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Energy Revolution Needs Space: Transformations to the Energy Landscapes on the Example of Myslibórz Commune (Poland, Pomerania)

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Abstract:

Purpose: *This article presents the characteristics of landscape changes related to the implementation of the renewable energy development strategy. The aim of the article is to determine the forms and extent of landscape transformation in the West Pomeranian region resulting from the ongoing energy transition.*
Design/Methodology/Approach: *The forms and scale of landscape transformation associated with energy production and transmission are presented on the example of a selected municipality. Using available spatial data, planning documentation and agricultural production statistics, the impact of changes in the structure of the energy sources used on the municipality's landscape structure was estimated.*
Findings: *In the analysed municipality, agricultural production is partly dedicated to energy purposes. Wind investments on large areas of agricultural land were made possible through local spatial planning acts. The greatest impact on the landscape was recognised in terms of photovoltaic investments.*
Practical Implications: *The energy transition contributes to changes in the landscape structure. Despite the low direct impact on the environment, RES investments, due to their large number, can have a significant cumulative impact (visual and functional). Energy crops (especially maize and rapeseed) compete with food crops.*
Originality/Value: *The local example of a typical Pomeranian municipality shows the dynamics and scale of the problems associated with the formation of energy landscapes in open countryside.*

Keywords: *Energy transformation, renewable energy, spatial policy, landscape transformation, Pomerania.*

JEL codes: *Q2, Q4, O2.*

Paper type: *Research article.*

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1. Introduction

One of the most important tenets of the energy transition and decarbonisation of the economy is the development of renewable energy installations related to the use of renewable energy resources (RES). An important aspect of these developments is the increasing demand for undeveloped rural space that can be used for energy production (Pasqualetti and Stremke, 2018). Space is characterised by limited availability due to the fixed size of this resource and the structure of its main elements.

The subordination of space to specific economic functions creates economic space. Significant changes in the development of rural space are led by rural business development - the emergence of companies related to the food sector (production facilities, warehousing, logistics), the development of renewable energy production (wind farms, photovoltaic farms, biomass utilisation installations), the launch of micro-enterprises related to rural basic services and processes of infarstructure development in rural areas (Heffner, 2016).

The development of distributed energy affects the form of agricultural land use in many ways. Solar and wind farms require conversion of use. In the case of wind farms, they do not block agricultural production space but require land for power plant siting, access roads and associated infrastructure. In the case of photovoltaics, the project site is excluded entirely from agricultural production, but this change is relatively easily reversible.

Crops associated with the production of biomass for biogas plants and the fuel additive industry compete with food production. Smart grids with their extensive technical infrastructure also take away agricultural production space.

The construction of new installations in areas not previously associated with energy production not only changes and diversifies the functions of an area (or one of these factors), but also transforms the structure of the existing cultural landscape and its perception (Ryszkowska *et al.*, 2017; Thalassinos *et al.*, 2022).

RES are no longer limited to remote and low population density areas, but appear commonly in urban and rural areas and at the end can achieve significal share in landuse (Oudes *et al.*, 2022).

One of the effects of the 'hunger for space' in rural areas associated with the diversity of distributed forms of energy production is therefore the formation of energy landscapes, in which a significant proportion of land use is related precisely to energy needs. The energy landscape is thus characterised by its own specificity both in terms of visual aspects (perception of space) and functional aspects (Tveit *et al*., 2006; Pociovalisteanu *et al.*, 2010).

The function of open farmland is changing dynamically. Not only are they the site of food production, often with enhanced values, but also are a provider of energy in various forms, through the production of energy raw materials, but also the direct production of energy from renewable resources (Heffner, 2016).

It should also not be forgotten that, due to the shrinking of natural landscapes, they have significant environmental potential (most of the less restrictive area-based forms of nature conservation include precisely agricultural areas, mainly of an extensive nature) and an important importance for recreation and tourism.

Approximately 60 % of space in Poland is agricultural. Their share is declining in favour of urbanised areas and industrial and communication functions, while at the same time the increase in agricultural productivity and overproduction of food allows the acreage under cultivation for food purposes to be reduced. Renewable energy (above-ground industrial installations) influences land use structure.

With its development, the saturation of land with technical infrastructure (installations, networks, roads) increases. The greatest space requirement is for ground-mounted photovoltaic installations. A plot of land on which a 1 MW power plant can be built must be approximately 1.5 -2 ha in size with a minimum width of 40-50 m.

A way to mitigate competition for space (between agriculture and renewable energy) may be to situate photovoltaic installations in the vicinity of motorway junctions - difficult to access for agricultural equipment and exposed to the impact of emissions on the quality of agricultural produce (Hełdak and Werner, 2018).

Any investment in high-speed roads triggers changes in the spatial organisation of agriculture. Areas where agricultural production has ceased are ideally suited for the location of photovoltaic farms, additionally often occupying significant areas, so they can develop significant areas (Heldak and Werner, 2018).

The development of renewable energy is undoubtedly an opportunity for rural areas. It makes it possible to develop fallow land, contaminated land, reclaimed land or marginal soils unsuitable for food production (Wielewska, 2014).

Understanding the functioning of rural energy landscapes can support the changes that energy tranformation entails in spatial unit planning and management processes. Developing 'best practices' can support the resolution of specific spatial conflicts, as well as finding the delicate balance and hierarchy of needs between the spatial demands of food production, environmental protection and energy production.

Therefore, this paper analyses the conditions related to the formation of an energy landscape in an average Central European municipality, located in the western part of Poland, characterised by a varied cultural landscape and a set of factors, typical

for this part of Europe, which favour, but also limit the use of open agricultural land for energy production.

2. Research Area and Methods

The study covered the commune of Myslibórz, located in the southern part of the Zachodniopomorskie Voivodship, in western Poland. It is a commune situated in the Pomeranian Lake District, characterised by great natural wealth and diversity of the landscape constituting a mosaic of forests, lakes and arable fields located on an earthy, hilly, young glacial relief).

The varied relief creates favourable conditions for the location of photovoltaic farms, allowing the installations to be masked in the landscape. The low population density, the compact and large-scale arrangement of agricultural fields and the good wind conditions, facilitate the location of wind farms.

An analysis of the formation of the energy landscape in the municipality was carried out on the basis of recognition of the land components already used and having potential for use for renewable energy purposes. Within the municipality, the status of investments in renewable energy sources (existing and planned locations of wind farms and photovoltaic farms) and the planning conditions favourable for their development (land reserved or recommended in planning documents) were analysed.

The structure of agricultural crops used for energy production (as biomass and fuel additives) was also analysed, using data from the Agency for the Restructuring and Modernisation of Agriculture. In order to estimate the land available for wind turbines, analyses were carried out for the still most popular 100m high devices.

The cumulative visual impact on the landscape was also estimated for a group of photovoltaic farms in the southern part of the analysed municipality, using the visibility analysis (binary viewshed methode, using plugin Visibility Analysis for Qgis) proposed by Kupiec and Dusza-Zwolinska (2021).

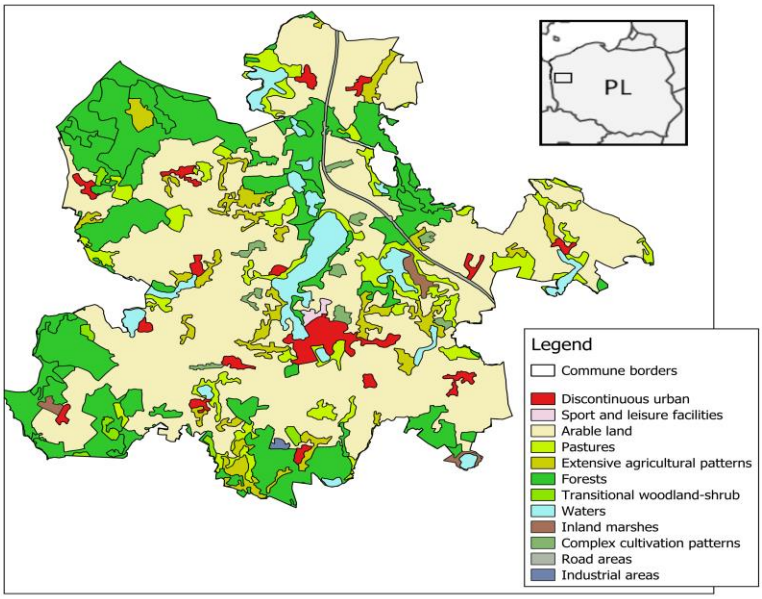
3. Results and Discussion

Open agricultural land in the Myslibórz municipality occupies a significant part of the area. Agricultural land (arable land, pastures, fallow land) occupied 63% of the municipality's area in 2018, forests about 23% and built-up land (buildings, communication and industrial areas) about 6% of the area (Corine Land Cover 2018, Figure 1).

However, due to the varied nature of the relief and the numerous water bodies and wet depressions, the landscape has the character of a mosaic of areas with different character. The specific nature of agriculture in Western Pomerania, resulting from historical and economic conditions, means that large-scale agricultural plots of

various shapes predominate. It lacks the ribbon-and-belt systems characteristic of the central regions of the country.

Figure 1. *Land use of the Myslibórz municipality (own elaboration based on Corine Land Cover data, 2018)*



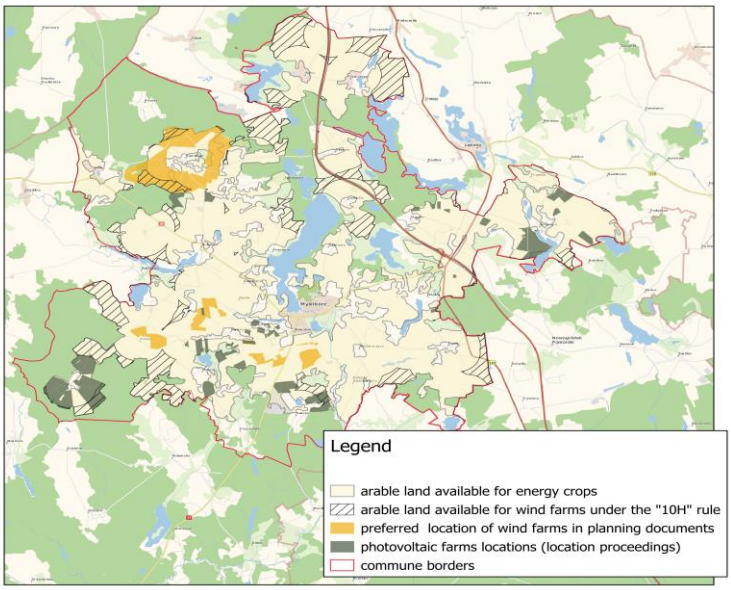
Source: *Own elaboration.*

Large farms dominate here (32ha in the Zachodniopomorskie Voivodeship), which are in fact still functionally enlarged due to the widespread leasing of large areas. The dominance of ownership forms is also an important feature: companies and cooperatives dominate in terms of acreage, covering about 90% of agricultural land, and dwarf family farms accounting for 77% of the number of farms cover the remaining percentage (SUiKZ, 2018).

This spatial characterisation of plots favours the location of installations based on renewable energy sources, both in terms of the required planning procedures and administrative decisions, technical feasibility and economic efficiency. The municipality is dominated by good soils of quality class III accounting for 52% of arable land complemented by medium soils of quality class IV (40%).

Crops are dominated by staple cereals and, due to the good soils and ownership structure, agriculture is intensive. The poorer soils concentrated around towns and marginal habitats provide a good spatial base for the development of buildings and protective functions of areas with high natural potential.

Figure 2. *Determinants of energy landscape development in the study area (own elaboration)*



Source: *Own elaboration.*

During the period of maximum interest in the construction of wind farms in Poland (up to 2015), the will of the municipal councils constituting local law included in local spatial development plans the possibility of locating wind farms in a significant part of the area. In the legal system at that time, rigid restrictions related to the minimum distance of turbines from built-up areas were not specified.

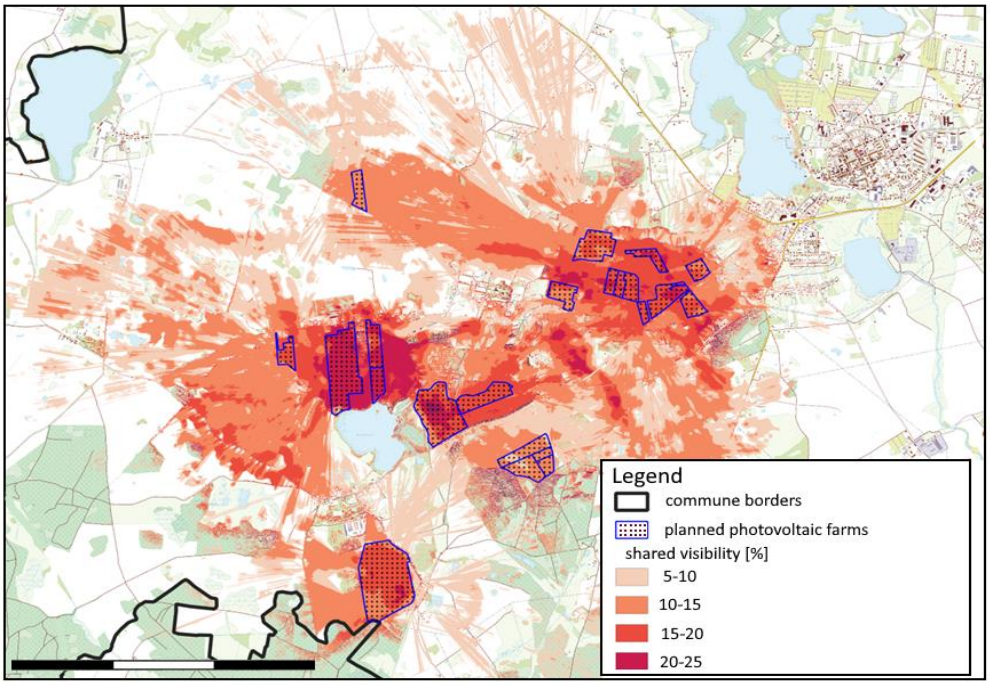
Thus, agricultural areas were designated on open hills, located a few hundred metres from the nearest buildings with good access to local roads. In mid-2016, the provisions of the Act of 20.5.2016 on investments in wind power plants (Journal of Laws 2016, item 961) introduced the so-called 10h rule enforcing the use of a distance between a wind power plant and a residential building (and vice versa) equal to ten times the height of the power plant, regardless of the actual extent of its negative impact.

In April 2023, liberalised regulations came into force replacing the 10h rule with a minimum distance of 700m. The distance regulations introduced in 2016 drastically reduced the spatial potential for the location of wind energy installations.

The situation is no different in the analysed municipality, where the land available for the location of wind turbines has shrunk to about 12% of the area of agricultural land, for a height of 100m, which is popular for investments (Figure 2), and only 3 turbines built before 2015 are in operation today.

At the same time, it should be noted that due to the lower population density and structure of agricultural land in the West Pomeranian Voivodeship, the situation here in this respect compared to the rest of the country is still significantly better (Gnatowska and Moryń-Kucharczyk, 2019).

Figure 3. Estimated cumulative visual impact range of a group of photovoltaic farms in the southern part of the analysed municipality (based on Szczepański, 2023)



Source: *Own elaboration.*

In the case of photovoltaic installations, a significant limitation of their location on arable land is the collision with its high bonitification and the resulting protection against change of use for non-agricultural purposes.

The necessity to change the use of land from agricultural to other uses for soils in classes I-III makes them practically excluded from location due to the lengthiness and arduousness of such a procedure (Law on Protection of Agricultural and Forestry Land, 1995).

In the analysed municipality, only in 2023, 34 administrative proceedings (on 67 land parcels) were underway to establish conditions for the realisation of photovoltaic farms. The planned investments covered nearly 6% of the municipality's agricultural land area, concentrated in its southern part (around the village of Chłopowo) where their implementation will change the way of farming on the vast majority of the agricultural land located there.

Apart from the functional aspect, the cumulative visual effect of the investment becomes important in the case of such a large concentration, despite the excellent screening conditions created by the hilly, mosaic landscape of the terminal moraine. Figure 3 shows the overlap of visual impact ranges for a dozen developments to the southwest of the municipal capital. Another factor limiting the potential development of this form of energy production is the availability of smart transmission networks to ensure the reception of the distributed energy produced (Iglinski *et al.,* 2023).

An energy production activity in the RES that is less evident in the landscape, but has a significant impact on the functioning of the economic system of the area, is crop production for energy purposes. This includes plant production of species dedicated strictly to use in incinerators or biogas plants (e.g., energy willow) and crops for which the energy function is one of the options for later use.

Under Polish agricultural conditions, this concerns maize crops, which are readily used in local biogas plants, rapeseed crops, which are used in the fuel additive industry, and the energy use of straw left over from cereal crops. Due to the properties of the soils in the area of the municipality under consideration, rapeseed crops in particular have been popular in recent years and have been growing rapidly.

Between 2020 and 2023, their acreage in the municipality almost doubled from 1710 to 3313 ha (Table 1), matching that of the main cereals. The acreage of maize does not change significantly, but it should be noted that for this crop the yield is very often exported to nearby biogas plants in Germany (Stolarski *et al*., 2020). It is very difficult to estimate what the actual share of energy use is for the crops presented, especially for the use of cereal straw. In the overall EU-wide agricultural product flows, it reaches 4% for maize and about 12% for rape (Avitabile *et al*., 2023).

Table 1. *Main spatial elements of energy landscape in research area (data for 2023, own elaboration)*

Type of landuse	*Area [hectares]*	*Share of commune area [%]*	*Share of commune arable land [%]*
Arable lands reserved for wind farms	*1082*	*3.29*	*6.25*
Photovoltaic farms	*981*	*2.98*	*5.67*
Maize crops	*683*	*2.08*	*3.95*
Rapeseed crops	*3313*	*10.08*	*19.15*

Source: *Own elaboration.*

4. Conclusions

The presented analysis shows that despite the initially promising physiographic and economic conditions for the development of various forms of renewable energy, the

legal, organisational and spatial realities significantly limit the possibilities of locating this type of investment. Even under the conditions of a less urbanised Pomerania, with its open cultural landscapes, there is not enough space for RES and the only form available becomes the energy use of crops, resulting, however, in increasing competition with the needs of food production, in sectors where the European Union relies heavily on imports anyway (Avitabile *et al*., 2023).

Renewable energy, especially in the form of ground-mounted photovoltaic installations, competes for space mainly with agricultural production. This is because it is characterised by the highest rate of land requirement per unit of energy production (1.5-2.0 ha per 1 MW). A factor limiting the development of renewable energy based on energy installations is the high quality of arable soils which are protected from change of use for non-agricultural purposes.

Dynamic development of renewable energy resulting in permanent change of land use affects the landscape. The accumulation of these impacts in a limited area is causing increasing public concern and these are the reasons for the restrictions introduced in the local law regarding the conditions for the location of such installations.

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