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Babyna Olha

Assistant of the Department of Agrarian Management,

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ORCID: 0000-0002-0115-6600

[DOI: 10.24411/2520-6990-2020-11824](https://doi.org/10.24411/2520-6990-2020-11824)**ASSESSMENT OF THE EFFECTIVENESS OF THE DEVELOPMENT OF INNOVATION-
INVESTMENT ACTIVITY IN THE PRODUCTION OF ALTERNATIVE ENERGY SOURCES****Бабина О.М.,**

асистентка кафедри аграрного менеджменту,

Вінницький національний аграрний університет, м. Вінниця

**ОЦІНКА ЕФЕКТИВНОСТІ РОЗВИТКУ ІННОВАЦІЙНО-ІНВЕСТИЦІЙНОЇ ДІЯЛЬНОСТІ У
ВИРОБНИЦТВІ АЛЬТЕРНАТИВНИХ ДЖЕРЕЛ ЕНЕРГІЇ****Abstract**

The article identifies the need for active involvement of investments in the development of innovative activities for the production of energy from alternative sources, the development of use of AES and improving the country's energy efficiency. The programs for stimulating the development of innovative activity in the production of energy from alternative sources are considered there. It has been determined, that one of the instruments for stimulating the development of alternative energy in Ukraine was the establishment of a "green" tariff for electricity (feed-in tariff), produced from alternative sources. The measures on support of innovative activity by the state are considered in this article. The technically achievable potential of energy production from alternative energy sources and alternative fuels has been investigated. The dynamics of energy production from AES is analyzed. Rating of AES development directions according to technically-achievable potential was carried out. The analysis on conformity of targets of electricity production from AES to the ones, defined in the Strategy is carried out. The technical-achievable thermal potential of the topsoil and air in Ukraine has been investigated. The main risks of development of innovation and investment activity in the production of alternative energy sources in Ukraine are described. It is determined, that the urgent task is to ensure the proper level of development of innovative investment activity and the deployment of alternative energy capacities in Ukraine.

Анотація

В статті визначено необхідність активного залучення інвестицій у розвиток інноваційної діяльності задля виробництва енергії з альтернативних джерел, розвитку використання АДЕ та підвищення енерго-ефективності країни. Розглянуто програми зі стимулювання розвитку інноваційної діяльності у виробництві енергії з альтернативних джерел. Визначено, що одним з інструментів стимулювання розвитку альтернативної енергетики в Україні стало встановлення «зеленого» тарифу на електричну енергію (feed-in tariff), вироблену з альтернативних джерел. Розглянуті заходи щодо підтримки інноваційної діяльності державою. Досліджено технічно-досяжний потенціал вироблення енергоносіїв з альтернативних джерел енергії та альтернативних видів палива. Проаналізовано динаміку виробництва енергії з АДЕ. Здійснено рейтингування напрямів освоєння АДЕ за технічно-досяжним потенціалом. Проведено аналіз на відповідність цільових показників виробництва електроенергії з АДЕ до визначених в Стратегії. Досліджено технічно-досяжний тепловий потенціал верхнього шару ґрунту та повітря в Україні. Охарактеризовано основні ризика розвитку інноваційно-інвестиційної діяльності у виробництві альтернативних джерел енергії в Україні. Визначено, що нагальним завданням є забезпечення належного рівня розвитку інноваційно-інвестиційної діяльності та розгортання потужностей альтернативної енергетики в Україні.

Ключові слова: альтернативні джерела енергії, інвестиції, інновації, біоенергетика, сонячна енергетика, вітроенергетика.

Keywords: alternative energy sources, investments, innovations, bioenergy, solar energy, wind energy.

In our opinion, this can be achieved by creating favorable conditions for businesses and households in the field of use of innovative energy production technologies from alternative sources. For this purpose the legislative and regulatory regulation of the production and use of energy from alternative sources should be improved.

Innovation in the development of energy from alternative sources, just like any other innovation activity requires significant investment resources, both own and borrowed. The support of programs to stimulate the development of innovative activities in the production of

energy from alternative sources is done in different ways. Due to the limited internal investment resources, financial instruments of international financial institutions are actively involved. Among the powerful organizations represented in Ukraine are: USAID (US Agency for International Development), EBRD, EIB, Global Environmental Facility, GIZ (German Society for International Cooperation). Over the last five years, a number of projects have been implemented in cooperation with them, including in the field of energy efficiency: USAID "Municipal Energy Reform Project in Ukraine", GIZ Projects "Creating of Energy Agencies

in Ukraine", "Energy Efficiency in Communities", "Partnership for modernization: energy efficiency in hospitals", "Implementation of the standard of energy management systems in the industry of Ukraine", etc. [1].

The priority program for development of Ukraine on the development of AES was the program "Greening the economy in the countries of the Eastern Partnership" ("EPGREEN") - a regional program, that was being implemented by the European Economic Commission of the United Nations, OECD, UNEP and UNIDO. The program covered six Eastern Partnership countries: Armenia, Azerbaijan, Belarus, Georgia, the Republic of Moldova and Ukraine. The aim of the program was to facilitate the transition of the Eastern Partnership countries to a "green" model of developing and doing business by separating economic growth from the environmental degradation and resource depletion.

Although the investments in energy efficiency and green energy programs in 2019 amounted to 3.9 billion euros, by the number of AES objects, the amount of energy, produced by them and the share of energy from AESs in the TPES Ukraine is significantly behind the countries of the European Union.

Currently, a number of investment incentives are being used to help to solve energy-saving problems and to build modern power generating facilities, including using AES.

In particular, according to the clauses 14, 16, part 1 of Article 288 of the Customs Code [2] and the clause 197.16 of the Article 197 of the Tax Code [3] there is a permanent exemption from import duties and VAT of goods, imported into the customs territory of Ukraine and which are used by taxpayer for own production and if the identical goods with similar quality indicators are not produced in Ukraine:

- AES equipment, energy-saving equipment and materials, means of measuring, controlling and managing the consumption of fuel and energy resources, equipment and materials for the production of alternative fuels or production of energy from AES;

- materials, equipment and components used for the production of equipment, working on AES; materials, equipment and components, that are used in the production of energy from AES;

- energy-saving equipment and materials, products, the operation of which provides the economy and rational use of fuel and energy resources, etc.

According to the clauses 213.2.8 Article 213 of the Tax Code [3] there is a permanent exemption from excise tax on the sale of electricity, produced in Ukraine by cogeneration units and / or from AES.

One of the tools to stimulate the development of alternative energy in Ukraine has been the establishment of a "green" tariff (feed-in tariff), produced from alternative sources. Thanks to its introduction (since

2009), the construction of wind stations, SESs, small hydropower plants and other stations, operating on alternative energy sources has been intensified. Green tariffs for electricity, produced by economic utilities at power facilities, using alternative energy sources and green tariff surcharges for maintaining the level of use of Ukrainian production equipment are set annually. In 2020, 770 energy generating companies supply electricity according to the "green tariff".

The Law of Ukraine "On Amendments to Certain Laws of Ukraine on Ensuring Competitive Conditions for Generation of Electricity from Alternative Energy Sources" of 25.04.2019 aims at the transition from the "green" tariff model to the model of clean energy stimulation through auctions. Among the key positions of the Law are:

- 1) complete implementation of the auction system from 2020. (for SPS > 10 MW and WPP > 20 MW with gradual reduction of power);

- 2) the winners of the auction get state support for the sale of "green" energy for 20 years;

- 3) holding the auctions twice a year;

- 4) all types of AES generation can participate in auctions.

This model is generally regarded by experts as positive, although there are some warnings (regarding the allocation of annual support quotas and the complexity of foreign investors entering the AES market).

At the same time, according to experts of the Razumkov Center [4], the introduction of the "green" investment model and the transition to a complete environmental policy in Ukraine are substantially constrained by the lack of clarity of the formation of an active environmental policy by the authorities, which is largely influenced by the international community and domestic public (environmental movements and organizations). The low rating of sustainable development in general and "green" investment in particular is evidenced by the invisibility of the environmental component in the political programs of both the ruling and parliamentary opposition parties.

In recent years, Ukraine has made significant advances in electricity generation from AES: for example, in 2018 the production increased by almost 40% - to 2632 million kWh, although the share of AES in generating electricity remains miserable - only 4.6% (against 0.5% in 1990). But this figure is much lower than in the individual EU countries (Czech Republic - 7.7%, Hungary - 3.6%, Romania - 8.6%, Poland - 19.5%) and Turkey (37.7%) [5] and twice smaller of the strategic goal for 2018, set by "The New Energy Strategy for Ukraine by 2035" [6] - 9.1%

However, the targets for electricity production from AES, which have been defined in the Strategy, have not been reached yet (Fig. 1).

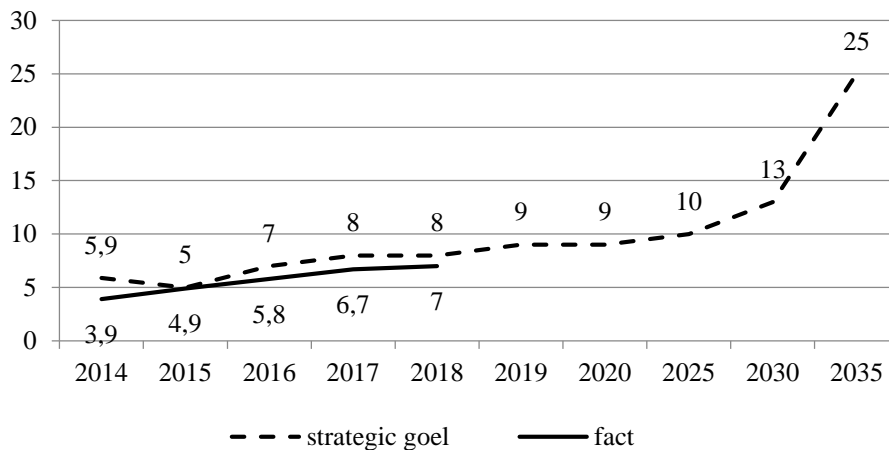


Fig. 1. Total share of energy from AES in the energy balance of Ukraine, %

Based on the State Energy Efficiency [7] of the technically achievable potential of energy production

from alternative energy sources (Table 1), we will compare the actual and potential energy production with AES.

Table 1

Technically achievable potential of alternative energy sources

№	Areas of development AES	Annual potential		
		mill.tons	in % to total volume replacement	potential
1.	Wind power	28,0	28,57	2
2.	Solar energy, including	6,0	6,12	5
2.1	- electrical	2,0	2,04	
2.2	- thermal	4,0	4,08	
3.	Low hydropower	3,0	3,06	6
4.	Bioenergy, including:	31,0	31,63	1
4.1	- electrical	10,3	10,51	
4.2	- thermal	20,7	21,12	
5.	Geothermal thermal energy	12,0	12,24	4
6.	Environmental energy (heat pumps)	18,0	18,37	3
Total replacement of traditional FER		98,0	100,00	-

Compiled and calculated by the author in [7]

In the rating of directions of development of AES according to technical and attainable potential bioenergy holds the first place (31.63% of the total replacement of traditional FER, or 31.0 million t.cf), which is due to the significant biomass potential, available for energy production. Biofuels produced in 2018 were sufficient for the energy supply of 5 regions of Ukraine. At the same time, the pace of bioenergy development in Ukraine is still significantly behind the European ones. Simultaneously, the share of biomass in gross final energy consumption is 1.78%. Annually, about 2 million tonnes of biomass of different types is used for energy production in Ukraine, that is only 6.45% of technically achievable potential.

Wood accounts for the highest percentage of utilization of economically viable potential - 80%, whereas for other biomass types (except sunflower husk) this figure is an order of magnitude lower. The energy potential of cereal straw and rapeseed is the least active (at 1% level), although more than 50 million tons of cereals are harvested annually in Ukraine, and according to experts [8], 1.5 to 2 tons of straw or vegetable residues can be obtained from each ton of grain. Utilizing

the technically achievable energy potential of solid biomass in Ukraine, according to expert estimates, it allows to save about 22 billion cubic meters of natural gas annually. If we use about a third of agricultural waste as an energy resource, it can be replaced by the equivalent of up to 9 billion m³ of gas per year, which is one third of Ukraine's gas needs. The highest potential of solid biomass is concentrated in Poltava, Dnipropetrovsk, Vinnytsia and Kirovograd regions (more than 1.0 million tons / year). It is advisable to grow energy crops on about 4 million hectares of low-yielding land, which will allow the replacement of up to 20 billion m³ of gas per year in equivalent [8]. At 14 enterprises of the oil industry more than 500 thousand tons of sunflower husk are burnt and 120 thousand tons of it are granulated. To increase the investment attractiveness of biomass heat production at the legislative level, a guaranteed tariff of 90% of the heat tariff from gas. Since 2014, over 2300 MW of generating capacity has been installed, which generate heat from biomass.

The forested area of Ukraine is about 16% of its total area. Annually, 16-17 million m of commercial wood is harvested, up to 10 million cubic meters of

wood is processed, about 70% of which in the form of sawdust, chips, pellets and briquettes is used as biofuel.

The annual technically achievable energy potential of liquid biofuels in Ukraine is equivalent to 1 million tons. Its use makes it possible to save about 1.2 billion cubic meters of natural gas annually. The largest potential of liquid biofuels is concentrated in Vinnitsa and Poltava regions, where it is more than 90 thousand tons / year. The production of bioethanol is mainly carried out at reconstructed alcohol factory. In recent years, the production of fuel bioethanol has been established at four alcohol factories, by 2022 this figure is expected to triple.

The annual biogas potential in Ukraine is estimated to be 3.2 - 7 billion cubic meters, which in turn is up to 25% of annual gas consumption. The largest potential is concentrated in Dnipropetrovsk, Donetsk and Kyiv oblasts and is over 150 thousand tons / year. A potential technology for biogas production is methane digestion of livestock biomass, which is 60-70% composed of methane. Other sources of biogas are landfills at municipal solid waste landfills, sewage, whose disposal provides solutions to important environmental, energy and social problems of cities, especially metropolitan areas. Biogas is a multicomponent gas and its composition may vary depending on the morphological composition of the landfill and the conditions of their disposal. However, the main components of biogas are methane (40-60%) and carbon dioxide (30-45%). As of the end of 2019, there are 46 production plants with a total capacity of 72 MW (against 7 plants in 2014) [9].

The second place in the rating belongs to wind power - 28.57 million tons, or 28.57% of the total replacement (see Table 2.3.5). During the year, the planet receives 15,000 times more energy, than the current consumption of all countries of the world. About 3% of solar energy is converted to wind energy, which means, that wind energy resources are about 50 times larger than humanity's total energy needs. In the 1930s, the largest wind power plant (WPP) with a capacity of 100 kW was built in the Crimea, and soon a new WPP with a capacity of 5,000 kW was designed, but the war interrupted this project. In 1996, the Novoazovskaya WPP was designed with a capacity of 50 MW and in 1997 the Truskavets WPP was established. In 1998-1999, three more new wind turbines began operating. In 2000, 134 turbines were operating in Ukraine and about 100 foundations were installed for 100 kW turbines [10]. Significant growth in the construction of wind power plants has been observed since 2009, after the introduction of the "green" tariff by the Government of Ukraine. Modern wind power plants of megawatts power class are able to return up to 3-4 times expenses, spent on them during the period of their operation. The average annual growth of the world wind power is on average 26-27% and it is the highest, compared to other sources of energy. From the alternative energy sources the better economic results, compared with the wind power, can be provided only by medium and high capacity hydropower plants (for example, in the USA, where the operation of NPPs and TPPs is not supported by subsidies or dotations from the state

budget, the cost of electricity produced at NPPs is 10-11 cents / kWh, TPP - 9-10 cents / kWh, wind plants - 4-5 cents / kWh) [11].

The installed capacity of wind power plants in Ukraine amounted to 514 MW (only 0.93% of the total generation capacity), which produces over 1200 million kWh of electricity per year [7]. To compare the increase in wind power capacity in 2014, the leading countries in the field of wind power were: China - 7.1 GW, Germany - 1.8 GW, Brazil - 1.3 GW, India - 1.1 GW. In Ukraine, in terms of potential, the most promising areas for wind power development are Dnipropetrovsk, Odessa, Zaporizhia, Kherson regions.

In order to achieve the competitiveness of the Ukrainian wind plants, mass production and increase of wind power capacity are required. Modern wind engineering of mass production of German, Danish and Spanish companies with the correct design of wind farms is profitable in all regions of Ukraine, where it will pay 3-4 times for all costs for its construction in 25-30 years of its life cycle. If the production of modern wind engineering in Ukraine is adjusted and its cost is reduced by 25-40%, its payback period can be reduced by 1.5-2 times.

Using modern European-style wind turbines in Ukraine it is possible to build a wind farm with a total capacity of 1500 GW, which is 20-30 times higher than the capacity of the United Energy System of Ukraine. The largest areas for the construction of efficient wind farms are in the shallow waters of the seas, continental shelf, gulfs, estuaries and inland waters. Significant reduction of capital investment for construction can also be achieved through the construction of hydroelectric power plants near hydropower plants, hydroelectric power plants, thermal power plants for the joint use of transformer substations, transmission lines, roads, dispatch lines and so on. According to Ukrhydroproject estimates, based on the infrastructure of ChNPP and Kiev Hydroelectric Power Station, on the equator, islands and coastal zone of the Kiev Sea WPP can be constructed with a total capacity of about 5,000 MW. Ukraine is one of the few countries that has the technology of floating hydropower construction in the high seas and, in view of energy shortages, this direction of wind power needs to be developed rapidly in our country.

The third place in the rating belongs to the energy of the environment, the sources of which are the heat of atmospheric air, water of rivers, seas, topsoil and groundwater - the annual technical and achievable energy potential is 18, 0 million tons. cf. or 18.37% of the total replacement. Using of this potential saves about 15.6 billion m³. For example, for the energy potential of the topsoil and air in Ukraine the leaders are: Donetsk (924 thousand tons / year and 10269 thousand tons / year respectively), Dnipropetrovsk (735 thousand tons / year and 840 thousand tons / year respectively) cf. / year and 840 thousand tons / year respectively) and the Kyiv region (700 thousand tons / year and 861 thousand tons / year, respectively), Table. 2.

The fourth place of AES's rating in terms of technically achievable potential belongs to geothermal thermal energy - 12.0 million tons. cf. and 12.24% of the

total replacement. On the territory of Ukraine (in Crimea, Carpathian and Transcarpathian regions, in the eastern and coastal regions), there are many fields with favorable conditions for extraction of geothermal energy at the depths available for drilling. According to the Institute of Technical Thermophysics of the National Academy of Sciences of Ukraine, at a depth of 2-

4 km from the soil surface there are geothermal resources, sufficient for a cost-effective and complete supply of the needs for the heat of the communal sector of Ukraine. At depths of 4 to 7 km, there are deposits with parameters of the coolant sufficient for the construction of a complex of geothermal thermal power plants with a total capacity of 3-4 thousand MW electric and up to 30 thousand MW thermal [11].

Table 2

Technically achievable thermal potential of the topsoil and air in Ukraine, thousand tons of conventional fuel

Regions	Top soil		Air	
	Thousand tons of conventional fuel	rating	Thousand tons of conventional fuel	rating
Ukraine	5922		6027	
Vinnitsia	84	20	70	21
Volyn	119	12	84	16
Dnepropetrovsk	735	2	840	3
Donetsk	924	1	1029	1
Zhytomyr	119	13	84	17
Transcarpathian	56	23	56	23
Zaporozhye	378	6	350	6
Ivano-Frankivsk	119	14	84	18
Kiev	700	3	861	2
Kirovohrad	189	9	140	10
Lugansk	462	5	406	5
Lviv	189	10	175	9
Nikolaev	119	15	126	11
Odessa	231	7	231	7
Poltava	231	8	210	8
Rivne	63	21	56	22
Sumy	14	24	126	12
Ternopil	63	22	42	24
Kharkiv	504	4	567	4
Kherson	98	19	70	20
Khmelnyskyi	119	16	84	19
Cherkasy	168	11	112	13
Chernivtsi	119	17	112	14
Chernihiv	119	18	112	15

The data are given without taking into account the temporarily occupied territories of the Autonomous Republic of Crimea, Sevastopol and from 2014-2018 without the part of the temporarily occupied territories in Donetsk and Luhansk regions.

Compiled and calculated by the author in [12].

The practical development of thermal waters in Ukraine was conducted in the temporarily occupied territory of the Autonomous Republic of Crimea, where 11 geothermal circulation systems were built, which correspond to the modern technologies of geothermal heat production. All geothermal installations were operated

at the research and industrial stage.

Large reserves of thermal water have also been found in Chernihiv, Poltava, Kharkiv, Luhansk and Sumy regions. Hundreds of wells that have discovered thermal water and are being conserved can be recovered for their further exploitation as a system of geothermal heat production [13].

The fifth place in terms of technically achievable potential in Ukraine is solar energy with potential capacity of 6.0 million tons. cf. per year, or 6.12% of total replacement. The average annual amount of total solar radiation that comes to Ukraine annually is in the range

of 1 070 kWh / m. sq. m. in the northern part of Ukraine and up to 1400 kWh sq. m. and higher in the southern regions. At the beginning of 2020, the total capacity of AES facilities in Ukraine reached 6932 MW, 4925 MW of which is for solar energy, 1170 MW for wind power, 553 MW for solar plants of households, 114 MW for small hydropower, 170 MW for the energy from biomass and biogas [14].

The final place in the rating belongs to small hydropower with 3.0 million tons. cf. and 3.06% of the total replacement. Many countries' experience has shown, that harnessing the potential of small rivers for small and micro-hydroelectric power plants helps to solve the problem of improving the energy supply of many consumers. The most efficient small hydropower plants are created on existing hydraulic structures. There are more than 63,000 small rivers in Ukraine. Their hydropower potential makes up 28% of the total technical potential of all rivers in Ukraine. In Ukraine,

the unused hydropower resources are smaller, than wind energy resources, but are valuable with lower costs and the ability to regulate electricity generation time [11].

Hydropower makes up 8% of the total installed capacity of our country's electricity generating facilities, new facilities may be located in any region with small or large rivers, but hydropower potential is only used by 60%, mainly due to the Dnieper cascade and other large hydropower plants.

Now the small hydropower industry of Ukraine has 102 small hydroelectric

power plants with a total installed capacity of about 80 MW, which annually generate about 250 million kWh. Compared to the 1960s, the number of HPPs has fallen by almost 10 times, although potentially micro-, mini- and small hydroelectric power plants can be a powerful source of energy for all regions of Western Ukraine, and for some regions of Transcarpathian and Chernivtsi regions - a source of full energy supply [15].

Since the development of alternative energy sources is impossible without the development of new technologies, it is possible to speak about the positive impact of the alternative energy strategy on the development of national science and technology, as well as production, which has a positive impact on the international prestige of the countries in the field of renewable energy [16].

The main risks of development of innovation-investment activity in the production of alternative energy sources in Ukraine are: high cost of attracting financial resources; significant capital expenditures; a change in state policy in the field of alternative energy, which is a source of distrust among investors.

In our opinion, it is possible to ensure high efficiency of innovative-investment activity in energy production from alternative sources and development of this energy sector of Ukraine by modernization and increase of efficiency of work of existing energy capacities with priority investment of projects of energy efficiency and alternative energy; increasing the volume of domestic and foreign investment in new facilities by simplifying the "green" tariff qualification process, accepting incentives for small investors and creating financing in the form of affordable bank products; using of local production facilities to create an accessible equipment market for alternative energy; investing in the development of bioenergy infrastructure.

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