

ECONOMIC, ENVIRONMENTAL AND SOCIAL ASPECTS OF GROWING PHYTOENERGY CROPS AND THEIR USE IN BIOENERGY

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Contemporary challenges associated with energy insecurity, climate change, the need to restore degraded land, and the ensuring sustainable development of the agricultural sector require the search for new sources of renewable energy. For Ukraine, this issue is of strategic importance, as the cultivation of energy crops can simultaneously provide a local feedstock base for biofuel production, reduce dependence on fossil energy resources, and create additional opportunities for rural development [1, 2].

Ukraine has considerable potential for the development of energy crop production. According to estimates from the Ukraine Bioenergy Association, the potential of energy crops can reach 7.45 million tons of equivalent oil per year if approximately 2 million hectares of agricultural land currently unused are brought into cultivation [2]. Promising phytoenergy crops include miscanthus, energy willow, poplar, switchgrass, sweet sorghum, grain sorghum, cup plant, Jerusalem artichoke, tuberous sunflower, and other crops characterized by high biomass yields and suitable for the production of solid biofuels, biogas, biomethane, and other energy products.

The economic efficiency of growing phytoenergy crops is primarily determined by biomass yield, its moisture content and energy value, the duration of plantation utilization, the costs of establishing and maintaining crops, the requirements for fertilizers and plant protection products, harvesting, transportation and feedstock preparation costs, as well as the stability of the market for biomass sales. Unlike conventional annual crops, perennial phytoenergy crops can provide biomass yields for several years after plantation establishment, thereby reducing the proportion of annual expenditures associated with primary tillage and sowing.

An important economic advantage is the possibility of using low-productivity, degraded and temporarily unused land for energy crop production where their suitability for food crop cultivation is limited. In this case, biomass production should not create direct competition with food production. At the same time, the economic feasibility of this approach is largely dependent on the availability of local biomass consumers and an appropriate logistics infrastructure. The establishment of energy plantations should be integrated with the development of local boiler houses, heat-generation facilities, pellet and briquette production enterprises, as well as biogas and biomethane plants.

The environmental component of the production of phytoenergy crops requires particular attention. Their use in bioenergy contributes to the substitution of fossil energy carriers and may potentially reduce greenhouse gas emissions. Energy plantations can also perform soil protection and phytomeliorative functions, contribute to the accumulation of organic matter in the soil, reduce erosion processes, and enhance soil biological activity [3]. This approach is particularly promising for areas where soil cover has been degraded as a result of intensive agricultural practices or other adverse impacts.

For the Steppe zone of Ukraine, the selection of crops capable of producing substantial biomass under conditions of limited precipitation and high temperature stress is highly relevant. Therefore, in conjunction with perennial crops, it is advisable to introduce drought-tolerant sorghum and species of the aster-family of phytoenergy crops that can ensure stable biomass production under insufficient moisture conditions. Improving cultivation technologies based on biologization, rational fertilization, the use of biological preparations, and minimization of unproductive water losses are of particular importance.

The environmental efficiency of energy crops should not be assessed solely by the amount of biomass produced. The entire life cycle of biofuel production and use should be considered, including soil preparation, fertilizer production and application, fuel consumption, harvesting, drying, transportation, processing, and direct energy generation. Therefore, technologies capable of ensuring high biomass productivity with minimal resource consumption are particularly promising. An important approach involves the application of micronutrient fertilizers and plant-residue biodecomposers, which contribute to more efficient nutrient cycling within the soil–plant–biomass system and can improve the efficiency of fertilizer utilization [4].

The social impact of the development of phytoenergy is manifested primarily in the creation of new jobs, the generation of additional income opportunities for agricultural producers, the development of small and medium enterprises and the improvement of the self-sufficiency of the energy of local communities. The use of locally produced biomass for heat generation can reduce the dependence of communities on centralized supplies of fossil fuels. This is particularly important for rural areas, where local value chains can be established, which encompass crop cultivation, biomass harvesting, processing, energy generation, and final consumption.

The development of phytoenergy can also contribute to the restoration of economic activity in territories affected by the consequences of military actions. The utilization of low-productivity or temporarily unused land for energy crop production, subject to prior evaluation of their safety and suitability, may become one of the directions for agricultural recovery. At the same time, such projects require extensive planning, as the establishment of energy plantations without a guaranteed market for biomass and adequate logistics may involve significant economic risks.

The use of phytoenergy crop biomass in bioenergy involves several pathways. The lignocellulosic biomass of miscanthus, willow, poplar, and other crops can be used for the production of wood chips, pellets, and briquettes, as well as for direct heat

generation. Crops with high sugar content or suitable biochemical characteristics can be used for the production of biogas and biomethane. Thus, the development of a diversified system for biomass utilization allows us to adapt technological solutions to the potential for resources and the specific conditions of a particular region [1, 5].

An important prerequisite for the sustainable development of bioenergy is the establishment of a complete production-to-energy value chain. An energy crop should not be regarded merely as a plant that needs to be cultivated, but as a feedstock that passes through the stages of harvesting, storage, transportation, processing, and energy utilization. Therefore, economic efficiency should be determined not only by the cost of producing one ton of biomass but also by the final cost per unit of energy generated.

Thus, the cultivation of phytoenergy crops represents a promising direction for diversifying agricultural production and developing renewable energy in Ukraine. Its advantages are comprehensive and cover the economic, environmental, and social dimensions. The economic effect consists of generating a new type of agricultural product and additional income opportunities; the environmental effect involves the substitution of fossil energy carriers, the potential reduction of greenhouse gas emissions, and possible improvements in soil condition; while the social effect is associated with job creation, local community development, and enhanced energy independence.

References

1. Heletukha H. H., Zheliezna T. A., Tryboi O. V. Prospects for the cultivation and use of energy crops in Ukraine : analytical note UABIO No. 10. Kyiv : Bioenergy Association of Ukraine, 2014. URL: <https://uabio.org/activity/1131/> (accessed: 12.09.2026).
2. Bioenergy Association of Ukraine. *Agrobiomass*. URL: <https://uabio.org/agrobiomass/> (accessed: 12.09.2026).
3. Opanassenko O. H., Perets S. V., Bebekh Yu. M., Borysenko V. I. Technological aspects of growing energy crops on drained organic soils of the Northern Forest-Steppe. *Agrobiology*. 2024. No. 2. P. 108–116. DOI: <https://doi.org/10.33245/2310-9270-2024-191-2-108-116>.
4. Hamayunova V. V., Pavlov V. O. From crop residues to healthy soil: the role of biodestructors in agriculture. *Agricultural Innovations*. 2024. No. 28. P. 32–37. DOI: <https://doi.org/10.32848/agrar.innov.2024.28.5>.
5. Bioenergy Association of Ukraine. *Bioenergy Development Strategy in Ukraine*. URL: <https://uabio.org/en/activity/topic-bioenergy-transition-in-ukraine/> (accessed: 12.09.2026).