Assessment of the Economic Feasibility of Using Alternative Energy Sources in Ukraine

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Abstract. The article deals with an analysis of the popular types of alternative energy sources and prospects for their application in countries with temperate climates, particularly in Ukraine. The need to compare the potential of alternative energy in Ukraine with the cost of equipment required for the use of alternative energy sources is substantiated. According to the specifics of each region, the concept of choosing efficient energy sources is defined, in particular, attention should be paid to comparing the cost of materials, capital operating and costs for each type of energy, in particular, Sun energy, biogas, biomass, air potential and geothermal energy. In the form of tables and nomograms presented data regarding to technically achievable energy potential for different regions of Ukraine. Analyzing the obtained data, it can be stated that geothermal energy, air potential and solar energy deserve special attention.

Keywords: Alternative energy sources · Sun energy · Energy potential · Energy technologies

1 Introduction

The problem of using energy sources that would become a full-fledged replacement for organic energy is becoming increasingly acute. Mankind is constantly looking for an alternative. There is a clearly defined category of "alternatives" to energy sources, which are: permanent, renewable and recurring [1]. Analyzing the current trends in the world energy supply system, the beginning of a qualitative stage of energy market development is observed. There is a process of reorientation of the energy strategy, not only of the European Union, but also of the Middle East. The strategy of energy development is being revised in the conditions of formed partnerships with the largest importers of natural resources, in particular Norway, Russia and Algeria, as well as in the conditions of a well-established industry for processing traditional energy sources. Alternative energy remains a priority for the European Union's economy. Continued government stimulus since 2004 has led to a rapid increase in the share of renewables in gross final energy consumption, as well as to significant investment by powerful Asian companies [2]. Although recently, at the global level, investment in renewable energy in 2017, investment decreased by 23% compared to 2015.

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According to the United Nations Environment Program (UNEP), the sector received less than $ 242 billion. The organization's report drew attention to the global share of electricity from renewable energy sources (RES), which increased from 10.3% in 2015 to 11.3% in 2016. Regarding renewable energy sources in terms of generation types, investments in solar energy in 2014 amounted to $ 114 billion, which is 34% less than in 2015. As for wind energy, it was financed in the amount of $ 113 billion, which is 9% less than in 2015. The policy of reducing state sup-port for RES has a negative impact on investment. The main reason lies in the "green" tariffs. In many EU countries, companies have received state guarantees for the sale of "green" electricity at fixed prices, while over time, prices have changed. Regardless of the development of events, energy consumption will continue to grow [3–5]. Of course, this will depend on state regulation of alternative energy development [6, 7].

In accordance with the classification of the International Energy Agency, renewable energy sources include the following categories [7]:

- renewable energy sources (RES), which are burned, and biomass waste:
- solid biomass and animal products: biological mass, including any material of vegetable origin used directly as fuel or converted into other forms before incineration (wood, vegetable and animal waste; charcoal obtained from solid biomass);
- biomass gas/liquid: biogas obtained in the process of anaerobic fermentation of biomass and solid waste, which is burned to produce electricity and heat;
- municipal waste: materials incinerated for the production of heat and electricity (waste from the residential, commercial and public sectors). Disposed of by the municipal authorities for the purpose of centralized destruction;
- industrial waste: solid and liquid materials, which are incinerated directly, usually at specialized enterprises, for the production of heat and electricity;
- hydropower: potential, or kinetic, energy of water converted into electrical energy by hydropower plants, both large and small;
- geothermal energy: thermal energy coming from the earth's interior, usually in the form of hot water or steam;
- solar energy: solar radiation used to produce hot water and electricity;
- wind energy: kinetic wind energy used to generate electricity in wind turbines;
- tidal energy, sea waves and ocean energy: the mechanical energy of tidal currents or waves used to produce electricity.

Appropriate conditions must be created for the production, supply, transportation, storage, supply and consumption of energy produced from alternative sources. The main measures to be outlined by the state remain organizational and legal, financial, economic and technical and technological [8, 9]. This is a forced policy, because alternative energy sources are environmentally friendly and directly affect the economic security of states [10, 11]. The Road Map of Energy until 2050 is proposed, which reflects the key role of RES in the energy supply of transport, industry and other consumers [12].

The potential of renewable energy sources is available throughout Ukraine. The main components of renewable energy include: solar energy, geothermal energy, solid biomass energy, biogas energy and energy of the upper layer of soil and air.

2 Types of Alternative Energy Sources Used in Ukraine

The leading environmentally friendly source of energy is the Sun. The potential of solar energy in Ukraine is high enough for the use of both solar collectors and photovoltaic panels in almost all areas. The use of flat solar collectors, which use both direct and scattered solar radiation, is effective for solar heat supply. Conversion of solar energy into electricity in the conditions of Ukraine it is expedient to use photovoltaic panels [13, 14].

Geothermal energy is the heat of the Earth, which is mainly formed due to the decay of radioactive substances in the earth's crust and mantle. The temperature of the earth's crust rises by 2.5–3 °C every 100 m (the so-called geothermal gradient). Thus, at a depth of 20 km it is about 500 °C, at a depth of 50 km – about 700 … 800 °C, and at the core of the Earth – about 5000 °C. In certain places, especially along the edges of the tectonic plates of the continents, as well as in the so-called "hot spots", the temperature gradient is almost 10 times higher, and then at a depth of 500–1000 m the temperature of the rocks reaches 300 °C. However, even where the temperature of the earth's rocks is not so high, geothermal energy resources are sufficient.

Geothermal energy is used for heating, water supply and air conditioning in residential and public buildings and structures in cities and rural areas.

The most appropriate at present is the use of energy from geothermal waters.

One of the directions of geothermal energy development is the use of combined systems for heat and electricity contained in geothermal heat carriers.

Currently, about 70% of wood waste in the form of sawdust, wood chips, pellets and briquettes is used as biofuel. Energy crops are some species of trees and plants that are specially grown for the production of solid biofuels. They are divided into three groups:

- fast-growing trees;
- perennial grasses;
- annual grasses.

Energy crops also include traditional agricultural plants grown for the production of biodiesel (rapeseed, sunflower), bioethanol (corn, wheat) and biogas (corn).

An effective way to supplement and replace traditional fuels is the production and use of biogas, which is formed as a result of anaerobic fermentation of organic biomass.

Biogas is a mixture of gases: methane, carbon dioxide, hydrogen sulfide, ammonia and other gases. Biogas can be obtained regardless of climatic and weather conditions. This type of fuel enables the production of both thermal and electrical energy, which makes it a competitive type of fuel.

Natural energy sources of the environment include atmospheric air, water of rivers, seas, topsoil and groundwater.

Thermal energy in the warm period of the year accumulates in the top layer of soil. This layer between the heating depth and the isothermal surface can be considered as a natural seasonal accumulator of thermal energy, and the energy that was used in the winter will accumulate in the warm period of the year. This also applies to groundwater located in the upper soil layers [15].

Geographical location, climatic conditions and the specifics of economic development of the region dictate the conditions for the prospects of using a particular type of alternative energy. Therefore, the research is based on scientific justification for the use of alternative energy sources for different geographical areas of Ukraine.

3 The Main Material

The purpose of the study is to create a map of rational alternative energy sources, taking into account the cost of equipment for the implementation of these measures and the geographical location of the region.

Ukraine occupies a large area and has a sufficient length from West to East, the climate in different regions can vary significantly. Therefore, there is a need to explore the prospects of using different alternative energy sources not for the country as a whole, but separately by region. The map is presented on the basis of the database of energy indicators of renewable energy sources and the distribution of their energy potential on the territory of Ukraine: 1. solar energy; 2. geothermal energy; 3. biomass energy; 4. biogas energy; 5. Environmental energy (topsoil and air potential) (Fig. 1).

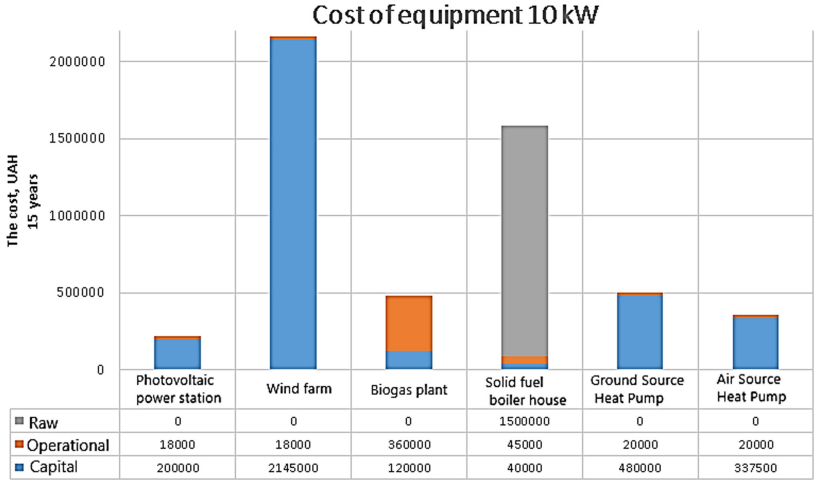

Fig. 1. Expenditures for the implementation of measures for the use of alternative energy sources, taking into account capital and operating costs

The calculation took into account the service life of 15 years.

Taking into account the capital costs for the implementation of measures for the production of alternative energy sources, the technically achievable energy potential for: solar energy, geothermal energy, biomass, biogas and air potential is presented.

The most efficient systems for obtaining energy are: 1. Solar power plant; 2. Biogas plant; 3. Ground heat pump; 4. Air heat pump (see Table 1).

Table 1. Technically achievable energy potential

	Regions	Sun	Geothermal	Biomass	Biogas	Air potential
		K, t_{oe}/year				
1	Crimea	270	775	827	111	280
2	Vinnytsia	170	217	1042	114	70
3	Volyn	130	168	348	73	84
4	Dnipro	220	266	1113	167	840
5	Donetsk	190	224	717	168	1029
6	Zhytomyr	180	252	779	73	84
7	Transcarpathian	100	596	144	56	56
8	Zaporizhzhia	200	252	932	78	350
9	Ivano-Frankivsk	90	123	190	76	84
10	Kyiv	180	245	873	187	861
11	Kropyvnytskyi	160	203	1019	61	140
12	Luhansk	190	224	670	86	406
13	Lviv	150	554	472	109	175
14	Mykolaiv	190	203	752	61	126
15	Odessa	260	284	946	99	231
16	Poltava	180	614	1158	90	210
17	Rivne	120	518	360	77	56
18	Sumy	150	600	700	55	126
19	Ternopil	100	119	465	70	42
20	Kharkiv	200	632	1000	101	567
21	Kherson	220	606	872	50	70
22	Khmelnytsky	140	175	689	94	84
23	Cherkasy	150	175	901	165	112
24	Chernivtsi	60	49	217	53	112
25	Chernihiv	200	326	836	73	112

The data, presented in the table were presented in the form of diagrams for individual regions, which will allow a better analysis of the current situation (see Fig. 2). The article presents the most typical cases, namely technically achievable energy potential for Lviv, Kyiv and Mykolayiv regions.

According to the obtained data, it is possible to identify the most appropriate energy sources for each region. Taking into account the cost of capital and operating costs, we obtain that: efficient energy sources for Ukraine are geothermal energy, air potential and solar energy, whereas, for example, wind power plants require significant investment, which leads to a longer payback period. However, the undisputed leader is solar energy.

The study proves that the use of certain alternative energy sources is a promising area of energy in Ukraine.

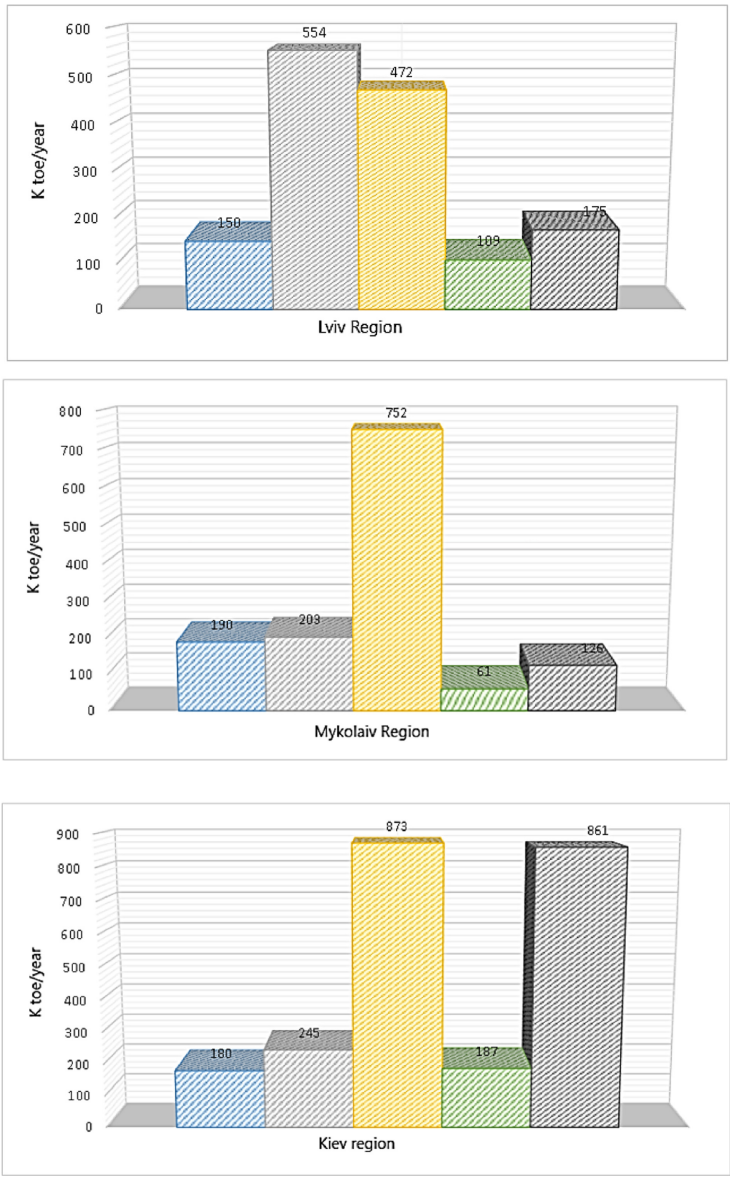

Fig. 2. Technically achievable energy potential for different regions of Ukraine – Sun energy; – Geothermal energy; – Biomass; – Biogas; – Air potential

4 Conclusions

The development of renewable energy shows the most dynamic development among other energy technologies in the world. The potential of alternative energy sources in Ukraine is presented, which can provide up to 50% of the total consumption of energy resources today, and in the future – 100%. The need to compare the potential of alternative energy in Ukraine with the cost of measures for the use of alternative energy sources is substantiated. The costs of funds for the implementation of measures for the use of alternative energy sources, taking into account capital and operating costs, determined that geothermal energy, air potential and solar energy are effective. The percentage costs for providing systems for the use of alternative sources are presented, so for the biogas plant amounted to 25% capital and 75% operating costs and for the air heat pump 94% capital and 6% operating costs.

The technically achievable energy potential for different regions of Ukraine is analyzed. Geothermal energy, air potential and solar energy deserve special attention. According to the peculiarities of each region, the concept of choosing efficient energy sources is defined, in particular, attention should be paid to comparing the cost of equipment and available resource potential. The most expedient energy sources for each region have been identified, although the use of solar energy and air heat pumps remains a priority for the territory of Ukraine.

References

1. Ye, S.: The concept of alternative energy sources A young scientist, no. 4(07), 44 (2014). (in Ukrainian)
2. Danilova, N.: Changing the policy of state regulation of the European market of alternative energy sources under the influence of current trends in international competition. Bull. Taras Shevchenko Nat. Univ. Kyiv Econ. **10**(162), 54–58 (2014). (in Ukrainian)
3. Ye, K.: Substantiation of perspective directions of development of alternative sources. Econ. Innov. no. 60, 217–225 (2015). (in Ukrainian). book 1
4. Holweg, M.: The genealogy of lean production. J. Oper. Manag. **25**(2), 420–437 (2007). (in Ukrainian)
5. Sokhatska, O.M., Strelbytska, N.Y.: Current trends in the global market of non-traditional and renewable energy sources. Energy saving. Energy. Energy Audit **11**(93), 38–52 (2011). (in Ukrainian)
6. Maistro, S., Voloshin, O.: Mechanisms of state regulation of alternative energy development: theoretical approaches to definition and content. In: Efficiency of Public Administration, Collection of Scientific Works, vol. 43, pp. 36–43 (2015). (in Ukrainian)
7. Matviychuk, L.Yu., Gerasymchuk, B.P.: Economic feasibility of using alternative energy sources. Econ. Forum (4), 12–16 (2013). (in Ukrainian). Lutsk National Technical University
8. Kaletnik, G.M., Pindyk, M.V.: The concept of alternative energy sources and their place in the implementation of energy efficiency policy of Ukraine. Econ. Financ. Manag. Curr. Issues Sci. Pract. **8**, 7–18 (2016). (in Ukrainian)
9. Onoshko, O.S.: Alternative energy in the system of economic security of Ukraine. Economics **1**, 32–39 (2013). (in Russian)

10. Stepanova, A.: Diversification of energy dependence of Ukraine. J. Taras Shevchenko Nat. Univ. Kyiv, Econ. **7**(172), 69–73 (2015). (in Ukrainian)
11. Geletukha, G.G., Zhelezna, T.A., Drozdova, O.I.: Analysis of the main provisions of the EU energy roadmap to 2050. Ind. Heat Eng. **34**(6) (2012). (in Ukrainian)
12. Voitko, S.V.: System analysis of energy security of countries: the use of renewable energy sources. Econ. Forum **4**, 29–35 (2013). (in Ukrainian)
13. Mysak, Y., Pona, O., Shapoval, S.: Evaluation of energy efficiency of solar roofing using mathematical and experimental research. Eastern Eur. J. Enterp. Technol. **3**(8(87)), 26–32 (2017)
14. Shapoval, S., Shapoval, P., Zhelykh, V.: Ecological and energy aspects of using the combined solar collectors for low-energy houses. Chem. Chem. Technol. **11**(4), 503–508 (2017)
15. Adamski, M.: Lean manufacturing: MathModelica in modeling of countercurrent heat exchangers. In: Proceedings - 8th EUROSIM Congress on Modelling and Simulation, EUROSIM 2013, vol. 21, no. 2, pp. 439–442 (2013)