

THE POTENTIAL OF RENEWABLE ENERGY ON AGRICULTURAL LAND

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Abstract. The need for electricity and its extraction without stimulating climate warming processes are currently more relevant than ever. Using wind energy to generate electricity is one of the most promising methods. When designing wind energy parks, it is necessary to choose a suitable place for their installation. This study examined the suitability of plots for the construction of these structures in the areas of abandoned land in non-urbanized and non-urbanized areas. In the course of the research, various limitations were examined, the territory was analyzed using geoinformation systems. Modeling of the selected territory has been carried out, areas suitable for the installation of wind energy plants have been identified. It was established that the total area of land that can be used for the installation of wind energy plants is small and the criterion of abandoned land is not the indicator on the basis of which it can be stated that the territory is suitable for the construction of wind energy plants.

Key words: renewable energy, wind energy; abandoned agricultural land.

Introduction

Reducing the amount of CO₂ in the atmosphere is an important issue in the context of climate change. One option is to generate electricity without increasing carbon dioxide emissions. Renewable energy sources, such as water power, solar power, wind power, etc., are used for this purpose. The European Commission has set a target of reducing greenhouse gas emissions by at least 55% by 2030. In line with these recommendations, the European Union (EU) encourages the installation of power plants that use renewable sources. One such source is wind. In 2022, 19 GW of new wind turbines (WT) will be installed in the EU, but this is not enough to meet the European Commission's climate and energy targets. Between 2023 and 2027, 129 GW of wind power capacity is expected to be installed in European countries, of which 98 GW will be installed by EU countries. Three-quarters of this capacity is expected to be installed onshore and the rest offshore. To meet the targets, the EU must build 30 GW of new wind power capacity annually (<https://windeurope.org/intelligence-platform/product/wind-energy-in-europe-2022-statistics-and-the-outlook-for-2023-2027/>).

The capacity of all wind turbines built in Lithuania this year exceeded 1 GW. This is only one fifth of the total capacity to be installed in Lithuania by 2030. Onshore wind turbines are expected to have a capacity of 3.6 GW and offshore parks 1.4 GW. Since 2020, there has been an increase in wind power capacity.

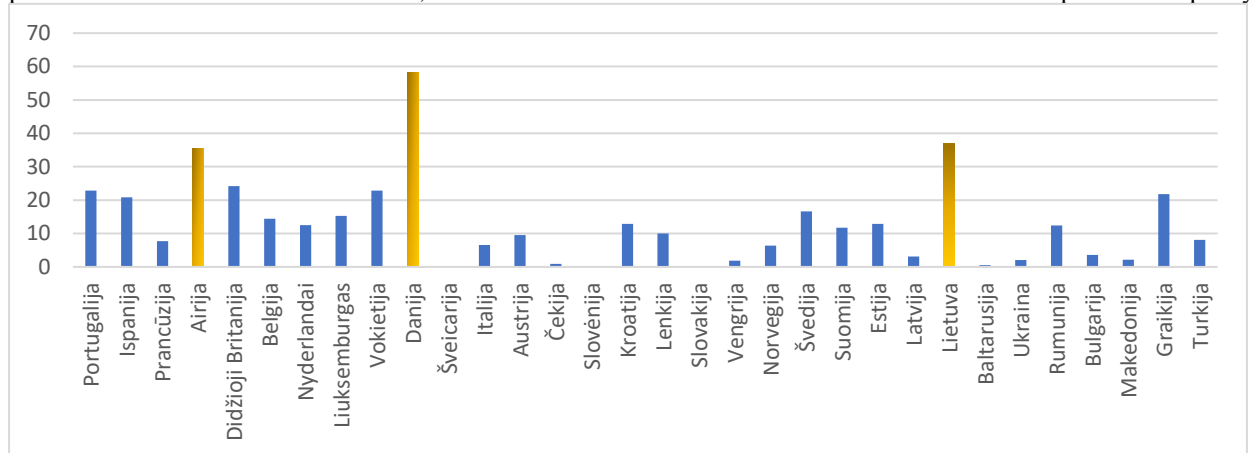


Figure 1. Amount of electricity generated by wind turbines as a percentage of total electricity generated in European countries (percentage) (<https://www.bp.com/en/global/corporate/energy-economics/statistical-review-of-world-energy.html>)

As can be seen from Figure 1, Denmark, Ireland and Lithuania account for the largest share of the country's total electricity generation capacity from wind turbines.

In Lithuania, as in other countries, there are various restrictions that have to be taken into account when installing wind turbines. The choice of site for this type of installation is rather complicated and depends on different terrain conditions. Various authors have investigated the suitability of sites for wind turbines in abandoned mines (Luo, 2014), abandoned agricultural land (Tumeliene *et al.*, 2022), sensitivity analysis of factors affecting site location (Rezaei *et al.*, 2020) and the various criteria selected (Dehshiri *et al.*, 2022). Depending on the number of factors selected, different results can be obtained for the same location. This study will investigate the suitability of abandoned land in the selected area to accommodate wind turbines.

The aim of the study is to investigate the suitability of abandoned land in Tauragnai eldership for the construction of wind turbines, taking into account the criteria restricting their construction.

Methodology of research and materials

The Tauragnai eldership, located in the eastern part of Lithuania, in the Utena district, was selected for the study (Figure 2). The area of the eldership is 213.6 km². Part of the eldership is covered by the Aukštaitija National Park, and it contains the town of Tauragnai and 85 villages and farmsteads (<http://www.tauragnai.eu/apie-tauragnu-seniunija>). The eldership was chosen because it is part of the 'belt' of abandoned land in eastern Lithuania (Puziene, Anikieniene, 2020).

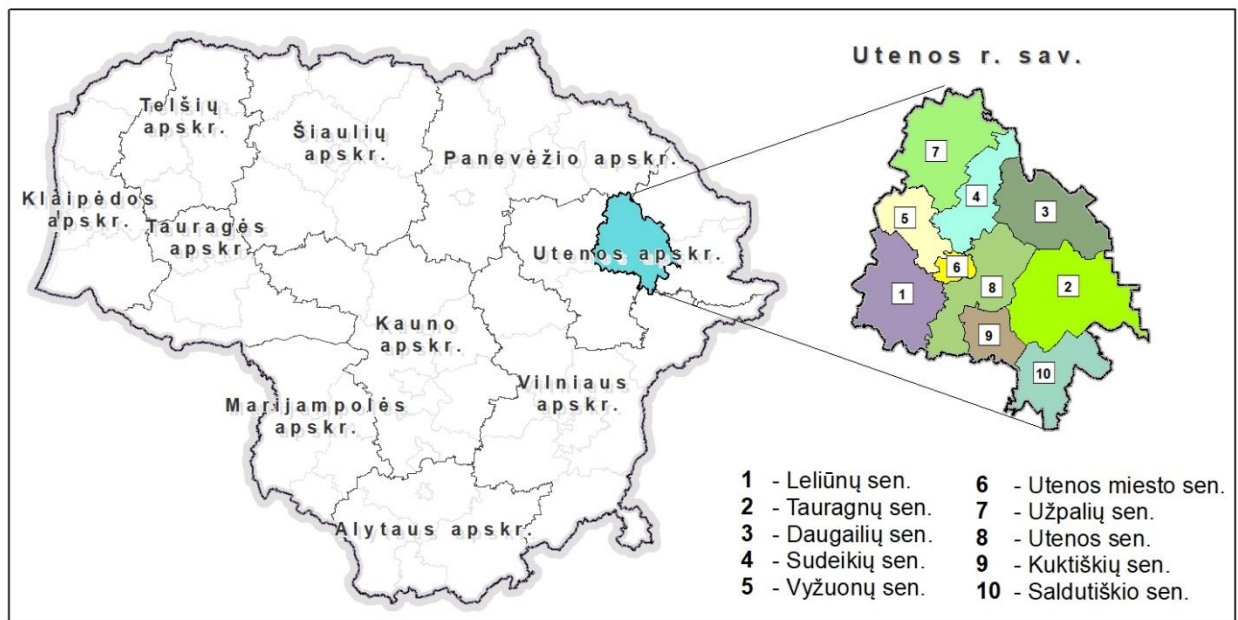


Figure 2. Tauragnai eldership

The following criteria were chosen for the study:

1. On 15 February 2016, by order of the Commander of the Lithuanian Armed Forces, a map of the territories of the Republic of Lithuania, where the design and construction of wind turbines may be restricted, was approved.
2. Aukštaitija National Park.
3. Žiezdriai Landscape Reserve.
4. Ažvinčiai (Gervėčiai Sengirė) Nature Reserve.
5. NATURA2000:
 - 5.1. Aukštaitija National Park (BAST)
 - 5.2. Western part of Aukštaitija National Park (PAST)
6. Natural heritage sites:
 - 6.1. Botanical natural heritage sites,
 - 6.2. Hydrogeological natural heritage sites,
 - 6.3. Zoological natural heritage sites,
 - 6.4. Geological natural heritage sites,
7. Real cultural heritage sites.
8. Sites of importance for the protection of biodiversity

- 8.1. Forest habitats
 - 8.2. Grassland habitats
 - 9. Mineral deposits.
 - 12. Protected area for water bodies.
 - 13. Water bodies protection zone.
 - 14. Transport and engineering environment.
- Spatial dataset on abandoned agricultural land downloaded from www.geoportal.lt.

The data were processed and analyzed using ArcGIS software. The areas of abandoned land in Tauragnai eldership are presented in Figure 3.

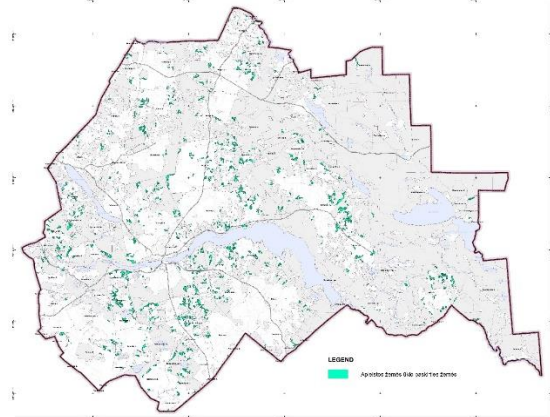


Figure 3. Location of abandoned agricultural land

Discussions and results

Once all the layers were loaded into the software package, the terrain was modelled. The area of abandoned land in the eldership is 278.6 ha and the eldership area is 21355.5 ha. The area of abandoned land covers 1.3% of the total area of the eldership. This does not seem like a lot, but the eldership is one of the areas with the highest percentage of abandoned lands. If the abandoned land criterion were relevant for the selection of sites for the installation of WT, it could be used as one of the main criteria during the preparation of the projects, which would facilitate the work of the designers.

In the first stage of the work, the map of the territories of the Republic of Lithuania where the design and construction of wind turbines may be restricted was uploaded, approved by the Order of the Commander of the Lithuanian Armed Forces. A visual assessment was carried out, and a "cut-off" of the abandoned land layer was made to identify the area prohibited for construction. At the same time, the areas covered by the Aukštaitija National Park were eliminated (Figure 4). As this area is completely unsuitable for wind turbine construction due to the prohibitions in place and covers a continuous area, the abandoned land in these areas was discarded without applying any occupancy survey for buffer strips/protection zones.

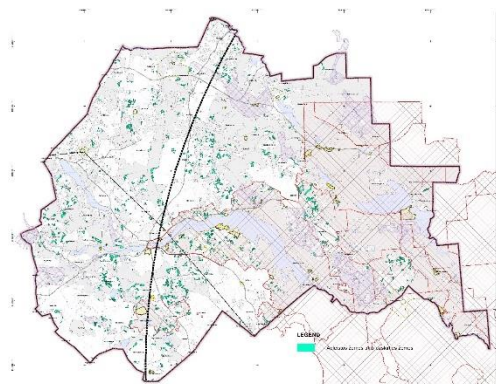


Figure 4. Areas where

Figure 4 shows that when analysing the suitability of abandoned land areas or other selected sites for wind turbines, it is important to analyse all the constraint criteria thoroughly, not just the protected areas, forestry cadastre and water layer, as sometimes chosen by other researchers. The absence of any one criterion may lead to erroneous results in the analysis.

In the course of further research, all remaining boundary layers were activated (Figure 5) and a comparison was made between them and the overlaps of the protection zones with the areas of abandoned land.

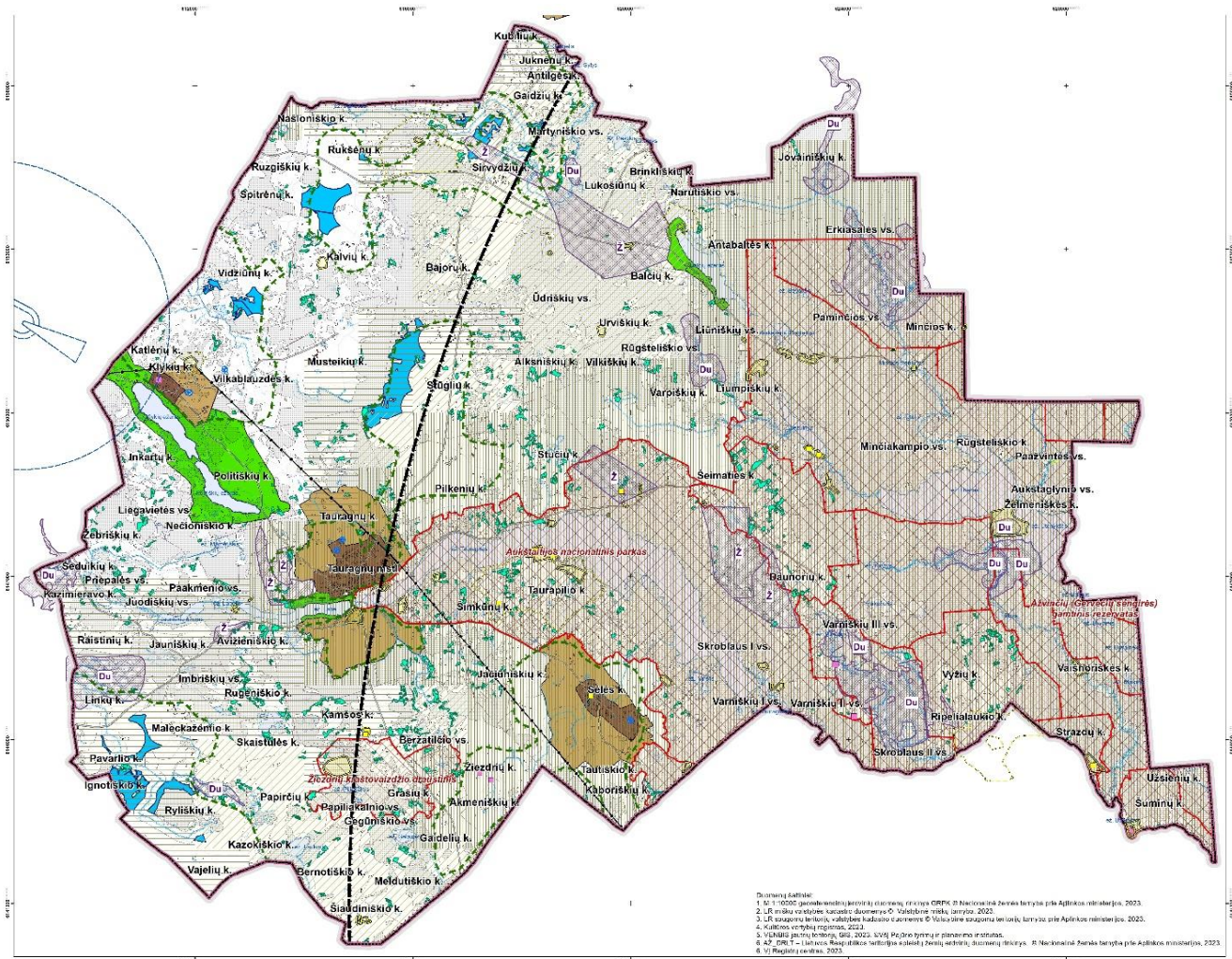


Figure 5. Criteria for limiting the installation of wind turbines in Tauragnai eldership
 The amount of abandoned land included in the areas covered by the restriction criteria and the size of the buffer zone applied are shown in Table 1.

Table 1.

Restriction zones and their parameters.

Name of restriction	Area of abandoned land in the protection zone, %	Restriction zone size, m
Aukštaitija National Park	54.8	2000
Žiezdriai Landscape Reserve	24.3	2000
Ažvinčiai (Gervėčiai Sengirė) Nature Reserve	1.8	2000
NATURA2000: Aukštaitija National Park (BAST) Western part of Aukštaitija National Park (PAST)	54.8 54.8	2000
Natural heritage sites	0.1	100
Real cultural heritage sites	9.2	200
Sites of importance for the protection of biodiversity: Forest habitats	0.1	-
Grassland habitats	0.3	-
Mineral deposits	2.9	-
Protected area for water bodies.	5.4	500
Water bodies protection zone	17.3	500
Transport and engineering environment	10	20-150*

*depending on the type of transport/engineering environment.

The data in Table 1 shows that the restricted areas cover a significant proportion of abandoned land, however, bear in mind that there may be overlapping areas - the same site may fall within the impact zone of more than one restriction. In order to avoid the possibility that areas may be wrongly excluded for this reason, we carry out a further analysis to identify the area that is generally suitable for wind turbines. We then exclude areas of abandoned land. The results are shown in Table 2.

Table 2.

Areas suitable for wind turbines in Tauragnai eldership.

	ha	%
The area falling within the potential construction area of the WT	221.6	1.0
Area of abandoned land falling within the area available for the construction of a WT	5.1	1.8

The areas of visually suitable abandoned land for the construction of a WT are shown in Figure 6. As can be seen from the survey results presented in this figure, the number of potential wind farm sites is limited. The areas of abandoned land in these areas are negligible and insignificant. Of the total area of abandoned land, only 5% is suitable for the construction of wind turbines, which represents 0.02% of the total area of the eldership. As much as 95% of the abandoned land is not suitable for the construction of WT due to the existing restrictions. On this basis, it can be concluded that the criterion of abandoned land is not relevant for the selection of sites for renewable energy plants.

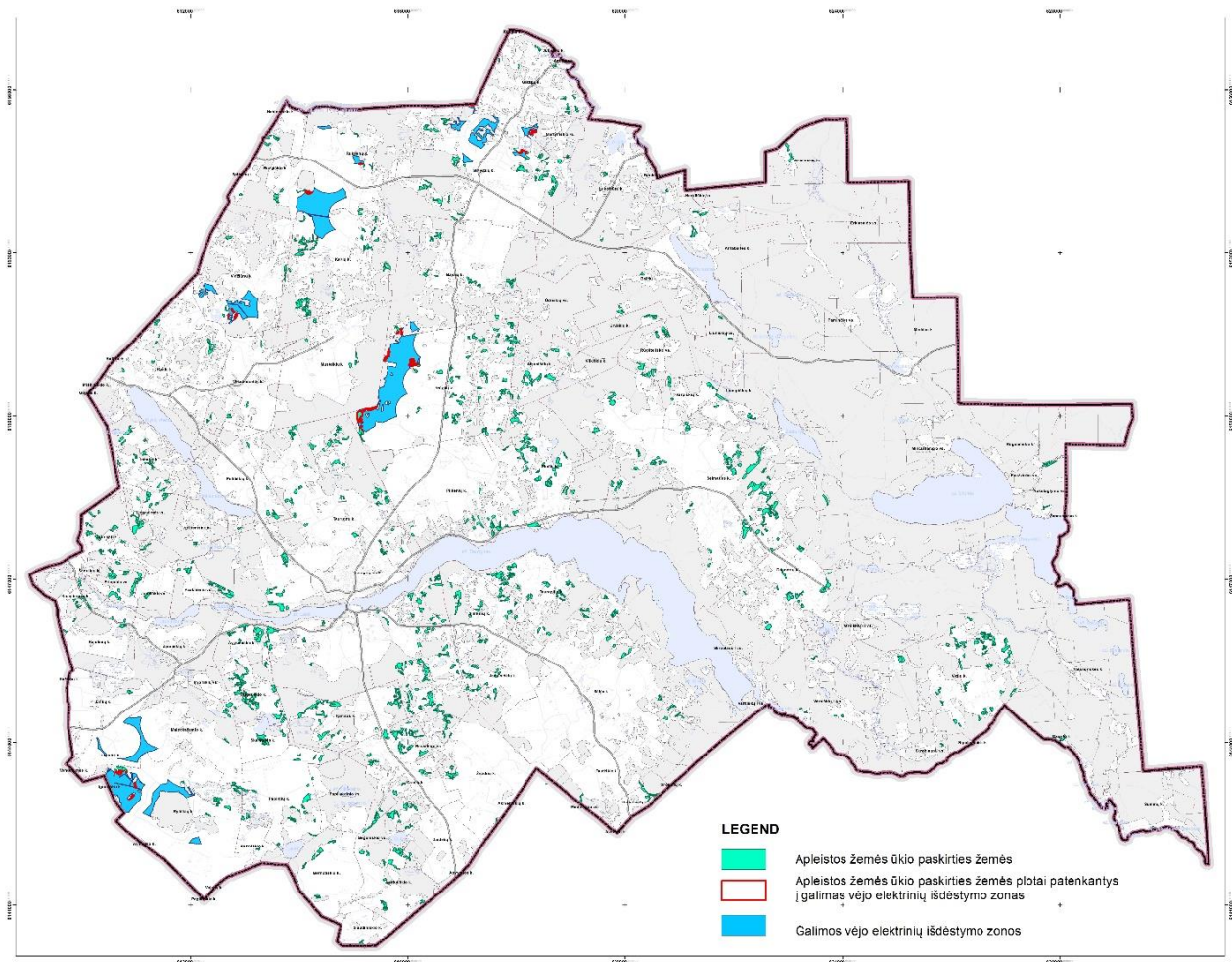


Figure 6. Areas of abandoned land suitable for wind turbines

Conclusions and proposals

Lithuania ranks third in Europe in terms of the amount of electricity generated by wind turbines (as a share of the country's total electricity production). The total capacity of all wind turbines built in Lithuania in 2023 will exceed 1 GW, but this is only a fifth of the total capacity to be installed by 2030.

There are a number of constraints when selecting sites for wind turbine constructions. Comparing the results obtained in the study with those published by other authors, it can be seen that if at least one constraint is not included in the analysis, the results differ significantly.

The Tauragnai eldership has only 221.6 ha suitable for the construction of WT. This area includes 5.1 ha of abandoned agricultural land, which is only 1.8% of the total abandoned land in the eldership. Although this eldership has one of the largest amounts of abandoned land in the Republic of Lithuania, the criterion of abandoned land is neither a decisive one nor a suitable one for selecting a site for a wind turbine.

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