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Chapter 1. Analysis of the structures and areas of activity of energy clusters depending on the type of region in Poland

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Streszczenie. W rozdziale przedstawiono analizę funkcjonowania klastrów energii w dwóch odmiennych regionach Polski – województwach podlaskim i śląskim – w celu określenia wpływu uwarunkowań społeczno-gospodarczych na ich strukturę organizacyjną i zakres działalności. Wyniki wykazały wyraźne różnice pomiędzy badanymi regionami. Profil społeczno-gospodarczy regionu silnie wpływa na charakter i efektywność funkcjonowania klastrów energii. W regionach rolniczych, takich jak województwo podlaskie, pełnią one funkcję integracyjną i zabezpieczającą potrzeby lokalnych społeczności, natomiast w regionach uprzemysłowionych, jak województwo śląskie, stają się platformami współpracy międzysektorowej, sprzyjającymi wdrażaniu innowacji technologicznych i transferowi wiedzy. W województwie podlaskim klastry mają głównie charakter społeczno-usługowy, oparty na współpracy samorządów, spółek komunalnych i instytucji publicznych. Dominującymi obszarami działalności są: produkcja energii (26%) i bilansowanie zapotrzebowania (26%), natomiast magazynowanie i handel energią występują rzadziej. W województwie śląskim klastry przyjmują formę bardziej techniczno-przemysłową, obejmującą spółki komunalne, przedsiębiorstwa przemysłowe, miasta na prawach powiatu i jednostki badawcze. Tam dominują działania związane z produkcją energii (27%) i bilansowaniem zapotrzebowania (26%), ale także z jej dystrybucją (18%) i magazynowaniem (16%).

Abstract. The chapter presents an analysis of the functioning of energy clusters in two different regions of Poland – Podlaskie and Śląskie Provinces – in order to determine the impact of socio-economic conditions on their organisational structure and scope of activity. The results showed clear differences between the regions studied. The socio-economic profile of a region has a strong influence on the nature and effectiveness of energy clusters. In agricultural regions, such as the Podlaskie Province, they perform an integrative function and secure the needs of local communities, while in industrialised regions, such as the Śląskie Province, they become platforms for cross-sectoral cooperation, conducive to the implementation of technological innovations and knowledge transfer. In the Podlaskie Province, clusters are mainly social and service-oriented, based on cooperation between local governments, municipal companies and public institutions. The dominant areas of activity are energy production (26%) and demand balancing (26%), while energy storage and trading are less common. In the Śląskie Province, clusters take a more technical and industrial form, involving municipal companies, industrial enterprises,

cities with county rights and research units. Activities related to energy production (27%) and demand balancing (26%) dominate there, but also energy distribution (18%) and storage (16%). (

Słowa kluczowe: klaster energii, województwo podlaskie, województwo śląskie, OZE

Keywords: energy cluster, Podlaskie Province, Śląskie Province, RES

Introduction

In recent years, there has been a dynamic increase in interest in renewable energy sources (RES), which are increasingly finding their way into both homes and industrial consumers [1]. Renewable energy sources are an excellent alternative to fossil fuels, which generate significant amounts of greenhouse gases and intensify the process of global climate change [2, 3]. Global warming caused by greenhouse gas (GHG) emissions is a serious challenge and a key issue in modern environmental protection. It is the source of serious health problems, weather changes, rising sea levels and changes in the ecosystem [4, 5]. The industrial and energy sectors are considered to be the main sources of greenhouse gas emissions [6]. In the face of rising global temperatures and increasingly extreme weather events, it is becoming urgent to implement sustainable energy solutions [7]. At the heart of these efforts is the urgent need to move away from fossil fuels towards clean, sustainable and efficient energy solutions. This is a response not only to the growing demand for energy, but also to the need to protect the planet and ensure a secure future for future generations [7].

Currently, energy-related issues in Poland are governed by numerous legal regulations designed to help European Union countries transition to a green economy. The goal is to achieve climate and resource neutrality and reduce dependence on fossil fuels. All planned measures are included in: climate strategies for 2030 and 2050, directives on energy from renewable sources, directives on energy efficiency, the Effort Sharing Regulation (ESR) and the EU Emissions Trading System (EU ETS) [8, 9]. The implementation instrument is the 'Fit for 55' package, which is intended to help implement the objectives of the European Climate Law in practice. Among other things, it includes a requirement to reduce emissions by 55% by 2030 compared to 1990 levels, and a requirement to achieve net-zero greenhouse gas emissions by 2050. This means that by 2050, greenhouse gas emissions in the EU are to be offset by their absorption [8, 9, 10, 11]. To meet the expectations set out in European Union legislation, many changes need to be made in the energy sector, industry, agriculture and socio-economic systems. [12,13]. Renewable energy sources (RES) play a key role in the transition [14]. Energy cooperatives and energy clusters are to help achieve the energy target.

An energy cluster is an agreement whose subject matter is cooperation in the generation, storage, balancing of demand, and distribution of electricity or heat, with the aim of providing its parties with economic, social, and environmental benefits

or increasing the flexibility of the power system. An energy cluster agreement must be concluded in writing under pain of nullity. The agreement should primarily include the rights and obligations of the parties, the scope of cooperation, the area of activity with an indication of energy consumption points and points of entry into the grid, and the authorisation of the energy cluster coordinator to access energy market information and measurement data for each member of the cluster. Prior to the amendment (Act of 20 February 2015), the regulations did not cover energy storage as part of the cluster's activities. The amendment to the regulations in 2023 not only enabled the accumulation of surplus energy, which allows for more efficient management of its consumption, but also increased the energy security of cluster participants by reducing the risk of supply interruptions [15, 16, 17].

The area of operation of an energy cluster is determined on the basis of the location of energy consumption points. The registration of a cluster defines its territorial boundaries – covering the area of one district or a maximum of five neighboring municipalities – and imposes an obligation on local government units or enterprises controlled by them to participate. The cluster's activities may not include cross-border connections with other countries. Only entities connected to the distribution network of the same electricity distribution system operator with a rated voltage below 110 kV may be members of the cluster [15, 16, 17]. There are currently several hundred energy clusters operating in Poland, but the most majority of them are not listed in the register kept by the President of the Energy Regulation Office. Registration of an energy cluster is voluntary, but it allows access to available support mechanisms, such as exemption from the RES fee and the cogeneration fee [16, 17].

The scope of activity of an energy cluster may vary and be adapted to local technical, social and economic conditions, covering many areas of activity [18]:

- generation of electricity and heat based on conventional fuels (including cogeneration, i.e. simultaneous generation of energy and heat);
- generation of electricity and heat from various renewable energy sources;
- production of gaseous and liquid fuels;
- distribution of electricity, heat and fuels within its own distribution system;
- sale of energy or fuels to end users at attractive prices;
- production and distribution or sale of cooling;
- storage of energy or energy carriers;
- management of agricultural waste;
- management of household waste;
- management of forest waste;
- utilisation of the energy potential of local watercourses and other forces of nature.

Despite the dynamic growth in the number of publications devoted to energy communities and microgrids, there is still a noticeable shortage of in-depth research on the actual functioning of energy clusters in Polish regions, especially in rural areas such as the Podlaskie Province. The existing literature focuses mainly on theoretical aspects, the optimisation of energy management systems (EMS) and the analysis

of individual cases, neglecting a broader comparative approach. There is a lack of comprehensive empirical analyses showing how the institutional structure of a cluster – comprising municipalities, enterprises, social organisations and universities – affects its operational profile, including energy production, storage and balancing, as well as the degree of utilisation of local renewable energy sources (RES).

To fill this gap, this study proposes a comparison of energy clusters operating in two regions: the Podlaskie Province, representing an area with a dispersed settlement structure and an agricultural economy, and the Silesian Province, characterised by a high degree of urbanisation, developed industrial infrastructure and greater access to capital. A comparison of these two types of regions will allow us to identify how differences in socio-economic conditions translate into the organisation, functioning and effectiveness of energy clusters.

Analysis of clusters in the Podlaskie Province

Table 1 presents the results of a review of energy clusters operating in the Podlaskie Province (as of 26 October 2025). The analysis includes the identification of cluster members and their nature (local government units, companies, educational institutions, social welfare homes etc.).

TABLE 1. Energy clusters in the Podlaskie Province

Klaster Jaćwing	• Urząd Gminy Szypliszki • Urząd Gminy Rutka-Tartak • Energia Przyszłości Filipów Sp. z o. o. • WWP "American-Plastic Bis" Andrzej Markiewicz
Klaster Energii – EKOOPER	• Gmina Zabłudów • Politechnika Białostocka • Uniwersytet Medyczny • Zakład Doskonalenia Zawodowego w Białymstoku
Klaster Powiatu Białostockiego	• Powiat Białostocki • Dom Pomocy Społecznej w Choroszczy • Dom Pomocy Społecznej w Uhowie • I Liceum Ogólnokształcące im. Adama Mickiewicza w Łapach • Centrum Kształcenia Zawodowego w Łapach • Zespół Szkół w Czarnej Białostockiej • Dom Dziecka w Supraślu • Dom Pomocy Społecznej "Jawor" w Jałówce • Zespół Szkół Mechanicznych im. Stefana Czarnieckiego w Łapach • Powiatowy Zarząd Dróg w Białymstoku • Powiatowy Środowiskowy Dom Pomocy w Łaźniach

Klaster Energii Powiatu Monieckiego	• Gmina Goniądz • Gmina Jasionówka • Gmina Jaświły • Gmina Krypno • Gmina Mońki • Moniecka Spółdzielnia Mleczarska w Mońkach • Przedsiębiorstwo Energetyki Cieplnej w Mońkach Sp. z o. o.
Klaster Energi Sokólsko-Białostocki	• Gmina Supraśl • Gmina Krynki • Gmina Szudziałowo • Powiat Sokólski
Klaster EnergyREGION Michałowo	• Gmina Michałowo • Gmina Gródek • Gmina Tykocin • Gmina Zabłudów • Zielona Energia Michałowo • IEN Energy Sp. z o. o. • Dom Pomocy Społecznej "Jawor" • Gminny Ośrodek Kultury w Michałowie
Klaster Energii Gmin Powiatu Sokólskiego	• Gmina Dąbrowa Białostocka • Gmina Janów • Gmina Kuźnica • Gmina Nowy Dwór • Gmina Suchowola • Gmina Sidra • Powiat Sokólski • DOEKO Group Sp. z o. o.
Białostocki Klaster Energetyczny	• Wodociągi Białostockie Sp. z o. o. • Miasto Białystok • PUHP LECH Sp. z o. o.
Siemiatycki Klaster Energii	• Miasto Siemiatycze • Przedsiębiorstwo Komunalne Sp. z o. o. • Gmina Dziadkowice • Gmina Mielnik • Powiat Siemiatycki • Samodzielny Publiczny Zakład Opieki Zdrowotnej • Eneris Sp. z o. o.
Nowa Suwalska Energia	• Przedsiębiorstwo Energetyki Cieplnej w Mońkach Sp. z o. o. • Park Naukowo-Technologiczny • Przedsiębiorstwo Wodociągów i Kanalizacji • Suwalskie Kopalnie Surowców Mineralnych • Miasto Suwałki • Malow

An analysis of the composition of energy clusters reveals considerable diversity – from structures dominated by municipalities and public institutions, through hybrid arrangements involving municipal companies, to initiatives with a strong educational background involving universities. They are accompanied by limited liability companies established by local governments to perform tasks in the field of energy

and municipal services. The role of local government units as the main coordinator and organisational stabiliser remains unchanged, which results from the requirements of the Act [15, 16].

Analysis of cluster structures in the Podlaskie Province

Figs. 1 and 2 present the results of an analysis of the internal organisational structure of energy clusters, with particular emphasis on the typology and number of members and the profile of activities (energy production, storage, balancing, trading). The Podlaskie Province is characterised by a dispersed settlement structure, a predominance of rural areas and an agricultural economy, which determines the specific nature and form of local energy initiatives.

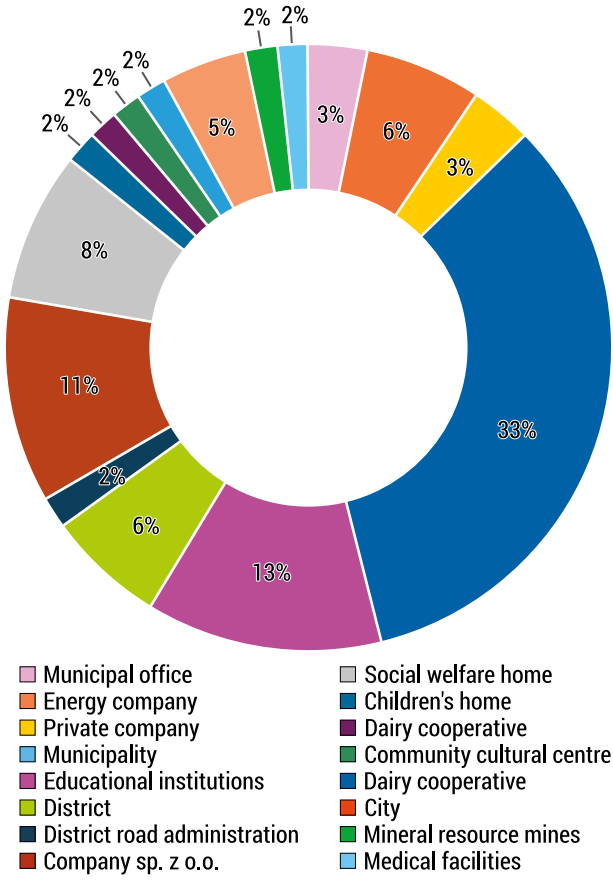

FIGURE. 1. Percentage share of institutions comprising the cluster in the Podlaskie Province

An analysis of the data presented in Fig. 1 shows that clusters in the Podlaskie Province most often consist of municipalities, followed by limited liability companies and social care homes. Municipalities and companies are most often involved because the law imposes an obligation on local government units or companies controlled by them to participate.

Each cluster has its own activity profile. One cluster may have several activity profiles. Most often, clusters are involved in energy production (26%) and balancing electricity demand (26%) – Fig. 2. This is followed by energy storage (20%) and energy trading (14%). Only one cluster reported activities in the field of heat production.

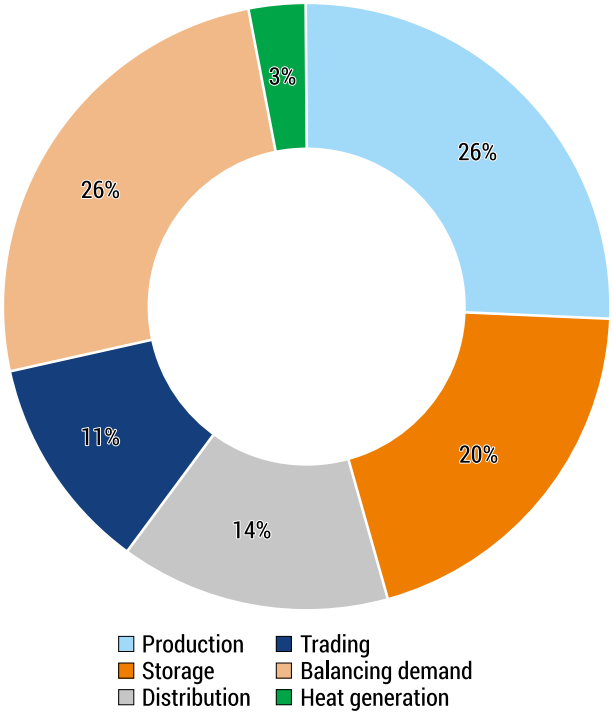

FIGURE 2. Percentage distribution of cluster activity sectors

Analysis of clusters in the Śląskie Province

Table 2 presents the results of a review of energy clusters operating in the Śląskie Province (as of 26 October 2025). Unlike the Podlaskie Province, this region is characterised by a high level of urbanisation, a significant concentration of industry and a well-developed technical infrastructure.

TABLE 2. Clusters of the Silesian Province

Klaster Energii w Gliwicach	Smart EPC Sp. z o. o. • Gliwice – miasto na prawach powiatu • Katowicka Specjalna Strefa Ekonomiczna S.A. Podstrefa Gliwice • Śląskie Centrum Logistyki S.A. • Przedsiębiorstwo Energetyki Cieplnej – Gliwice Sp. z o. o. • Przedsiębiorstwo Komunikacji Miejskiej Sp. z o. o. • Przedsiębiorstwo Wodociągów i Kanalizacji Sp. z o. o. • Przedsiębiorstwo Zagospodarowania Odpadów Sp. z o. o. • Śląska Sieć Metropolitalna Sp. z o. o. • ZPBE Energopomiar Sp. z o. o.
Ruda Śląska Klaster Energii i Wodoru	• Miasto Ruda Śląska • Przedsiębiorstwo Wodociągów i Kanalizacji Sp. z o. o. w Rudzie Śląskiej • Miejskie Przedsiębiorstwo Gospodarki Mieszkaniowej Towarzystwo Budownictwa Społecznego Sp. z o. o. • Aquadrom • Prezero Service Południe Sp. z o. o. • Węglokoks Energia ZCP Sp. z o. o.
Klaster Rybnicki	• Miasto Rybnik • Gmina Gaszowice • Gmina Jejkowice • Gmina Świerklany • Gmina Czerwionka-Leszczyny • DOEKO GROUP Sp. z o. o.
Klaster Energii Aglomeracji Częstochowskiej	• Gmina Miasto Częstochowa • Gmina Poczesna • Gmina Olsztyn • Gmina Mstów • Gmina Rędziany • DOEKO Group Sp. z o. o.
Klaster Eenergii Powiatu Częstochowskiego	• Gmina Blachownia • Gmina Koniecpol • Gmina Mykanów • Powiat Częstochowski • Gmina Kołomnice • Gmina Konopiska • Gmina Janów • Gmina Kamienica Polska • Gmina Lelów • Gmina Kruszyna • Gmina Dąbrowa Zielona • Gmina Przyrów • Gmina Starcza

Klaster Energii Powiatu Kłobuckiego	• Gmina Kłobuck • Gmina Krzepice • Gmina Lipie • Powiat Kołobucki • Gmina Miedźno • Gmina Opatów • Gmina Panki • Gmina Popów • Gmina Przystajń • Gmina Wręczyca Wielka • Związek Gmin i Powiatów Subregionu Północnego Województwa Śląskiego
Klaster Energii Powiatu Myszkowskiego	• Miasto Myszków • Gmina i Miasto Koziegłowy • Gmina Niegowa • Gmina Poraj • Powiat Myszkowski • DOEKO Group Sp. z o. o. • Związek Gmin i Powiatów Subregionu Północnego Województwa Śląskiego
Klaster Energii Ziemi Wodzisławskiej	• Miasto Rydułtowy • Miasto Radlin • Miasto Pszów • Gmina Marklowice • Gmina Godów • Gmina Mszana • Gmina Gorzyce • DOEKO Group Sp. z o. o.
Katowicki Klaster Energii	• Katowickie Inwestycje S.A. • Katowicka Specjalna Strefa Ekonomiczną S.A. • Miejskie Przedsiębiorstwo Gospodarki Komunalnej Sp. z o. o. • Katowickie Wodociągi S.A. • Katowickie Towarzystwo Budownictwa Społecznego Sp. z o. o. • Przedsiębiorstwo Komunikacji Miejskiej Katowice Sp. z o. o. • Narodowa Orkiestra Symfoniczna Polskiego Radia • Dalkia Polska Energia S.A. • Gonar-Bis Sp. z o. o.
Dąbrowski Klaster Energii	• Dąbrowskie Wodociągi – Nemo Wodny Świat • Zagłębiowskie Centrum Onkologii • Enalpha S.A. • Instytut Gospodarczy • Miasto Dąbrowa Górnicza
Klaster Energii Gmin i Powiatu Cieszyńskiego	• Powiat Cieszyński • Gmina Chybie • Gmina Wisła • Gmina Hażlach • Gmina Strumień • Gmina Ustroń • Gmina Zebrzydowice • Gmina Istebna • Gmina Goleszów • Agencja Rozwoju Regionalnego S.A. • Stowarzyszenie Samorządowe Ziemi Cieszyńskiej • Wodociągi Ziemi Cieszyńskiej Sp. z o. o.

Klaster Energii Zielone Bielsko-Biała	• Miasto Bielsko-Biała • Agencja Rozwoju Regionalnego S.A. • MZK Sp. z o. o. • ZIAD S.A. • AQUA S.A. • Zakład Gospodarki Odpadami S.A. • Therma Sp. z o. o. • Beskidzki Hurt Towarowy S.A. • PreZero S.A. • KSSE S.A. • TBS Sp. z o. o. • Parafia Ewangelicko-Augsburska w Bielsku-Białej
Klaster Energii Powiatu Bielskiego	• Gmina Bestwina • Gmina Wilamowice • Gmina Porąbka • Gmina Kozy • Gmina Wilkowice • Gmina Buczkowice • Gmina Szczyrk • Gmina Jaworze • Gmina Jasienica • EKO-WTÓR Jakubiec Sp. z o. o. • Agencja Rozwoju Regionalnego S.A. • Powiat Bielski
Klaster Energii "Przyjazna Energia w Powiecie Gliwickim"	• Gmina Wielowieś • Gmina Toszek • Gmina Rudziniec • Gmina Sośnicowice • Gmina Pilchowice • Gmina Knurów • Gmina Gierałtowice • Gmina Pyskowice • Przyjazna Energia Sp. z o. o.
Tyski Klaster Energii	• Miasto Tychy • Miasto Bieruń • Katowicka Specjalna Strefa Ekonomiczna S.A. • Regionalne Centrum Gospodarki Wodno-Ściekowej S.A. • Master – Odpady i Energia Sp. z o. o. • Okręgowa Spółdzielnia Mleczarska w Bieruniu • Przedsiębiorstwo Energetyki Cieplnej Sp. z o. o. • Sertop Sp. z o. o. • Tyskie Linie Trolejbusowe Sp. z o. o. • Bieruńskie Przedsiębiorstwo Inżynierii Komunalnej Sp. z o.o.
Bytomski Klaster Energii	• Gmina Bytom • Bytomskie Wodociągi Sp. z o. o. • Przedsiębiorstwo Energetyki Cieplnej Sp. z o. o. • Katowicka Specjalna Strefa Ekonomiczna S.A.

Zawierciański Klaster Energii	• Miasto Zawiercie • Zakład Gospodarki Komunalnej Sp. z o. o. • Spółdzielnia Socjalna Zielone Śląskie • Klastry Energii Sp. z o. o. • Zakład Komunikacji Miejskiej Sp. z o. o. • Rejonowe Przedsiębiorstwo Wodociągów i Kanalizacji Sp. z o. o. • Dabex Sp. z o. o. • Elgum Automotive Sp. z o. o. • Grupa Łapaj Sp. z o. o. • Lindem Sp. z o. o. • AXA Stenman Poland Sp. z o. o.
Ogrodzieniecki Klaster Energii	• Miasto Ogrodzieniec • ZAMEK Sp. z o. o. • Przedsiębiorstwo Komunalne Sp. z o. o. • Fundacja Bonera • Klastry Energii Sp. z o. o.
Orzeski Klaster Energii	• Miasto Orzesze • Spółdzielnia Socjalna Zielone Śląskie • Gmina Ornontowice • Klastry Energii Sp. z o. o.
Klaster Energii Zabrzańskie Innowacje Energetyczne	• Miasto Zabrze • KOMAG ENERGIA Sp. z o. o. • Instytut Techniki Górniczej KOMAG • Instytut Technologii Paliw i Energii • Miejski Ośrodek Sportu i Rekreacji Sp. z o. o. • Zabrzańskie Przedsiębiorstwo Energetyki Cieplnej Sp. z o. o. • Stadion w Zabrzu Sp. z o. o. • Zabrzańskie Przedsiębiorstwo Wodociągów i Kanalizacji Sp. z o. o. • Muzeum Górnictwa Węglowego w Zabrzu
Klaster Energii Racibórz	• Miasto Racibórz • Przedsiębiorstwo Komunalne Sp. z o. o. • Wodociągi Raciborskie Sp. z o. o. • Zakład Zagospodarowania Odpadów Sp. z o. o. • Klastry Energii Sp. z o. o.
Klaster Energii Bobrowniki-Wojkowice	• Gmina Bobrowniki • Gmina Psary • Miasto Wojkowice • SIM Zagłębie Sp. z o. o. • Klastry Energii Sp. z o. o.

A summary of data on energy clusters in the Śląskie Province reveals their clearly differentiated institutional structure, with a dominant share of municipal, infrastructure and industrial entities. Unlike the more community-based model of Podlaskie clusters, Śląska energy initiatives are mainly based on municipal companies, energy operators, water supply, heating and transport companies, reflecting the highly urbanised and industrialised nature of the region. Cities with county rights and special economic zones also play a significant role, providing access to capital, technology and investment facilities. Research institutes and scientific and technical units,

such as KOMAG and the Institute of Fuel and Energy Technology, are also present in the membership structures, indicating the growing role of innovation and knowledge transfer in the development of local energy.

Analysis of cluster structures in the Śląskie Province

Figs. 3 and 4 present the results of an analysis of the internal organisational structure of energy clusters, with particular emphasis on the typology and number of members and their activity profile. The data presented in Fig. 3 shows that clusters in the Silesian Province most often consist of municipalities, followed by companies, educational institutions and cities. The least common are institutions such as museums, stadiums, foundations, recreation centres, parishes, associations and medical facilities.

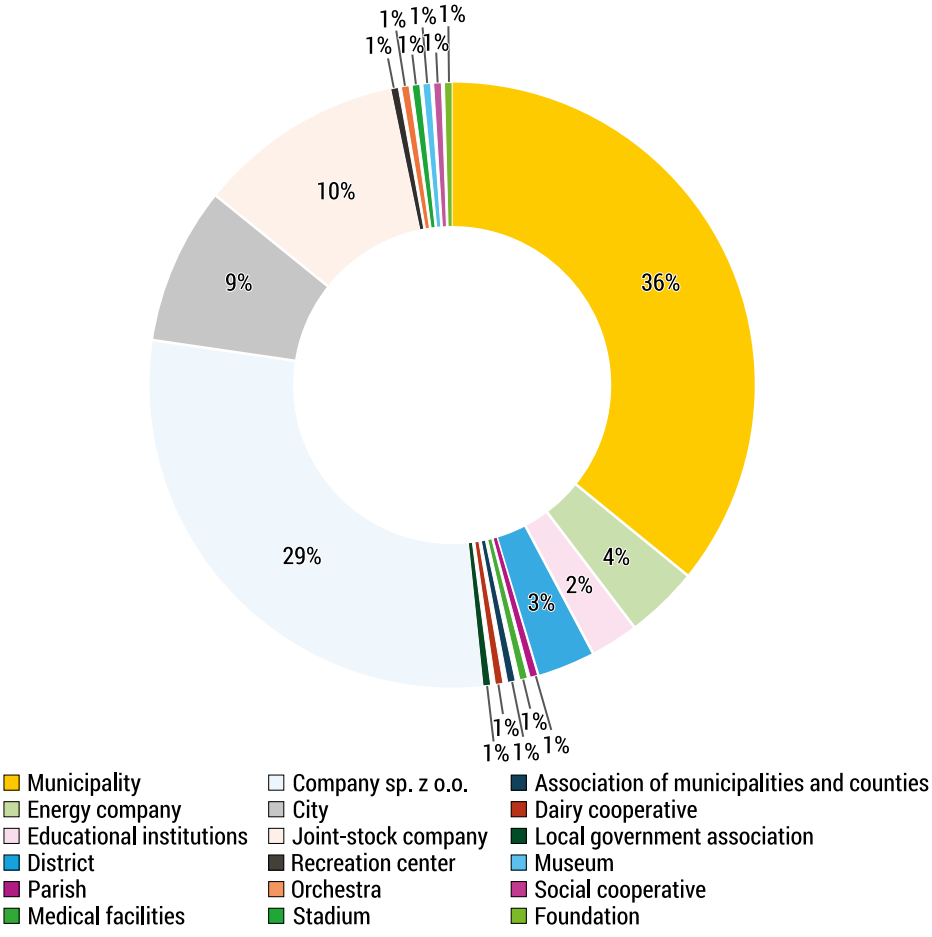

FIGURE 3. Percentage share of institutions comprising the cluster in the Śląskie Province

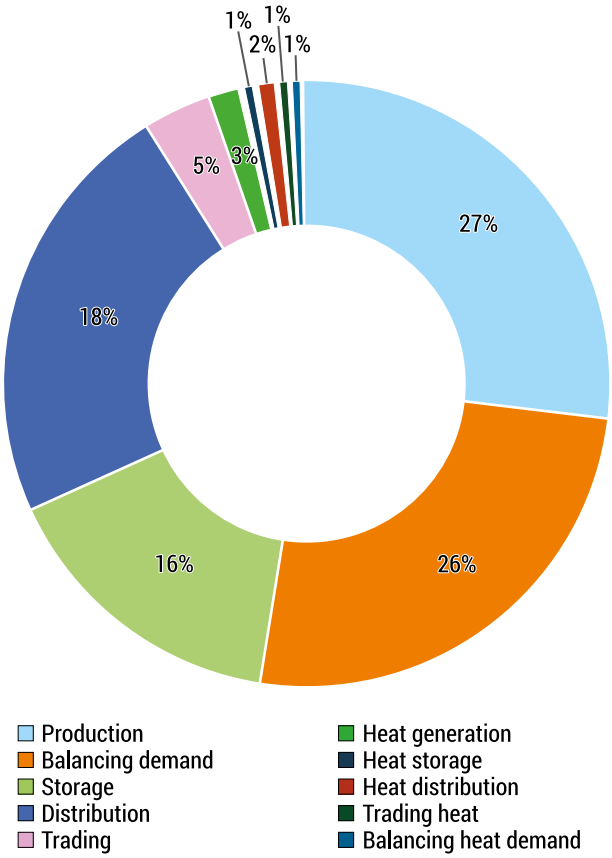

FIGURE 4. Percentage share of institutions comprising the cluster in the Śląskie Province

Clusters in the Śląskie Province are most often involved in energy production, demand balancing, distribution and storage – Fig. 4. Broader activity can be observed in the heat generation, storage, distribution and trading sectors. There was no storage, trading, distribution or balancing of heat demand in the Podlaskie Province.

Comparison of clusters in the Podlaskie and Śląskie provinces

In the Podlaskie Province, clusters are mainly based on municipalities (33%), educational institutions (8%) (mostly secondary schools), municipal companies (11%) and care institutions (10%), which translates into the social and service nature of activities and local infrastructure security. The dominant areas of activity are energy production (26%) and demand balancing (26%), with a smaller share of storage (20%) and energy trading (11%). The Podlaskie model therefore focuses on meeting local energy needs, with a strong involvement of local governments and public

institutions, which distinguishes it from the more industrial and diversified approach of the Śląskie region.

The Śląskie Province is dominated by municipalities (36%) with a strong share of municipal companies (29%) and educational institutions (10%). The dominant areas of activity are energy production (27%) and demand balancing (26%), with a smaller share of storage (16%) and energy distribution (18%). This structure indicates that Śląskie clusters have more advanced technological and logistical facilities, which allows them to carry out comprehensive activities in the field of energy – from production and distribution to storage and effective management of energy resources.

Although municipalities play an important role in the structure of energy clusters in both regions, the Śląskie Province clearly shows a stronger presence of industrial and infrastructure entities, such as municipal enterprises, service companies, waterworks and heating plants (Table 2). This composition gives Śląskie initiatives a more technical and commercial character, different from the social and service model dominant in Podlaskie clusters.

Summary

The article presented a detailed description and typology of energy clusters operating in the Podlaskie and Śląskie provinces, focusing on their organisational structure and operational profiles. The article presents a summary of the functioning of energy clusters in two extremely different regions of Poland: the Podlaskie and Śląskie provinces (as of 26 October 2025). The results of the analysis reveal significant differences in both institutional structure and activity profiles.

The distribution of sectors of activity among the analysed clusters indicates a strong focus on local energy generation and balancing, coupled with a shortage of storage infrastructure. The lack of adequate energy storage resources limits their ability to respond flexibly to changing market conditions and demand, which may hamper further operational development and integration into the wider energy system. In contrast, the Śląskie clusters (Fig. 4) show a more balanced distribution of activities – in addition to production and balancing, energy distribution and storage are also important, which may indicate a higher degree of technical sophistication and better links to the region's network infrastructure.

The results of the analysis clearly indicate that the socio-economic profile of the region has a significant impact on the organisational structure and functional scope of energy clusters. In agricultural and rural regions, such as the Podlaskie Province, energy clusters primarily serve as integrators of local communities and guarantors of energy security for public sector institutions. In urbanised and industrialised areas, such as the Śląskie Province, clusters function as platforms for cross-sector cooperation, bringing together local government units, industry representatives and the scientific community, which promotes the commercialisation of innovative solutions and technology transfer.

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