Engrettic Potential of Bio energy Development

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Abstract- **It is proved in this article that for Ukraine bio energy is one of the strategic directions of the renewable energy sector's development, in accordance to the country's high dependence on imported energy, primarily from natural gas. It is established that Ukraine has a great potential of biomass available for energy production, but the pace of bio energy development lags significantly behind European ones. To date, the share of biomass in gross final energy consumption is less than 2 percent. The results of the study showed a slight tendency to increase bio fuel production in recent years. It is determined that the annual economic potential of biomass in the Kyiv region is equivalent to 1743 thousand toe, and its use allows to save about 43% of fuel annually.**

The methodical approach to estimate the economic potential of waste through the use of alternative energy sources is substantiated. The possibility of using and producing bio fuels in Kyiv region is proved, the investment attractiveness of this region as a source of thermal energy is revealed.

The authors emphasize that in developed countries the use of biomass as an energy source continues to play an important role in a significant increase in prices for oil and gas, as well as the growing demand for environmental protection. Therefore, the introduction of modern technologies for ongoing energy production from biomass is an important condition for solving the problem of energy supply and preventing environmental degradation.

Keywords. Biomass, energy potential, alternative energy sources, resources, enterprises, fuel.

I. INTRODUCTION

Ukraine, as a member of the European Energy Community, has declared its conscious participation in a global policy aimed at sustainable development and reduction of harmful effects on the environment. Among the goals of this policy are important measures for the widespread use of renewable energy sources, which include solar energy, wind, geothermal energy, energy derived from biomass, various types of waste, and so on. Today, the trend in world power engineering is increasingly clear, which reflects the desire of the world's leading countries to replace traditional energy resources with appropriate analogues of plant origin. Such measures avoid dependence on traditional fuels and reduce environmental pollution, primarily by reducing greenhouse gas emissions.

II. LITERATURE REVIEW

Issues of effective formation of bio energy resources have been studied by many economists, in particular Galchynska Y.M. (Galchinska, 2018), Geletukha G.G. (Geletukha, 2014), Golub G.A. (Golub, 2013), Devianyn S.N. (Devianin, 2007), Shpychak O.M. (Shpychak, 2010), Kaletnik G.M. (Kaletnik, 2013), Mesel-Veseliak V.Ya. (Mesel-Veseliak, 2015), Kyrylenko I.G. (Kyrylenko, 2010) and others. Renewable energy is not a new concept nowadays; it becomes a regular issue in energy policy of EU countries. However, this sphere of economy still lack of uniformity, and even having quite a few types of renewable sources, they are not regulated equaly even in EU, not to tell about other countries. So by now we have a lot of works, dedicated to this topic. In Poland, this topic is top one in the Polish science. One of the known conferences, dedicated to the energy policy, "Energy Security - Pillars and Development Perspective" (2016-2020) became a ground for scholars for a discussion on energy issues. Many researchers on panels discussed and presented their thoughts on the renewable energy issues. Main foreman of this topic in Poland is Mariusz Ruszel, organisator and inspiration of the conference, as well as director of the Energy Policy Institute. One of these works is worth to mention as the example of background of our work is article of Jan Polaszczyk, Karolina Markiewicz (2019), in wchich authirs throughtfully analysed same topic on the basic of Visegrad group of contries. One of the most important findings of authors is the fact of lack of long-term plan with directly set goals. Main target of renewable energy management of Visegrad countries is to plan beforehand, create safe environment for development, lead and monitor increase of supply output and efficacy of the system and its' components, while focusing on an intelligent, sustainable development of crucial areas in Energy sector. Wiesław Lewicki (2019) stressed the need of diversification of supplies, differentiation of energy balance through increased use of renewable energy sources and increasing the energy effectiveness in historical aspect, while Nataliia Gerasymchuk (2018) outlined background of using renewable energy sources in order to ensure energy efficiency of Ukraine, given the statistic and existing situation in energy market, analized the resource base for renewable energy sources and local fuels for the energy efficiency and the reliability of Ukraine's energy supply, which became a start for this research. However, a comprehensive solution to this problem in the face of rising world energy prices remains relevant. In particular, in the agricultural sector, as one of the most energy-intensive industries, this has all the necessary conditions for biofuel production.

III. METHODOLOGY

The theoretical and methodological basis of the study is a dialectical method of cognition, which is based on a systematic and comprehensive approach to the study of domestic and foreign scientific positions and economic processes for the creation and use of various sources of bio energy. To achieve these goals, several research methods were used: scientific abstraction – to consider the scientific basis for the use of energy potential of biomass, to assess the key features of renewable energy, including bio energy as a component of sustainable development; graphic – to depict the results of the study; monographic – for the purpose of in-depth analysis of the process of energy supply for the production needs of individual agricultural enterprises. The energy needs approach used costing methods, as well as energy and economic modelling. Should be noted that the application of this approach is much more complex, which is due to the use of a large amount of information in the calculations. Despite the complexity of this approach, the results not only provide an opportunity to assess the current biomass potential of the study area, but also to forecast these indicators.

IV. RESULTS AND DISCUSSION

Ukraine, as a developed agricultural country, has significant energy development potential in the field of bio energy. This is facilitated by a rich fund of fertile lands and unproductive lands suitable for growing unpretentious energy plants, a favourable climate for agriculture, and the availability of the necessary human and material resources. High yields of major crops provide a sustainable resource base. Plant biomass plays the most important role in bio energy. Today it produces about 15% of the total thermal energy in the EU (Anonymous, 2017; Davydenko, 2015).

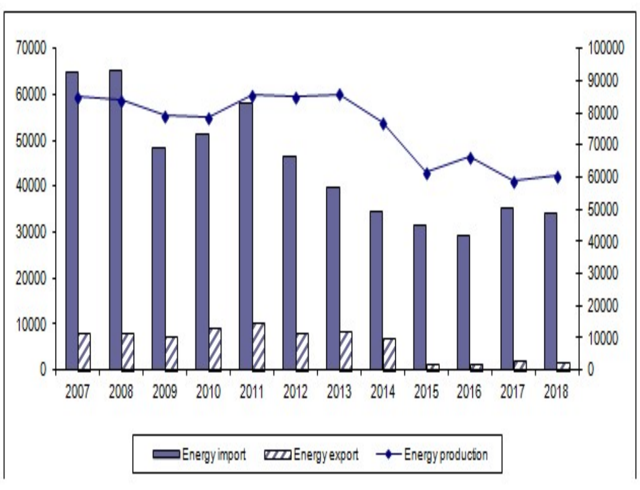

Figure 1: Production, export-import of energy in Ukraine, thousand toe Source: author's calculations

In the energy balance of Ukraine in 2018, the total supply of primary energy amounted to 93.1 million tons of oil equivalent (million toe) and decreased compared to 2007 by 33.1% (Fig. 1).

The supply of primary energy in 2018 is characterized by structural changes, in particular the share of renewable energy sources was 4,6%.

According to the data, the production and import of energy decreases. The total supply of primary energy from biomass increased to 3195 thousand toe, which is 2.1 times more than in 2007, but occupies only 3.4% of the total supply of primary energy. In electricity generation, hydropower still accounts for a significant share of renewable sources.

Thus, the most important in the structure of energy production from renewable sources is biomass. The growth of energy production from renewable sources is an important area for replacing natural gas, as there is a large reserve for the reorientation of biomass exports to the domestic market.

Biomass is becoming an increasingly important renewable energy source, due to the urgent need to reduce the consumption of expensive fossil fuels.

Technologies for energy production from biomass are well known and successfully applied. Biomass is a local fuel, and its use increases regional added value by minimizing imports of natural gas, oil and coal. Biomass production and supply contributes to the creation of new work places, mainly in rural areas, which is important for the local economy.

Sustainable development of bio energy requires, first of all, a careful assessment of the available biomass potential. Therefore, as an example, we have assessed the economic potential of biomass in the Kyiv region.

Kyiv region is an agrarian region in which large volumes of by-products and waste suitable for energy use are generated. Large areas of agricultural land create significant potential for growing energy crops.

The main source of biomass in the Kyiv region is primary crop waste (nutrient residues such as straw from cereals and industrial crops, corn stalks, sunflower husks, etc., as well as pruning of fruit trees).

To determine the economic potential of biomass from pruning fruit trees use the formula:

$$P_e = \sum_{i=1}^{n} Spac_i \cdot Pr_i \cdot Kt_i \cdot Koe_i \quad | \qquad (1)$$

Where: Spaci. – Area under fruit trees of the i-th species in fruiting age, thous. Ha;

Pri (2.4 for seed, 3.0 – for stone) – specific yield of pruning of fruit trees of the i-th species at fruiting age to calculate the theoretical potential of biomass, t / ha;

Kti = 0, 8 (approximate value) – coefficient of technical availability of pruning for calculation of technical potential of biomass;

Koei (0.406 for grain, 0.400 – for stone) – the coefficient of conversion of biomass potential into oil equivalent: calorific value of crop waste, calorific value of oil equivalent (Klius, 2012).

Table 1: Areas of perennial plantations in fruiting age in agriculture enterprises of Kyiv region, thus. Ha

	2014	2015	2016	2017	2018	2019
Areas of perennial plantations in fruiting age in agriculture enterprises, thous. ha						
Grain	2.60	1.80	1.50	1.30	1.00	1.00
Stone	0.10	0.10	0.10	0.10	0.10	0.10
Economic energy potential of wood from pruning's of fruit trees and vineyards, thousand toe						
Grain	2.00	1.40	1.20	1.00	0.80	0.80
Stone	0.10	0.10	0.10	0.10	0.10	0.10
Total	2.10	1.50	1.20	1.10	0.90	0.90

Source: author's calculations

The analysis shows that the area under grain plantations for the period 2014 –2019 decreased by 2.6 times, and under the stones remained unchanged. Therefore, according to our calculations, the economic energy potential of perennial plantations in the Kiev region is 0.9 thousand toe (Table 1).

The calculation of the economic potential of processing waste is carried out according to the following formula:

$$P_e = \sum_{i=1}^{n} Cpr_i \cdot Kr_i \cdot Koe_i \qquad (2)$$

Where: Cpri – volume of processed raw materials of the i-th type (sunflower seeds).

Kri – waste ratio, which determines the amount of waste generated during the processing of a certain type of raw material (Kr = 0.15 for sunflower seeds means that 150 kg of husk per ton of processed seeds or 15% of the volume of processed raw materials).

Koei – coefficient of conversion of biomass potential into oil equivalent: calorific value of processing waste / calorific value of oil equivalent (Coe = 0.358 – for sunflower husk) (Klius, 2012).

Table 2: Volumes of processed raw materials, thus. Tons

	2014	2015	2016	2017	2018	2019
Sunflower seeds	326	338	363	363	385	370
Economic energy potential of waste from processed raw materials, thousand toe						
Husks of sunflower seeds	17.50	18.10	19.50	19.50	20.70	19.90

Source: author's calculations

Analysis of processed raw materials by agricultural enterprises of Kyiv region shows that its volume for the analyzed period remained virtually unchanged and amounted to 2019 – 370 thousand tons, which in terms of economic energy potential of waste processed raw materials are 19.9 thousand toes (table 2).

In the process of logging activities, which consists of felling for general use and sanitary felling, several "streams" of wood biomass are formed, which can be considered as fuel. These are fuel chips, firewood, waste from logging (crown, twigs, stumps, branches, etc.), waste from primary and secondary wood processing (sawdust, shavings, trimmings, etc.).

The energy potential of wood waste Wood is determined by the formula:

$$P_{wood} = (V_{wood} * K_1 + (V_{wood} - V_{com}) * K_2 + V_{wood} * Q_{wood} \qquad (3)$$

Where: Wood – volume of wood logging, m3;

K1 = 0, 1 – waste ratio for logging;

V com – volume of round wood (commercial wood), dense m3;

K2 =1– (0, 2 ... 0, 25) = 0, 8 ... 0, 75 – total waste ratio of primary and secondary wood processing. Given the loss of waste that occurs in the process of wood processing and is 5 – 10%, we take K2 = 0.70.

Q wood= 0,186 тoe /dense m3 – calorific value of dense wood during logging (Klius, 2012).

Years	Wood logging, thous. m3	Round wood (commercial wood), thous. m3	The volume of wood waste		Firewood logging, thous. M3	Economic potential of wood waste, thous. toe
			Logging, thous. m3	Processing, thous. M3		
2015	1608,7	563,5	161	732	518,7	262,5
2016	1785,3	547,1	179	867	551,6	297,0
2016	1912,2	522,7	191	973	1139,0	428,3
2017	1916,0	440,0	192	1033	1219,2	454,6
2018	2077,5	589,2	208	1042	1196,5	455,0
2019	2015,2	559,7	202	1019	1100,8	431,7

Source: author's calculations

Studies show that wood logginging in the Kyiv region is increasing. So, in 2015 1608.7 thous. m3 of wood were harvested, and in 2019 – 2015.2 thous. m3, which is more by 25.3%. Also, during the corresponding period, firewood logging increased 2.1 times, as a result of which the economic potential of wood waste increased 1.6 times and amounted to 2019 – 431.7 thous. Toe against 262.5 thous. Toe in 2015 (table 3).

Formula for calculating the energy potential of biogas (toe) from organic waste:

$$E_{LS} = \sum_{i=1}^{n} \frac{365 \cdot N_i \cdot q_{mi} \cdot \frac{TS_i}{100} \cdot \frac{VS_i}{100} q_i^{bg} Q_{LHV}^{bq}}{Q_{LHV}^{oe}} \quad (4)$$

Where: Ni – the total number of animals of the i-th species, heads;
qmi – specific yield of organic waste of the i-th type, kg / (h.-day);
TSi – dry matter content in organic waste of the i-th type, %;
VSi – the proportion of organic matter in the dry residue of the i-th species, %;
– Expected specific yield of biogas from organic waste of the i-th type, m3 / kg DOM (dry organic matter); – Expected lower heat of combustion of biogas (LHV), generation from organic waste of the i-th type, MJ / nm3;
=41,868 MJ / kg – lower heat of combustion of oil equivalent (Tararyko, 2011).

There is no centralized collection of organic livestock waste in small enterprises of Kyiv region, so the calculation of the economic energy potential of livestock waste will be carried out only for agriculture enterprises with a population of at least: cattle – 2000 heads, pigs – 9000 heads and poultry over 400 thousand heads. Only such enterprises ensure the operation of a cogeneration unit with a capacity of at least 200 kW.

Analysis of the data shows that for the period 2014 – 2019 livestock changed, namely cattle and pigs decreased by 15% and 1.3% accordingly, and poultry increased by 6.0% over the same period (Table 4).

Table 4: Economic potential of biogas from organic waste

	2014	**2015**	**2016**	**2017**	**2018**	**2019**
Livestock *, thousand heads						
Cattle total	40	38	37	35	34	34
Pigs	228	226.5	225	224	226	225
Poultry	15958	16005	16402	16454	16589	16921
Biogas from organic waste, thousand toe						
	2014	2015	2016	2017	2018	2019
Cattle total	10.2	9.7	9.4	8.9	8.6	8.6
Pigs	13	12.9	12.8	12.8	12.9	12.8
Poultry	38.3	38.4	39.3	39.5	39.8	40.6
Total	**61.4**	**61**	**61.6**	**61.1**	**61.3**	**62**

Source: author's calculations

Due to the increase in poultry and its largest share in the total population, which in 2019 amounted to 16.9 million heads, biogas from organic poultry waste can be obtained the most – 40.6 thous. toe.

Calculating the total economic potential of biogas shows that these types of livestock can get 62.0 thous. toe.

Today, the issue of using alternative sources for energy production is one of the most pressing in the world. Biogas plants are becoming an important component of energy and industrial complexes. Their advantages are indisputable: it is not only the production of fuel that can be used for electricity production, other industrial needs of industrial complexes, but also the solution of waste utilization – instead of the cost of their removal and disposal, the company receives additional income (Anonymous, 2019).

In a number of countries around the world, biomass energy has taken an important place in the energy balance. For example, in Denmark, the share of biomass energy accounts for more than 7% of total energy, in Austria – 12%, in Sweden – 21%, and in Germany – more than 24%. In general, the EU produces 14% of its total energy demand each year. The European market for biogas plants is estimated at $ 3 billion, and is projected to grow to $ 25 billion by 2020 75% of biogas is produced from agricultural waste, 17% – from organic waste from private households and businesses and another 8% – sewage treatment plants (Geletukha and Zhelezna, 2017).

Also available for energy production are straw from rye, wheat, barley, oats, millet, buckwheat, peas, canola, soybeans, as well as corn and sunflower stalks. Therefore, the share of vegetable waste from agriculture can be used for energy production. To determine the yield of straw, the yield of by-products is taken into account, which depends on the yield of crops.

The calculation of the yield of by-products (straw) for energy purposes is based on the loss factor; determination of the amount of by-products for fertilizers up to 50% and the needs for livestock, feed and litter.

The distribution of straw in the enterprises of Kyiv region by areas of use shows that in 2019 the available amount of straw is – 1538.4 thousand tons, 769 thousand tons of which are applied as fertilizers, 189 thousand tons – used for litter and 547.8 thousand tons – can be used for energy use.

There are different types of biomass potential and there are usually three main ones: theoretical, technical and economic. Theoretical potential is the total maximum amount of terrestrial biomass theoretically available for energy production within fundamental biophysical limits. In the case of wastes and residues of different types, the theoretical potential is equal to the maximum formed volume of these wastes and residues. Technical potential – the share of theoretical potential available under certain technical and structural conditions and current technological capabilities. In addition, spatial constraints caused by competition between different land users, as well as some environmental and other non-technical constraints, are taken into account. Economic potential – the share of technical potential that meets the criteria of economic feasibility under these conditions. In our study, only the economic potential is assessed, as it best reflects the amount of biomass available for energy needs.

Table 5: Economic potential of grain and industrial waste, thousand toe

	2014	2015	2016	2017	2018	2019
Wheat	123.6	143.3	167.1	91.8	125.1	153.8
Rye	3.7	3.4	3.4	3.7	4.0	3.5
Barley	22.9	22.6	27.6	13.3	18.6	27.8
Oat	1.0	0.7	0.6	0.4	0.4	0.4
Millet	0.1	0.1	0.1	0.0	0.1	0.5
Buckwheat	1.0	1.0	1.0	0.9	1.0	0.8
Legumes	2.5	2.4	2.7	2.3	2.2	2.6
Corn stalks	592	413	525	456	819	795
Sunflower stalks	60	59	91	80	114	100
Soybean straw	104	87	98	73	86	61
Rapeseed straw	30	26	13	20	34	36
Total	**941**	**758**	**929**	**741**	**1205**	**1182**

Source: author's calculations

The results of the assessment of the economic potential of crop residues of grain and industrial crops in agricultural enterprises of Kyiv region are shown in Table 5. Agricultural enterprises of this region mainly grow wheat, barley, sunflower, soybean, rapeseed and corn for grain. Not all farms use crop rotations. Some of the by-products together with crop residues are mainly used as fertilizers, and some – for livestock needs, especially barley straw. Thus, the assumptions accepted in the methodology for estimating and calculating the biomass potential are confirmed, that up to 40% of by-products of rapeseed, corn and sunflower and up to 30% of other crops can be used for energy purposes.

Table 6: Economic energy potential of waste in Kyiv region, thousand toe

	2014	2015	2016	2017	2018	2019
Straw and waste	941	758	929	741	1205	1182
Sunflower husk	18	18	20	20	21	19,9
Pruning trees	2	1	1	1	1	1
Wood	262	297	428	455	455	432
Manure	61.4	61	61.6	61.1	61.3	62
Total	**1285**	**1135**	**1440**	**1278**	**1743**	**1697**

Source: author's calculations

The analysis of the obtained data shows that the economic energy potential of crop residues significantly depends on crop yields. In terms of oil equivalent, the largest energy potential in 2019 had straw and its waste – 1182 thousand toe. Next are wood – 432 thousand toe, and manure – 62.0 thousand toe. The lowest economic energy potential is obtained from sunflower husk and tree pruning – 19.9 and 1 thousand tons (Table 6).

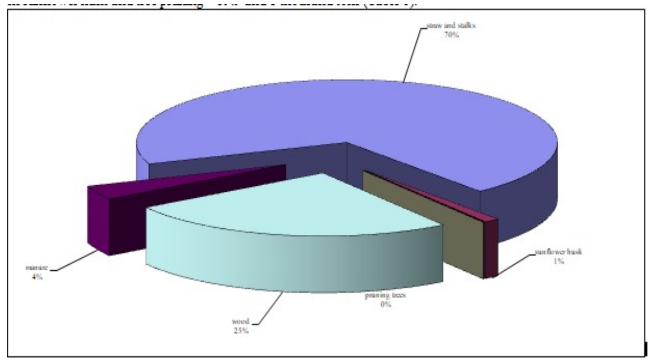

Figure 2: Structure of biomass energy potential in Kyiv region, 2019

Source: author's calculations

The total amount of economic energy potential in the Kiev region is – 1697 thousand tons, of which 70% is straw and stalks, 25% – wood, 4% – manure, 1% – sunflower husk (Fig. 2).

Analysis of the actual use of fuel in the Kyiv region shows that 4019 thousand toe were used in 2018, and according to our estimates the economic potential of waste and wood is 1743 thousand toe (Table 7).

Table 7: Total amount of used fuel in the Kiev region, thousand toe

Indicators	2014	2015	2016	2017	2018
Total fuel used, thousand toe	5101	4100	4222	3298	4019
Economic potential of waste and wood, thousand toe	1285	1135	1440	1278	1743
Including waste	1022	838	1011	823	1288

Source: author's calculations

Studies show that in conditions of rising energy prices, heating with natural gas and coal is very expensive. According to our calculations, the Kyiv region can annually replace the use of this type of fuel by 43.3% with an alternative type of bio fuel.

V. CONCLUSIONS

Representatives of the biophysical economy have discovered the mechanism of energy conversion into life processes of biological objects, thus determining the importance and need for the development of bioenergy. Therefore, we can conclude that agricultural bioenergy should be based on the principles of physical and economic concepts.

Biomass reserves rank fourth after coal, gas and oil. Because biomass is a solid fuel, it can be compared to coal. However, from an environmental point of view, the use of biomass in energy production based on modern technologies is much safer than coal. Biomass is an important raw material for heating and electricity production in the world.

The main advantages of biomass over traditional fuels are: high environmental friendliness; more efficient use of natural resources; greater economic benefit; solving waste disposal issues; biomass is a local energy resource (Syrotiuk, 2015).

Biomass is a relatively pure alternative to more toxic fuels, but biomass releases toxic substances into the atmosphere during combustion. Chemical emissions vary depending on the plant's raw materials, but contaminants such as nitrogen oxides, sulfur dioxide, carbon monoxide and particulate matter are common. These include filters, purifiers, biomass sources and gas systems. A large amount of carbon remains from oil, which is used to transport forest and industrial waste to the biomass plant. Greenhouse gas emissions can have a secondary impact on the environment for energy from biomass, but they are important.

Therefore, all these issues need to be studied in more detail so that renewable energy sources (in this case biomass) are truly 100% clean and environmentally friendly.

VI. ACKNOWLEDGEMENTS

Thus, the Kyiv region has all the necessary conditions for bio fuel production, both in terms of available land resources and plant potential. Already today, the potential of biomass in the region, suitable for cost-effective production of liquid bio fuels (bioe thanol and biodiesel) and gives grounds to argue about the prospects of this area.

Economic analysis shows a general global trend towards both rising energy prices and Ukraine's dependence on oil supplies from Russia and other countries, making it vulnerable to fuel for vehicles, agricultural and other machinery. Therefore, the expansion of areas for growing energy crops and the organization of biodiesel production using the latest world technologies and equipment is one of the priority strategic tasks of the state in the field of energy. The use of biofuels will reduce greenhouse gas emissions and will have a positive impact on reducing imports of petroleum products.

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