the Kruskal-Wallis test by ranks) for indicators of investment activity of towns, co-financed from EU funds and allocated to renewable energy sources in Poland within the financial frameworks for 2007–2013 and 2014–2020

Ling variable	Variable	ANOVA on ranks (Kruskal-Wallis test)	Significance level
size of local government unit*	number of projects	1.4323	$p = 0.4888$
	total value of projects	1.729	$p = 0.4214$
province	number of projects	6.1152	$p = 0.0001$
	total value of projects	108.9619	$p = 0.0001$

*measured by the number of inhabitants, with towns being divided into three groups: up to 20 thous. inhabitants, from 20 to 100 thous. inhabitants and those over 100 thous. inhabitants.

Source: the authors' elaboration based on [Zasady działania…].

and other local government units is determined by many factors. Thus, three logit models were developed, illustrating the effect of socio-economic, financial and environmental factors, respectively[5], on investment activity of towns in the acquisition of projects dedicated to green energy and co-financed from EU funds. The results of the estimated logit models are presented in Table 3. The estimated models showed good fit to empirical data, as well as high statistical significance of investigated parameters at explanatory variables.

The conducted empirical analyses showed that among the socio-economic factors, the investment activity of towns related to the acquisition of projects dedicated to renewable energy sources and co-financed from EU funds jointly in the two studied financial frameworks recorded a significant effect for the demographic situation, the level of entrepreneurship, the number of people working on farms, the level of education of town councilors, and the level of tourism development. The conducted empirical studies showed that the increasing value of the explanatory variables, such as the percentage of town councilors with university education or the number of hotel beds in tourist accommodation per 10 thousand inhabitants, resulted in an increased probability of the town acquiring projects dedicated to renewable energy sources co-financed from EU funds. The development potential of a commune is directly dependent on the activity of local government bodies of communes in acquiring funds for development, with their success being dependent, first of all, on qualified staff. Additionally, towns that are tourist resorts are concerned about air quality and focus on the development of green energy infrastructure. Factors stimulating the investigated phenomenon also include the number of individuals working on farms per 1000 people of working age. An increase in their number results in increased probability of acquiring renewable energy projects by towns (Table 3).

In turn, the increasing number of enterprises per 10 thousand people has led to a reduced likelihood of towns acquiring and implementing green energy projects. This means that the size and socio-economic development of a town have no significant impact on its ability to secure EU funds for renewable energy development, despite the greater need for such funds in larger towns due to higher levels of air pollution and CO_2 emissions. As a result, smaller towns with lower entrepreneurial standards or a relatively significant agricultural role also prioritize the social and economic benefits that investments in green energy can provide. These benefits primarily include the potential to create additional stable jobs for less skilled workers and stimulate economic activity in both urban and suburban areas. Furthermore, the conducted analyses have revealed that the financial factors influencing towns' investment activity in renewable energy projects co-financed by EU funds are primarily related to their own income potential and overall investment activity, including the acquisition of EU funds. As mentioned earlier, renewable energy projects co-financed by EU funds are more commonly undertaken by towns with lower levels of development. The results of the estimated logit model regarding financial conditions indicate that the higher a town's income potential (measured by per capita income), the lower the probability of acquiring EU funds for co-financing renewable energy projects. Conversely, towns with greater investment activity (measured by the proportion of capital expenditure to total expenditure), including those receiving EU funds for EU projects, demonstrate a higher likelihood of realizing such projects (Table 3). This highlights the significance of the beneficiary's experience in the EU funding acquisition process. Additionally, the level of indebtedness of towns decreases the probability of obtaining and implementing renewable energy projects co-financed by EU funds. Common law regulations specify limits on the indebtedness of local government entities, which then impact their potential for financing or co-financing public tasks using retransferred sources, as well as their ability to apply for debt funds [Dworakowska 2016, Kozera 2017].

In the third group of environmental factors, the investment activity of towns related to the development

[5] Empirical data showing conditions for investment activity of towns related to renewable energy sources came mainly from 2020. This study investigated jointly almost 50 different variables, including 19 variables illustrating the socio-economic situation, 19 variables presenting the financial situation and 8 environmental variables. Finally, only those models were discussed, which constituted statistically significant variables.

Table 3. Results of estimation for parameters of logit models developed for investment activity of towns dedicated to renewable energy sources and co-financed from EU funds in Poland within the financial frameworks for 2007–2013 and 2014–2020

Explanatory (independent) variables		Coefficient	Std. Error	Odds ratio	p-values	Relevance [b)]
Socio-economic [c)]	Change in the number of residents per 1000 inhabitants (total for 2007–2020)	–0.0050	0.0027	0.9950	0.0632	*
	Entities registered in REGON business register per 10 thous. Inhabitants of working age	–0.0014	0.0003	0.9986	<0.0001	***
	Percentage of town councilors with university education (%)	0.0382	0.0096	1.0390	<0.0001	***
	Hotel beds per 10 thous. inhabitants	0.0002	0.0001	1.0002	0.0119	**
	Number of people working on family farms per 1000 people of working age	0.0207	0.0084	1.0209	0.0136	**
Financial [d)]	const	–0.0857	0.5905	0.9178	0.8846	
	Own income per capita (in PLN)	–0.0004	0.0002	0.9996	0.0550	*
	Share of capital expenditure in total expenditure (%)	0.0962	0.0270	1.1010	0.0004	***
	EU funds for financing of programs and EU projects per capita in the years 2014–2019 (in PLN)	0.0003	0.0001	1.0003	0.0204	**
	Total liabilities per capita (in PLN)	–0.0003	0.0002	0.9997	0.0263	**
Environmental [e)]	const	2.2355	0.8866	9.3509	2.5210	**
	Forest cover (%)	–0.0241	0.0096	0.9762	−2.497	**
	Developed and urbanized land (%)	–0.0344	0.0136	0.9661	−2.538	**
	Water consumption per capita (in m^3)	0.0541	0.0297	1.0556	1.8230	*
	Consumption of electricity per capita (kWh)	–0.0031	0.0012	0.9969	−2.637	***

Models were constructed based on balanced samples (95 communes, which in the investigated period acquired min. 1 project dedicated to renewable energy sources co-financed from EU funds (1) and 95 communes, which showed no investment activity in this respect (0)); If p-value ≤0.001 it is flagged with three stars (***), 0.001 <p-value ≤0.05 – two stars (**), 0.05 < p-value ≤ 0.1 – one star (*); c) Joint test for model coefficients: χ^2 = 40.3, p = 0.000, number of accurate prediction cases = 67.7%; d) Joint test for model coefficients: χ^2 = 26.8, p = 0.000, number of accurate prediction cases = 64.7%; e) Joint test for model coefficients: χ^2 = =18.2, p = 0.000, number of accurate prediction cases = 58.4%.

Source: the authors' calculations using the Gretl program based on data from [Zasady działania…, GUS and BDL, Ministerstwo Finansów 2021].

of green energy supported by EU funds was influenced by several variables. These variables included the percentage of developed and urbanized land (%) and forested area (%), as well as the consumption of electricity and water per capita. However, among these factors, only a higher water consumption per capita was found to be associated with a greater likelihood of acquiring a project co-financed from EU funds and dedicated to renewable energy sources. On the other hand, a higher share of developed and urbanized land, as well as forested areas, resulted in a lower probability of acquiring the analyzed projects by commune local government bodies (Table 3). It may be stated here that greater awareness regarding investments in renewable energy sources is observed in towns with well-developed industries, as this sector consumes as much as 74% of water [Hosmer and Lemeshow 2000]. This confirms earlier results regarding spatial variation in the absorption of EU funds for renewable energy sources, with towns from the Śląskie province leading the way. However, it is worth noting that effective beneficiaries also included towns that are currently at an early stage of development, rather than just those that are already highly developed. We can expect a greater commitment to participating in green solutions and initiatives in locations where the standard of development is highest, and therefore where the needs are also greatest.

DISCUSSION

That renewable energy positively influences urban development is indisputable [Hoang 2021]. As Szlufik [2017] points out, using renewable energy makes it possible to create a healthy and clean environment for future generations. Polish local governments are only now beginning the transformation, often based on the experience of other countries that have been undertaking these projects for a long time. An example is the German city of Wörrstadt, which has been supplying 100% of its energy from RES for many years [Jachimiuk 2011]. European cities are setting further important pro-environmental challenges, such as Copenhagen, which has set a target of achieving 100% energy neutrality by 2025. Other Danish cities have similar ambitious goals, as do cities in Finland, Norway, and the United States [Hagos et al. 2014, Barbiére 2015, Thellufsen and Lund 2016, Jacobson et al. 2018, Thellufsen et al. 2020].

Czyżak et al. [2021] indicate that the RES potential in Poland is sufficient to achieve the EU climate targets in the 2030 perspective. However, in order for this to happen, certain issues related to RES development need to be resolved. These include unblocking the development of wind power plants, creating incentives for the construction of energy storage facilities, adopting a program for the development of biogas plants (particularly important in rural areas), obtaining funding for the energy transition, and addressing legal instability. Financial or institutional barriers are highlighted by Eleftheriadis and Anagnostopoulou [2015] and Polzin and team [2016], among others. In Poland, as noted by Slotwinski [2022], legal conditions at the national level are currently an inhibiting factor for the direct active participation of municipalities in the generation and supply of energy from RES, especially to cover their own energy needs. The entire bureaucratic process related to new investments in renewable energy also needs to be streamlined. As Kubiczek and Smoleń [2023] note, despite the financial and technical challenges, it is necessary to accelerate the modernization of electricity networks, even going beyond the plans contained in the Charter for the Efficient Transformation of the Distribution Networks of the Polish Energy Sector [URE 2022].

CONCLUSIONS

In light of climate change, the geopolitical situation, and increased energy demand, we may observe a growing interest in cheap and renewable energy sources. For this reason, the development of renewable energy sources is a priority in the EU's strategy for achieving climate neutrality by 2050, and it is one of the pillars of the European Green Deal. The European Union supports the development of renewable energy sources and provides co-financing for such investments, as necessary, considering their capital intensity. In Poland, these funds are allocated to local government bodies, including the basic tier – communes. This is because local government is one of the largest energy consumers in the areas they administer, especially in communes with town rights, where they may also be significant energy producers. Among all types of communes, towns generate the highest energy demand and often face greater environmental pollution. As a result, they should focus on seizing the opportunity to acquire EU funds that support energy transformation in their area. Renewable energy infrastructure can also be successfully implemented in urban spaces.

Based on the conducted analyses, it may be stated that interest in renewable energy projects co-financed from EU funds is increasing among Polish towns and cities with each successive financial framework. In the years 2007–2013, only one in ten towns (and only in seven regions) received such support. However, in the 2014–2020 financial framework, more than a quarter of towns (in 13 regions) received this support. Not only did the percentage of towns implementing these projects increase, but there was also an increase in the number of projects (almost three times more) and their value (a five-fold increase). However, it should be noted that there is a significant and growing concentration of renewable energy projects. The regions with the highest investment activity in communes with town rights for the acquisition and implementation of projects dedicated to renewable energy development were the Podlaskie and Lubelskie provinces. In terms of the number and value of projects, towns in the Śląskie province were the most successful. The obtained results indicate that there may be statistically significant differences in the EU support received by towns in individual provinces for the development of renewable energy sources. The conducted non-parametric analysis of variance confirmed this hypothesis, and the in-depth post-hoc analysis showed that this is due to the high activity of towns in the aforementioned provinces: Podlaskie, Lubelskie, and Śląskie.

In turn, the estimated logit models identified significant socio-economic, financial, and environmental factors influencing the activity of towns dedicated to investments in the development of renewable energy sources co-financed from EU funds. Among the socio-economic conditions, a significant role was played, among other things, by the percentage of town councilors with a university education, as well as the number of hotel beds per 10 thousand inhabitants. Higher values of these indexes resulted in a greater probability of acquisition and realization of projects developing green energy resources in towns. A factor stimulating this phenomenon also included the number of people working on farms per 1000 people of working age. It indicates considerable potential for the development of renewable energy sources in rural areas located within towns, where not only large wind farms may be constructed, but also biomass may be utilized. In turn, the increasing number of enterprises per 10 thousand inhabitants caused a decrease in the probability of acquiring and realizing green energy projects by towns. This means that the size of a town, the standard of its socio-economic development had no significant effect on the acquisition of EU funds for the development of renewable energy sources. Among financial factors, the level of own income potential and the level of town indebtedness proved significant. At the same time, these analyses showed that towns with a greater investment activity (quantified by the share of capital expenditure in total expenditure), including those acquiring EU funds for the realization of EU projects, were characterized by a greater probability of realizing such projects. Again, this shows the importance of the beneficiary's experience in the EU subsidy application process. In turn, among the last, third group of environmental factors, only greater water consumption per capita resulted in a greater probability, while a higher share of developed and urbanized land as well as forested area led to a lesser probability of acquiring these projects by towns. It may be stated that greater awareness of investments in renewable energy sources is found in towns with well-developed industry, since water consumption is greater there. This confirms earlier results concerning spatial disparity in the absorption of EU funds for renewable energy sources, with towns from the Śląskie province being leaders. At the same time, effective beneficiaries were towns being still at an early stage of development, not necessarily those best developed. Diversification and decentralization of energy generation should concern not only rural areas and small towns but also larger urban centers. We may expect greater commitment and involvement in green initiatives and solutions on the part of towns, where the development is most advanced and as a result the needs are also greatest. Nowadays, it seems that no city mayor needs to be persuaded to obtain EU funds, as the financial and material effects of investments made with their participation are noticeable. Rather, they need to be persuaded to build urban policy in a sustainable (i.e., also pro-environmental) way. This is important because local authorities are not only able to carry out such actions themselves, but through the programs they introduce, they can encourage inhabitants or companies to take joint action. This study, therefore, forms the basis for a broader discussion on the implementation of the energy transition, the use of EU funds for this purpose, and the role of local authorities in this process.

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NIEZALEŻNE ENERGETYCZNIE MIASTA? AKTYWNOŚĆ INWESTYCYJNA MIAST W ZAKRESIE REALIZACJI PROJEKTÓW WSPÓŁFINANSOWANYCH ZE ŚRODKÓW UE W ZAKRESIE ODNAWIALNYCH ŹRÓDEŁ ENERGII I JEJ UWARUNKOWANIA W POLSCE

STRESZCZENIE

Cel: Celem głównym artykułu jest ocena skali, zakresu i znaczenia inwestycji miast w odnawialne źródła energii (OZE) współfinansowanych ze środków UE oraz identyfikacja ich uwarunkowań w Polsce w dwóch ostatnich perspektywach finansowych, tj. w latach 2007–2013 i 2014–2020. **Metody:** Badania empiryczne przeprowadzono na podstawie danych pochodzących z bazy Ministerstwa Funduszy i Polityki Regionalnej, Banku Danych Lokalnych Głównego Urzędu Statystycznego oraz Ministerstwa Finansów. W badaniu oceny aktywności inwestycyjnej miast w zakresie OZE wykorzystano podstawowe metody statystyki opisowej, a w celu identyfikacji jej głównych uwarunkowań społeczno-ekonomicznych, finansowych i środowiskowych regresję logistyczną. **Wyniki:** W badanym okresie zwiększyła się rola miast w zakresie realizacji projektów związanych z OZE, choć jest ona nadal stosunkowo niewielka na tle pozostałych typów administracyjnych gmin. W perspektywie finansowej 2007–2013 niespełna co dziesiąte miasto, natomiast w latach 2014–2020 już ponad, co czwarte miasto zrealizowało przynajmniej jeden projekt związany z rozwojem OZE przy wsparciu środków pochodzących z UE. Dyspersja pomiędzy aktywnością miast w ujęciu regionalnym była olbrzymia. Inwestycje te częściej realizowały miasta o niższym poziomie rozwoju, pełniące funkcje turystyczne, mające doświadczenie w zakresie realizacji tego typu inwestycji, a czynnikiem mającym wpływ na niższą aktywność inwestycyjną miast miał ich poziom zadłużenia. **Wnioski:** Do tej pory jednym z głównych czynników rozwoju OZE na obszarach miejskich był aspekt ekologiczny, związany z poprawą jakości powietrza, natomiast obecnie pod uwagę brany jest coraz częściej aspekt bezpieczeństwa energetycznego.

Słowa kluczowe: zielona energia, dekarbonizacja miast, inwestycje lokalne, gospodarka komunalna, środki unijne, gminy miejskie