CIVIL AND ENVIRONMENTAL ENGINEERING REPORTS

E-ISSN 2450-8594

CEER 2024; 34 (1): 0037-0046
DOI: 10.59440/ceer/179712
Original Research Article

EFFECTIVENESS OF FINANCING MEASURES TO REDUCE LOW EMISSIONS IN POLAND - A CASE STUDY

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A b s t r a c t

Local authorities are increasingly facing the challenges of climate change, which requires adaptation of various elements of local government systems, including infrastructure, communities and local economies. Operating in an ever-changing reality, local government units should plan for the necessary sustainable local government investments, with particular attention to structural gaps and financial mismatches. Local government is responsible for ensuring local energy security and thus for 'environmental sustainability'. The overall objective of this study is to assess the effectiveness of financing low-emission lowering measures from the Environmental Protection and Water Management Fund in municipalities in Lubusz Province in 2020. The article uses cause-effect relationship analysis (regression models). Investments implemented by local governments generally have a positive impact on the reduction of low emissions, although the results of the study indicate a negative impact of financing investments in alternative energy sources (RES). This may be related to large investment outlays, as well as difficulties in spatial planning, environmental impact and administrative inefficiency.

Keywords: effectiveness, low carbon economy, air pollution, low emissions, local government

1. INTRODUCTION

The term "emission" is defined as "the introduction directly or indirectly, as a result of human activity, into the air, water, soil or land: substances or energy such as heat, noise, vibrations or electromagnetic fields" [1]. Low emissions are defined as emissions of harmful dust and gases at a low height. Not more than 40 m. Pollutants introduced into the air at this height accumulate around the place of origin causing damage locally (usually places of compact residential buildings) [2]. Polutions are a problem associated with the emission of harmful dusts and gases resulting from the inefficient combustion of fuels (hard coal, charcoal, petrol, diesel, etc.) in domestic boiler rooms, cookers, fireplaces, as well as vehicles used in road transport. The main local sources of pollution are anthropogenic emissions from chimneys of individually heated houses (surface emissions) and road transport (linear emissions). The latter,

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influences pollutant concentrations especially in areas directly adjacent to roads with significant traffic. A significant share of the air concentrations of pollutants in the Lubusz Voivodeship is due to their influx from others regions of Poland and Europe [3]; [4]; [5]. Low emissions have a significant impact on air quality. Low-lying emission sources often lead to high concentrations of pollutants in the human habitation zone [3]. Playing a significant role in shaping local air pollution levels [6].

Effectiveness, in the universal approach, is a basic measure of efficient action [7]; [8]. It is understood as the conformity of the result to the goal/task. It is regarded as an assessment of performance. It defines the relationship between the description of the event that is the goal/task and the description of the result [9]. Effective actions are called those that to some extent lead to the effect intended as the goal.

The measure of effectiveness is only the degree to which the goal is approached (achieved, enabled or attained). In assessing effectiveness, cost is therefore not taken into account. Effectiveness refers to the objective and means the degree to which the planned objective is achieved [10]. It should therefore be assessed through the prism of contributing to the achievement of the organisation's objective and not in terms of individual production or profit. Lubinska [11] writes that performance is related to the objectives formulated by managers, the implementation of which should be as correct as possible. In the public finance sector, effectiveness should relate directly to the objectives, which the more they are realized in accordance with the budget assumption, the more one can speak of meeting the condition of effectiveness. Effectiveness should be more related to the measure of meeting social needs as a result of budget performance [35].

The process of transforming Poland's traditionally coal-based economy into one that uses low-carbon technologies faces the problem of diversifying energy sources, especially in rural areas [12]. The reasons are twofold: the depletion of coal resources [13] and the emission of harmful gases and dust into the atmosphere. Therefore, it is important to protect the environment by implementing new innovative technologies and modernising currently existing facilities [14].

The supply of heat, electricity and gaseous fuels to residents and businesses operating in the area and its planning rests with the municipal authorities. Hence, the cooperation of the municipality with the local community, especially with the owners of individual residential buildings, in the installation of modern central heating boilers fired by solid fuels and the use of other renewable energy sources (RES), will result in saving fossil and reducing emissions of pollutants to the environment, thereby improving its condition and the health of the population [15].

Support programs for various projects implementing the demands of a low-carbon economy are implemented at the level of the European Union, individual member states and local government units [36]. Most of the financial instruments are aimed at businesses, local government units and other institutional entities [37]. The resources available to local governments are also an important factor of effectiveness. Most publications analyze the impact of environmental spending on air and water pollution or ecological footprint [38, 39] or on economic performance [40]. In the literature, barriers to financing pro-environmental projects include inadequate public budgets [41], high upfront costs, difficulties in obtaining loans [42], and problems in implementing nationally and sub-national funded projects [43]. Lack of flexibility in local government and institutional blockages, regulatory disincentives and procedural complexity [41, 44], and infrastructure [45] have also been cited as barriers to success.

Local government plays an important role in creating a low-carbon economy and sustainable socio-economic development. The activities of local and regional authorities related to improving energy efficiency, developing renewable energy sources, low-carbon technologies and clean public transport, promoting new consumption patterns, etc. are part of the idea of sustainable development in terms of a low-carbon economy [16]; [17]; [18]; [19]. The implementation of a low-carbon economy at

the local level not only has a positive impact on environmental protection, but also (through positive feedback) will further increase the pace of sustainable development in the region [20]. The multitude of environmental, economic, political and social challenges facing local governments makes it challenging for municipalities to implement these measures effectively.

Investments to reduce the level of low emissions usually require large financial outlays. The economic efficiency of using public funds for this purpose is very important, not only because of their limited nature, but also because of the socially significant issue of environmental protection This also requires changes in the management and transfer of knowledge about counteracting low-level emissions at central and local levels [21]; [22] .

The aim of this article is to answer the question of what factors influence the financing of low-emission reduction measures by municipalities in the Lubusz region by the Environmental Protection and Water Management Fund.

2. METHODS

2.1 Sample

In examining the effectiveness of the implementation of low emission reduction programmes in the Lubusz Voivodeship, surveys (main and supplementary) were conducted twice among 82 municipalities in two research periods. In 2020, covering the research period for 2014-2019, and in 2022, covering the research period for 2020. Used as well as data from the Environmental Protection and Water Management Fund.. The territorial area of the study was limited to the Lubusz Voivodeship region. Due to the desire to find out the determinants influencing the financing of municipalities in low-emission reduction measures using external funding from the Environmental Protection and Water Management Fund in one of the smallest provinces in the country. The second premise is the widespread awareness that financial programmes of this type are not very well implemented in Poland, although we already know that this is mainly due to insufficient financial incentives for energy transition. As the region adopted for the study is not representative of all in Poland, the approach adopted implies the need to continue analogous studies in other voivodships.

2.2. Variables

In accordance with the adopted research objective, the dependent variable informs about the financing from the Fund for Environmental Protection and Water Management of activities reducing low emission in 2020.

Independent variables significantly influencing the effectiveness of raising funds for low emission reduction measures from the Environmental Protection and Water Management Fund projects in the Lubusz Voivodeship in 2020 include: the requested grant amount, grant amount received, as well as the replacement of heat sources for residents, connecting buildings to the district heating network, replacing heating boilers with new ecological ones in municipal buildings , replacing street lighting with LED or solar ones.

2.3. Economic methods

Due to the qualitative nature of the dependent variables and the specificity of the research sample, it was decided to use stepwise regression. This method makes it possible to introduce into the model only those variables, predictors, which significantly predict the dependent variable. Thus, out of the thicket of sometimes redundant variables, those are obtained that actually have an impact on the prediction of the

dependent variable. The stepwise method eliminates the problem of collinearity, i.e. highly correlated predictors. The successively introduced predictors also take into account the mutual correlation between them.

Calculations were made at the significance level of α=0.1, α=0.05, α=0.01. Statistical significance of the models is determined using the Wald chi-square statistic, and verification of parameter significance using the Student's t-statistic, based on asymptotic standard errors of judgement.

The Fisher-Snedecor test and Student's t-test for the model coefficients were used to verify the model. Under the assumption that the errors (residuals) have a normal distribution [23]. The verification process also involved testing the properties of the residuals (random components) of the regression model: conformity to a normal distribution, the occurrence of the phenomenon of autocorrelation of the model residuals and homoskedasticity. The basis for accepting the model for statistical inference is to determine its predictive properties on the basis of an analysis of the distribution of regression residuals [24]. For this purpose, a normality plot of the residuals was produced. The homoskedasticity of the random component was diagnosed on the basis of scatter plots of the residuals against the predicted (theoretical) values. The evenness of the points on these graphs is a confirmation of the homogeneity of the variance of the model residuals [25].

3. RESULTS

The results presented in this paper are the result of surveys conducted in two rounds - 2014-2019 and 2020 - among 82 municipalities, as well as data from the Environmental Protection and Water Management Fund. The territorial area of the survey was limited to the Lubusz Voivodeship region. Due to the desire to find out the determinants influencing the financing low emission reduction activities using external financing from the Environmental Protection and Water Management Fund in one of the smallest provinces in the country.

Tabela 1. Results of the estimation of the parameters of the linear model describing the effectiveness of low emission reduction funding from the Environmental Protection and Water Management Fund in 2020

	Parameter	Standard Error Statistics	Statistics t Student's	p-value
The requested grant amount	0,191988921	0,0919783926	2,08732634	0,0415923521
Grant amount received	0,262187889	0,0931062847	2,81600634	0,00677521853
Replacement of heat sources for residents	0,309344927	0,0954467104	3,24102241	0,00204223837
Connecting buildings to the heating network	0,437599205	0,0932007406	4,69523313	0,00001866304
Replacement of heating boilers with new ecological one in municipal buildingss	0,184643089	0,0842604064	2,1913387	0,0327608734
Replacement of street lighting with LED or solar	-0,197541625	0,081587163	-2,42123415	0,0188582335
Coefficient of determination R^2	0,733391148			
Corrected coefficient of determination R^2	0,684019139			
Fisher statistics F(10,54) p-value	14,8543913 <0,00000			
The standard error of the estimation	639298,546			

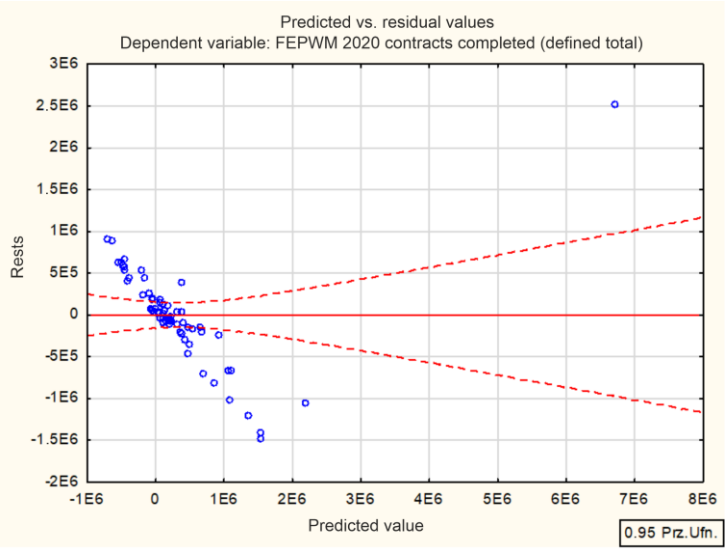
Source: own work on the basis of research using Statistica software

In the model presented in Table 1, six variables are statistically significant predictors of the effectiveness of municipalities' own expenditure in low-emission reduction projects in 2020. Each doubling of the funding applied for by the municipality increases the effectiveness of the municipalities' activities in low-emission reduction projects. It is therefore worth applying for further funds. The behaviour of local authorities has changed positively in the context of cooperation in low-emission reduction projects [26]. The increasing amount of funding applied for (not obtained) for low-emission projects effectively influences the acquisition of external funding. Despite the complexity, intricacy and highly dispersed financing of environmental policy in Poland, there is a visible increase in local government units applying for such funding [27].The use of external funds (including international aid) by local authorities demonstrates that multi-level governance is effective and necessary to achieve sustainable development goals [28].

Investments implemented by municipalities funded by external projects generally have a positive impact on the reduction of low emissions. Most of the municipal and local efforts focus on the energy sector and concern energy efficiency measures (mainly on the municipality's own properties and activities), energy conservation and renewable energy generation. It can be seen from Table 1 that measures related to the connection of buildings to the district heating network, as well as the replacement of heating boilers in buildings under the authority of the municipality [29] and also in the residents of the municipalities, are mainly covered by external funds including the Environmental Protection and Water Management Fund which, has a positive effect on reducing the municipality's own costs. They are one example of energy infrastructure on a local scale. They have the potential to significantly reduce the energy intensity and carbon emissions associated with heat supply, improve air quality and reduce energy costs especially when heat is sourced from renewable sources [30]; [31]. The closer connection between suppliers and end-users, and the smaller scale of the technology, creates an opportunity for new actors to engage with local energy infrastructure, including municipalities, community groups and social enterprises. The motivation of local actors to engage in energy provision is increasingly focused on social and environmental impacts [32]; [33].

A negative example of investments funded by the Environmental Protection and Water Management Fund are projects in alternative energy sources (RES), mainly the replacement of street lighting with LED or solar lighting. This is associated with large investment outlays and with difficulties in spatial planning, environmental impacts and administrative inefficiencies [34]. The consequence of these barriers is that the expenditure for this purpose increases faster than the subsidy received.

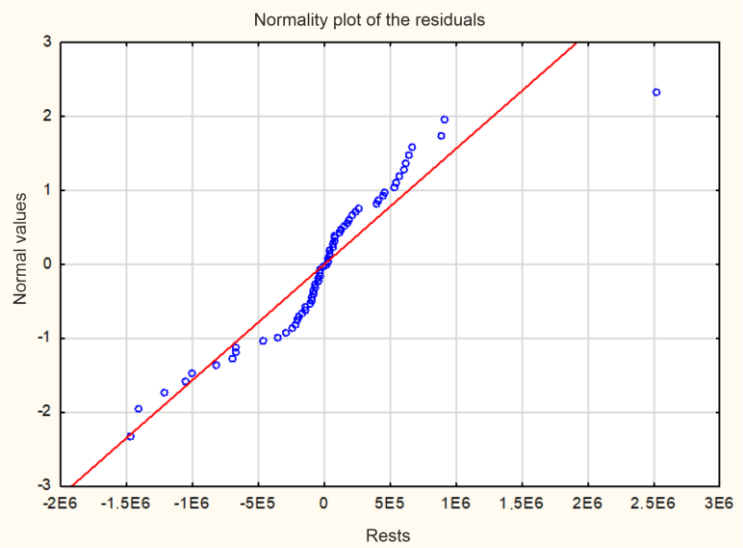
The results of the analysis carried out above show that the independent variables adopted allow 73.34% of the total variance to be explained by the value of municipalities' own expenditure in low-emission reduction projects in 2020, (adjusted $R2 = 0.7334$), which turned out to be a statistically significant result (Fisher's F statistic = 14.85; $p < 0.0005$). The estimated model meets the assumptions of the method of least squares. The analysis of the residuals of the analysed model confirmed its validity. The homoskedasticity of the variance of the random component is confirmed by the even distribution of points on the scatter plot of the residuals against the predicted values, as shown in Figure 1.



Source: own elaboration based on surveys conducted

Fig. 1. Scatter plot of the residuals against the effectiveness of funding for low emission reduction measures from the Environmental Protection and Water Management Fund in 2020

A graph of the normality of the residuals for this model is presented in Figure 2.



Source: own elaboration based on conducted research

Fig. 2. Residual value normality plot values for the effectiveness of low emission reduction funding from the Environmental Protection and Water Management Fund in 2020

The calculated model is a good fit to the real data. The statistics developed in it allow us to identify the factors stimulating and destimulating the effectiveness of funding from the Environmental Protection and Water Management Fund for low emission reduction measures in 2020. The stimulating effect of local governments' impact to obtain financing from external funds is visible through the prism of the implemented effects of these activities.

4. CONCLUSIONS

Lubusz province in terms of size is one of the smallest provinces in the country. Forested areas cover more than 49% of the province. In some municipalities, forests cover more than 70% of the area. Lubusz province is characterized by an average degree of air pollution compared to the country. The results of the study show that local governments have a positive impact on the effectiveness of municipalities in obtaining funding from the Environmental Protection and Water Management Fund for low emission reduction measures in 2020. Investments implemented by local governments financed by external projects generally have a positive impact on the reduction of low emissions, although the results of the study indicate a negative impact of financing investments in alternative energy sources (RES). The survey detailed investments in replacing street lighting with LED or solar. This may be related to large investment outlays, as well as difficulties in urban planning, environmental impact and administrative inefficiency. The focus of local governments on energy efficiency and conservation measures is apparent. Mainly on the municipality's own properties and activities, and the increasing participation of residents in taking these measures.

Coal is and will continue to be the primary heat carrier for the foreseeable future, despite increasing environmental requirements. In the author's view, further subsidization of energy efficiency measures in buildings, as well as energy policy reform and increased investment in RES are needed to significantly reduce greenhouse gas emissions and cost savings. Effective financing of environmental protection, including low emissions, means ensuring that the environmental effect is maximized from available resources.

It seems appropriate to introduce additional support for the poorest municipalities and regions and to link it to the state of the area's environment. It is also a matter of making both local authorities and residents aware of the importance of investing in a low-carbon economy (including renewable energy sources) and ensuring not only a good environment for future generations, but also Poland's energy security.

The research results presented here do not exhaust all issues related to the activities of local government units in Poland in the context of implementing a low-carbon economy. The variety of activities undertaken by municipalities in obtaining external funds for the implementation of low-emission low-carbon investments, as well as socio-economic conditions, can provide a good starting point for further analysis, especially regarding the impact on reducing emissions in the areas covered by these investments.

The stepwise regression method used makes it possible to reveal the factors that affect the effectiveness of financing low-emission reduction programs, as well as the power of each program. However, the sample size and representativeness used in the study were relatively small, so the results obtained cannot be fully generalized. The survey is cross-sectional in nature, and therefore no causal conclusions can be drawn about the efficiency of low-emission reduction programs nationwide. Despite these limitations, the results obtained are significant, as the correlations between the variables studied were strong in this relatively small sample. Given that the region adopted for the study is not representative of all in Poland, the approach adopted implies the need to continue analogous studies in other provinces.

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