

TERRITORIES PLANNING FOR THE USE OF RENEWABLE ENERGY SOURCES AS AN IMPORTANT AREA OF SUSTAINABLE LAND MANAGEMENT

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ABSTRACT Effective land management in the context of renewable energy development is an important area of modern scientific and practical activity. The article discusses topical issues of renewable energy sources (RES) integration into spatial planning and land use, taking into account their impact on ecosystems, socio-economic conditions and possible land conflicts. Particular attention is paid to the challenges associated with the use of land for solar power plants, wind farms and bioenergy complexes. The article emphasizes that the development of renewable energy sources requires significant areas of land, which necessitates strategic planning and minimization of negative environmental impact. The article highlights global and national trends in the introduction of renewable energy, especially in the context of Ukraine's post-war recovery. The expediency of using degraded and contaminated lands for the placement of renewable energy facilities is substantiated, which will optimize spatial development and contribute to the country's energy independence. The methodological basis of the study is the analysis of legal acts, international experience and scientific approaches to land management in the field of renewable energy. The article also discusses potential risks and limitations that may arise during the implementation of renewable energy projects. The possibilities of attracting crowdinvesting in renewable energy projects are discussed separately, which will allow not only to finance the development of energy infrastructure, but also to attract the general population to participate in the energy sector. The results obtained will contribute to the formation of effective land management strategies and their integration into sustainable development policy, both in Ukraine and in Poland.

MATERIALS AND METHODS The research methodology is based on the analysis of scientific papers and regulations governing land management and renewable energy development, as well as on the study of international experience in integrating RES into spatial planning. The theoretical and methodological basis is the concepts of sustainable development, green energy, and landscape planning. In the course of the study, the methods of analysis and synthesis were used to summarize modern approaches to land management in the context of renewable energy development.

Spatial Resources for RES Development in Poland and Ukraine

The effective development of renewable energy sources is strictly dependent on the availability of suitable spatial resources. In Poland, significant degraded land resources include post-extraction sites, mining waste heaps, closed landfills, and post-industrial areas within urban agglomerations. Examples of effective utilization of such areas include the installation of the "Silesia Solar" photovoltaic farm in Bytom and photovoltaic farms on closed landfills in Ruda Śląska.

Similarly, in Ukraine, spatial resources used for the development of RES include areas degraded by industrial activity, urbanization, and warfare. A significant portion of agricultural land currently requires reclamation or alternative management.

In both countries, a crucial element for effective spatial management for RES installations is the creation of integrated systems for the inventory of degraded land and the development of digital registries of potential locations.

Spatial Problems and Social Conflicts Related to RES Development

The development of RES generates numerous spatial and social problems. In Poland, controversy was sparked by the "10H rule," which limited the possibility of locating wind farms close to residential buildings, thereby significantly restricting sectoral growth. The 2023 amendment partially relaxed these restrictions, allowing for flexible adjustment of distances through local spatial planning. Conflicts also concern the location of photovoltaic farms on high-quality agricultural land, raising concerns about the permanent loss of landscape values and agricultural functions.

In Ukraine, similar problems stem from the lack of mature planning mechanisms and the effects of warfare. Degradation of agricultural land and limited spatial planning control hinder the harmonious implementation of RES projects.

Mechanisms for Financing the Development of Renewable Energy Sources

In Poland, the development of RES is supported through national subsidy programs ("My Electricity", "Agroenergia"), EU funds (RRP, Operational Programme Infrastructure and Environment), and crowdinvesting initiatives (Beesfund, Crowdway). These instruments enable the engagement of various social groups and financial institutions in the implementation of RES projects.

In Ukraine, the traditional "green tariff" system has been partially replaced by new auction-based support mechanisms, while interest in community-based financing forms is growing, particularly at the local level. Stability of support systems, simplification of administrative procedures, and reduction of investment risks remain key conditions for further growth of the RES sector in both countries.

Utilization of Degraded Lands for RES Purposes

In Poland, examples of effective utilization of degraded lands include photovoltaic farms on mining waste heaps and closed landfills. Polish practice highlights the importance of systematic land inventory and adaptation of sites to new functions in accordance with the principles of sustainable development.

In Ukraine, the challenges related to the use of degraded lands are intensified by the consequences of warfare. Rational management of these areas through the development of RES installations may constitute an important element of economic and ecological recovery.

Social Models and Participation in Energy Transition Processes

In Poland, the development of energy cooperatives and energy clusters fosters local acceptance of RES projects. Consultation procedures and the transparency of investment processes strengthen social consensus around energy transition.

In Ukraine, the model of social participation is at an early stage of development; however, growing interest in energy communities supporting local energy resilience is observable.

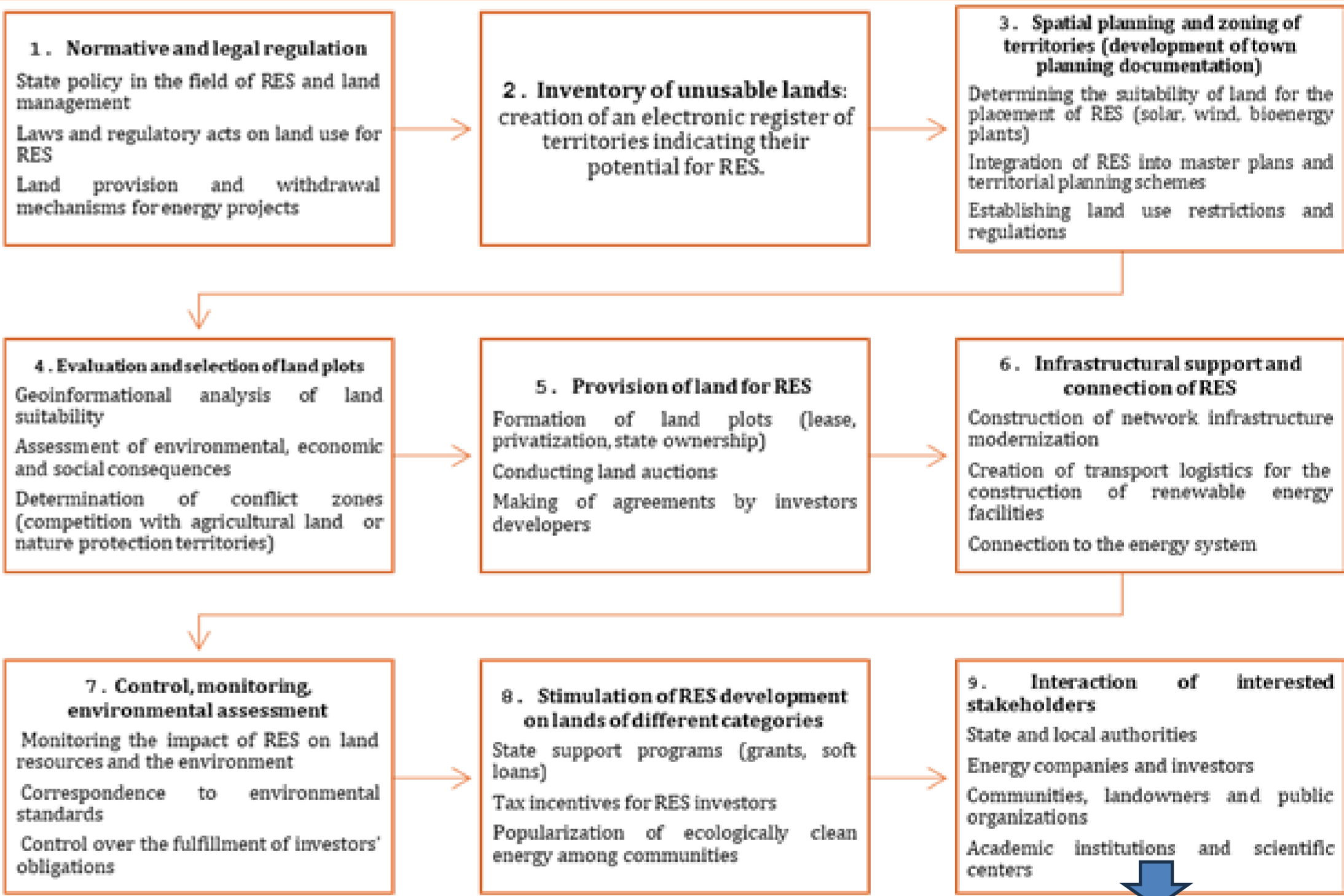
RESULT Table 1 shows that to establish the prospects for the development of renewable energy in Ukraine, calculations are made on their potential, which are periodically updated by various groups of experts, estimated as of 2022 at more than 98.0 million tons of oil equivalent annually. At the same time, in Poland this indicator is at the level of 77.0 million tons.

Table 1 Technically achievable potential of energy production from renewable energy sources and alternative fuels in Poland and Ukraine

№	Areas of RES development	Annual technically achievable energy potential [million tons of conventional fuel]	
		Ukraine	Poland
1.	Wind energy	28.0	24.0
2.	Solar energy, including	6.0	8.5
3.	Small-scale hydropower industry	3.0	2.5
4.	Bioenergy, including:	31.0	22.0
5.	Geothermal heat energy	12.0	6.0
6.	Environmental energy (heat pumps)	18.0	14.0
Total volume of replacement for traditional fuel and energy resources		98.0	77.0

An effective increase in energy production from renewable sources in the region is possible only if there is an appropriate natural resource potential.

The geographical location of renewable energy facilities varies depending on the type of renewable energy source that corresponds to the natural potential of a particular region of our country.



Financing investment projects for the placement of RES through crowdinvesting

Figure 1. Structural and logical scheme of land management for the development of renewable energy sources.

Crowdfunding is gaining popularity around the world today as a method of collective financing in which a large number of people invest in projects or companies through special online platforms. This will enable local communities to finance the construction of solar and wind power plants and other environmental initiatives. This approach allows attracting funds from a wide range of investors, promoting the development of sustainable projects and the efficient use of unsuitable land. The introduction of crowdinvesting in renewable energy will not only help reduce dependence on traditional energy sources, but will also allow the efficient use of degraded or unsuitable agricultural usage land. Involving the public in financing such projects through crowdfunding platforms will increase transparency and trust in the initiatives, as well as ensure broad support for sustainable development and environmental solutions.

CONCLUSION Effective land management in the context of renewable energy development is a key factor in ensuring Ukraine's sustainable development, especially in the context of post-war recovery. Given the growing need to use land for solar, wind, and bioenergy plants, it is necessary to develop comprehensive approaches to spatial planning that take into account environmental, social and economic aspects. Ukraine has significant potential for the development of this sector, but its realization requires proper land management, legal regulation and prevention of land conflicts. Much of the country's land resources have been degraded due to industrialization, military operations and man-made disasters.

The use of such territories for renewable energy facilities could be a strategic solution that would optimize land use, reduce environmental impact, and contribute to the country's energy independence. It is necessary to improve the legislative framework for the integration of renewable energy sources (RES) into spatial planning, in particular, to define criteria for the use of degraded and contaminated land, as well as to introduce financial and administrative mechanisms to stimulate the deployment of RES in unproductive areas. It is important to use geographic information systems to optimize spatial planning, ensure the involvement of local communities through consultation mechanisms and public hearings, and adapt the best practices of EU countries for effective land management in the context of RES development.

The analysis of the experiences of Poland and Ukraine indicates the possibility of developing synergies in legislation, land inventory, spatial planning, and RES financing mechanisms. Joint research and development initiatives, knowledge transfer, and the integration of actions within the framework of the European climate and energy policy may contribute to accelerating the energy transition in both countries and to strengthening socio-economic stability in the Central and Eastern European region. Further research and implementation of effective land management mechanisms will minimize negative consequences and ensure a harmonious combination of energy transition with the needs of society and the environment.

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