BUSINESS PERSPECTIVES

LLC "CPC "Business Perspectives"
Hryhorii Skovoroda lane, 10, Sumy, 40022, Ukraine

www.businessperspectives.org

Carl Zulauf (USA), **Natalia Pryshliak** (Ukraine), **Eleonora Kirieieva** (Ukraine), **Olena Prutska** (Ukraine)

ASSESSMENT OF THE POTENTIAL FOR A BIOFUELS INDUSTRY IN UKRAINE

Abstract

Ukraine is the only major agricultural country whose production of biofuels has declined since 2010. Nevertheless, it has set a target of 11.5 percent of primary energy supply from biomass, biofuels and waste by 2035. Agricultural land needed to produce biofuels feedstock is calculated for two scenarios based on its current 11.5 percent target and previous 5.0 percent target specified as a share of transport energy consumption. The export orientation of Ukraine's crop sector and resulting foreign currency earnings pose trade-offs if crops are diverted from exports to biofuel feedstocks. Given these trade-offs, policy options for developing a biofuels industry while satisfying Ukraine's export and domestic markets are to (1) bring land not currently cultivated into production and (2) increase yield. Both options are found to have substantial potential.

Keywords alternative energy, biofuels, energy consumption structure, production scenarios, state policy

JEL Classification O32, Q16

Received on: 23rd of March, 2018
Accepted on: 3rd of October, 2018

Carl Zulauf, Ph.D., Professor Emeritus, Ohio State University, USA.

Natalia Pryshliak, Ph.D. in Economics, Senior Lecturer of the Department of Administrative Management and Alternative Energy Sources, Vinnytsia National Agrarian University, Ukraine.

Eleonora Kirieieva, Ph.D. in Economics, Associate Professor of the Economics Department, Vinnytsia National Agrarian University, Ukraine.

Olena Prutska, Doctor in Economic Sciences, Professor, Professor of the Finance, Banking and Insurance Department, Vinnytsia National Agrarian University, Ukraine.

INTRODUCTION

Ukraine has identified development of its agriculture as a strategic goal. However, it confronts tough global competition in agricultural markets and limited financial resources. Development of a biofuels sector offers the potential to both develop Ukraine's agriculture and increase its energy independence (Lupenko & Mesel-Veseliak, 2012, p. 3).

In 2012, Ukraine enacted "On Alternative Fuels", its first law on biofuels production. A five percent blend of all fuels sold in Ukraine was mandated by 2014. On February 12, 2015, Verkhovna Rada revoked the law. Neither the infrastructure to blend biofuels nor a government system to monitor compliance were in place. In 2017, Ukraine set targets for 2035 of 25 and 11.5 percent of Ukraine's primary energy supply, respectively, from renewable energy and from biomass, biofuels and waste (Energy Strategy of Ukraine, 2017).

Interfacing with this domestic agenda is Ukraine's desire to be integrated into the European Union (EU-Ukraine Association Agreement, 2016). Important components of this integration are cooperation in the energy sphere and development of renewable energy. The European Energy Security Strategy of 2014 sets a renewable energy target of 20 percent of final energy consumption by 2020, increasing to 27 percent by 2030. An earlier Directive, 2009/28/EU, set a renewable energy target of 10 percent of transport energy by 2020.

1. LITERATURE REVIEW

Assessments of bioenergy in Ukraine are few. Demirbas (2009) included Ukraine in a general examination of the world biofuels industry. Advantages of biofuels were emphasized. They included higher income, investment in plants and equipment, lower greenhouse gas emissions, greater energy independence, and new value-added domestic markets for domestic crops. Bilotskiy (2017) connected Ukraine's integration into the EU with renewable energy's role in global and Ukrainian energy markets. Support provided to renewable energy by the European Parliament and implementation of a biofuels certification program by Ukraine were discussed.

Delzeit (2018) examined policies to develop biofuels production in the EU and concluded that these policies need to consider the complexity of agricultural value chains, interlinks between sectors, different political instruments, food security, international trade, and ecological priorities. This conclusion mirrored an earlier article by Zilberman et al. (2011) that concluded biofuels in general offer great opportunities for both developed and developing countries, but a number of social, economic, environmental and technical issues must be confronted.

Numerous studies address biofuels production and policy in individual countries or groups of countries. A representative list follows. Murphy el al. (2015, p. 6392) and Cheteni (2017) analyze the potential for developing a sustainable biofuels sector in Ireland and South Africa, respectively. Elliott (2017) contains an extensive review of analyses of the US biofuels industry and policy, including the role of biofuels and biofuels policy in food prices and climate change. Beckman (2018) discusses development of biofuel production in Brazil, EU, US, China and India, focusing on upward pressure on agricultural commodity prices from using agricultural feedstock for both fuel and food. Vimmerstedt et al. (2015) develop a detailed model of the dynamics of biofuels production for several scenarios based on policies of leading biofuels producing countries (p. 160). Stafford et al. (2017) analyze biofuels development in different regions, focusing on the strengths and challenges of developing biofuels production. Medipally et al. (2015, p. 2) examine the impact of globalization on the development of alternative energy around the world.

Aims. Objectives of this research are to (1) describe Ukraine's current biofuels market, (2) compare it with world trends, (3) develop future scenarios, (4) report on a SWOT analysis, and (5) identify key policy needs for developing Ukraine's biofuels industry.

2. METHODS

Government and international agency data are compiled. They are analyzed using descriptive statistics and graphic methods. Scenario analysis is used to identify possible pathways and associated government policy needs to develop Ukraine's biofuels industry. Strengths, weaknesses, opportunities and threats are identified using SWOT analysis.

3. RESULTS

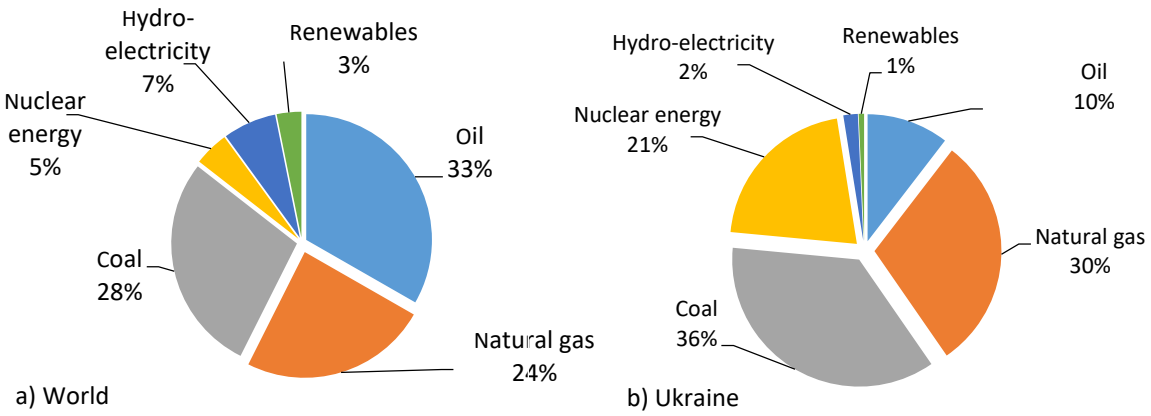
According to data from BP, oil supplied 33 percent of world energy consumption in 2016, followed by coal at 28 percent and natural gas at 24 percent (Figure 1). Coal supplied 36 percent of Ukraine's energy consumption, followed by natural gas at 30 percent and nuclear energy at 21 percent. Renewables (wind, geothermal, solar, biomass, and waste) supplied 3 percent for the world and 1 percent for Ukraine.

Between 2010 and 2016, world production of biofuels increased by nearly 30 percent (see Table 1). In 2016, biofuels comprised 20 percent of world renewable energy production. Ukraine is the only major agricultural producer in Table 1 with declining biofuels production.

The USA primarily uses corn to produce ethanol. According to the US Department of Energy, ethanol production accounted for approximately 134 million tons, or 35 percent, of total U.S. corn production in 2016. In comparison, bioethanol feedstock for the EU in 2016 is estimated at 8.9 million tons of cereals and 8.8 million tons of sugar beets, or about three and seven percent of total EU cereal and sugar beet production, respectively (USDA Foreign Agriculture Service; EU Biofuels Annual, 2016). Primary cereal feedstock is wheat in Northwestern Europe and corn in Central Europe.

http://dx.doi.org/10.21511/ppm.16(4).2018.08

Source: Developed by the authors using BP Statistical Review of World Energy (2017, p. 9).



Area	Oil	Natural gas	Coal	Nuclear energy	Hydro-electricity	Renewables
	Million tons of oil equivalent					
World	4418.2	3204.1	3732.0	592.1	910.3	419.6
Ukraine	9.10	26.1	31.5	18.3	1.6	0.6

Figure 1. Structure of world (a) and Ukraine (b) energy consumption by type, 2016

We agree with Geletukha and Zheliezna (2017) that Ukraine has great potential for bioenergy production. To focus our discussion, two scenarios are identified. Scenarios are plausible situations to be studied (USDA, 2017). The two scenarios are based on historical and current targets Ukraine has set for biofuels production (see Table 2). As Maack (2001) notes, "Scenario analysis has been used by the private sector for the last 25 years to manage risk and develop robust strategic plans in the face of an uncertain future. Its success in helping firms manage large capital investments and change corporate strategy has made it a standard tool of medium- to long-term strategic planning. Scenarios have helped public sector agencies plan for population growth and regional development, state transportation investments, and the distribution of landfills".

Table 2. Scenarios for biofuels share of Ukraine's transport fuel consumption by 2035

Source: Developed by the authors.

Scenario A Rescinded Ukraine target in "On Alternative Fuels", 2012	Scenario B Ukraine target in "Energy Strategy of Ukraine", 2017 applied to transport fuel
0.350 million metric tons in oil equivalent	0.805 million metric tons in oil equivalent
7 million metric tons of gasoline and diesel consumption times 5% biofuels target blend of all fuels sold in Ukraine by 2014	7 million metric tons of gasoline and diesel consumption times 11.5% current target for energy from biomass, biofuels and waste as a share of primary energy supply by 2035

Table 1. Biofuels production in the period 2010–2016 (thousand tons of oil equivalent)

Source: Developed by the authors using the data from BP Statistical Review of World Energy and USDA Foreign Agriculture Service.

Place	Year							Share in 2016	% increase: 2010–2016
	2010	2011	2012	2013	2014	2015	2016		
World, including:	64,008	65,834	66,863	72,293	79,703	80,024	82,306	100.0	28.6
USA	28,044	31,184	29,808	31,057	32,890	33,849	35,779	43.5	27.6
European Union (28)	11,466	10,707	11,593	12,394	14,286	13,820	13,580	16.5	18.4
Brazil	16,866	14,403	14,739	17,114	18,005	19,332	18,552	22.5	10.0
Argentina	1,670	2,234	2,295	2,014	2,644	2,038	2,828	3.4	69.3
Indonesia	723	1,110	1,397	1,750	2,547	1,354	2,503	3.0	246.2
China	1,584	1,970	2,130	2,346	2,609	2,653	2,053	2.5	29.6
Russia	n/a	n/a	n/a	58	72	84	96(e)	0.1	65.5
Ukraine	14	15	38	32	14	12	11	0.0	–21.4

Table 3. Estimated hectares to meet Ukraine's biofuel targets for transport fuels

Crop	2012–2016 average hectares in Ukraine, (thousand)	Share of all cropland planted in the period 2012–2016, %	Gross biofuel output, metric tons of oil equivalent from 1 ha	0.350 million metric tons in oil equivalent	0.805 million metric tons in oil equivalent
				Hectares to attain biofuel target for transport fuels (thousand)	
Ethanol production					
Corn	4,432	16.3	1.20	93	226
Wheat	6,250	22.9	0.79	131	319
Sugar beet	316	1.2	2.36	7	16
Biodiesel production					
Rapes	706	2.6	0.81	15	36
Soybean	1,710	6.3	0.31	36	87
Sunflower	5,327	19.5	0.62	112	272
Other cultivated land	8,538	31.2	–	–	–
Total	27,279	100	–	394	956

Given 2012–2016 average annual consumption of gasoline and diesel in Ukraine of 7 million tons of oil equivalent (State Statistics Committee of Ukraine), the hectares needed to meet the targets in Table 2 are presented in Table 3. They are calculated assuming the share of a crop devoted to biofuels production is the same for all crops. Crop output is converted into ethanol or biodiesel output using the conversion factors in Kaletnik (2018). The factors are 0.3002, 0.3121, and 0.0790 tons of ethanol per ton of corn, wheat, and sugar beets, respectively; and 0.3696, 0.1760, and 0.3520 tons of biodiesel per ton of rapes, soybeans, and sunflowers, respectively. They are multiplied by 0.68 to convert into oil equivalent output, then multiplied by 2012–2016 average Ukraine yields to derive the biofuel output per hectare for a crop, which are presented in column 4 of Table 3. Given these assumptions and calculations, the targets for scenarios A and B can be met with 394 and 956 thousand hectares, or 2.1 and 5.1 percent of average hectares cultivated during the period 2012–2016.

Ukraine's cereal agriculture is export oriented. Among the countries in Table 4, it has the highest export share for corn and close to the highest share for wheat. Exports of agrarian and food products in 2017 amounted to 17.9 billion US dollars and 41 percent of the value of all exports from Ukraine. Sunflower oil, wheat, corn and soy account for 24, 17, 15, and 6 percent, respectively, of Ukraine's exports of agrarian and food products. Ukraine may be unwilling to give up this source of foreign currency to develop its bioenergy industry. If so, Ukraine will need to increase crop production to meet its biofuels target.

Using the data from the State Service of Ukraine for Geodesy, Cartography and Cadastre, cultivable land not currently cultivated is calculated

Table 4. Comparison of corn and wheat production and export, major producers, 1,000 metric tons, 2016–2017 market years

Sources: Developed by the authors using United States Department of Agriculture Foreign Agricultural Service and FAOSTAT.

Place	Wheat production	Wheat exports	Wheat export share	Corn production	Corn exports	Corn export share
USA	62,833	29,488	46.93%	384,778	55,535	14.43%
EU (28)	145,369	27,319	18.79%	61,739	2,171	3.52%
Brazil	6,834	713	10.43%	98,500	19,794	20.09%
Argentina	18,400	12,275	66.71%	41,000	22,951	55.98%
Australia	31,819	15,000	47.1%	436	63	14.5%
Canada	31,700	20,500	64.7%	13,889	1,538	11.1%
China	128,845	748	0.58%	231,837	50	0.02%
Russia	72,529	27,809	38.34%	15,305	5,589	36.52%
Kazakhstan	14,985	7,250	48.38%	762	22	2.89%
Ukraine	26,791	17,200	64.20%	27,969	21,334	76.28%

http://dx.doi.org/10.21511/ppm.16(4).2018.08

Table 5. Yield of major crops for biofuels production, major agricultural producing or exporting countries, tons per hectare, 2012–2016 average

Source: Developed by the authors using FAOSTAT.

Country \ Crop	Maize	Rapeseed	Soybeans	Sugar beet	Sunflower seed	Wheat
Argentina	6,8	1,8	2,8	Not grown	1,9	3,0
Australia	7,2	1,3	2,2	Not grown	1,3	2,0
Brazil	5,1	1,3	2,9	Not grown	1,4	2,5
Canada	9,6	2,1	2,8	66,4	2,0	3,1
China	5,9	1,9	1,8	55,3	2,6	5,2
France	8,7	3,3	2,7	87,2	2,2	7,0
Kazakhstan	5,3	0,8	2,0	23,9	0,7	1,1
Russian Federation	4,8	1,1	1,3	41,6	1,4	2,3
Ukraine	5,9	2,5	2,0	44,1	2,0	3,7
United States of America	10,0	1,9	3,1	66,6	1,7	3,1

to be 5.2 million hectares. Biofuels that could be produced from this land are calculated assuming the (1) share of uncultivated land planted to corn, wheat, sugar beets, rapes, sunflower, and soybeans is the same as cultivated land in the period 2012–2016, (2) yield for uncultivated land equals 2012–2016 average yield for cultivated land, and (3) biofuel conversion factors are the same as in Table 3. Given these assumptions, biofuels equal to 4.4 million tons of oil equivalent could be produced from currently uncultivated land. This output is 63 percent of average consumption of gasoline and diesel during the period 2012–2016 and far exceeds the biofuels targets of Scenarios A and B.

Another strategy is higher yield on cultivated land. Table 5 compares average yield of the six biofuels crops for 10 major agricultural producing and exporting countries. Ranked from highest to lowest, Ukraine's yield ranks sixth for corn, third for wheat, second for rapes, eighth for soybeans, and third for sunflower. Among the seven countries that grow sugar beets, Ukraine's yield ranks fifth. Ukraine's average yield is 41, 48, 49, 27, 35, and 23 percent below the highest average yield for corn (USA), wheat (France), sugar beets (France), rapes (France), soybeans (USA), and sunflowers (China), respectively. Ukraine average yields for 2012-2016 would have to increase by 2.3 and 5.3 percent to increase output enough to meet the bio-

Table 6. SWOT analysis of biofuels industry development in Ukraine

Source: Developed by the authors.

INTERNAL	**STRENGTHS**	**WEAKNESSES**
	1. 42.7 million hectares of agricultural land (32.5 million hectares of arable land) (State Service of Ukraine on Geodesy, Cartography and Cadastre, 2018). 2. High scientific and intellectual potential: 27,755 post graduate students at Ukraine universities in 2016 (State Statistics Committee of Ukraine. 2018). 3. Highly-trained employees: 1.369 million students at 287 universities in 2016 (State Statistics Committee of Ukraine, 2018). 4. Plants have good access to roads, railway and some water transport: 20,952 km of operating rail lines; 1,569 km of navigable rivers; 163,033 km of highways. (State Statistics Committee of Ukraine, 2018)	1. Low level of innovation: Ukraine is 50th in global index of innovation (The Global Innovation Index Report, 2017). 2. Lack of biofuel infrastructure (Kaletnik, 2017). 3. Need for inputs such as fossil fuels, fertilizers and pesticides to produce bioenergy feedstock. 4. Possible higher price of feedstock crops from greater demand, making biofuels less competitive (Banse, 2014; Diachenko, 2018). 5. Degradation of land and water resources caused by intensive cultivation (Gomiero, 2017)
EXTERNAL	**OPPORTUNITIES**	**THREATS**
	1. Increase crop yields (see Table 5). 2. Reduce crop yield variability. 3. Bring uncultivated land into production (State Service of Ukraine for Geodesy, Cartography and Cadastre, 2018). 4. Create new jobs (Sereda, 2016). 5. Spur rural development (Kaletnik, 2017). 6. Help meet condition for EU integration: 27% renewable energy share by 2030 (European Energy Security Strategy, 2014). 7. Improve energy security: Ukraine imports 80% plus of liquid oil fuels (Energy Sector of Ukraine: the results of 2016)	1. Lack of government support (Janda, 2017). 2. Lack of interest from end users (Kirieieva, 2016). 3. Monopoly in traditional fuels market (Polukhovich, 2016). 4. Political and social instability: war in Eastern Ukraine (Kornievsky, 2017). 5. Corruption: Ukraine is 130th least corrupt nation out of 175 countries, (2017 Corruption Perceptions Index, Transparency International)

fuels targets of Scenarios A and B, respectively. In summary, a strategy of increasing yields appears feasible. A second potential benefit of a genetic breeding program could be lower yield viability, thus enhancing Ukraine's reliability as an international supplier. For a more extensive discussion of Ukraine's yield variability, see Zulauf (2017).

Using the preceding discussion as background, the main factors that will impact development of Ukraine's biofuels market are identified using a SWOT analysis (see Table 6). SWOT is a strategic planning tool used to evaluate Strengths (S), Weaknesses (W), Opportunities (O), and Threats (T) of a business venture (Rutz & Janssen, 2007). Factors internal to the venture are usually classified as strengths or weaknesses; factors external to the venture are usually classified as opportunities or threats.

The SWOT analysis identifies the following key biofuel policy needs for Ukraine:

1. Investment in breeding programs and science to develop new and high-yield crops.
2. Incentives to bring uncultivable land into production, such as tax exemptions and low interest loans.
3. Investment in biofuels infrastructure.
4. Establishment of a government agency for biofuels.

RESULTS AND DISCUSSION

Ukraine is the only major agricultural producer with declining biofuels production since 2010. Nevertheless, in 2017, Ukraine set a target of 11.5 percent of its primary energy supply from biomass, biofuels and waste by 2035 (Energy Strategy of Ukraine, 2017). Moreover, Ukraine seeks integration into the EU, which has set a renewable energy target of 10 percent of transport energy from renewable energy by 2020.

Ukraine's agricultural sector is a potential resource for biofuels production. However, the export orientation of Ukraine's agricultural sector and resulting foreign currency earnings pose trade-offs if crops are diverted from exports to biofuels feedstock. Given these trade-offs, policy options to achieve Ukraine's biofuels target are to (1) bring the 16 percent (5.2 million ha) of cultivable land not currently cultivated into production and (2) increase yields. The production resulting from bringing all uncultivated land into production would be 63 percent of average consumption of gasoline and diesel during the period 2012–2016. Ukraine's yields are between 20 and 50 percent of the highest yield among countries who are major agricultural producers or exporters. Ukraine's average yields for the period 2012–2016 would have to increase by only 4.1 and 8.8 percent to increase output enough to meet, respectively, the rescinded biofuels targets for 2014 or the current biomass, biofuels and waste target for 2035 if applied to transport fuels. The possibility thus exists for Ukraine to both develop a biofuels industry and satisfy its export and domestic markets if it willing to invest in bringing uncultivated land into production or in a genetic breeding program to enhance yields.

REFERENCES

1. Banse, M. F., Junker, A. G., Prins, E., Stehfest, A., Tabeau, G., Woltjer, & Meijl, H. Van (2014). Global impact of multinational biofuel mandates on land use, feedstock prices, international trade and land-use greenhouse gas emissions. *Landbauforschung Volkenrode, 64*(2), 59-72. http://dx.doi.org/10.3220/LBF_2014_59-72
2. Beckman, J. E., Gooch, Gopinath, M., & Landes, M. (2018). Market impacts of China and India meeting biofuel targets using traditional feedstocks. *Biomass and Bioenergy, 108,* 258-264. https://doi.org/10.1016/j.biombioe.2017.11.018
3. Beckman, J., & Nigatu, G. (2017). *Global Ethanol Mandates: Opportunities for US Exports of Ethanol and DDGS*. Electronic Outlook Report from the Economic Research Service (BIO-05).
4. Bilotskiy, S. N., Danylova, O., Grinenko, O., Karmaza, O., & Koucherets, D. (2017). Legal and economic aspects of Ukrainian enterprises activity at

http://dx.doi.org/10.21511/ppm.16(4).2018.08

the European renewable energy market. *Investment Management and Financial Innovations, 14*(2), 71-78. https://doi.org/10.21511/imfi.14(2).2017.07

5. BP (2017). *BP Statistical Review of World Energy*. Retrieved from https://www.bp.com/content/dam/bp/en/corporate/pdf/energy-economics/statistical-review-2017/bp-statistical-review-of-world-energy-2017-full-report.pdf
6. Cheteni, P. (2017). Sustainable development: biofuels in agriculture. *Environmental Economics, 8*(2), 83-91. https://doi.org/10.21511/ee.08(2).2017.09
7. Delzeit, R., Winkler, M., & Söder, M. (2018). Land Use Change under Biofuel Policies and a Tax on Meat and Dairy Products: Considering Complexity in Agricultural Production Chains Matters. *Sustainability, 10*(2), 419. https://doi.org/10.3390/su10020419
8. Demirbas, A. (2009). Political, economic and environmental impacts of biofuels: A review. *Applied energy, 86*(1), 108-117. https://doi.org/10.1016/j.apenergy.2009.04.036
9. Directive 2009/28/EU of the European Parliament and of the Council of 23 April 2009 on the promotion of the use of energy from renewable sources and amending and subsequently repealing Directives 2001/77/EC and 2003/30/EC (Text with EEA relevance) (n.d.). Retrieved from https://eur-lex.europa.eu
10. Dyachenko, Yu. A. (2018). World corn market and Ukraine's place in it. *Young Scientist, 2*(54), 391-393. Retrieved from http://molodyvcheny.in.ua /files/journal/2018/2/91.pdf
11. Elliott, K. A. (2017). *Global Agriculture and the American Farmer: Opportunities for U.S. Leadership*. Center for Global Development. Washington, DC.
12. Energy Strategy of Ukraine for the period up to 2035 "Safety, Energy Efficiency, Competitiveness". Order of the Cabinet of Ministers of Ukraine dated August 18, 2017 No. 605-p (n.d.). Retrieved from http://zakon2.rada.gov.ua/laws/show/605-2017-%D1%80
13. European Commission (2014). *European Energy Security Strategy. Brussels, 28.5.2014. COM (2014) 330 final*. Retrieved from https://www.eesc.europa.eu/resources/docs/european-energy-security-strategy.pdf
14. EU-Ukraine Association Agreement (n.d.). Retrieved from https://eur-lex.europa.eu
15. Food and Agriculture Organization of the United Nations (n.d.). The official website. Retrieved from http://www.fao.org/faostat/en/#data/QC
16. Geletukha, H., & Zheliezna, T. (2017). Status and prospects of bioenergy development in Ukraine. *Industrial Heat Engineering, 2*(39), 60-64.
17. Gomiero, T. (2017). Large-scale biofuels production: a possible threat to soil conservation and environmental services. *Applied Soil Ecology*.
18. Janda, K., & Stankus, E. (2017). *Biofuels Markets and Policies in Ukraine*. Retrieved from https://mpra.ub.uni-muenchen.de/76747/1/MPRA_paper_76747.pdf
19. Kaletnik, H. (2018). *Production and use of biofuels: second edition, supplemented: textbook* (226 p.). Vinnytsia: LLC "Nilan-Ltd".
20. Kaletnik, H. M., Honcharuk, H., & Dovhan, Y. (2017). Investment and innovation support for the cultivation of bioenergy crops and the production of biofuels. *Economy. Finances. Management: actual issues of science and practical activity, 1,* 7-18. Retrieved from http://efm.vsau.org
21. Kaletnik, H., Skoruk, O., & Branitskyi, Y. (2017). Organizational and economic principles of biofuel production organization in Vinnytsia region on the basis of Uladovo-Lyulinets Experimental breeding station *Economy. Finances. Management: actual issues of science and practical activity, 5,* 7-25. Retrieved from http://efm.vsau.org
22. Kirieieva, E. A. (2016). Biofuels production: world experience and possibility for developing in Ukraine. *Economy, finances, management topical issues of science and practical activity, 4,* 7-14.
23. Kornievsky, O. A., & Nechiporenko, V. O. (2017). Modern Challenges to Civil Society in Ukraine in Conditions of Political Instability. *Strategic Panorama, 1,* 61-66.
24. Lupenko, Yu. O., & Mesel-Veseliak, V. Ia. (2012). *Strategic directions of development of agriculture of Ukraine for the period till 2020*. NNTs "IAE". Retrieved from http://agroua.net/docs/strateg.pdf
25. Maack, J. (2001). *Scenario analysis: A tool for task managers* (Social Development Paper No. 36). World Bank, Washington, DC. Retrieved from http://siteresources.worldbank.org/INTPSIA/Resources/490023-1121114603600/13053_scenarioanalysis.pdf
26. Medipally, S. R., Yusoff, F. Md., Banerjee, S., & Shariff, M. (2015). Microalgae as Sustainable Renewable Energy Feedstock for Biofuel Production. *BioMed Research International, 2015,* 513-519. http://dx.doi.org/10.1155/2015/519513
27. Murphy, F., Devlin, G., Deverell, R., & McDonnell, K. (2013). Biofuel Production in Ireland – An Approach to 2020 Targets with a Focus on Algal Biomass. *Energies, 6,* 6391-6412. https://doi.org/10.3390/en6126391
28. Polukhovich, V. I. (2016). The main directions of development of competition and antimonopoly regulation on the markets of fuel and energy complex of Ukraine. *Private Law and Entrepreneurship, 16,* 136-140.
29. Razumkov Centre (2017). *Energy sector of Ukraine: the results of 2016*. Retrieved from http://razumkov.org.ua/uploads/article/2017_ENERGY-FINAL.pdf
30. Sereda, O. V., & Fedorus, L. A. (2016). Renewable energy as a promising direction for the sustainable development of rural areas. *Economic Forum, 2,* 145-151.

31. Stafford, W., Lotter, A., Brent, A., & von Maltitz, G. (2017). *Biofuels technology A look forward*. UNU-WIDER. Retrieved from https://www.wider.unu.edu/sites/default/files/wp2017-87.pdf

32. State Service of Ukraine on Geodesy, Cartography and Cadastre (n.d.). The official website. Retrieved from http://land.gov.ua/

33. State Statistics Committee of Ukraine (n.d.). The official website. Retrieved from http://www.ukrstat.gov.ua/

34. The National Security Strategy of Ukraine. Approved by the Decree of the President of Ukraine dated May 26, 2015, No. 287/2015 (n.d.). Retrieved from http://zakon4.rada.gov.ua/laws/show/287/2015

35. Transparency International. The global coalition against corruption (n.d.). The official website. Retrieved from https://www.transparency.org/country/UKR

36. United States Department of Agriculture (n.d.). The official website. Retrieved from https://apps.fas.usda.gov/psdonline/circulars/grain-corn-coarsegrains.pdf

37. United States Department of Agriculture Foreign Agricultural Service (2016). *EU Biofuels Annual 2016*. Retrieved from https://gain.fas.usda.gov/Recent%20GAIN%20Publications/Biofuels%20Annual_The%20Hague_EU-28_6-29-2016.pdf

38. United States Department of Energy (n.d.). The official website Retrieved from https://www.afdc.energy.gov/data/10339

39. United States Energy Information Administration (n.d.). The official website. Retrieved from https://www.eia.gov/todayinenergy/detail.php?id=32152

40. Vimmerstedt, L., Brian, J., Bush, W., Hsu, D. D., Inman, D., & Peterson, S. O. (2015). Maturation of biomass-to-biofuels conversion technology pathways for rapid expansion of biofuels production: a system dynamics perspective. *Biofuels, Bioprod. Bioref, 9,* 158-176. https://doi.org/10.1002/bbb.1515

41. WBA Global Bioenergy Statistics (2017, December 30). Retrieved from https://worldbioenergy.org/uploads/WBA%20GBS%202017_hq.pdf

42. World Intellectual Property Organization (WIPO) (2017). *The Global Innovation Index Report*. Retrieved from http://www.wipo.int/edocs/pubdocs/en/wipo_pub_gii_2017.pdf

43. Zilberman, D., Rajagopal, D., Sexton, S., Hochman, G., & Serra, T. (2011). The economics of biofuels, food, and the environment. In A. Schmitz, N. L. Wilson, Ch. B. Moss & D. Zilberman (Eds.), *The Economics of Alternative Energy Sources and Globalization* (pp. 24-34).

44. Zulauf, C. (2017). Ukraine grain and oilseed production: assessing recent success to attain sustainable success. *Economy. Finances. Management: topical issues of science and practice, 2,* 7-14.

http://dx.doi.org/10.21511/ppm.16(4).2018.08