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Local Authority Investments in the Field of Energy Transition and Their Determinants (on the Example of South-Eastern Poland)

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Abstract: This article deals with the development of renewable energy sources and their role in the transformation of energy. The main purpose of this article is to analyze the role of local governments in Poland in accelerating energy transformation at the local level through the implementation of municipal investments. The potential activities of the municipalities in the area of local eco-energy were presented, with particular emphasis on their own investment projects. The involvement of municipalities in the implementation of their own projects in the area of energy transformation was assessed, and the sources of financing for such projects were determined. A diagnosis of barriers and limitations to the increase in the participation of communes in this area was also made. This research was carried out in the Podkarpackie and Lublin regions in southern Poland. The research results indicate that local government authorities are willing to accept contributing to eco-energy projects, but only when nonrepayable funds are involved in the financial assembly. In such a situation, they are also willing to seek loans as a source of bridge financing or financing the unit's own contribution. Financial constraints are of key importance for municipal investments in the area of energy transformation. Among the internal factors that hinder the investments of communes in the area of energy transformation, financial constraints (budget) were definitely dominant. These limitations far exceeded the costs associated with energy planning, as well as the spatial and location barriers felt by local government officials.

Keywords: renewable energy; local authorities; local governments; RES; energy transformation

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1. Introduction

The development of renewable energy sources, a low-carbon economy, and improvement in the energy efficiency of the economy are very important elements of sustainable economic development, both at the national, regional, and local levels. In Poland, at the local level, the energy transition process has been boosted in the last decade with the contribution of European Union (EU) funds, including in particular the *Operational Programme Infrastructure and Environment* 2014–2020 (OPI&E). At the end of 2016, there were 428 producers of "green energy" from small RES installations in Poland. After five years, their number increased by nearly 79%, and at the end of 2020 it amounted to 765. Compared to the previous year, when there were 697 producers, there was an increase of almost 10%. For comparison, there are almost 460,000 producers in micro-installations (including prosumer ones) in Poland. It should be noted that a significant part of these installations was built thanks to OPI&E funds [1]. The share of renewable energy sources in total primary energy increased in 2016–2020 from 13.7% to 21.6%, and in gross final energy consumption, it increased from 11.4% to 16.1%. The energy generated from photovoltaic cells in 2016 is 123.9 MW, and in 2020 it is already 1957.9 MW; that is, nearly 16 times more [2]. Such an increase in the production of energy from RES, including energy from PV installations, would not have been possible without the involvement of EU funds, e.g., under the OPI&E program and Regional Operational Programmes. These funds supported many projects

implemented by households, enterprises, and local governments [3]. The budget of the entire OPI&E program (financed from the European Regional Development Fund, ERDF) amounted to EUR 27.4 billion, of which EUR 2.8 billion was planned to finance investments related to energy, and the total budget for competitions related to environmental protection and counteracting climate, including those related to renewable energy, amounted to EUR 6.3 billion [4].

As a result of formal requirements included in the OPI&E program, local authorities have turned towards a low-carbon economy and energy transition investments. A condition for applying for financial support for energy transition projects was the development and adoption of Low Carbon Economy Plans (pol. PGN—Plan gospodarki *niskoemisyjnej*) by the local authority. As a result, the program has successfully created this extremely important strategic planning instrument for local energy transition. Currently, the vast majority of municipalities in Poland have resolutions to adopt this strategic document. Its preparation, in fact, implied the need for a change in thinking about the municipality's development directions. Among many other no less important development goals of local government units, a number of efforts to improve energy efficiency [5], reduce energy demand, and increase the share of renewable energy sources (RES) in the energy consumption structure have also begun to gain importance. Thanks to PGN, it has already become popular to think of a municipality as a functional and spatial center with a heterogeneous demand for energy and requiring targeted projects in various sectors, including housing, transport, trade, services, and industry, as well as public utilities.

On 14 July 2021, the European Commission presented its new "Fit for 55" climate package under the European Green Deal. It includes measures to reduce greenhouse gas emissions by 55% by 2030 compared to 1990 [6]. The decarbonization challenges arising from the 'Fit for 55' climate package will affect both energy producers and the behavior of energy consumers, including those in the public sector. The currently rising energy and fuel prices also encourage the diversification of energy sources by increasing RES in energy consumption and actions aimed at reducing energy consumption (e.g., through thermal modernization of buildings). Low-carbon management plans and management-coordination activities for shaping the local energy sector are important planning tools in the hands of municipalities to implement inevitable changes. The direct involvement of local governments in projects related to the energy transition is of key importance in the implementation of these plans. This involvement can essentially take two forms:

(1) initiating and promoting the energy transition among residents and local businesses and supporting their activities in this regard—in informational, organizational, and financial terms;
(2) involving local governments in municipal or public–private partnership investments, whereby the local government is the producer and supplier of energy, its end user, or a beneficiary of energy savings that the implemented investments can bring.

In this paper, our attention will be devoted to the latter aspect of local government involvement in the energy transition process. This issue will be analyzed using the example of municipalities in south-eastern Poland.

By *energy transition* investments, we mean investments in the production and storage of energy from renewable sources (RES), but also investments aimed at saving heat and electricity (replacement of heat sources with ecological ones and improvement in energy efficiency of buildings). We will also refer to investments of this type as *investments in eco-energy.*

Municipal investments in the field of energy transition aim to improve the energy efficiency of municipal resources, and some of them aim to change the structure of the energy sources used, e.g., by increasing the use of RES. Their goal may also be to become more independent from external energy suppliers, and thus improve energy security and increase the municipality's resilience to energy price shocks. Investments may concern not only the production and consumption of energy by the municipality itself (by the authority, municipal units, schools, etc.). The involvement of municipalities in projects carried out in

partnership with other entities (e.g., energy companies, local businesses, and other local governments) may serve to build effective and pro-ecological energy management at the local and regional levels.

Investments in eco-energy can also serve as good practices and promote, for example, renewable energy sources among residents and local business entities. This type of involvement of municipalities in the local energy transition also supports the first of the previously mentioned areas of their activity. The experience of many countries shows that municipal investments can play such an activating role. They contribute to a greater acceptance and implementation of RES technologies by households [7,8].

In this article, the problem of municipal involvement in the energy transition process will be analyzed in the example of Poland [9,10]. Lignite and hard coal are still the dominant units of the system in the energy sector of Poland. Strong legislative pressure, as well as pressure from society, which expects difficult but necessary energy transformation processes, give some hope for changes in the approach to the energy sector. One of the three pillars of the strategic direction document—Energy Policy of Poland until 2040—concerns the issue of a zero-emission energy system. This area assumes the need for a very strong development of local and community energy, and the measure of effective action is the increase in the share of consumers actively participating in the market. By 2030, 300 energy-sustainable areas and one million prosumers are planned in Poland [9,10]. One of the solutions to accelerate the energy transition at the local level is to get local governments more involved in the process, e.g., through municipal investments carried out independently by municipalities or in partnership with other local government units and private sector entities.

The problem is, to what extent do municipalities have the opportunity to support the energy transition through their own investments? This issue depends on many factors that are both external and internal in relation to the local government unit [11]. In this study, we will seek answers to the following questions:

- What is the interest of local authorities in investing in renewable energy sources and increasing energy efficiency? The issue is the importance of these investments in the hierarchy of investment preferences of local governments;
- What are the most important barriers to the implementation of such investments (internal and external);
- What funding model for energy transition investments is practiced, and what is expected by the local government?

The aim of this study is to analyze and evaluate the involvement of local governments in Poland in the process of the energy transition at the local level through the implementation of municipal investments. Sources of funding for energy transition investments were examined. Barriers and limitations faced by local governments implementing such investments were also diagnosed, which also served to identify the main determinants of growth of their involvement in this area.

Research carried out on municipal investments by local governments in the area of energy transformation is an issue rarely addressed in the literature. The question of investments in renewable energy sources dominates. The subject of numerous publications is investments in RES carried out by enterprises and households. The topic of RES investments implemented by public sector entities, in particular those implemented by local governments, is less frequently discussed [3,11–16]. There is a gap in the literature on investments carried out by local government units, but in the area of energy transformation. Therefore, it is about a much broader subjective scope of investments, not limited only to RES. Although there are publications on energy transformation at the local level, they focus on the role of local communities in this process [17,18], spatial conditions of energy transformation [19], or the policy of financial support for energy transformation [20]. There is a lack of research that directly refers to the role of local self-governments in this process, implemented through municipal investments. This article has the opportunity to close this gap in the literature.

The article is divided into several parts. Thus, Section 2 reviews the most important items related to the issues discussed. The most important research results of other authors dealing with the problem of installing RES in local government units were presented. Section 3 presents the methodology used in the article. The results of this study are presented in Section 4. Section 5 is a summary with an indication of the most important conclusions.

2. Literature Review

Many studies indicate that local governments can play a key role in implementing the energy transition at the local level [21–24]. Local authorities can initiate, invest, produce, and be the end users of renewable energy [12,25]. Research on this topic is being conducted in various countries and regions. Local authorities play a major role in the implementation of renewable energy through energy planning at the local level and incentives and campaigns to make residents aware of the benefits in this area [26]. Local authorities also initiate or accompany energy projects on their territory [27].

Municipalities can support the energy transition goals of residents' households through involvement in publicly co-financed projects. Micro-investments concern not only the production of "green energy" from photovoltaic, solar, or heat pump installations, but also the thermo-modernization of buildings or the replacement of old boilers with new environmentally and energy-efficient ones. Such activity by municipalities has been evident in Poland in recent years (2018–2022), but the scope of the projects, due to financial constraints, was usually small, as support covered about 1–2% of households in the municipality [23]. However, the importance of these projects for triggering the positive effect of imitation is also important. Achieving the desired local energy goals through this type of local authority involvement requires planned and often long-term activities [21]. Positive effects are also conditioned by the existence of additional incentives for residents on the part of central authorities through favorable legal regulations for prosumer energy, subsidies for households implementing RES micro-installations, or implementing measures to improve the energy efficiency of buildings and heating installations [11,23].

Many authors emphasize the significant role of local governments in creating community renewable energy (CRE), i.e., network or cluster-like initiatives bringing together various local entities involved in the generation, distribution, and consumption of energy based on locally distributed renewable sources [10,28–32].

Projects implemented directly by municipalities or as part of public–private partnerships in the area of energy transition are usually small-scale, territorially dispersed investments, whose scale and socio-economic and environmental significance are local. In greater numbers, however, they are an important element of efforts to achieve the energy transition goals for the economy as a whole and to meet low-carbon targets.

Table 1 presents a catalog of investment projects in the field of low-carbon economy, energy efficiency improvement, and RES, which may be used by local government units (LGUs). Of course, this catalog is not complete, but it presents the most commonly used projects and types of RES technologies used in the municipal sector. The division of projects into separate types is also conventional, as many projects in the field of energy transformation combine ecological and efficiency (saving) objectives.

Table 1. Catalog of investment projects in the field of low-emission economy, improvement in energy efficiency, and renewable energy used by local government units.

Development of a Low-Emission Economy	Improved Energy Efficiency	Use of RES in the Municipal Sector
• thermal modernization of public utility buildings and communal apartments; • replacement of internal lighting in public buildings; • construction of a biogas plant on a landfill or in a sewage treatment plant; • purchase of energy-efficient equipment for the office, subordinate units, • purchase of ecological buses; • introduction of an energy management system in buildings and municipal facilities; • installation of smart meters and real-time energy consumption monitoring software.	• use of energy-saving lighting in buildings; • use of energy-saving street lighting; • thermal modernization of external partitions (windows, walls, ceilings); • modernization of the heating installation, i.e., heating sources and systems; • use of ventilation heat recovery systems; • use of intelligent transport systems in cities.	• installation of RES in public utility buildings (local government units); • local renewable energy plants (municipal). Technologies used: - photovoltaic panels; - solar panels; - heat pumps; - micro-biogasification; - small wind farms; - biomass boilers.

Source: [33,34].

The sequent theme referred to in the literature is the rationale for investment activity of local governments in the sphere of renewable energy [3,11,13,35] and the sources of their financing [3]. It is emphasized that the main barrier to the involvement of local governments is the high cost of investment in RES, which is often beyond their budgetary capacity [36]. In many countries, including Poland, the problem is the low scale of public support for this type of investment [37,38]. Research in Poland has proven that public subsidies have a strong impact on municipal investments in renewable energy [3,13]. In particular, access to subsidies from EU funds was the most important determinant of municipal investments in renewable energy [13]. Apart from this factor, the financial condition of municipalities, including their debt levels, was the most significant factor. The high indebtedness of the municipality was a significant barrier to energy transition investments [33].

The results of research conducted by Szlufik and Sasinowski can confirm the barriers mentioned above. The authors presented the results of the research that show that complicated legal procedures and frequent legislative changes significantly limit the implementation of RES projects [39]. In turn, the results of the Warsaw Institute of Banking research report, in addition to legal barriers, also indicated the significant importance of financial factors in the implementation of RES projects [33]. Additionally, the results of research by Kasztelan et al. [40] indicate financial factors as the main barriers, and apart from them, legal factors and awareness of the local society.

Apart from financial barriers and constraints, other limitations are also indicated that hinder or inhibit the involvement of local governments in the implementation of investments related to RES, or more broadly, energy transition. These include, in particular, the lack of experience and competence of local government administrations in the implementation of such projects. This is partly related to a lack of sufficient technological expertise, but also knowledge of the regulations regarding the possibility to implement such investments, the conditions necessary to obtain permits, or the possibility to discharge surplus energy to the power grid [28]. Knowledge is also necessary to negotiate with the network energy distributor specific conditions for connecting the RES installation to the grid, as well as price conditions and settlement rules for the municipality as, on the one hand, the producer, and on the other hand, the user of energy. This refers to the relationship

between the price of energy consumed from the grid and the feed-in tariffs [28]. The regulations related to the protection of the natural environment and determining the minimum distance of installations (e.g., windmills) from residential buildings may also be a barrier to RES investments. In Poland, legal regulations prohibit residential development at a distance equal to 10 times the height of the windmill (including the wing), which basically blocked the development of this energy sector from 2016 [41]. The distance of wind energy installations from residential buildings has also become a cause of social conflicts, as some residents do not accept such installations in close proximity to residential buildings. In turn, other residents protest against the "distance" act due to the exclusion of areas located within a radius of 10 times the height of the windmill from the possibility of residential development [42].

Local acceptance is recognized as one of the main determinants of renewable energy use at the local level [8,11,26,43–45]. This applies not only to investments carried out by private entities (e.g., wind farms), which have been approved by local authorities, but also to investments made by the local government on facilities and land owned by the municipality.

3. Materials and Methods

This study was conducted in the Podkarpacie Region of south-eastern Poland. The choice of Podkarpacie was due to the fact that next to Lubelskie, Podlaskie, and Opolskie Voivodeships, this region records the highest level of the energy poverty index (LIHC) [46]. Meanwhile, municipalities in these two regions are quite active in the implementation of municipal investments, including investments co-financed by EU funds. This is evidenced by the relatively higher share of this type of expenditure per capita in 2019 and 2020 compared to Polish averages [47]. The question remains: what proportion of these investments relate to projects supporting the energy transition?

The role of municipalities in the development of the energy transition, in particular through their own investments, was considered from the perspective of local government authorities. For this purpose, in-depth and structured questionnaire interviews were conducted with representatives of the authorities of 21 municipalities in the Podkarpackie and Lubelskie regions. The interviews were conducted in the first half of 2020. The selection of municipalities for this study was random quota, taking into account the type of municipality, i.e., urban, urban–rural, and rural. As a result of such a selection of units for research, the structure of the sample reflects the structure of Podkarpackie and Lubelskie municipalities in terms of the aforementioned feature.

Qualitative analysis was used in the research. The interview questionnaire mostly contained open or semi-open questions, i.e., with the possibility of indicating an additional own answer, not included in the list of answers. Closed-ended questions were multiple-choice and contained answers scaled according to a three-point or five-point scale (where 1 meant the lowest level of a feature or assessment of a given factor).

Open-ended questions concerned:

- information on investments in the area of energy transition carried out by municipalities in 2015–2019 and the sources of their financing;
- the reasons for the municipalities' involvement in the implementation of these investments and their importance in the hierarchy of municipal investments;
- the problems and barriers in the implementation of energy transition investments;
- expected external support, in particular financial support for this type of investment carried out by municipalities.

The research was conducted in 2 of the 16 regions of the country. Municipalities in the Podkarpackie and Lubelskie regions do not differ significantly in terms of their financial condition from the ones in other regions of Poland. They function in the same legal, technological, and macroeconomic conditions. Hence, it was assumed that the answers to the questions concerning the motives for municipalities' involvement in energy transition investments and their importance in the structure of pro-development activities would be

characteristic of the entire set of municipalities in Poland; this was similar for the answers regarding the sources of financing investments in eco-energy or the barriers encountered by municipalities in the implementation of such projects.

Standard qualitative research tools were used to collect empirical data (through in-depth structured interviews) and to analyze qualitative data [48]. Due to the small sample size, basic methods and parameters of descriptive analysis (mean, structure indicators, etc.) were used in the analysis of quantitative data.

4. Results of Empirical Studies

The directional goals of the energy transformation in the European Union, which were set out in the Clean Energy Package (CEP), are the decentralization of large-scale energy, replacing it with pro-ecological, distributed generation sources, and building a civic dimension of energy. The EU's Clean Energy Package (CEP) was finalized in June 2019 after its final publication in the Official Journal of the European Union, following trialogue negotiations between the European Commission, Council, and Parliament. The CEP consists of eight legislative texts—four Directives and four Regulations—on the electricity market and consumers, energy efficiency and energy efficiency of buildings, renewable energies and bioenergy sustainability, and the governance of the Energy Union [49]. Community legislation does not impose a precise formula for the implementation of the energy transition headline targets, leaving individual member states free to act. Building energy self-sufficiency at the local level is possible on the basis of institutions called Energy Communities (ECs) [50]. Local governments can play an important role in these endeavors by being a participant in an energy cluster or energy cooperative. A municipality, being a participant in such institutions, becomes both an energy producer and a user. However, Poland lacks experience in implementing such projects. Clusters or energy cooperatives with the participation of local government units are still rare, and municipalities in their structure mainly play the role of consumer and user of energy [32]. Still, the key importance of municipalities in the energy transition is based on their direct involvement in the implementation of investments in this area. Municipalities with good experience in their mutual cooperation, working with the local environment (business, municipal companies, and local leaders) gained from previous projects implemented jointly, may help to create local energy communities involving municipalities [32,51].

Implementation of investment projects by municipalities in the field of energy transition, especially renewable energy, is possible not only due to the possession of appropriate financial resources (sources of investment funding), but to the equally important element of the appropriate level of knowledge in the field of a given investment area and knowledge of local RES resources. Investments in the energy transition should be in line with the municipality's long-term strategic plans for local energy management and plans related to environmental protection. As a result, such investments should bring not only economic but also social and environmental benefits, which generated in the long term may become an important element of sustainable development of the municipality [52].

The results of empirical research conducted in the Podkarpackie and Lubelskie regions indicate that 76.2% of municipalities have identified local renewable energy resources, 14.3% were in the process of doing so, and 9.5% have not made such an identification (Figure 1). Almost half of the surveyed local government officials (47.6%) declared having knowledge about the amount of electricity and heat obtained locally from renewable sources, while 38.1% of the municipal authorities did not have such knowledge, and 14.3% of the respondents were in the process of acquiring such knowledge.

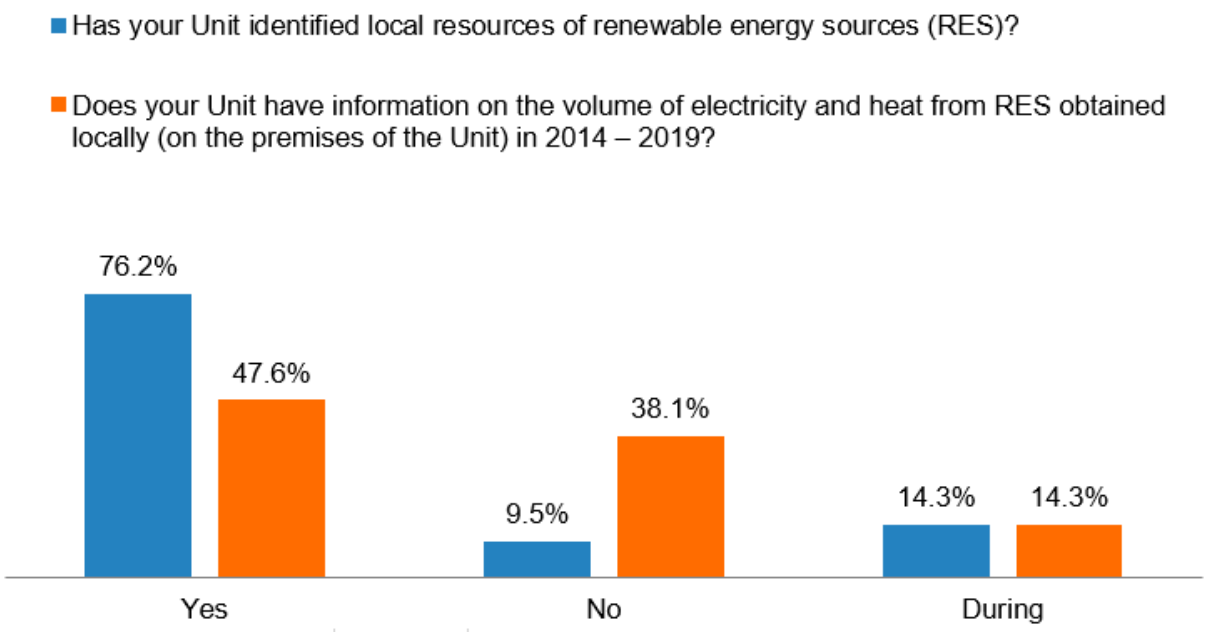

Figure 1. Recognition of local RES resources by the commune authorities and knowledge about their acquisition (% of indications). Source: own research.

For the implementation of some investments related to eco-energy, municipalities must be in possession of certain obligatory documents. Each municipality performs energy planning tasks at the local level in accordance with the local spatial development plan or, in the absence of such a plan, with the municipality's development directions contained in the municipality's spatial development conditions and directions study, as well as with the relevant *Air Protection Programme*. The municipality can present the *Low Carbon Economy Plan* (PGN), *Draft assumptions for the heat supply plan, electricity and gaseous fuel supply plan* (hereinafter: *Draft assumptions* (...)), as well as, for example, the *Sustainable Urban Mobility Plan or Climate Change Adaptation Plan*. Some of the above-mentioned documents are mandatory for the implementation of investments in the field of eco-energy, as they are required by relevant legal acts, i.e., the Spatial Planning and Development Act [53]; Energy Law Act [54]; and Environmental Protection Law [55]. A *Strategic Environmental Impact Assessment* may be such a legally required document when implementing a specific investment. Other listed documents, e.g., PGN and the *Draft assumptions* (...) are not obligatory; however, they are required from municipalities when applying for investment support from EU funds under the Regional Operational Programmes (ROP) or the Operational Programme Infrastructure and Environment (OPI&E) for 2014–2020.

All municipalities covered by the research had a PGN. Slightly less than half of the surveyed units have the *Draft assumptions* (. . .) (Figure 2). In contrast, only 19% of municipalities have a Strategic environmental impact assessment for municipal energy investments (Figure 2).

The *Local spatial development plan* or *Municipal spatial development study* had 86% of units, although it should be added that usually these documents did not cover the entire territory of the municipality. These spatial planning documents facilitate the implementation of RES investments, but they are also needed to prepare other documents closely related to energy planning at the local level. In order to prepare PGN and the *Draft assumptions* (...), public consultations are needed, also in the form of surveys of residents. Such consultations were carried out by 81% of municipalities, while 71% of those municipalities are in possession of elaborated programs and investment plans which take into account investment projects in the field of energy transition.

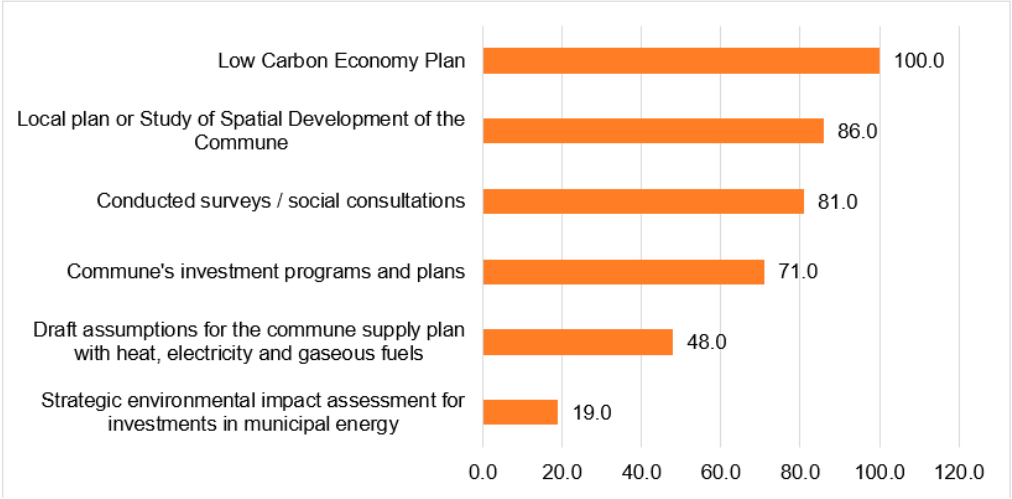

Figure 2. Documents held by communes necessary to undertake investments related to the energy transformation (% of communes). Source: own research.

The activities of preparing and collecting the necessary documentation for eco-energy investments should be considered as "soft" activities of municipalities related to the use of renewable energy resources existing in a given area and the need to improve the energy efficiency of municipal facilities. They are also a manifestation of meeting the needs of the inhabitants, e.g., in improving air quality. All of the surveyed municipalities indicated that they also undertook other soft measures related to the use of existing renewable energy resources; e.g., they obtained information on the possibility of implementing investments and available sources of their financing. The research results, therefore, prove that municipalities are interested in investing in RES, reducing low gas emissions, and improving the energy efficiency of municipal resources. All surveyed municipalities have already implemented or at least planned specific projects in this area.

All municipalities surveyed (100%) were implementing investments related to thermal modernization and energy efficiency improvement in municipal buildings in 2015–2019. Slightly fewer, i.e., 81% of the surveyed units undertook actions related to the modernization of street lighting (Figure 3). They usually included only a part of street lighting, and the full replacement of lighting with LEDs (sometimes in combination with a micro-installation for solar and wind power generation) was planned to be implemented in the next 2–3 years, due to the costs of such a project. Importantly, some municipalities undertook to implement this type of investment from their own funds (without subsidies), aiming to reduce street lighting costs by at least 30%. In turn, 76.2% of municipalities have installed RES installations in their municipal resources. The most common installations were photovoltaic and solar, mounted on houses (buildings or adjacent land) of schools, nurseries and kindergartens, municipal offices, hospitals, and indoor swimming pools. This type of investment often also included replacing the heat source (central heating boiler) with a more energy-efficient one. Relatively few investments involved connecting the building to the district heating network or installing a heat pump (around 5%). Almost every fifth municipality (19%) undertook environmentally friendly public transport projects. In turn, the construction of a passive building in their municipality was indicated by 9.5% of those surveyed.

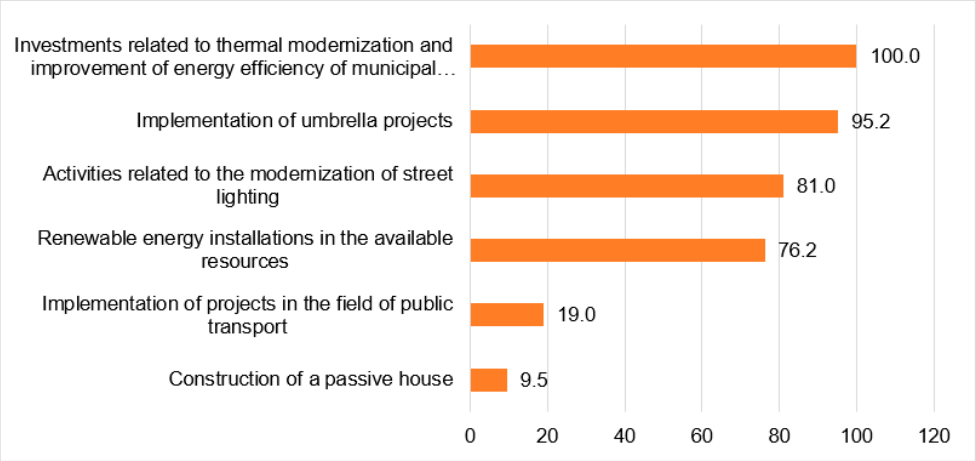

Figure 3. Percentage of municipalities (%) in terms of investments in the area of energy transformation implemented in 2015–2019. Source: own research.

It is worth noting that as many as 95.2% of the surveyed municipalities implemented umbrella projects in the field of RES. Through the implementation of these projects, municipalities have helped households implement a specific renewable energy technology. Implementing such projects is possible thanks to EU funding under Regional Operational Programs [23]. As an intermediary entity and helping households under umbrella projects, the commune prepares, commissions, and coordinates the construction of RES micro-installations (e.g., PV installations, solar collectors, or heat pumps). Such installations are used by households in the commune, because of which the energy situation in a given region improves. The project may be financed from public funds (EU funds) in the amount of up to 85% of eligible costs. Thus, the end user covers only 15% of the expenditure, which is his own contribution. However, the most common situation is when the user's own contribution is higher (often reaching even 40%), because in competitions for umbrella projects, additional points are awarded for a higher own contribution for users. When the self-subvention increases, the chance of obtaining financial support increases [56]. The installation is covered by a 5-year warranty, after which it becomes the property of the user. The involvement of municipalities in such projects theoretically does not bring direct benefits to LGUs (e.g., in the form of a reduction in energy expenditure). However, the implementation of such projects is a very important element of supporting energy transformation in the local community.

The research shows that the expenditure of municipalities related to the consumption of heat and electricity in the municipal sector ranged from 0.33% to 7% of current expenditure in terms of heat energy costs (in 2019). The share of electricity costs in current expenditure ranged from 0.58% to 3.91%. In turn, the percentage share of municipal investments in heat and electricity in total investment expenditure ranged from 1.03% to 50%. The percentage of public facilities in which thermal modernization was applied in the surveyed units ranged from 5% to 90%. Such a large diversification of municipalities' expenditure on electricity and heat was mainly related to the specificity of a given territorial unit and activity in the investment area. In the period covered by the analysis (2015–2019), entities implemented mainly those eco-energy investments that were supported with external funds coming mainly from EU funds (there were also investments financed from the Norwegian Mechanism or the Swiss–Polish Cooperation Programme) and from the national budget (subsidies from the National Fund for Environmental Protection and Water Management and its regional operatives).

A large increase in the scale of investments in photovoltaic, LED lighting, and, to a lesser extent, low-carbon transport and heat pumps took place in 2019 and 2020, i.e., in the year in which the research was carried out. In some rare cases, local government authorities also conducted talks with potential private investors aimed at initiating investments in

wind power, geothermal, or hydropower. In one case, these talks resulted in the launch of a joint geothermal project.

When assessing the benefits of energy transition investments, the surveyed local government officials valued those related to improving the quality of life of the population the most (Figure 4). Improvement in the municipality's image was also of great importance to local government officials, both in the context of caring for ecology and the image of local government authorities, which are active in the implementation of investments and care for the development of the municipality.

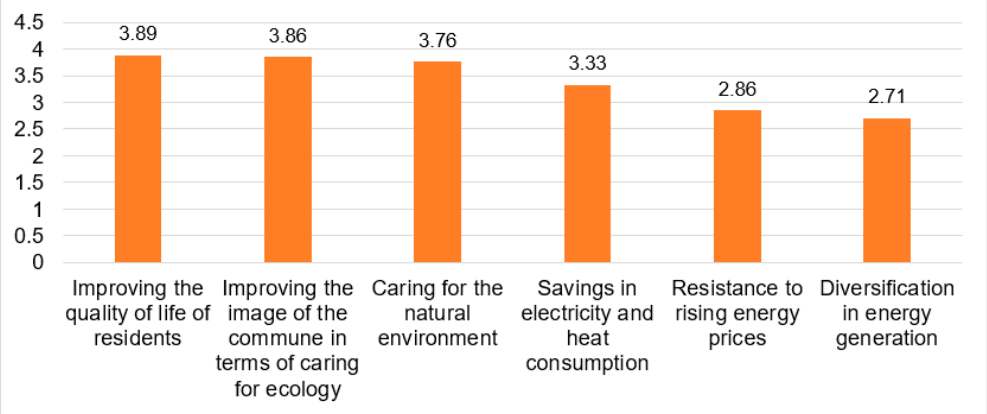

Figure 4. The most important benefits resulting from the implementation of municipal investments related to the energy transformation in the assessment of local authorities (on a scale of 1–5, where 5 is the highest rating). Source: Own study.

The interviews with the municipal authorities took place in the first half of 2020, i.e., in the initial period of the COVID-19 pandemic, but many months before the outbreak of war in Ukraine and the resulting rapid increase in energy raw material prices and problems with their supply. At that time, in the opinion of local government officials, the environmental benefits of investments related to RES and, more broadly, energy transition were superior to those related to energy security and energy cost savings (Figure 4). It seems that if these surveys were repeated in 2022, the hierarchy of respondents' indications could be completely different. Undoubtedly, the problems and trends that appeared in the energy market after 24 February 2022, i.e., the moment when Russia began its aggression against Ukraine, made the issue of energy security, diversification of energy sources, and the search for opportunities to reduce energy consumption particularly important and urgent.

Representatives of local authorities often pointed to the link between the objectives of energy transition investment and the objectives set in the strategy of the surveyed municipality. They indicated that the main reason for the investment was the expectations of the local community for environmental care, energy savings, or diversification of energy sources.

The municipal authorities planned to implement investments in the area of energy transition in the coming years. All municipalities planned the thermal modernization of public buildings, replacement of street lighting with energy-saving ones, and implementation of renewable energy sources with the use of photovoltaic and solar collectors and heat pumps (Table 2). Some municipalities planned to modernize the heating installation in public buildings. Municipalities were also planning investments within municipal resources to reduce harmful gas emissions and investments to improve the energy efficiency of buildings (Table 2). However, none of the surveyed municipalities declared potential investments involving the construction of installations such as biogas plants, biomass boiler plants, or wind turbines.

Table 2. Investment plans of municipalities in the field of energy transformation.

Planned Activities and Investments	Percentage Municipalities
thermal modernization of public utility buildings	100.0
thermal modernization of communal flats	14.3
installation of RES in public utility buildings	100.0
replacement of internal lighting in public buildings	38.1
construction of a biogas plant on a landfill or sewage treatment plant	-
purchase of ecological buses	4.8
introduction of an energy management system in municipal facilities	14.3
use of energy-saving lighting in buildings	38.1
use of energy-saving street lighting	100.0
thermal modernization of external partitions (windows, walls, ceilings)	100.0
modernization of the heating installation, i.e., heating sources and systems	38.1
use of intelligent transport systems in cities	-
photovoltaic panels	100.0
solar panels	9.5
heat pumps	47.6
micro-biogas plants	-
biomass boilers	-
small wind farms	-
small hydropower plants	-

Source: own research.

Representatives of local authorities were asked to indicate the factors hindering the implementation of investments in the sphere of local energy transition and to assess their importance on a point scale from 1 to 5 points. The barriers indicated by the respondents were divided into two groups, i.e., external and internal (Table 3). Among the external barriers, the respondents attributed the highest importance to legal conditions, i.e., instability of law in the area of RES and unfavorable—in their opinion—regulations from the perspective of the local government as an investor. These include regulations that determine the possibility of energy generation, distribution, and trading by local government units through energy clusters or energy cooperatives. According to the respondents, these regulations are complicated and create many barriers. Another barrier to the implementation of RES-related investments is formal and legal requirements related to energy planning. The average score (4.14) indicates that these requirements are a very significant burden for local governments.

Table 3. Barriers hindering the implementation of investments in the field of energy transformation (average rating on a scale of 1–5, where 5 points mean very high difficulty).

Itemization	Average Rating
External Barriers	
Changeability of legal regulations in the area of RES and unfavorable regulations for local government units	4.23
A multitude of obligatory energy plans and other documents needed to implement the investment	4.14
Too little public support for municipal investments in eco-energy	4.12
Bureaucratization and long processing of applications for financial support	3.90
Difficulty in "breaking through" the unit's projects in the assessment of application forms under EU programs (strong competition from other municipalities in obtaining non-repayable funds)	3.29
Strategic environmental impact assessment (costs, time necessary for its implementation, various ecological constraints for the implementation of the investment)	3.12

Table 3. *Cont.*

Itemization	Average Rating
Lack or difficulties in cooperation with neighboring local government units in the implementation of joint projects, difficulties in coordinating activities between municipalities in the implementation of joint investments. Strategic environmental impact assessment (costs, time necessary for its implementation, various ecological constraints for the implementation of the investment)	2.29
Lack of interest of private investors in projects under public–private partnership	2.19
Complicated tender documentation and difficulties with conducting the tender and selecting the contractor	2.05
Internal Barriers	
Financial barriers (budget constraints, high investment costs)	4.57
Low economic efficiency of the investment (long payback period of the invested capital) or	3.00
Local spatial development plan (none, residual)	2.85
Energy planning—costs	2.81
Spatial and location barriers: lack of good (socially acceptable) places for investment, the problem of excluding the necessary land from agricultural production	2.62
Insufficient knowledge and experience of employees in project management and settlement	2.33
Obtaining development conditions and building permits	2.05
Low awareness of residents regarding the benefits of investing in renewable energy	2.05
Discrepancies in the expectations of residents in relation to local investments and their effects	1.97
Knowledge and experience of local administration in the field of energy transformation (regulatory and technological aspects)	1.76

Score scale from 1 to 5, where 5 points mean very high difficulty. Source: own study.

Municipal investments often involve administrative procedures covering planning, environmental, or construction issues. All these requirements are constraints placed high by local government officials in the hierarchy of impediments to the implementation of energy transition projects, particularly the implementation of RES investments.

Financial constraints are of key importance for municipal investments in the area of energy transition. As for external barriers, in the opinion of respondents, they result from too little public support directed to local government units in this area. Respondents also pointed to major bureaucratic difficulties in applying for public support, especially from EU funds, as well as high competition from other municipalities in obtaining non-returnable funds. Among external barriers, environmental and social constraints for some renewable energy investments were also indicated. Barriers such as difficulties in cooperation with other local government units in the implementation of joint projects and the lack of interest of private investors in the implementation of projects in the public–private partnership formula were of slightly less importance.

Among the internal factors hindering the investments of municipalities in the area of energy transition, financial (budget) constraints were definitely dominant. These limitations were ahead of the costs associated with energy planning, as well as spatial and location barriers, which were painfully felt by local government officials (Table 1). Another barrier was the low economic efficiency of investment projects implemented in the area of eco-energy, or the lack of knowledge and experience of the administration in relation to the legal and technological aspects of the energy transition, as well as the management of projects implemented with external funds.

Barriers to the implementation of investments by local governments in the area of energy transformation, listed in Table 3, and, in particular, investments in RES, are also observed in other countries [57–59].

Despite the many barriers related to the implementation of RES projects, it is worth mentioning the factors that motivate local governments to implement such projects. In-

terviews with representatives of local authorities indicate that the most important factors positively determining communes for investments related to energy transformation include:

- Increasing environmental awareness of local authorities and residents;
- Experience and competencies gained by local government administration in acquiring external funds and managing projects supporting local investments;
- A sense of responsibility on the part of local government authorities for ensuring energy security at the local level;
- The emergence of programs and financial tools supporting the development of RES and local government investments in this area.

The research conducted by Klepacki et al. [13] shows that an important factor conducive to investments of communes in projects related to renewable energy sources are:

- Good financial condition of communes expressed by the average annual budgetary income of the commune (total and per capita);
- High investment activity of communes, expressed by the share of capital expenditure in total expenditure.

Thanks to the growing expectations of the local community related to the implementation of municipal ecoinvestments and the factors mentioned above, it is possible to overcome some of the limitations and undertake more and more investments in the field of energy transformation. It should be noted that the factors supporting investments in RES and, more broadly, in the area of energy transformation, as well as the barriers that limit such projects, are closely related. Thus, financial constraints are a barrier that strongly impedes investments. In turn, the financial factor supporting the development of RES investments in local governments are subsidies and loans available from public funds (domestic and foreign, mainly from the European Union funds). Barriers such as, for example, bureaucracy when communes apply for investment support from public funds are important for local government officials, but the pressure of the local community, the sense of responsibility to care for the natural environment, and the need to secure local energy needs for electricity or heat "push" local authorities to act despite numerous barriers. An example to confirm this thesis was the participation of 88.5% of the communes in Poland in 2022 in the government program for the purchase and preferential sale of coal to households. This program was a tool for the intervention of the public sector (government and local government) as a result of the energy crisis caused by the armed conflict in Ukraine. Participation in the program was optional for municipalities and was associated with many administrative, logistic, and financial problems, and yet the vast majority of municipalities in the country decided to participate in it to meet the needs of their residents [60].

The financial constraints faced by municipalities in implementing energy transition investments are not homogeneous. They are in fact a conglomeration of various financial and budgetary factors, often interrelated. Accordingly, representatives of local authorities were asked what type of financial barriers are most relevant to the implementation of energy transition projects.

Among the financial factors assessed as barriers, the highest importance (4.57 points on a scale from 1 to 5) was attributed by the respondents to budget constraints, i.e., insufficient own funds (income). Difficulties in obtaining non-repayable funds (3.43) and reluctance to incur debts for the implementation of projects in the area of energy transition (3.33) were ranked next in the hierarchy of financial barriers. Another problem limiting investments is the high costs of external repayable financing (Figure 5). Respondents' answers indicate that obtaining a bank loan to finance eco-energy investments is not a major problem for municipalities. However, it is evident that in the hierarchy of sources of funding for such investments, bank loans, or more broadly repayable sources of funding, are ranked further down. In the first instance, municipalities reach out and continue to intend to reach out for non-repayable funds under national and European funds supporting RES, a low-carbon economy, and energy efficiency improvements in the economy. Such a hierarchy of funding

sources is not surprising as it has been present in the financial policy of municipalities in Poland for many years [3,25,61,62].

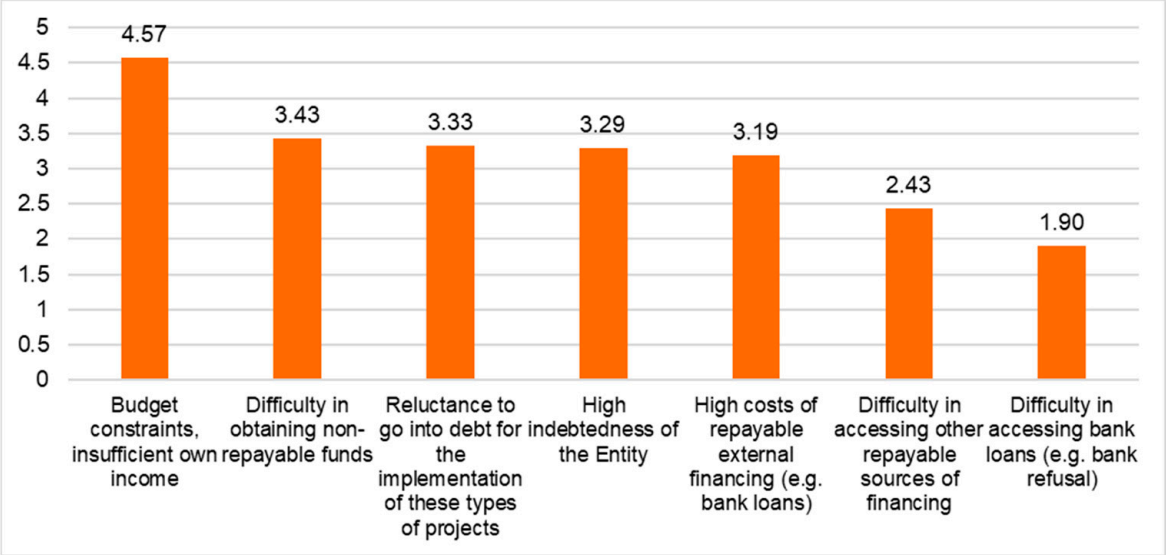

Figure 5. Types and importance of financial factors in the implementation of projects in the area of eco-energy (average rating)*. "*" means informations about the possible rating scale from 1 to 5. Source: own study.

Commercial loans formally dedicated to financing energy transition investments were only used by 14.3% of the surveyed municipalities. However, as many as 90.5% of municipalities used long-term bank loans to finance the budget deficit. According to Polish law (Article 242 of the Public Finance Act), the operating budget cannot be in deficit, so the overall budget deficit is the result of property expenditures. Hence, it can be argued that the municipalities that implemented energy transition investments and used bank loans or bond issues to cover the budget deficit financed these projects to some extent with repayable financing sources. However, it is difficult to precisely determine the percentage of such municipalities, and the share of municipal loans or bonds in financing projects related to eco-energy projects. Nevertheless, this share was not large and did not exceed the share of non-repayable funds (public subsidies). Some municipalities (9.5%) also benefited from preferential loans (low-interest rate and partially redeemable) for financing the thermal modernization of buildings.

Energy cooperatives and energy clusters are envisaged as one of the basic forms of support for RES energy production [10,32,56]. They can also be a way to overcome some limitations, including financial ones, related to the implementation of investments in RES. However, research shows that these forms of cooperation with other entities in the energy sector are not well known and accepted by local government authorities. Only 29% of respondents showed interest in cooperation within the energy cluster. Even less interest was shown by local authorities in cooperation within energy cooperatives (9.5% of respondents). Most of the respondents, 57.1%, pointed to "other forms of cooperation", which mainly concerned the creation of joint energy purchasing groups (Figure 6).

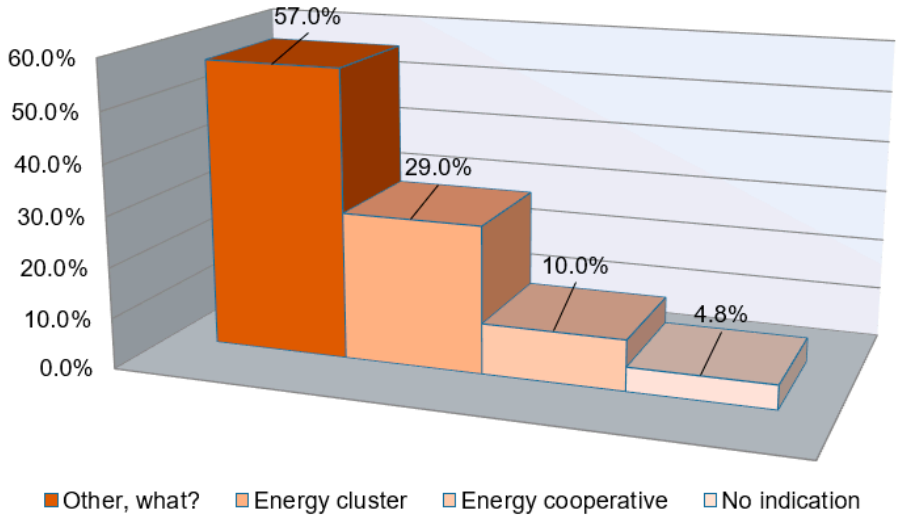

Figure 6. Forms of cooperation with other entities in the field of energy management at the local level accepted by the communes (in %). Source: own study.

5. Conclusions

In 2015–2019, municipalities in south-eastern Poland implemented energy transition investments mainly in three areas, i.e.,

(1) thermal modernization of municipal buildings;
(2) RES installations on municipal facilities (e.g., photovoltaic installations on school buildings and hospitals);
(3) modernization of street lighting.

Some municipal communes have taken action in the area of sustainable transport. It is worth mentioning that local government units implemented projects in the field of installation of RES systems (photovoltaics and replacement of heat sources) in households of residents. Many municipalities implemented these projects, as well as projects related to thermal modernization of public buildings (less frequently public transport), in cooperation with other local governments within the framework of an association of municipalities, or in the form of less formal cooperation between two or three municipalities. In the case of public transport, such cooperation was also implemented by companies with the participation of interested local governments. However, public–private partnership investments are still rare. There are individual examples of investment cooperation between the public and private sectors, e.g., in the area of photovoltaic farms. Local governments also have institutional solutions at their disposal, such as energy clusters and energy cooperatives. Yet, the research shows that such institutions of partnership and cooperation in the production and distribution of energy are still unique in Poland, and did not exist in the surveyed regions.

Local government authorities in Poland are interested in investing in the energy transition, but they determine this interest by assessing the potential economic and environmental benefits it may bring.

Due to the catalog of obligatory tasks and budget constraints, investing in the energy transition, and especially investments in RES, are still ranked low in the hierarchy of preferences of local authorities. Access to non-repayable or partially repayable funds is therefore the main determinant of the involvement of municipalities in these types of projects. In financing them, municipalities follow a funding-source hierarchy strategy in which bank loans or other repayable funding sources are used when non-repayable funds and own funds are exhausted.

Local government officials expect an increase in public funds, mainly in the form of subsidies, directed to support investments in the area of energy transition. They also expect

easier access to these funds by simplifying the administrative requirements and procedures for obtaining and settling these subsidies.

In addition to easing financial constraints, local government officials perceive legal regulations as the most important for accelerating energy transition processes at the local level. They expect, for example, simplification of requirements related to energy planning and energy management by municipalities, and favorable changes in the field of public procurement law. They also expect the introduction of regulations supporting municipal investments in RES more effectively, in terms of possibilities and conditions for selling surplus energy produced to the power grid. Legal changes that make it easier for municipalities to carry out investments in public–private partnerships are also needed.

This study analyzes the role of local governments in Poland in accelerating energy transformation at the local level through the implementation of municipal investments in the area of eco-energy. Additionally, an attempt was made to evaluate the own investment projects that are carried out on the initiative of local governments in the area of energy transformation, and it was determined what sources of financing are used during the implementation of such projects. A diagnosis of barriers and limitations to the increase in the share of communes in this area was also presented. The results obtained correspond with those of other authors. As an example, it is worth quoting the results of the research by Szlufik and Sasinowski, who evaluated legislative barriers during the implementation of RES projects by local governments. The most important problems were bureaucratization and frequent changes in regulations [39]. Additionally, the Warsaw Institute of Banking Report in one of its segments analyzes the potential barriers that most often occur when applying for funds for the implementation of RES projects among local governments. The most common obstacles among LGUs were complicated procedures and difficulties in obtaining funds from subsidies, as well as the high costs of bank loans [33,63]. Capellán-Pérez and others assessed how postsocialist countries are doing in implementing renewable energy projects. Indicating the most effective areas, in one of the segments they also attempted to assess the most important factors hindering the implementation of RES investments. The biggest constraints were financial factors [64]. In turn, Palm conducted a survey among households in Sweden on the limitations related to the implementation of renewable energy. The author obtained results, of which clearly the greatest barrier hindering the implementation of RES projects by households is economic factors. Despite the high ecological awareness of households, financial barriers were most often indicated as a factor preventing the implementation of RES projects [65]. It should be noted that the topics covered in this publication have not been the main research topic so far. Despite the publications cited above, it should be noted that the subject of energy transformation and the role of local governments is rarely taken up as the subject of scientific research. While there are many publications related to investments in RES in terms of enterprises and households, in the case of issues related to investments in renewable energy by public sector entities, and in particular at the local level, there are not many.

In light of the results of the research presented in this article, as well as research by other authors, it appears that the intensification of the investment activity of local governments in the area of RES and, more broadly, energy transformation, requires financial support for local governments from public funds. Such support for communes in Poland is already available, e.g., from the structural funds of the European Union and from the national budget, but its scale is too small in the opinion of local government authorities. Municipalities compete for such funds and, in many cases, also cooperate with each other, but there is a need to increase the number of programs directly supporting municipal investments in the field of energy transformation, and to increase funds for this purpose. Limitations in the access of local governments to these funds (e.g., bureaucratic ones) and barriers that directly hinder investments in the area of energy transformation should also be removed or mitigated. These issues should be the subject of further in-depth research, which will not only focus on the diagnosis of limitations in the implementation of municipal investments related to the energy transformation, but will also allow the proposal

of solutions that can strengthen the role of local governments in the energy transformation at the local level.

The authors are aware of the limitations of this study. The main one is a small research sample of 21 units, which did not allow the use of more advanced statistical analyses. However, the structure of the research sample reflects the structure of communes in Poland by type (urban, urban–rural, and rural). Because of this, it can be assumed that the test results reliably reflect the tested processes. According to the authors, these results can be the basis for conclusions that can be generalized to a large extent, i.e., related to the entire general population. We are convinced that the importance and timeliness of the issue of local government investments in the area of energy transformation addressed in this article require further in-depth research, conducted on a larger scale. These studies should take into account the specificity of communes in relation to their type or their economic and financial situation. Accelerating the energy transformation at the local level requires the involvement of all stakeholders in this process; however, the role of local governments is crucial. Therefore, it is worth examining not only the factors that positively determine and limit the involvement of local governments in the energy transformation, but also the factors that determine the effectiveness of municipal investments in this area.

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