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Forms of Public Support for Energy Clusters. The Example of the Dolnośląskie Voivodship (Poland)

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Abstract

The aim of the research was to determine the forms of support provided to energy clusters in Poland. The author sought to answer the following questions: what activities do energy clusters receive support for; whether the support obtained come from foreign (EU) or domestic funds; what the opinion of cluster facilitators is about access to public support; and how do energy clusters fit within the current cluster policy in Poland? The study area was the Dolnośląskie Voivodship — one of 16 administrative regions (NUTS 2) of Poland. The author selected this region because it has the largest number of energy clusters in Poland. The following methods were used to achieve the goal of the research goal: (1) a review of literature and industry reports, (2) a CAWI survey of clusters, and (3) interviews with cluster facilitators. Public support received by the surveyed clusters concerned either the commencement or the continuation of cluster activity. In the initial phase of the clusters' activity, the support received concerned documentation work, the drafting of plans for the expansion of the power grid and the purchase of an energy monitoring and management system. At later stages of cluster development, the implemented projects mainly concerned the construction of ground-based PV farms and the construction of photovoltaic installations on the roofs of public utility buildings. Less frequently implemented projects included the thermal modernization of public buildings, hybrid investments (PV and wind turbines) and energy storage facilities. Additionally, educational projects were implemented. The public support received came mainly from EU funds (Operational Programs and the Interreg program). In turn, support from national funds came from the Voivodship Fund for Environmental Protection and Water Management, from local government funds or from the Polish Deal — i.e., the government's program of strategic investments.

Keywords: cluster energy, cluster energy public support, public support cluster policy

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Introduction

Subject of the research

In the past 10 years, EU countries have implemented several important directives and regulations regarding energy and climate transformation. Among them is the Fit for 55 package proposed in 2021, which assumes, among other things, a 55.0% decrease in greenhouse gas emissions by 2030, an increase in the renewable energy target share in the EU's energy economy to 40.0% and the introduction of the Carbon Border Adjustment Mechanism (CBAM). In 2023, the new Renewable Energy Directive (RED III) increased the required share of renewable energy sources in electricity production to 42.5%, with the ambition to reach 45.0%. To comply with these requirements, EU member states are intensifying their energy transformation efforts. The individual development paths are different because their starting points are different. Poland is one of the countries whose energy economy still relies on coal. At the end of 2024, over 41.0% of electricity production came

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from hard coal, less than 21.0% from lignite and less than 10.0% from natural gas. All renewable energy sources accounted for less than 28.0% of the energy mix.[1] This structure is slowly changing. The share of hard coal (56.0% in 2021) and lignite (26.0%) is decreasing, while the share of renewable energy sources (13.0% in 2021) and natural gas (less than 8.0%) is growing. In this context, further action becomes necessary to improve the energy system, which plays the role of an internal bloodstream and, together with other systems, determines the efficient functioning of the entire national economy.

The establishment of energy clusters contributes to the increase in the share of electricity from renewable sources in Poland. Clusters play an important role in the economy by offering networking and business partner matching. They help to disseminate knowledge, including good practices, and build value chains. In addition, they bring together enterprises, research institutions, business environment institutions, and non-governmental organizations. An energy cluster is an agreement among entities aimed at generating, storing, distributing and trading electricity from distributed generation sources connected to the distribution network. Energy clusters fit within the formula of the development of distributed energy based on savings resulting from locating energy production close to its recipients. Therefore, energy clusters are local initiatives based on micro-grids and the local energy community. They are intended to create positive consequences at the regional and national level, reaching far beyond the area of their respective counties (LAU 1).

Purpose and Methods

The purpose of the research was to determine the forms of support provided to energy clusters in Poland. The author sought to answer the following questions: what activities do energy clusters receive support for, whether the support obtained come from foreign funds, including EU funds, or from domestic sources, how cluster facilitators assess access to public support, and how energy clusters fit within the current cluster policy in Poland.

The study area was the Dolnośląskie Voivodship, one of Poland's 16 administrative regions (NUTS 2). The author chose this region because it has the largest number of active energy clusters in Poland (14) identified in the database of the National Chamber of Energy Clusters at the beginning of 2025 (table 1).[2] The number of energy clusters in other regions was lower and ranged from 3 to 10. The study was conducted from January to February 2025. Data collection proved to be a tedious process and, including interviews, took a total of three months.

The first stage of the research involved the cluster facilitator completing a survey consisting of 35 open- and closed-ended questions concerning various topics characteristic of clusters. The questions inquired about the motives for establishing the cluster, types of internal links, and the clusters' cooperation with their environment. The CAWI (computer-assisted web interview) method was used. The facilitators were asked to complete a form, the link to which was emailed to their provided contact address.

In the second stage of the research, information was obtained through a telephone in-depth interview (TDI). TDI is a method for collecting qualitative information which allows for obtaining more details on phenomena that have not been fully explained in a standardized tool—the survey questionnaire. During the interviews, the author was able to devote more time to the issues that were interesting from the cognitive perspective.

The questions were answered by cluster facilitators—i.e., legal entities that organize and animate the development of interactions. The facilitator's tasks also include managing external cooperation, the day-to-day administration of the cluster, and carrying out other functions necessary for its proper functioning.

1. According to data (as of 2025-02-21) published by rynekelektryczny.pl, available at https://www.rynekelektryczny.pl/produkcja-energii-elektrycznej-w-polsce/.

2. New regulations governing the operation of energy clusters came into effect on January 1, 2024. However, not all provisions have yet entered into force due to the delay in launching the CSIRE (Central Information System for the Energy Market) system in 2024. Nevertheless, these regulations include several significant changes, including a new Energy Cluster Register at the Energy Regulatory Office. This register currently includes 11 energy clusters (as of October 14, 2025).

Table 1. List of energy clusters (in alphabetical order) and their locations

No	Name of the energy cluster	County (LAU 1)
1	Ares Energy Cluster (Autonomous Energy Region of the Sudetes)	kłodzki
2	Copper Basin Energy Cluster	polkowicki
3	Dzierżoniów Energy Cluster	dzierżoniowski
4	Energy and Hydrogen Cluster in Miękinia	średzki
5	Energy Cluster Siechnice	wrocławski
6	Karkonosze Energy Cluster	karkonoski
7	Legnica Cluster of Renewable Energy Sources	legnicki
8	„LKIaster" Legnica Hydrogen and Energy Cluster	legnicki
9	Oława Energy Cluster ECO	oławski
10	Southwest Energy Cluster	zgorzelecki
11	Świdnica Renewable Energy Cluster	świdnicki
12	Wałbrzych Energy Cluster	wałbrzyski
13	Wałbrzych Energy and Hydrogen Cluster	wałbrzyski
14	"ZKIaster" Zgorzelec Renewable Development Cluster	zgorzelecki

Source: Based on the KIKE database

1. The concept of a cluster in the literature on the subject — an overview

Cluster research emerged as a result of the growing importance of a new paradigm of economic development emphasizing the transition from a competition-driven to a cooperation-based economy. It is the combination of cooperation and competition that has been found to be an effective strategy for gaining leverage in the market.

The foundations for contemporary cluster research have been laid by M.E. Porter and his work from the 1990s (e.g., Porter 1998) in which clusters were described as geographic concentrations of interconnected firms, specialized suppliers, businesses in related industries, and the associated institutions (e.g., universities and industry associations) that compete and cooperate with each other. The definitions of clusters, of which large numbers have been offered in the literature on the subject over the last 30 years, stress primarily the importance of links between cluster members (e.g., Bergman and Feser 2020; Rosenfeld 1997; Wolman and Hincapie 2015). In such approaches, the essential element is shared learning enabling the flow of knowledge between entities. Geographical proximity of cluster members is also important, as it translates into benefits for the entire cluster and may lead to further investments/innovations (Beaudry and Breschi 2003; Coenen, Raven, and Verbong 2010; Cooke 2002; Gordon and McCann 2000). However, according to some researchers, the impact of the entities' location on cluster success should not be overestimated (cf., den Hertog and Maltha 1999; Martin and Sunley 2003).

The strategic role of clusters is to use public support. Especially at the early stages of their development clusters often receive support from the government, the EU or from regional programs. This support often takes the form of funding. It may also involve employee training, job creation, education and promotion of new social attitudes (Cooke 2001; Yamawaki 2002). However, clusters involve primarily the establishment of cooperation networks that include not only companies, but also local government units, research centers and universities. Often it is universities and research centers that play the leading role in cluster creation (Bramwell and Wolfe 2008). The cooperation initiated as above can result in bring the flow of knowledge to a larger group of recipients and in the development of innovative technologies. External and internal links are formed, involving knowledge transfer (Vicente and Suire 2007), employee flows (Saxenian 1994) and the formation of various formal and informal interactions (Casper 2007). These processes may be accompanied by the exchange of information and the so-called "local buzz" (Bathelt, Malmberg, and Maskell 2004). In the initial stages of cluster formation, social trust is important, but as the cluster develops,

it gives way to human capital (Yamamura 2009). All these activities are aimed at involving clusters (and thus the member entities) in dynamic changes leading to maintaining the dynamics of economic development and increasing economic resilience (Späth and Rohracher 2010; Xu, Zhong, and Wang 2024).

This paper is devoted to energy clusters. The purpose of energy clusters is to combine the idea of concentration of entities operating on the basis of competition and cooperation with the local development of the renewable energy sector. The goal is to facilitate the transition of territorial units to a more sustainable economy based on green energy (Loorbach and Rotmans 2006; Lu et al. 2025; McCauley and Stephens 2012). Energy clusters are characterized by complementarity of various energy sources and by bidirectional energy flows. They arise in both urban centers and in rural areas (Lowitzsch, Hoicka, and van Tulder 2020), including remote communities dependent on conventional energy supplies (Underwood et al. 2007). The potential of energy clusters also contributes to technical transformation and to changes in societal attitudes toward energy issues (McCauley and Stephens 2012; Sovacool, Geels, and Iskandarova 2022). All these factors increase the importance of energy clusters in policies and climate change response strategies.

Regional policy uses two concepts: cluster and cluster initiative (cf. Kowalski and Marcinkowski 2014; Morgulis-Yakushev and Sölvell 2017). A cluster initiative is a formalized forum aimed at intensifying the growth and increasing the competitiveness of a cluster, encompassing companies operating within the cluster, as well as academic and public institutions. The actions taken by cluster facilitators are of great importance in this respect. In general, cluster initiatives serve cluster development, so that they can achieve appropriate critical mass, foster intensive interactions and achieve a high level of competitiveness and innovation. This separation of concepts — cluster vs cluster initiative — is not always articulated in publications. However, some papers, including this one, actually concern cluster initiatives.

2 Cluster policy in Poland at national and regional level

At the national level, the institutions responsible for cluster policy are the Ministry of Economic Development and Technology (formerly the Ministry of Economic Development) and the Polish Agency for Enterprise Development (PARP). Both of them are involved in cluster development policy (i.e., activities aimed at increasing the potential and boosting the competitiveness of clusters) and cluster-based development policy (e.g., activities aimed at engaging clusters in the implementation of public tasks). For the purposes of implementing cluster policy, the Ministry of Economic Development and Technology has established the Working Group for Cluster Policy and the Council of Key National Clusters. The Polish Cluster Association is an advisory body that represents clusters and presents its position in relations between clusters and the ministry.

The Polish cluster development policy has a strong influence on the rate of establishment of new cluster structures. In 2004–2006 the main focus was on promoting the idea of clustering and on training potential animators to consolidate the business community. At that time the first cluster initiatives were established in a bottom-up process. Also, during that period the first structural funds began to be offered. Generally, that period can be referred to as the spread of the idea of clustering. The years 2007–2013 were a period of dynamic establishment and development of clusters. The most popular programs were the Innovative Economy Operational Program 2007–2013 (Measure 5.1) and the Eastern Poland Operational Program (Sub-Measure 1.4.3). Many cluster initiatives were created at that time (in some regions even over 50), but only some of them have survived to this day. A significant number of clusters have either been dissolved or are currently in operational hibernation. The following years (2014–2020) were a period of limited support for clusters and of gradual professionalization of cluster management. The focus was on a group of highly developed clusters that were awarded the Key National Cluster (KKK) certificate. The implementation of projects devoted to Key National Clusters was funded from the Smart Growth Operational Program 2014–2020 (including Sub-measure 2.3.3: Internationalization of Key National Clusters).

In 2020, the Working Group for Cluster Policy operating on behalf of the relevant Minister published a document on the directions of cluster policy development following 2020, which

includes cluster policy development plans and the recommended development paths for individual clusters.[3] According to the new guidelines, active cooperation with clusters is desirable in the implementation of tasks in the field of innovation policy, digitization and adaptation to the needs of Industry 4.0, circular economy, energy transformation, education and the development of smart specializations. Therefore, it is advisable to use the potential of clusters to implement tasks concerning the above-mentioned challenges. For example, in the field of innovation policy, cooperation with scientific institutions is being initiated, while in the field of education, there is a noticeable willingness to engage in cooperation with educational institutions, which is a consequence of, among other things, the lack of qualified employees. The declarations show that over 40% of clusters would like to be involved in the vocational and specialized education of pupils or students.[4]

At the same time, the certificates of the Key National Clusters were maintained. These certificates are issued periodically, so the number of KKKs varies (currently there are 12). The KKK status is obtained through a competition in which the following are assessed: human resources, infrastructural and financial resources, economic potential of the cluster, creation and transfer of knowledge, activities for public policies, and customer orientation. In addition to key national clusters (KKK), seed and growth clusters have also been defined. Seed clusters were defined as clusters in the early stages of development, operating primarily locally. Growth clusters, on the other hand, are both stable clusters with growth potential and those which face difficulties on the way to further development. The results obtained in 17 categories determine the category a cluster will be classified into. For example, in order for a cluster to be defined as a KKK, it must have, among other things, at least 10 members conducting R&D activities, at least 3 joint projects, at least 2 patents/utility models/industrial designs, at least 1 international project and it must have been operating for at least 3 years.

Cluster policy at the national level has for years been more visible than that at the regional level. Regional policies lacked instruments dedicated to clusters, although references to clusters were made in most regional development strategies. As a result, cluster members were beneficiaries of instruments under regional operational programs, although these programs were not dedicated specifically to clusters. Financial support for clusters came mostly from regional operational programs. This support was intended for initiatives strengthening the potential of regional specializations, including support for pro-export activities, initiating and developing R&D cooperation, establishing international partnerships and cooperation with schools (dual education, internship programs). In addition, all marshal's offices conducted information activities as part of which they published information on cluster activities or on the implementation of cluster policy. Various cluster-related events (conferences, matchmaking events) were organized to promote activities on a national and international scale.

Currently, the cluster policy in Poland, previously focused on KKK and supra-regional growth clusters, is undergoing certain modifications. Greater focus is placed on regional growth clusters and on seed clusters. It is proposed to strengthen the regional level of intervention. In this way, competitions/programs organized at the national level can be available to all growth clusters and seed clusters. Conversely, KKKs and supra-regional clusters also have access to support instruments at the regional level. In such a system, in order to achieve synergy effects and effectively support clusters, coordination of activities between both central and local government units is necessary. Moreover, regional-range clusters are characterized by their large number. As a result, despite smaller effects and scale of impact, they can become an important tool for the economic development of regions. Cluster policy also aligns with the assumptions of the National Regional Development Strategy 2030, which highlights the need to support the development of new and existing clusters as well as other structured forms of economic cooperation. It should also be added that energy clusters fit within the current development trends not only through their form but also through their mission.

3. See: Kierunki rozwoju polityki klastrowej w Polsce po 2020 roku [Directions for the development of cluster policy in Poland after 2020]. Document prepared by Justyna Choioska-Jackiewicz, Beata Lubos, Marcin Łata, Marta Mackiewicz, and Agata Wancio, Ministerstwo Rozwoju, Departament Innowacji, Warszawa, czerwiec 2020 r., available at https://www.gov.pl/web/rozwoj-technologia/krajowe-klastry-kluczowe.

4. Ibid.

The Strategy for Responsible Development includes key areas, the so-called National Smart Specializations, on which public intervention will be focused. The topics identified include high-efficiency, low-emission and integrated energy generation, as well as storage, transmission and distribution systems. It therefore seems that energy clusters fit ideally into the need to create a comprehensive support system for the networked activities of enterprises in the energy sector.

3 Energy clusters in Poland

Clusters in the energy sector in Poland are a relatively new idea, defined in the RES Act of July 1, 2016 (Article 2[15a]).[5] According to these regulations, an energy cluster is an agreement aimed at generating, storing, distributing and trading electricity from distributed generation sources connected to a distribution grid with a rated voltage lower than 110 kV. The area of operation of a cluster cannot exceed one county (LAU 1) or 5 communes (LAU 2), and this area is determined on the basis of the connection points of producers and consumers who are members of such a cluster. Energy clusters in Poland are focused on the development of renewable energy, often in the form of cogeneration and trigeneration. The need to develop renewable energy, reduce greenhouse gas emissions and generally decarbonize the economy are the main challenges facing Poland's energy economy. It is also a response to the need to continue work on the energy transformation of countries across the EU member states. Therefore, the energy clusters established in Poland in recent years are one of the ideas contributing to the development of renewable energy sources. This concerns distributed energy at the local level. However, its consequences are expected to be regional and national.

In addition to reducing the energy intensity of the economy and increasing the share of renewable energy sources in the national mix, the main strategic goals of energy clusters are to improve the quality of power supply, to increase and enhance the use of local energy resources and to reduce energy poverty. The aim is also to achieve economic goals, including cheaper energy supply and gaining independence from external energy price subsidies. In terms of infrastructure and technology, energy clusters are expected to contribute to, among others, the creation of energy storage facilities and to the thermal processing of waste. Work on achieving the goals was already visible in the initial phase of the clusters' activity. However, the expected results will not be visible until the growth phase of individual clusters.

The number of energy clusters in Poland varies. For example, Kryjom's research showed that there were 16 energy clusters across the country.[6] In their paper from 2020, Siudek and Klepacka (2020) presented a list of 66 energy clusters operating in Poland. The same number of clusters were awarded the Pilot Energy Cluster Certificate in the competition organized by the Ministry of State Assets in 2017–2018. In January 2025, the database of the National Chamber of Energy Clusters listed 100 energy clusters across the country, including 24 new initiatives that were launched in 2023–2024 in response to favorable changes in support for local and regional cluster initiatives.

4 Support for energy clusters in the Dolnośląskie Voivodship — research results

The author identified a total of 14 active energy clusters in the study region. All of them operated in the field of electricity generation and developing energy communities. The clusters examined were created in 2017–2024, 11 of which were set up in 2017–2021 and 3 in the last three years. The current number of entities constituting the clusters studied ranges from 11 to 80, with the median being 15 entities. The correlation between the length of cluster operation and the number of cluster members measured by Kendall's tau coefficient was 0.313 (on a scale from −1 to 1). This means that the agreement between the characteristics examined is poor. There is therefore no strong cor-

5. See: Ustawa z dnia 22 czerwca 2016 r. o zmianie ustawy o odnawialnych źródłach energii oraz niektórych innych ustaw [Act of June 22, 2016, amending the Act on Renewable Energy Sources and certain other acts], DzU z 2016 r. poz. 925.

6. See: Diagnoza stanu klastrów w Polsce [Diagnosis of the state of clusters in Poland]. Presentation by Piotr Kryjom, Polish Agency for Enterprise Development, PFR Group, 2019, available at https://www.parp.gov.pl/images/dzialanie/ClusterFy/2_Diagnoza_stanu_klastrw_w_Polsce_PARP_190603.pdf.

relation between the number of member entities in a cluster and the duration of its operation on the market. The study also showed that institutional clusters (8)—according to the typology of Ann Markusen (1996)—in which members are concentrated around a local government unit at the LAU 1 or LAU 2 level dominate among the analyzed clusters. The scope of impact of the analyzed clusters is limited to one county (LAU 1), which is in line with the intention of the legislator. None of the clusters studied is a Key National Cluster.

Public support received by the surveyed clusters concerned either the commencement or the continuation of cluster activity. Support for starting a cluster typically came from the National Recovery Plan (NRP)—a reform and investment program that is part of the EU's Recovery and Resilience Facility. The projects mainly concerned drafting a development strategy, carrying out documentation work related to new connections, plans for the expansion of the power grid and the purchase of an energy monitoring and management system. At this stage, support was also provided for the performance of specialist analyses—e.g., regarding wind conditions for the location of a wind farm forming part of a hybrid complex. Part of the support concerned the development of energy communities based on renewable energy sources and it mainly involved educational and training projects. Support for the launch of activity also came from the Provincial Fund for Environmental Protection and Water Management. It is a regional fund for the implementation of green programs, supervised by the minister responsible for climate and environment. This fund mainly financed education-related activities. Among them were workshops for children and youth and specialized scientific and technical conferences.

Support for continuing cluster activities was more diversified, both in terms of the purpose, source and the amount of support. The projects mentioned mostly concerned energy installations. In most cases, the projects involved the construction of ground-based PV farms (e.g., 125 PV installations with a total capacity of 3 MW) or projects involving the construction of photovoltaic installations on the roofs of public utility buildings together with energy storage facilities. The total power of such installations ranged from 1.25 to 89.00 MW per cluster. Typically, these installations were installed in different locations, from two to a dozen or so places (up to 50 km apart) within a county (LAU 1). In a few cases (3–4) the projects concerned the preparation of technical documentation for the connection or thermal modernization of public buildings. In individual cases (1–2), projects were implemented concerning hydrogen storage, hybrid investments (PV and wind turbine), biogas plants operating based on corn silage and a plant generating electricity from wastewater disposal. Among the latest projects that have been launched in the last two years, those related to transport (installation of carports and electric chargers for EVs) are noteworthy. In addition to those mentioned, training and educational projects were also implemented.

Support for the continuation of cluster activities came mostly from the National Operational Program or from Regional Operational Programs co-financed by the European Regional Development Fund under the EU's cohesion policy. In addition, the surveyed clusters received support from Interreg—a dedicated program for cross-border areas which is also co-financed by the European Union. The Interreg program was used under the TriLand project, which aims to support the sustainable development and energy transformation of the German-Polish border region, and under the Transition project, which concerns the management of the transformation of coal regions in this border region. Support from other aid programs was also noticeable, mainly from the Provincial Fund for Environmental Protection and Water Management (WFOŚiGW), from local government funds, as well as from the Polish Deal, a government strategic investment program established to eliminate crisis situations caused by the COVID-19 epidemic.

In total, the clusters surveyed implemented 35 projects, including 28 projects financed (co-financed) from EU funds: 17 from the Regional Operational program, 9 from the National Recovery Plan (KPO) and 2 from Interreg. Seven projects were financed entirely from national funds: 3 from the Voivodship Fund for Environmental Protection and Water Management, 3 from local government funds and 1 from the Polish Deal program. Domestic funds also complemented funding for most of the EU-financed projects. The support amount ranged from EUR 30 thousand to over EUR 7,100 thousand. The highest average value of support received was characteristic of projects

funded from the Regional Operational Program and amounted to EUR 1.920 million. It should also be added that three of the thirteen clusters did not receive any public support.

The problem with obtaining support was one of the main challenges in the functioning of the studied energy clusters (figure 1). According to the cluster facilitators, among the greatest barriers to development were difficulties in obtaining external support and the existing legal framework and regulatory obligations. Financial problems also translated into a slower pace of expansion of RES installations, an inability to create their own energy distribution network and problems with the purchase of energy distribution concessions. All these barriers resulted directly from the imbalance between the investment plans and the financial capabilities of the cluster.

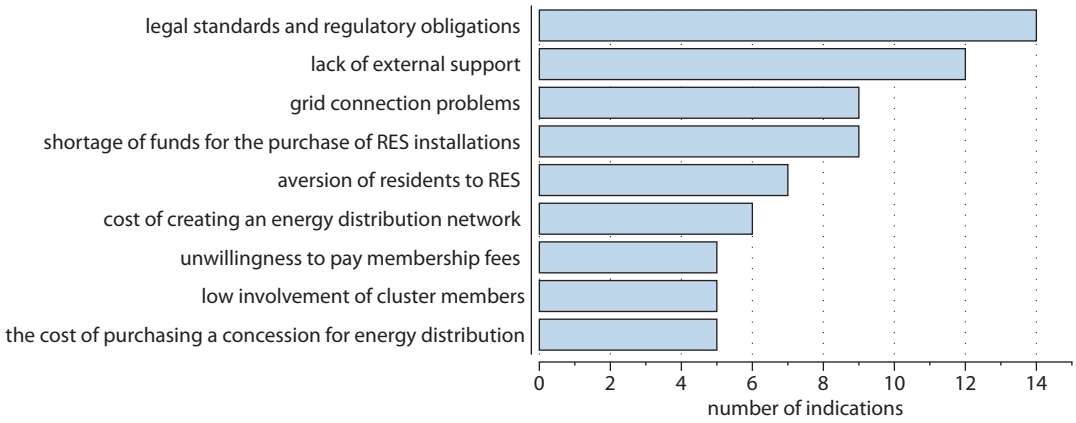

Figure 1. Barriers to the development of energy clusters (barriers mentioned at least three times are listed).
Source: Author's study

5 Discussion

The above conclusions should be supplemented with a few comments. First of all, noteworthy is the very small number of wind turbines installed in the Dolnośląskie energy clusters. This is not accidental. In 2016, the so-called 10H Act came into force, prohibiting the location of new wind farms at a distance less than ten times the height of the wind turbine from existing buildings. For example, a 150 m high turbine requires a development-free area with a radius of 1,500 m. For smaller wind turbines, the radius will be smaller, but it cannot be less than 700 meters. In this way, potential areas for investment were significantly limited and, as a consequence, the development of wind energy was stopped. For example, in the Dolnośląskie Voivodship, only 5% of the area meets this criterion. The majority of wind turbines currently in operation had been commissioned prior to the entry into force of the 10H Act. In December 2024, work began on amending the Act and reducing the required distance to 500 m from development. However, these changes have not yet been approved by Parliament. This situation has an impact on the responses obtained from facilitators. The results of the survey show that the analyzed clusters focus on solar energy, biogas and biomass. Most clusters do not have wind energy and do not plan to have it at present (apart from three clusters, two of which obtained positive environmental impact analyses and zoning approvals before 2016).

The vast majority of the surveyed clusters received external financing. It is also noticeable that energy clusters were established in periods when favorable changes were introduced to cluster policy, particularly regarding financial support. The above leads to the conclusion that energy clusters have become dependent on external financing. It is difficult to provide a clear-cut assessment of this situation. On the one hand, the presented picture raises the question of whether external funds used as part of cluster policy have not distorted the idea of clustering. They created expectations regarding the inflow of public aid but weakened the focus on the durability of ties. However, the clusters that have the greatest chance of generating added value are those that are connected by long-term cooperation, numerous projects and the certainty that they will continue to operate when a single project is over. On the other hand, however, the activities of energy clusters focused on

energy transformation serve the common good — they help improve air quality, diversify energy sources and shape new social attitudes. In this context, financial support serves not only to enhance the market position of the entity, but above all to improve the energy situation. The outcomes obtained are therefore doubly valuable.

Summary and conclusions

In Poland, there are clusters representing both traditional industries — i.e., construction, the wood industry, and the ceramics industry, as well as clusters representing modern economic sectors: ICT, medicine, nanotechnology and renewable energy. Energy clusters are among the newest. They started to be established in 2017, after their definition was included in the law passed in July 2016. Currently, cluster policy in Poland is undergoing certain modifications. Greater focus is placed on regional growth clusters and seed clusters, and not just on Key National Clusters. This change results in more opportunities for smaller-impact clusters to receive public support. Energy clusters are by their nature regional, so the changes that have taken place in cluster policy are favorable for them.

Public support received by the surveyed clusters concerned both the start-up of cluster activity and its continuation. In the initial phase of the clusters' activity, the support received concerned documentation work, drafting of plans for the expansion of the power grid and the purchase of an energy monitoring and management system. On the other hand, at later stages of cluster development, the implemented projects mainly concerned the construction of ground-based PV farms and the construction of rooftop photovoltaic installations on public utility buildings. Other implemented projects concerned thermal modernization of buildings, hybrid investments (PV and wind turbine) and energy storage facilities. Recent years have witnessed the start of work on, among other things, the construction of an agricultural biogas plant, a waste disposal plant (cogeneration) and the installation of carports and chargers for electric vehicles. There was little interest from the clusters studied in building onshore wind turbines, which is a consequence of the introduction in 2017 of a law requiring wind turbines to be built at a distance of at least 700 m from buildings. The above was reflected in the responses provided by facilitators who complained about the existing legal restrictions and considered them to be the biggest barrier to the development of energy clusters (cf. Namyślak 2020). In addition to those mentioned, educational projects were also implemented, for which funding was sought both at the initial and later stages of cluster development.

Overall, the prevailing portion of the received support originated from EU funds. The public support received came mainly from the National Operational Program, Regional Operational Programs and the Interreg program, which aims to support sustainable development in the cross-border area of Poland and Germany. On the other hand, domestic support came from the Provincial Fund for Environmental Protection and Water Management, from local government funds or from the Polish Deal program, which is a government strategic investment program established to eliminate crisis situations caused by the COVID-19 epidemic. In total, the examined clusters received 35 projects, including 28 projects financed (or co-financed) from EU funds. The support amount ranged from EUR 30 thousand to over EUR 7,100 thousand. The highest average value of support received was characteristic of projects funded from the Regional Operational Program and amounted to EUR 1.920 million.

In the opinion of cluster facilitators, limited access to financial support was one of the main problems in the operation of energy clusters. Financial problems translated into a slower pace of expansion of RES installations, inability to create energy distribution networks and problems with purchasing energy distribution concessions. All these barriers resulted from the cluster's limited investment capabilities in relation to the intended development plans.

Existing and emerging energy clusters in Poland face difficult challenges. By the end of 2026, they must meet the following conditions: (1) at least 30% of the energy generated and fed into the grid must come from renewable energy sources, (2) the energy generated must cover at least 40% of the annual demand of the cluster members, and (3) the total installed capacity of energy storage facilities must be at least 2% of the total installed capacity of energy sources. The fee for providing

distribution services will also change. It will depend on the relationship between the electricity consumed by cluster members and the energy fed into the distribution network. The more energy is transmitted, the lower the fee. These provisions are intended to encourage clusters to increase their capacity and further expand their installations.

The prospects for the development of energy clusters seem to be good. A constant strategic dialogue is maintained between cluster facilitators and local government authorities. The new cluster policy model implemented after 2020, supporting emerging clusters that have not yet reached maturity, also seems to be favorable. The possibility of supporting clusters from European and national funds as systems supporting innovation ecosystems is also important. In the future, the author would like to continue research on energy clusters throughout Poland to demonstrate their spatial differentiation and track their development paths.

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