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SPATIAL DIVERSITY OF ENERGY COOPERATIVES IN POLAND

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Purpose: The aim of the study is to identify the regional specialization of energy cooperatives in Poland.
Design/methodology/approach: The research employs a quantitative approach using the location quotient (LQ) method to analyze regional specialization. Three LQ indicators were calculated to assess the relationship between the capacity of photovoltaic installations and the number of cooperative members, number of installations, and number of energy consumption points. The analysis was conducted at the voivodeship level to identify regions with a strong concentration of large photovoltaic farms and higher specialization in energy cooperatives.
Findings: The study found significant regional disparities in the development of energy cooperatives in Poland. Four voivodeships (Kujawsko-Pomorskie, Łódzkie, Warmińsko-Mazurskie, and Wielkopolskie) demonstrated strong regional specialization with high LQ values in all three criteria, indicating a high concentration of large-capacity photovoltaic installations.
Research limitations/implications: The study focuses on quantitative indicators of specialization and does not incorporate qualitative factors such as policy influences or market conditions. Future research could explore these aspects to provide a more comprehensive understanding of the regional dynamics of energy cooperatives.
Practical implications: The findings can guide policymakers and stakeholders in identifying regions with high potential for the development of energy cooperatives.
Originality/value: This paper offers a perspective by using the location quotient method to evaluate the specialization of energy cooperatives beyond merely counting the number of cooperatives.
Keywords: energy cooperatives, spatial diversity, the location quotient (LQ), rural area.
Category of the paper: research paper.

1. Introduction

The current energy system in Europe largely relies on external suppliers. The escalation of Russia's military actions against Ukraine has severely disrupted the global energy system and highlighted the excessive dependence of EU countries' energy security on imports of gas, oil, and coal from Russia. The European Commission notes that decentralizing energy production

could reduce European countries' reliance on Russian fossil fuels and accelerate the adoption of renewable energy. Considering that by 2050, 50% of citizens could produce energy from renewable sources to meet 45% of their needs, emphasis is placed on a grassroots-driven energy transition involving society (European Commission, 2022).

Energy communities can contribute to mitigating the effects of the energy and climate crisis and reducing energy poverty. Energy cooperatives primarily operate in the member states of the European Union. The largest numbers of energy cooperatives contribute to the energy market in Germany, Austria, and Denmark (Marzec, 2021). The concept of energy cooperatives in Poland was implemented based on German experiences. In Germany, as early as the late 19th century, the first cooperatives were established to distribute electricity and create the necessary infrastructure for the country's electrification. After the Fukushima nuclear disaster in 2011, the German authorities decided to intensify investments in renewable energy sources. As noted by Hartmann and Palm (2023), during this period, the concept of "citizens' energy cooperatives" (German: Bürgerenergiegenossenschaften) emerged. These cooperatives enable local communities to jointly invest in renewable energy technologies and take responsibility for their energy consumption. The development of German energy cooperatives exemplifies an energy transition aligned with sustainable development principles and widely accepted by society (Klagge, Meister, 2018).

The rationale for investing in energy independence and developing a stable and innovative infrastructure to support economic growth and social well-being is reflected in global and European strategies. These objectives are included in the 2030 Agenda for Sustainable Development, particularly Goal 9 (A/RES/70/1) (UN, 2015), as well as in the "6 priorities of the European Commission for 2019-2024", which align with the European Green Deal. The strategy, known as the "Green Deal", introduced in 2019 (EC, 2019), sets a goal of achieving climate neutrality by 2050.

In Polish law, the term "energy cooperative" has been in use since 2016. As Marzec (2021) notes, the impetus for creating a legal framework for this type of initiative in Poland was inspired by German solutions. The implementation of the energy cooperatives concept in Poland took place through the Renaldo Program, initiated by the Kuyavian-Pomeranian Agricultural Advisory Center. The program, approved in 2019, was an initiative of the Ministry of Agriculture and Rural Development aimed at providing expert support in establishing pilot energy cooperatives in the Podlaskie and Kuyavian-Pomeranian regions. The entire project was 100% financed by the European Union under the Structural Reform Support Program and the German Federal Ministry for the Environment, Nature Conservation, and Nuclear Safety. According to Spiller (2023), the experiences gained during the program allowed for the development of best practices, support tools (such as the Renaldo Calculator), and recommendations for legislative changes.

According to the definition contained in the Act of August 17, 2023 (Dz.U. 2023, item 1762), an energy cooperative is a form of cooperative or agricultural cooperative engaged in the production of electricity, biogas, biomethane, or heat from renewable energy sources, as well as their distribution and storage for its own needs and those of its members. A cooperative member can be any entity whose installation is connected to the power, gas, or heating network. Polish literature emphasizes the need to prioritize promoting energy cooperatives in rural areas, where, compared to urban areas, there is a greater risk of poverty, including energy poverty (Błażejowska, Gostomczyk, 2018). These suggestions are reflected in the conditions that energy cooperatives in Poland must meet. According to regulations (Dz.U. 2019, item 1524; 2021, item 1093; 2022, item 1723), cooperative members are required to operate within the area of a rural or mixed rural-urban municipality or within no more than three directly neighboring such municipalities.

In Poland, the first energy cooperative was registered in December 2021. This cooperative comprised 19 members who owned 20 photovoltaic installations with a capacity of 0.18 MWe and consumed energy from 20 consumption points. The establishment of additional energy cooperatives was only noted in 2023. In 2023, the KOWR Register recorded 19 new cooperatives with 48 members who owned 94 photovoltaic installations with a total capacity of 3.62 MWe and consumed energy from 320 points. The following year, 35 new energy cooperatives were established, comprising 117 members who consumed energy from 281 points and owned 141 installations with a total capacity of 10.43 MWe. In January 2025, seven more energy cooperatives were established, bringing together 27 members who owned 27 photovoltaic installations with a total capacity of 2.22 MWe and consumed energy from 38 points. As of January 29, 2025, Poland had 62 registered energy cooperatives comprising 211 members consuming energy from 659 points and owning 282 installations with a total capacity of 16.45 MWe. All energy cooperatives' activities are based on electricity production using photovoltaic installations. Additionally, one cooperative operates a wind power plant, and another has an energy storage facility.

Energy cooperatives are unevenly distributed across the country. Interestingly, for two cooperatives, the registered office address (Małopolskie Voivodeship) differs significantly from the area of operation (Świętokrzyskie and Wielkopolskie Voivodeships). Therefore, further analyses consider the location of the operational area rather than the registered address of the energy cooperative.

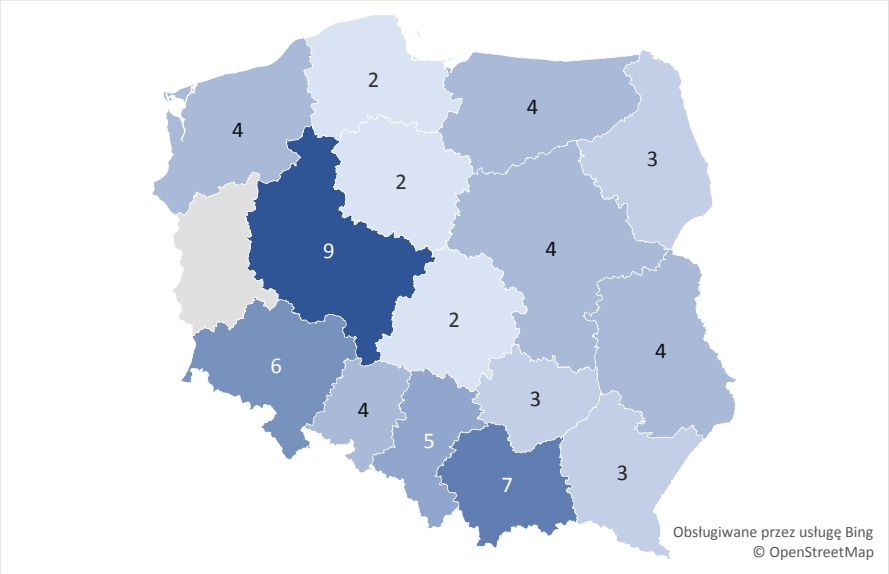

Figure 1. Number of energy cooperatives in Poland by Voivodeship. As of January 29, 2025.

Source: Own elaboration based on the List of Energy Cooperatives maintained by the National Support Centre for Agriculture (KOWR).

As we can see, a significant number of cooperatives operate in the southwestern part of the country. Most of them are in the Wielkopolskie (9), Małopolskie (7), Dolnośląskie (6), and Śląskie (5) voivodeships, the latter of which saw the establishment of Poland's first energy cooperative in 2021. Only in the Lubuskie Voivodeship has no energy cooperative been registered yet.

2. Material and Research Methodology

Using data obtained from the literature (desk research) and statements from members of the National Forum of Energy Cooperatives in Poland, the process of implementing energy cooperatives in Poland was presented. Based on data from the Register of Energy Cooperatives maintained by the National Support Centre for Agriculture (KOWR), the dynamics of the establishment of successive energy cooperatives in Poland over the years were shown. To assess regional specialization, the location quotient (LQ) was used. This is a classic indicator that allows for the determination of local specialization and concentration (Gwosdz et al., 2021). The location quotient (LQ_i), also known as the regional specialization index, for a spatial unit (region) is the ratio of the value of a specific economic or social activity indicator (S_i) in a spatial unit (region i) to the value of this indicator (A) in a higher-order spatial unit (country):

$$LQi = \frac{Si}{A} \quad (1)$$

LQ_i indicates in which regions there is an "overrepresentation" of a particular activity (LQ > 1) and where there is a relative "deficiency" (LQ < 1). "Overrepresentation" can be positively interpreted as regional specialization. The location quotient (LQ) also enables comparisons across different time periods (Czyż, 2016). To assess regional specialization, three indicators were used, based on photovoltaic installation capacity, the number of photovoltaic installations, the number of energy cooperative members, and the number of energy consumption points.

3. Energy Cooperatives in Poland - Regional Specialization

Knowing that regional specialization cannot be assessed solely on the basis of the number of organizations, the study utilized analytical tools and a well-established indicator in the scientific literature, namely the location quotient (LQ) (Gwosdz et al., 2021). The applied index method assumes a realistic approach, in light of which even non-directly observable cognitive constructs (e.g., residents' entrepreneurship) can be described by observable empirical or empirical-inferential indicators (e.g., the number of companies established by residents) (Czyż, 2016). The main objective of using the location quotient and analyzing its values in this study is to identify in which regions (voivodeships) in Poland there is a specialization resulting from the number and capacity of photovoltaic installations and the number of points from which energy is drawn by members of energy cooperatives.

The study used the regional specialization index (location quotient LQ_i) in three aspects. First, as the ratio of the indicator showing the relationship between the power generated by energy cooperatives and the number of members (S_{i1}), second, to the number of installations owned by cooperatives (S_{i2}), and third, as the ratio of the number of energy consumption points (S_{i3}). Then, individual indicators S_{i1-3} in the voivodeship were compared to the value of this indicator (A) in a higher-order spatial unit, i.e., the country.

$$\mathrm{LQi} = \frac{\mathrm{Si}}{\mathrm{A}} \tag{2}$$

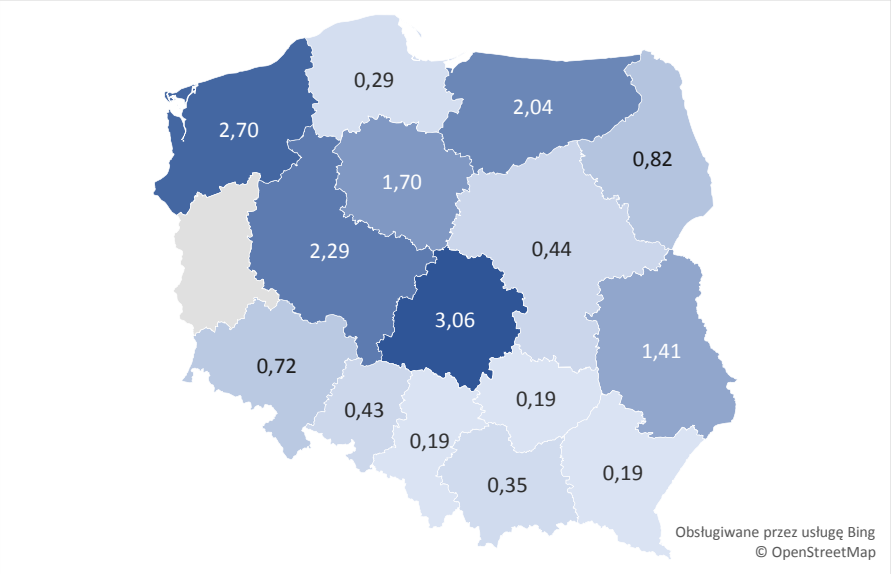

Figure 2. Location quotient (LQ_1) for the installation capacity per number of cooperative members.

Source: Own elaboration based on the List of Energy Cooperatives maintained by the National Support Centre for Agriculture (KOWR).

Based on the data presented in Figure 2, we can observe that the highest value of the location quotient (LQ_1) was recorded in the Łódzkie Voivodeship (3.06). This indicator value suggests that the power of installations per energy cooperative member in this region is more than three times higher than the national average. High values (indicating regional specialization) were also noted in the Zachodniopomorskie (2.70), Wielkopolskie (2.29), Warmińsko-Mazurskie (2.04), Kujawsko-Pomorskie (1.70), and Lubelskie (1.41) voivodeships. In the remaining regions, the index value was below 1.

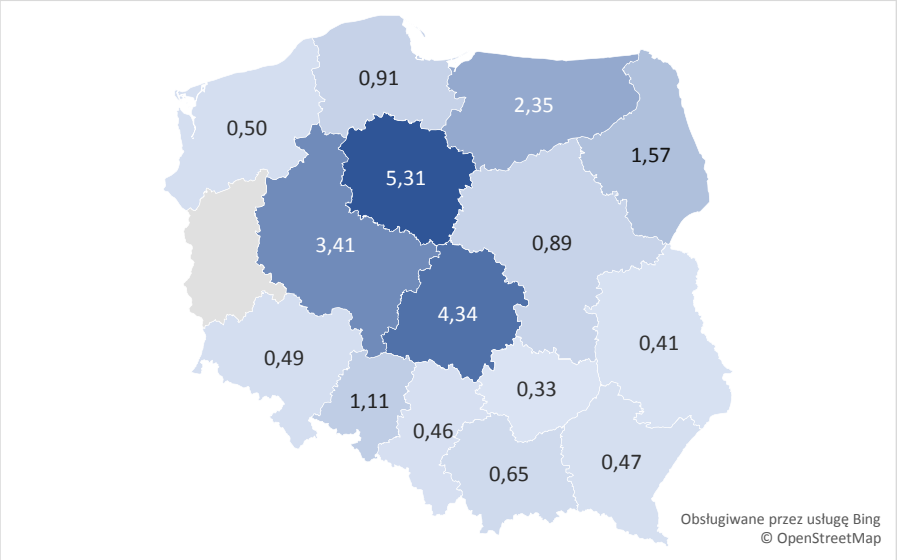

Figure 3. Location quotient (LQ_2) for the installation capacity per number of energy consumption points.

Source: Own elaboration based on the List of Energy Cooperatives maintained by the National Support Centre for Agriculture (KOWR).

Figure 3 illustrates the values of the location quotient (LQ_2) from the perspective of the ratio of photovoltaic installation capacity owned by energy cooperatives to the number of their energy consumption points. The highest values of this indicator were recorded in the Kujawsko-Pomorskie (5.31), Łódzkie (4.34), and Wielkopolskie (3.41) voivodeships, indicating that each energy consumption point is associated with significantly higher photovoltaic installation capacity. Above-average values (LQ2 > 1), albeit much lower, were also observed in the Podlaskie (1.57) and Opolskie (1.11) voivodeships. In the remaining regions, the indicator value was below 1, with the lowest value noted in the Świętokrzyskie Voivodeship (0.33).

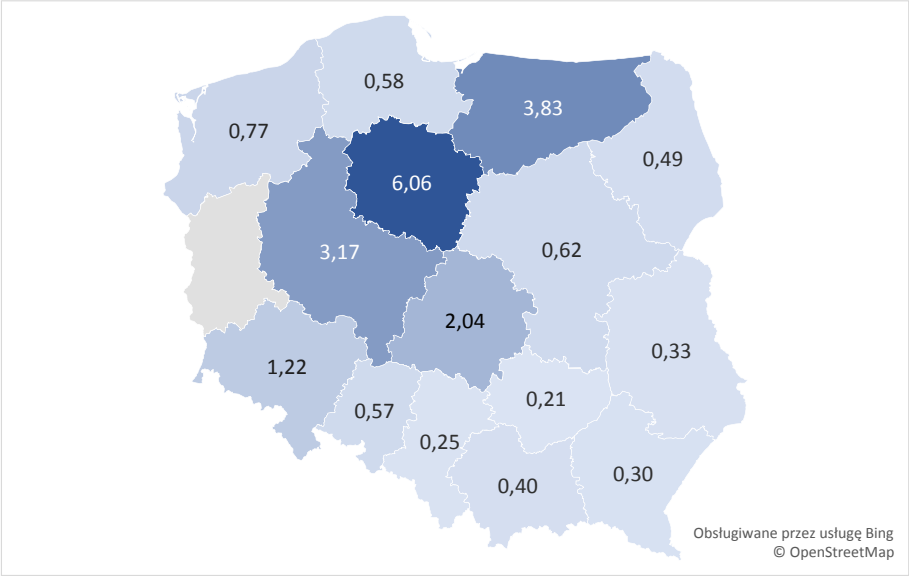

Figure 4. Location quotient (LQ_3) for the installation capacity per number of existing installations.

Source: Own elaboration based on the List of Energy Cooperatives maintained by the National Support Centre for Agriculture (KOWR).

Figure 4 presents the value of the location quotient (LQ_3) for installation capacity per the number of installations. The highest value was observed in the Kujawsko-Pomorskie Voivodeship (6.06), indicating that photovoltaic installations owned by energy cooperatives in this region have more than six times the capacity of the national average. Next, relatively high-capacity installations are found in the Warmińsko-Mazurskie (3.83), Wielkopolskie (3.17), Łódzkie (2.04), and Dolnośląskie (1.22) voivodeships. In the remaining regions, the installations have lower capacity than the national average.

4. Summary

The literature emphasizes that the location of energy cooperatives is spatially diverse (Kostecka-Jurczyk et al., 2024). However, these conclusions were based on an analysis of the distribution of energy cooperative headquarters in Poland. This study focused on analyzing the

location of energy cooperatives from the perspective of the voivodeship in which they operate, considering the capacity of their installations, the number of installations, the number of energy consumption points, and the number of cooperative members.

The obtained values of the location quotient indicators for all three categories are summarized in Table 1.

Table 1.
Voivodeships according to the location quotient index LQ_{1-3}

Voivodeship	LQ power capacity/number of cooperative members	LQ power capacity/number of energy consumption point	LQ power capacity/number of installations
dolnosląskie	0,72	0,49	1,22
kujawsko-pomorskie	1,70	5,31	6,06
lubelskie	1,41	0,41	0,33
łódzkie	3,06	4,34	2,04
małopolskie	0,35	0,65	0,40
mazowieckie	0,44	0,89	0,62
opolskie	0,43	1,11	0,57
podkarpackie	0,19	0,47	0,30
podlaskie	0,82	1,57	0,49
pomorskie	0,29	0,91	0,58
śląskie	0,19	0,46	0,25
świętokrzyskie	0,19	0,33	0,21
warmińsko-mazurskie	2,04	2,35	3,83
wielkopolskie	2,29	3,41	3,17
zachodniopomorskie	2,70	0,50	0,77

Source: Own elaboration based on the List of Energy Cooperatives maintained by the National Support Centre for Agriculture (KOWR).

The analysis of these values reveals significant regional differences, indicating the uneven development of energy cooperatives in Poland. Regional specialization is observed in four voivodeships: Kujawsko-Pomorskie, Łódzkie, Warmińsko-Mazurskie, and Wielkopolskie. In these regions, the location quotient (LQ) value exceeded 1 in all three criteria, highlighting a strong concentration of large photovoltaic farms with high-capacity installations relative to the number of installations, energy consumption points, and energy users.

Voivodeships such as Dolnośląskie, Lubelskie, Opolskie, Podlaskie, and Zachodniopomorskie exhibit regional specialization in only one of the examined aspects.

Regions like Małopolskie, Mazowieckie, Podkarpackie, Pomorskie, Śląskie, and Świętokrzyskie are characterized by a smaller number of installations with lower capacity. This may result from geographical conditions, the investment policies of cooperative members, or the availability of energy infrastructure.

Moreover, it should be noted that the example of the Małopolskie Voivodeship is a good illustration of the value of the location quotient (LQ) analysis as a measure of specialization. It provides a different perspective than if we only considered the number of energy cooperatives operating in a given area.

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