PERSPECTIVES OF USING ALTERNATIVE ENERGY SOURCES IN UKRAINE IN THE CONTEXT OF INCREASING ENERGY EFFICIENCY IN EUROPE

Lidiya Shergina
Associate Professor, PhD, Kyiv National Economic University after named Vadym Hetman,
e-mail: lidiyashergina@ukr.net, orcid.org/ 0000-0001-9031-0616, Ukraine
Alla Zhemba
Associate Professor, PhD, National University of Water and Environmental Engineering,
e-mail: a.i.zhemba@nuwm.edu.ua, orcid.org/ 0000-0003-0268-3258, Ukraine
Nataliia Revutska
PhD, Batumi State Maritime Academy,
e-mail:n.revutska@bsma.edu.ge, orcid.org/ 0000-0003-4658-5131, Georgia
Yulia Burma
Post-graduate, Kyiv National Economic University after named Vadym Hetman,
e-mail: yulia.burma01@gmail.com, orcid.org/ 0000-0003-3852-5454, Ukraine

Abstract. The article is devoted to the issues of the functioning and development of energy in each country, caused mainly by the economic expediency of renewable energy and the requirements of energy independence. Also, the article examines the importance of replacing traditional fuels with alternative energy sources. The international experience of the countries in the field of efficient use of available natural resources of the fuel and energy complex and enhancement of the potential of the energy sector have been analyzed. A number of common characteristics and directions of energy efficiency improvement for European countries are highlighted. Alternative types of energy and measures necessary for their implementation have been offered. The potential resources of renewable energy sources have been analyzed. The article is devoted to the use of economical and ecological type of fuel - biofuel for Ukraine. On the basis of the analysis of the situation on the energy market, renewable energy is examine, which plays a compensatory role in global energy consumption in the conditions of growing exhaustion of non-renewable sources.

Keywords: energy efficiency, energy saving, renewable energy.

DOI: http://dx.doi.org/10.23856/2705

Introduction

At the end of the second millennium, the world turned into a global economic system, where the decisive development factor is effective implementation of the scientific and technical research achievements. Increasing the energy efficiency of the economy by using alternative energy sources is one of the main characteristics of the modern development of world economy.

Economic and energy security are key factors in the country's high competitive status. At the present time the development of the state's economy depends not on the available natural resources, industrial development, or agriculture. The important indicator of the high economic development is the share of services in the GDP structure, as well as ensuring development according to the sustainability paradigm by introducing alternative energy sources.

The energy supply of the economic activity in business sector on the basis of intensive and innovative development both as increasing energy efficiency of production traditionally provide for raising the economy of the country at a high stage of its development. Therefore, the reduction of energy dependence and the definition of the main priorities of the energy complex modernization have a significant impact on the socio-economic development of the state.

The problem of energy saving appears not only at the state level, but also reaches the world scale. Traditional sources of energy associated with the use of natural resources such as oil, gas, black and brown coal, peat, fuel shale, etc. tend to exhaust their stocks. Therefore, an important global issue is the search for the alternative energy sources that can at first partially, and later completely replace traditional ones.

At the 70s of the twentieth century, the introduction of new energy sources intensified due to the very rapid increase in oil prices. Among others, Central and Eastern European countries such as Poland, Hungary, and the Czech Republic decided to upgrade their own energy complex. Subsequently, Ukraine joined them. The issue of ensuring its own energy independence is also intensifying due to the fact that this is one of the conditions for becominy a member of the European Union. In our opinion, research on alternative energy sources is extremely important as it will help countries to strengthen their energy security and minimize the negative impact of global economic crises.

Subtitle of the body

Issues of the economy's energy efficiency increasing, searching for alternative energy sources and their implementation at the country level are considered at the research of such scientists as A.B. Lovins, E.F. Schumacher, L. Brooks, B. Laponche, P. Bertholdy, J. Cornilli and others.

Issues of improving the energy efficiency of the economy have also been reflected in the work of the International Energy Agency (IEA), the World Energy Council (CEEC), the European Commission's Articles within the framework of the "Smart Energy for Europe" program, the World Bank (WB) and the European Bank for Reconstruction and Development (EBRD). Although already at the present stage there is a large number of various developments in theoretical and practical focus, the solution of the issue of energy efficiency requires further research.

The concept of "energy efficiency", to which the topic of our study is dedicated, is considered as the ratio of input-output of fuel and energy resources in a particular country *(Industrial Development Report, 2011)*. According to V. Oikonomou, the concept of energy efficiency increasing means the use of advanced technologies to reduce energy consumption to obtain a unit of product *(Oikonomou, 2009)*.

With regard to the European Union and its energy efficiency policy, energy efficiency means the energy resource – negajoule- the consumption of fuel and energy resources that has been avoided due to increased energy efficiency.

It should be noted that the term "energy efficiency" and "energy conservation" are related, but have significant differences in their meaning. If energy efficiency means a qualitative component of the national economy, then energy conservation is, first and foremost, an activity aimed at reducing the use of natural resources of the fuel and energy complex *(Tsapko-Piddubna, 2014)*. Therefore, research on alternative energy sources will be one of the key elements of "energy conservation".

To determine measures energy efficiency improving, it is necessary to assess the efficiency of fuel and energy resources using in the Europe, on the basis of which our research will be based. A number of indicators are used for evaluation, which differ in macro- and micro levels. At the macro level it is possible to apply GDP per unit of consumed energy and to the inverse energy intensity indicator - the amount of fuel and energy resources spent on production of GDP units. At the macro level will be relevant indicators such as equipment thermal energy efficiency and energy intensity of certain products.

The beginning of the 21st century is characterized by a variety of qualitative and quantitative changes in the energy sector. Thus, the key objective of world spreading trends is maximally using of existing natural resources and increasing the potential of the energy sector for the growth of the world economy. According to the International Energy Agency (IEA), the following trends will operate in the global energy sector at the present stage *(Denisyuk et al., 2016):*

1. Restructuring the gas market.
2. Increased ecological requirements, where priority will be given to the wind and solar power stations, as they have much less environmental impact than traditional NPPs, hydroelectric plants, etc.
3. Many changes in energy due to technological progress, which is one of the key factors in the development of the modern economy.
4. Demand for "digital energy"; "Electrification" of the energy market and reduction of heat supply.
5. The integration of new technological solutions, new customers and new suppliers, as well as the application of these new energy elements in urban and industrial systems (intelligent systems and networks built according to the requirements of the Smart Grid concept).

Although, the key features of the energy complex development in each country are different, however, it is possible to identify a number of characteristics of energy efficiency, which are common to most countries. Thus, such characteristics include: energy security, which is achieved by reducing energy imports, reducing domestic demand for increased exports of fossil fuels, monitoring the growth in demand for energy. Economic development and competitiveness are possible if a number of measures are taken in the field of energy intensity reduction, industrial competitiveness increase; reduction of production cost; increasing the affordability of prices for energy consumers.

In terms of climate change, it should be noted that the energy efficiency driving forces in this case are contributing to global mitigation and adaptation actions; fulfillment of international obligations under the UN Framework Convention on Climate Change; compliance with requirements or directives of a supranational nature.

Already from the beginning of the 20th century, the main directions of energy efficiency improvement in Europe were measures for the introduction in all institutional sectors such technologies and equipment that differ among others with increased energy efficiency. In addition, alternative energy sources have been actively involved, energy transportation and energy consumption has been reduced.

In November 2016, the EU introduced a number of measures that should enhance energy efficiency. These measures include the fact that each year the volume of energy sales should decrease by 1,5%; at least 3% of the buildings owned by the EU Member States should be subject to an energy update; premises provided for sale or leased out must have certificates of energy efficiency; every three years in the EU countries should prepare action

plans for improving energy efficiency; large companies must carry out an energy audit. Thus, searching for and implementation of alternative energy sources is one of the components of reducing the use of traditional fuel and energy resources *(Denisyuk et al., 2016).*

Energy security ensuring is possible both by finding new alternative energy sources and by improving the use of fuel and energy resources. As you know, the energy efficiency of the economy depends primarily on the available natural resources, as well as on the share of alternative energy sources in the overall structure of the country's energy complex. National energy security of the state depends on the country's policy on solving existing problems of the energy complex. It should be noted that even those countries that have significant reserves of natural resources and are among the most resource-rich in the world, because of ineffective state policies regarding their own mineral resources, do not bring enough benefits to the domestic economy.

The main trend in the modern world is that the available fuel and energy resources are not able to meet the needs of all countries. That is why many enterprises need to identify innovative ways to solve this problem. In our opinion, the problems of the shortage of this type of resources can be solved by the development of non-traditional energy sources. Therefore, we're faced with an important task: searching for new renewable energy sources and the introduction of the latest resource-saving technologies.

This will enable to create the global level environment where the economic and energy independence of countries from external factors will be ensured. Alternative energy in its essence involves the receipt and use of energy from renewable sources. Renewable sources of energy include the energy of seas, rivers, tributaries, solar radiation, biomass or even secondary energy resources. Most developed countries in the world are actively introducing alternative energy sources in practice. This reduces the use of traditional sources, and, equally important, contributes to the preservation of the environment. According to the Ukrainian Association of Solid Fuel Producers, the share of alternative sources in the overall structure of the energy complex for 2015 is only 1% *(Statistichni zbirnik, 2015).* Compared to this, in Sweden, this indicator reaches a mark of 31.5%, in Austria - 22.4%, in Denmark - 9.9%, in the USA - 7%, and in Germany - 6.9%.

Table 1

Alternative types of energy and measures required for their implementation

Alternative form of energy	Necessary measures for implementation	Traditional energy source
Solar radiation	Setup of solar panels	Nuclear power
Hydraulic energy flows of rivers, tides and ocean waters, waves	Setting up activities near the great seas, oceans	Nuclear power
Wind power	Production of windlasses	Nuclear power
Biomass Energy	Biomass Processing	Oil and gas
Hydrogen energy	Hydrogen production equipment	Oil and gas

Source: According to data *(Kustovska, Ivanov, Kosenko, 2007)*

Ukraine has enough resources, but even this does not allow the country to be energy independent. Thus, due to the fact that 90% of Ukrainian energy resources are concentrated in its marine areas (oil reserves reach 3 billion tons of oil), and their extraction under these

conditions is complicated due to existing drilling problems at depths of more than 4 - 5 ths.m in the absence of technological and financial-economic opportunities, Ukraine is forced to be dependent on imports of energy resources. This significantly weakens its energy security and makes Ukraine's economy too vulnerable to global economic fluctuations.

The energy intensity of Ukraine's GDP is quite high, what negatively affects the competitiveness of its economy. However, it should mentioned about such potential sources of renewable energy sources as hydropower, wind power, solar, geothermal, biogas, waste utilization, energy of tides and outflows.

Table 2

Potential sources of renewable energy sources

The direction of renewable energy sources (RES) development	**Annual technically achievable energy potential**		**Annual volumes of replacement of natural gas**
	Billion kw per year	Million t conventional fuel	Mlrd. m^3
Wind power	41,7	21,0	18,3
Solar power	28,8	6,0	5,2
Geothermal energy	105,1	12,0	10,4
Small hydropower	8,3	3,0	2,6
Bioenergy	162,8	20,0	17,4
Energy environment	154,7	18,0	15,7
Total Renewable Energy Sources	501,4	80,0	69,6

Prepared according to the Institute of Renewable Energy National Academy of Sciences.

Data from the State Agency for Energy Efficiency and Energy Conservation indicate that alternative sources will provide to obtain about 98 million tons of conditional fuel per year: bioenergy accounts for 31 million tons, wind power - 28 million tons, and solar power - 6 million tons. In total, this represents about 40% of the total energy balance of Ukraine (*The Ministry of Agrarian Policy of Ukraine, 2018)*. One of the most affordable, economical and environmentally friendly types of fuels for Ukraine is biofuels, which companies create through the processing of biomass. Biomass includes renewable substances of organic origin, undergoing a biological decomposition (first of all, waste from agriculture, forestry complex and other related sectors of the economy) *(Kravchenko, 2007).*

In this context, the situation with the use of energy resources in other countries, which are also on the way to European standards of energy efficiency is interesting. Among such countries, we can cite the example of Georgia.

Over the last decade electricity consumption has grown largely in line with real GDP growth rate and reached10.4 TWh in 2015. If This trend continues, in 10 years Georgia will have significant generation deficit. Between 2004 and 2010 as a result of renewal and rehabilitation of existing HPPs generation also grew significantly. Since 2012 twelve new HHPs have been commissioned, but as consumption continues to rise not only in Georgia, but in neighboring countries as well, there is great opportunity to develop new power plants to

keep up with this ever increasing demand. According to estimates, only 25% of Georgia's energy potential is exploited. Meaning that there is huge untapped potential, mostly from hydro resources, but also from wind, solar, geothermal and biomass sources as well. *(Georgian National Investment Agency, 2018).*

Currently, 17 hydropower plants are under construction, seven of them, with total installed capacity of around 300 MW, started in 2015. By the end of 2015, a 230 MW gas-fired combined cycle Thermal Power Plant was commissioned and construction of first Wind Power Plant in Georgia has started. In 2016, construction works on 14 new HPP's will commence. Georgian Energy sector is developing rapidly.

Ukraine has great potential in developing of enterprises for biofuel production. This is supported by climatic conditions, available natural resources, as well as a significant amount of cheap labor. In the future, our state can produce non-traditional types of energy not only for domestic consumption, but also for supplying abroad. In our opinion, biofuel production will help Ukraine to deprive of energy dependence, help create new jobs, balance the share of different fuel types in the market, and also monetize the results by obtaining funds from the supply of energy sources of biological origin to other countries. In particular, our state has significant waste of agricultural production and energy crops. The main resource for the production of biofuels may be corn, sugar beet, wheat, sunflower, etc. From non-traditional types of resources, new varieties of poplar and willow are distinguished.

Ukraine has favorable conditions for growing crops (rapeseed, soy, corn, sunflower, etc.) as raw material for biofuel production. Under the condition of the allocation of 10% of agricultural land for rape and crop capacity about 25 centner per hectare, the country can grow up to 8.5 million tons of rapeseed each year. The processing of such volume provides an output of about 3 million tons of biofuels annually. This can provide for about 60% of country's annual need for diesel fuel. However, optimistic estimates of the development of the biofuel market contrasts with the problems of the existence of energy-intensive biofuel production technologies and the lack of institutional provision for the biofuel market.

Table 3

Energy potential of biomass in Ukraine

Fuel type	Energy potential, mln. conditional fuel per year
Straw of cereals (without corn)	5,6
Stem, maize and corn	2,4
Stem, sunflower husk	2,3
Waste wood	2,0
Liquid fuels (biodiesel, bioethanol)	2,2
Energy crops (willow, poplar)	5,1
In general (including other fuels types)	**24,2**

Source*: (The Concept of Non-Nuclear Development of the Power Industry of Ukraine, 2006)*

The advantage of biomass is renewable and cheaper costs than traditional sources. The price of alternative energy is from 3 to 17 times lower than natural, which is actively used in

most sectors of the economy. It is worth noting that biofuels can have solid, liquid and gaseous states *(The Ministry of Agrarian Policy of Ukraine, 2018)).*

This tendency is due to the fact that the launch of the biogas plant requires an investment of 2 to 4 million euros, and these funds are not available for all enterprises. In order to realize these projects, it is necessary to search for investors as the use of own bioresources reduces the cost of traditional energy resources, helps to reduce the cost of manufacturing products, contributes to the preservation of the environment and helps entrepreneurs to maximize their profits. Namely, such principles are among the most important in the innovation activity of enterprises.

The use of biofuels in the future will contribute to solving not only energy but also environmental problems: improving the condition of the air, which is now very contaminated with harmful substances, reducing emissions to the atmosphere of greenhouse gases. Biomass is one of the types of environmentally friendly fuel, provided its rational and efficient use.

The annual technically feasible energy potential of solar energy in Ukraine is equivalent to 6 million tones of conventional fuel, and its use can save about 5 billion m^3 of natural gas. The annual technically feasible energy potential of wind energy in Ukraine is equivalent to 15 million tons of conventional fuel, and its use can save about 13 billion m^3 of natural gas. Annual volumes of electricity production at the use of technically feasible potential of small rivers of Ukraine are estimated at 8.3 billion kWh / year, what will allow to obtain organic fuel economy in volumes equivalent to 3 million tons of GDP or 2.6 billion m^3 of natural gas.

The annual technically feasible energy potential of the environment in Ukraine is equivalent to 18 million tons of fuel equivalent, and its use can save about 15.6 billion m^3 of natural gas. Ukraine has a significant potential for biomass, suitable for energy production. According to expert estimates, based on official statistics, the total potential of biomass in Ukraine is about 50 million tons of standard fuel, technically feasible - 36 million tons of fuel equivalent, economically feasible - 27 million tons of fuel equivalent.

According to the draft of New Energy Strategy for 2035 "Security, Energy Efficiency, Competitiveness" one of the key priorities is the issue of reducing the import of energy resources. After all, in 2015, according to the State Statistics Service of Ukraine, the structure of fuel and energy resources was characterized by a high share of natural gas (28.9%, 26 million tons of oil equivalent). The share of nuclear power was 25.5% (23 million tons of nuclear energy); coal - 30% (27 million tons of oil equivalent); crude oil and petroleum products - 11.6% (10.5 million tons of oilseed); biomass (biomass, fuel and waste) - 2.2% (2 million tons of oil equivalent); GES - 1.1% (1 million tons of oil equivalent); thermal energy (thermal energy of the environment and waste resources of technogenic origin) - 0.6% (0.5 million tons of oil equivalent) and WEU and SES together - 0.1% (0.1 million tons of oil equivalent).

The total share of all RES was 3.6 million tons, or only 4%. Taking into account the limited natural resources in Ukraine, in 2015, the import dependency ratio, taking into account the supply of nuclear fuel, amounted to 51.6%, which poses a risk to energy security.

Conclusions and suggestions

Consequently, we can conclude that the issue of the energy efficiency of the national economy lies in one plane with the problem of energy supply. High-quality energy supply is a key factor in increasing the efficiency of the functioning of all spheres of the national economy. The volume and efficiency of production and consumption of energy largely determines the level of development of the country and the well-being of its population. In the last decades, the renewable energy sector has became of the dynamic segment of the world energy market, which plays a compensatory role in global energy consumption in the face of growing exhaustion of non-renewable sources.

The key factors in the development of renewable energy are a significant reduction in the cost of developing technology in this area, rising prices for traditional energy resources, a rapid increase in the level of environmental taxation of the business sector and large-scale support from the state energy-efficient projects. Implementation of renewable energy in all spheres of public life promotes the development of low carbon economy countries, reduction of greenhouse gas emissions into the atmosphere, and also weakens anthropogenic pressure on the global resource base.

References

Denisyuk, S. P., Kocar, O. V., Tchernetska, Y. V. (2016). Energy efficiency of Ukraine: Best Project Ideas. Project "Professionalization and Stabilization of Energy Mendez in Ukraine".

Georgian National Investment Agency. (2018). Invest in Georgia [Data file]. Retrieved from http://www.investingeorgia.org/en/keysectors/energy. [in English].

Industrial Development Report. (2011). Industrial Energy Efficiency for Sustainable Wealth Creation. Capturing environmental, economic and social dividends. UNIDO, 259. [in English].

Kravchenko, I. P. (2007). Main Directions of Biomass Research for Energy Production. Kyiv: Parlamentske vidavnictvo. [in Ukrainian].

Kustovska, A. D., Ivanov, S.V., Kosenko, O. I. (2007). Alternative fuels. Kyiv: Nacionalni aviaciyni universitet. [in Ukrainian].

Oikonomou, V., Becchis, F., Steg, L., Russolillo, D. (2009). Energy saving and energy efficiency concepts for policy making. Energy Policy, No. 37, 4787–4796. [in English].

State Agency on Energy Efficiency and Energy Saving of Ukraine. (2018). [Data file]. Retrieved from http://saee.gov.ua/. [in Ukrainian].

The Ministry of Agrarian Policy of Ukraine. (2018). Statistical information on the number of Ukrainian enterprises manufacturing biogas production equipment. [Data file]. Retrieved from http://minagro.gov.ua/en/node/16768. [in Ukrainian].

The Concept of Non-Nuclear Development of the Power Industry of Ukraine. (2006). [Electronic resource]. Retrieved from www.necu.org.ua/upl/nnconcept2.pdf. [in Ukrainian].

Tsapko-Piddubna, O. I. (2014). Theorethical Basis of Energy Efficient use Policy. Visnyk of the Lviv University, No. 35, 155 -163. [in Ukrainian].

Ukraine in Figures. (2015). Consolidated statistical analysis. [Data file]. Retrieved from http://istmat.info/files/uploads/53010/ukraina_v_cifrah_2015.pdf [in Ukrainian].

Kyiv: Igor Sikorsky Kyiv Polytechnic Institute. [in Ukrainian].