



## **PRODUCTION AND CONSUMPTION OF ENERGY RESOURCES IN UKRAINE IN THE CONTEXT OF RENEWABLE ENERGY DEVELOPMENT**

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### ***Abstract***

Cheap and ecologically friendly energy resources are vital factors for sustainable development of the national economy. Due to global climate change and the depletion of fossil fuel resources, renewable energy may promote energy security and decrease harmful emissions. This paper aims at studying strategic directions for biofuel production and its utilization in Ukraine. On the basis of the literature review, steady world trends of renewable energy use have been revealed. Production of energy resources and the efficiency of their utilization have been analyzed. The modern aspects and priority of bioenergy use are highlighted. To evaluate the competitiveness of biofuels and their influence on energy security and ecological safety, organizational and managerial measures have been proposed.

**Keywords:** energy dependence, fossil fuels, governance, renewable energy resources, biofuels, energy safety, ecological safety

### **INTRODUCTION**

One of the priorities of the world economy is to increase the efficiency of industrial production and utilization of energy resources. At the moment, the energy system and its policy (concerning supply security and global climate

change) are not farsighted. For any energy system, investment resources are needed. They are used to search for new sources of energy, to upgrade infrastructure and equipment.

Energy is a vital factor for achieving sustainable economic progress. However, increasing the energy demand of conventional fuels (coal, crude oil, and natural gas), energy resource price rise, harmful emissions are endangering economic growth (Sebri 2015). In some countries (e.g. China and India), where the economy is booming, energy consumption is increasing dramatically. Asian countries are experiencing some growth, but a lack of energy restrains their standard of living and further economic development (Terrapon-Pfaff *et al.* 2014; Kalinichenko *et al.* 2017).

Solving contemporary economic, ecological, social and climate change issues is possible on the basis of sustainable economic growth (Menegaki and Tugcu 2017; Menegaki and Tiwari 2017). A sustainable economy should rely on energy usage and comprise the following components: economic, environmental, and social (Beça and Santos 2010; Moldan *et al.* 2012; Kalinichenko *et al.* 2018).

Fossil fuels are exhaustible and detrimental to the environment. Renewable energy is a substitution for the above. Renewable energy resource usage improves energy security, decreases pollution and create new jobs (Vaona 2016; Alper and Oguz 2016). Renewable energy technologies may be divided into two groups. The first group includes mainstream energy technologies such as biomass (solid, liquid, and gaseous), solar energy (photovoltaic and thermal), hydropower, wind, and geothermal energy. The second group includes emerging renewable energy technologies such as advanced biofuels, marine energy, etc. (Hussain *et al.* 2017).

The growth of biofuel production impacts on the world food economy and it is of significant scientific interest (Zhang *et al.* 2013, Boucher *et al.* 2014). The crude oil price increasing and environmental impacts of petroleum fuels have resulted in the increase in renewable fuel production and land requirement. The influence of biofuel production on the ecology and food supply has great importance (Popp *et al.* 2011). State policy and regulation must help to maintain both energy consumers (industry, transport, etc.) and the agricultural sector (Murphy *et al.* 2011, Mohr and Raman 2013, Kalinichenko *et al.* 2018).

In these conditions, the state governance apparatus is expected to strive to be more adaptable and flexible (Palmer 2012). According to the Directive 2009/28/EC (European Union 2009) there are two compulsory goals by 2020: a 20% share of general energy consumption and a 10% share of energy (biofuels and electricity) from renewable sources in transport (Armeanu *et al.* 2017).

There is no easy way in which national governments can solve the multiple problems faced by bioenergy. This is argued by regulatory complexity (Gamborg *et al.* 2014). Exhausting fossil fuels causes complication for technology and an

increase in energy intensity of fossil fuel industrial production. It results in a decrease in economic efficiency. Therefore, our society needs to seek new reliable energy resources; bioenergy may be a way out.

Consequently, modern politics and market trends around the world are changing rapidly and dramatically. In the long run, low-carbon and environmentally-friendly energy is not only possible, it is even more beneficial than continuing the policy of consuming fossil fuels. However, the future of energy should not be the complete or partial replacement of one harmful technology into another, less dangerous. It is necessary to develop a new, more effective system, which will significantly improve both the use of energy and also its production, transformation and transportation. Getting energy from biomass is dynamically developing energy dependent countries because the intensive growth of the renewable energy market has not only the economic and energy aspects but also the environmental aspect. Such a strategic direction of energy use meets the conditions for sustainable development of the planet and the stable economic existence of society. Due to the constant shortage of fossil fuels, energy dependent countries are being interested in the substitutes for the above. Ukraine does not remain isolated from this process. And the technologies of production and use of various types of biofuels acquire important economic, energy and environmental significance.

## **RESEARCH AIM AND METHODOLOGY**

The purpose of the paper is to present the priority directions of sustainable economic and energy development to ensure energy independence and improve the environmental situation in Ukraine. The paper reveals the essence of modern trends in the efficiency and diversification of world energy consumption. On the basis of state statistical materials, the total consumption and actual production of primary energy resources in Ukraine have been analyzed. The consolidated energy balance has been analyzed.

During research, the following scientific methods were used: dialectical (systematization of historical trends in the development of world and domestic energy); monographic (research on priority principles of formation and management of energy policy and biofuel production); forecasting (formation of conceptual bases for regulation and development of strategies to reach competitive biofuel production); abstract-logical (theoretical generalizations and formulation of conclusions).

The information sources of the research were the scientific works of domestic and foreign scientists, information resources of the Internet network, statistical information of the State Statistics Service of Ukraine, the Ministry of Energy and the Coal Industry of Ukraine, and the results of their own research.

## RESULTS AND DISCUSSION

In the period of a market economy, solving of the global issues of energy safety of human life has become one of the key approaches. Due to incentives, tax breaks, and certain government programs for many developed countries, bio-energy is one of the priorities and main trends of renewable energy (Shershun *et al.* 2012, Goncharuk *et al.* 2018). Energy safety of any country is characterized by the availability of the sufficient amount of fuel and energy resources and indicators of their effective and rational use. The current direction of the modern period of Ukraine's development is the integration of its economic system into the European and world economies, which should provide strategic benefits from the participation in the world allocation of labor. At the same time, entry into the market system of the world economy must be inextricably linked with the establishment of serial production of competitive products both by the value and quality indicators. Further expansion of the international economic cooperation of Ukraine requires introduction of the energy policy in accordance with the political decisions of the leading countries of the world, first of all the European community, which have set the goal of transition to sustainable development of the economy. At the same time, the discrepancy between Ukraine's energy policy and practical activities in this area may be the situation discriminatory that is connected with a set of problems related to the support of the energy production and its rational use as well as the increase in the probability of threats to energy and economic safety.

Ukraine's energy supply is one of the most complex and problematic parts of management, the solution of which will proportionally and directly depend on the ability of quick overcoming the crisis processes in the national economy. First of all, it is necessary to ensure high efficiency of using domestic energy resources (coal, natural gas and oil), which will reduce the energy import dependence of Ukraine (Table 1).

The statistical data indicate that the domestic supply of the main energy resource, i.e. natural gas (including petroleum gas), on average comprises 43.1%. Crude oil (including gas condensate) has even lower domestic supply, which is 43.0%. The highest rate of supply is provided by coal – 80.6%.

A substantial decrease in the consumption of primary energy resources in 2014-2018 is caused by the fact that statistical yearbooks of Ukraine represent the data that are given and calculated without consideration of the temporarily occupied territory of the Autonomous Republic of Crimea, the city of Sevastopol and a part of the zone of the anti-terrorist operation.

In general, Ukraine's supply with the primary energy resources is 55.6%, which according to the world standards allows us to attribute our state to the middle level of energy dependence. The identified deficit of primary fuel and

energy resources of 44.4% is covered by their imports (mainly from Russia by 2014). However, according to the world energy security standards, energy supply from one importing country to the energy dependent country should not exceed 25% of the total deficit, otherwise it is necessary to increase the consumption of domestic renewable energy sources at the economically beneficial level.

**Table 1.** Total consumption and domestic mining of the main primary energy resources in Ukraine, 2000-2018

Years of research	Coal, million tons			Natural gas, billion m <sup>3</sup>			Oil, million tons		
	total consumption	domestic mining	supply, %	total consumption	domestic mining	supply, %	total consumption	domestic mining	supply, %
2000-2004	64.6	60.6	93.8	68.4	18.9	27.6	18.4	3.9	21.2
2005-2009	67.8	59.1	87.2	64.7	21.2	32.8	14.1	4.3	30.5
2010	67.8	55.0	81.1	55.9	20.5	36.7	11.3	3.6	31.8
2011	72.5	62.7	86.5	57.4	20.7	36.1	9.3	3.3	35.5
2012	73.3	65.7	89.6	53.4	20.5	38.4	4.8	3.4	70.8
2013	71.3	64.4	90.3	49.7	21.3	42.8	3.9	3.1	79.5
2014	53.9	45.9	85.2	40.0	20.1	50.2	4.2	2.8	66.7
2015	45.3	30.2	66.7	32.8	19.9	60.7	4.0	2.5	62.5
2016	48.7	31.6	78.2	34.0	20.0	58.8	3.6	2.3	63.9
2017	42.7	24.2	64.9	31.5	20.5	65.1	3.0	2.2	73.3
2018*	44.5	26.1	58.6	32.3	21.0	65.0	3.2	2.3	71.9
Average figures	59.3	47.8	80.6	47.3	20.4	43.1	7.2	3.1	43.0

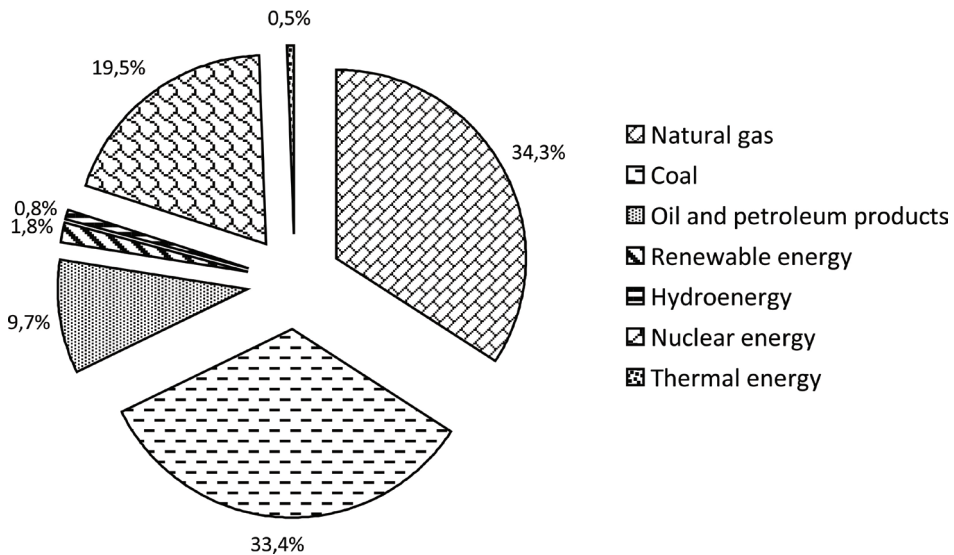
\*preliminary data

Source: Statistical yearbooks of Ukraine (2004, 2007, 2010, 2014, 2017), Socio-economic situation of Ukraine for 2018, Ministry of Energy and Coal Industry of Ukraine and authors' calculations

The analysis of results of the consolidated energy balance sheet of Ukraine for the period of 2010-2018 (Figure 1) indicates a leveling in the structure of energy consumption between the natural gas (34.3%) and coal and peat (33.4%), which is a positive aspect in the formation of energy supply of the country, taking into account significant domestic reserves of coal.

A negative factor is the reduction of consumption of crude oil and petroleum products on average by 9.7% as well as the import of a significant amount of petroleum products, but this provides an incentive for the development of biofuel production. In addition, in the generation of electricity, almost one fifth is nuclear power plants (19.5%), further operation of which is very dangerous (taking into account the previous domestic and world unfortunate experience).

The use of renewable energy sources in Ukraine is too low, therefore their contribution into the energy balance of the country is rather low (1.8%). In order to increase the amount of energy resources provided by the renewable energy sources in the structure of domestic energy consumption, the government needs to carry out intensive organizational activities and increase the number of objects of alternative energy of different ownership forms for the most promising technological developments concerning the biofuel production and consumption.



Source: formed by the authors on the basis of Statistical yearbooks of Ukraine (2004, 2007, 2010, 2014, 2017), Socio-economic situation of Ukraine for 2018, Ministry of Energy and Coal Industry of Ukraine

**Figure 1.** The structure of energy consumption in Ukraine, 2010-2018

According to natural and climatic factors as well as socioeconomic factors, our country has a strong energy potential in the biofuel production, since the economically feasible potential of the biomass available for energy use is estimated at about 32.09-33.59 million tons of conventional fuel per year and there is a tendency towards growth. The area of unutilized agricultural lands in Ukraine is about 3-4 million hectares. Using of biomass for renewable energy production will meet up to 25% of Ukraine's primary energy needs (according to the average index of the total energy consumption) (Klymchuk 2018). Approval of renewable energy sources, in particular biological fuels, in the Ukraine's energy consumption will play a significant role in the energy sector, which requires the support of the general public and combining of stakeholders to develop the infrastructure that would ensure the balanced use of energy resources in the state.

Biofuels in Ukraine should be considered as a viable alternative to fossil fuels. Domestic production of biofuels will lead to reduction in energy prices, promotion of environmental energy, focusing on the development of bioenergy technologies. In addition, the intensive and dynamic development of bioenergy requires a comprehensive optimization of this process, taking into account the needs of both the fuel and food sector of the economy, as well as state regulation of exports of biofuel raw materials. The biofuel market in Ukraine needs to be formed on the basis of organic combination of the state regulation and market mechanisms of self-regulation of the economic system (adherence to the principles of free competition, liberalization of the price policy on the energy resources, etc.). The biofuels production should be aimed at obtaining a maximum of stable and dynamically growing profits for an indefinitely long period, rather than immediate and excessive enrichment. The development of a regulated biofuels market should be based on biased decisions in the system of pricing policy that do not oppose free competition (Klymchuk 2015).

The process of industrial production of biofuels in Ukraine will improve the condition of the natural environment, which at the current stage of functioning of the national economy is characterized by unsatisfactory environmental indices on the emissions of major pollutants and carbon dioxide into the atmosphere (Table 2).

The average figures in Table 2 indicate that emissions of environmental pollutants range within the limits of 5660.4 thousand tons. Among them, in structural terms, the largest share is comprised by carbon monoxide (43.3%), sulfur dioxide (20.4%), methane (12.2%), and oxide compounds of nitrogen (nitrogen dioxide and monoxide 9.8%), which in the overwhelming majority are formed as a result of mining and further use of fossil fuels and accumulation of organic waste in the process of economic activity. It should also be noted there also occurs a gradual increase in the carbon dioxide emissions (especially in the period of 2010-2014) with an average value of 186.8 million tones, which is the main greenhouse gas in the formation of the greenhouse effect of anthropogenic origin.

One of the important approaches of ecologization should be an increase in the share of the structure of energy consumption of renewable energy sources, in particular – bioenergy, the development of which will contribute to the weakening of the energy dependence of Ukraine on imports of energy resources and improvement of the environment quality. Due to this, the processes of formation of a raw material base for the production of biodiesel and bioethanol should be paid special attention, while biogas production belongs to non-waste technologies (it performs environmental and resource-saving functions) that enables to solve energy saving problems. The proposed approach will help to increase Ukraine's energy safety, reduce the dependence of agricultural enterprises on the

external energy supplies, such as oil and natural gas (Khodakivska and Bigdan 2012, Kaletnik and Klymchuk 2013).

**Table 2.** Emissions of major pollutants and carbon dioxide in Ukraine, 2000-2018

Years of research	Emissions of pollutants, thousand tons							Carbon dioxide, million tons
	total	including					soot	
		sulfur dioxide	oxide compounds of nitrogen	carbon monoxide	methane	non-methane VOC*		
2000-2004	6115.4	1008.9	458.9	2875.0	666.2	221.1	20.5	126.9
2005-2009	6935.3	1281.2	584.7	3058.3	993.4	260.8	34.5	188.7
2010	6678.0	1235.2	612.6	2951.9	853.0	359.3	38.9	198.2
2011	6877.3	1363.4	656.8	2908.2	886.2	350.8	39.5	236.0
2012	6821.1	1430.3	649.1	2830.5	894.9	338.1	40.7	232.0
2013	6719.8	1413.3	648.8	2782.1	928.7	325.7	40.8	230.7
2014	5346.2	1160.6	553.7	2283.4	586.7	270.1	34.9	194.7
2015	4521.3	854.0	463.1	1971.9	519.4	225.8	33.3	162.0
2016	4264.2	1109.7	536.3	1878.5	472.8	412.8	32.7	179.9
2017	4057.5	926.2	484.4	1728.4	499.0	253.1	32.3	154.2
2018**	3928.3	894.8	424.3	1705.3	485.6	242.8	30.5	151.7
Average Figures	5660.4	1152.5	552.1	2452.1	693.7	296.4	34.4	186.8
Emission structure, %	100.0	20.4	9.8	43.3	12.2	5.2	0.6	–

\*VOC – volatile organic compounds; \*\*preliminary data

Source: Statistical yearbooks of Ukraine (2004, 2007, 2010, 2014, 2017), Socio-economic situation of Ukraine for 2018, Ministry of Energy and Coal Industry of Ukraine and authors' calculations

Consequently, the strategy of sustainable development of Ukraine's economy and energy cannot be implemented without solving complex environmental problems and ensuring the necessary level of protection of the environment and water basins from contamination with harmful substances. A negative impact of fossil fuels on the environment is manifested not only in the growing volumes of annual emissions of pollutants (in the period of 2000-2013), but also in the withdrawal from the natural resources of significant terrestrial territories, water resources, violation of the territorial landscape, impact on the climatic factors as well as the storage of large volumes of secondary resources. When developing a highly efficient state economy, it is necessary to compare the environmental impact of measures in the sphere of economy and consumption of various types



of fuel and energy resources and related environmental costs. There can be recommended only those measures of saving and use of fuel and energy resources, ecological effects of which justify necessary expenses and ensure an increase in the rates of the energy and ecological safety of the country.

As a result, an increase in the efficiency of mining and consumption of fuel and energy resources and achievement of the optimal rates of energy use will ensure a significant improvement of Ukraine's environmental safety. Without exaggeration, it can be argued that Ukraine needs a system of ecological safety that should take into account the peculiarities of the domestic fuel and energy complex and provide effective support of the state of socioeconomic relations, in which the activities of the state bodies of administration and the individual are deliberately directed towards prevention of emerging ecological threats and risks. Such a system is identified with the mechanism of guaranteeing human rights for environmentally safe living and working conditions, providing a comprehensive environmental protection of citizens and the environment for effective social and economic development. As a result, a set of environmental and energy problems of Ukraine is to be subjected to immediate solving and regulation, while formation of the competitive biofuels production is a promising way of their overcoming.

Therefore, solving of the problem of the increase in consumption of renewable energy resources is Ukraine's issue. The development of bioenergy significantly reduces the use of fossil fuels without slowing down of the economic growth. In addition, modern energy development strategies tend to focus on the implementation of effective bioenergy technologies at the regional and municipal levels.

## **SUMMARY AND CONCLUSIONS**

On the basis of official statistical data we have determined that Ukraine may be classified as a mid-level energy dependent country.

Due to the use of renewable energy sources, including biofuels, there are significant prospects for the development of society, the economy and the elimination of environmental problems. Governments should take into account the above in their energy, ecology, land use, water supply and agricultural programs. It should be noted that in modern society ecologically clean environment begins to manage the economic and political interests. It requires the development of a fundamental state approach to the biofuel production which is environmentally friendly energy resources.

First of all, before starting their own biofuel production, it is necessary to study the possible fallouts on the economic and social spheres, as well as a comprehensive impact on the environment. Only on the basis of the obtained

reliable results it is possible to develop strategies for the development of the bioenergy industry. It should take into account the general requirements and possible volumes of biofuel production, the economic justification, feedstock base, the advanced technologies and equipment. It is also necessary to factor in the current economic situation, the consumer preferences, and, the most important fact, investment climate.

Ukrainian fuel and energy complex must transit (consistently and systematically) from import fossil fuels and nuclear energy utilization to cover national energy needs at the expense of own renewable and nonrenewable energy resources. The state needs the development of a flexible system or economic and energy security. And the historical experience and the economic potential in bioenergy must be primary components of the strategy. This process is inevitable and should be carried out on the basis of well-known technologies in order to achieve its own energy independence and improve the environmental situation.

To develop the competitive biofuel production in Ukraine, the state regulation strategy should include the following measures: the termination of non-renewable energy resource subsidies; reduction of bank lending rates for producers and consumers of biofuels; tax exemption (at least 50%) for biofuel consumers and producers; environmental tax on harmful emissions from fossil fuel utilization; mandatory application of biofuels (bioethanol and biodiesel); innovation and investment attraction. Biogas production at large biogas plants is an actual and promising way in modern economic conditions. Its economic feasible potential is up to 6.5 billion cubic meters per year (Klymchuk 2018).

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