

## DEVELOPMENT OF ENERGY INNOVATIONS AS AN OBJECTIVE NEED TO SECURE THE ENERGY INDEPENDENCE

### РОЗВИТОК ЕНЕРГЕТИЧНИХ ІННОВАЦІЙ ЯК ОБ'ЄКТИВНА НЕОБХІДНІСТЬ ЗАБЕЗПЕЧЕННЯ ЕНЕРГЕТИЧНОЇ НЕЗАЛЕЖНОСТІ

У статті здійснено системне дослідження, критична оцінка теоретичних положень та діючої практики розвитку енергетичних інновацій як об'єктивної необхідності забезпечення енергетичної незалежності в Україні. Проаналізовані етапи входження в Об'єднаний енергетичний системи України із правом реалізації електроенергії за «зеленим» тарифом. Здійснено аналіз потужності відновлюваної енергії за видами енергії в Україні за період 2015-2018 рр. Здійснено детальний аналіз розвитку в Україні трьох основних видів відновлювальних джерел енергії: сонячної, вітрової та біомаси. Доведено, що Україна за останні роки продовжує створювати значний фонд для фінансування енергоефективності в житловому секторі, зокрема, за фінансової підтримки Європейського Союзу. Доведено, що необхідність впровадження в діяльність промислових підприємств альтернативних джерел енергії зумовлена енергетичною, економічною та політичною кризами в Україні. Розглянуто проблеми та тенденції процесу впровадження альтернативних джерел енергії в економічні сектори України.

**Ключові слова:** енергозбереження, енергоефективність, енергетичний сектор, відновлювальні джерела енергії, сталій розвиток.

*В статтю здійснено системне дослідження, критична оцінка теоретич-*

*ських положень і діючої практики розвитку енергетичних інновацій як об'єктивної необхідності забезпечення енергетичної незалежності в Україні. Проаналізовано етапи входження в Об'єднані енергосистеми України з правом реалізації електроенергії по «зеленому» тарифу. Осуществлен анализ мощности возобновляемой энергии по видам энергии в Украине за период 2015-2018 гг. Осуществлен детальный анализ развития в Украине трех основных видов возобновляемых источников энергии: солнечной, ветровой и биомассы. Доказано, что Украина за последние годы продолжает создавать значительный фонд для финансирования энергетической эффективности в жилом секторе, в частности, при финансовой поддержке Европейского Союза. Доказано, что необходимость внедрения в деятельность промышленных предприятий альтернативных источников энергии обусловлена энергетическим, экономическим и политическим кризисами в Украине. Рассмотрены проблемы и тенденции процесса внедрения альтернативных источников энергии в экономические сектора Украины.*

**Ключевые слова:** энергосбережение, энергоэффективность, энергетический сектор, возобновляемые источники энергии, устойчивое развитие.

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*The article comprises a system study and critical assessment of theoretical foundations and established practices for development of energy innovations as an objective need to secure energy independence in Ukraine. The work includes the analysis of stages of admission into The Integrated Power System of Ukraine with the right to sell electricity according to the «green» tariff. An analysis is conducted on the capacities of the renewable energy sector by the kind of energy in Ukraine between 2015-2018. A detailed analysis is undertaken to study the development of three major renewable energy sources in Ukraine: solar, wind and biomass energy. It has been proved that lately Ukraine continues to build up substantial funding to finance energy efficiency in the housing sector, in particular with the financial support of the EU. It is asserted that the need to implement alternative energy sources into activities of industrial enterprises is substantiated by energy, economic and political crises in Ukraine. Issues and trends related to the process of implementation of alternative energy sources into economic sectors of Ukraine are examined. Harmonization of Ukrainian legislation will promote the competitive capacity of the national economy on a global scale. The paper reviews the peculiarities of nuclear energy use in the system of ensuring proper level of energy security and sustainable development of Ukraine. It is established that Ukraine must make utmost effort to secure its own energy independence. Regrettably, the percentage of renewable energy sources in the energy balance of Ukraine is currently one of the lowest in Europe. Large share of fixed assets within the energy sector is obsolete and requires considerable investment for their modernization. Expanding the cooperation with the EU will enable Ukraine to achieve long-term strategic objectives: to form competitive energy market, sustainable social and economic development and to ensure energy security. Nonetheless, an issue arises with regard to maintaining equal partnership – a joint effort of Ukraine and EU member states in various sectors of economy, specifically the energy sector.*

**Key words:** energy saving, energy efficiency, energy sector, renewable energy sources, sustainable development.

**Introduction.** Energy sector of countries is a core component of national economies and Ukraine is no exception within this context according to the Directive 2009/28/EC of the European Parliament and of the Council. Presently, the energy sector of Ukraine undergoes profound changes which are supposed to contribute to the formation of national energy sector over the next decades. Changes in the global environment, technological innovations and search for new alternative energy sources on par with growing use of renewable energy sources are some of the major energy-related trends in Ukraine.

Alternative energy (AE) is the sphere of energy production that provides the generation of electrical,

heat and mechanical energy from renewable energy sources (RNE). Stimulating its development would allow increasing energy security and independence of economic entities with consequent share of AE in the structure of total primary energy supply by 2020 growing by 75% – from 2,0% to 3,5% [14] and the target value of total capacity of traditional and renewable energy constituting a minimum of 10% from the total installed capacity by 2030 [15]. Combined with the comprehensive analysis of legislative and regulatory framework in the sphere of alternative energy, undertaken within the scope of the paper, a ranking of priority in the development of AE for Ukraine has been established with emphasis

placed upon the expedience of full-on implementation of similar projects.

**Analysis of recent research and publications.**

Currently there exists a vast number of studies in the energy sphere and peculiarities of energy innovations development. As an instance, we may refer to such scholars, as Bluszcz A. [1], Boersma T., Goldthau A. [2], Matschoss K., Repo P. [7], Nasiritousi N. [8], among others. Nonetheless, numerous issues remain outside of the scholarly focus. In particular, the need to develop renewable energy sources within the context of energy saving at the micro-level of economy.

**Formulation of objectives of the article.**

The objective of the article is a comprehensive study, critical evaluation of theoretical foundations and existing practices in the development of energy innovations as an objective need to secure energy independence in Ukraine.

**Results.**

Ukraine's electricity market is a constituent part of the Integrated Power System of Ukraine (IPSU). The IPSU acts as a multi-agent entity: an energy-generating and energy distribution economic entity.

The issues of state regulation by means of licensing the activities in the sphere of energy and public utilities, formation of pricing and tariff policies, government control and use of means of direct coercion belong to the jurisdiction of The National Energy and Utilities Regulatory Commission (NEURC) [12]. Study of the

requirements for admission into the WEM (Wholesale Electricity Market) with the right to sell electricity according to «green tariff» allowed to provisionally single out 5 stages (Figure 1).

The first stage stipulates the drafting of the project, its feasibility study (FS), coordination and approval of the location of the Solar Power Plants (SPP), etc.

The second stage stipulates the coordination of technical and organizational issues related to the connection to the IPS of Ukraine. Depending on the technical aspects of the project the coordinating entities might be represented by the member of the local community whose territory would be used for the construction of the SPP, the natural monopolist – the energy supplier or the NEURC. The third stage incorporates the construction and entry into operation of the SPP. This stage is material- and cost-intensive and, under favorable conditions, concludes together with the fourth stage which stipulates the coordination of organizational issues with the NEURC.

In accordance with the designated stages the accounting system of the enterprise forms the accounting and analytical provisions to control the compliance of project-related processes with the requirements of the approved project documentation, FS of the SPP construction, approved technical specifications (TS) of the project on connection to the power grid of the IPSU, licensing provisions, contract for sale of electricity, current legislation concerning the

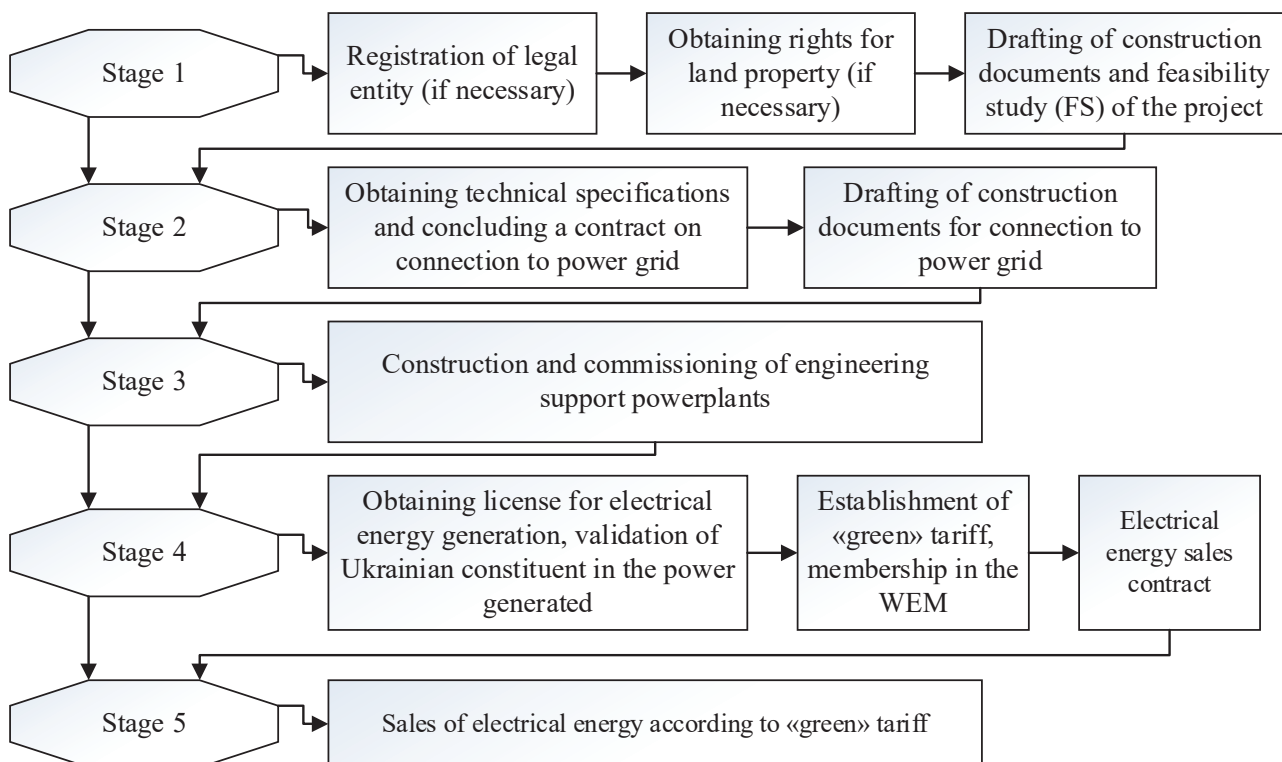


Figure 1. Stages of admission into the Integrated Power System of Ukraine with the right to sell electricity according to «green» tariff

Source: compiled by the author

observance of the conditions of the «green» tariff with 50% surcharge for Ukrainian-produced constituent of the equipment in use.

In 2016 Ukraine ratified the Paris Agreement having demonstrated its ultimate readiness for transition to low-carbon power, preparedness for reducing the risks related to the consequences of climate change and ensuring the objectives of the sustainable development [10].

However, despite all the issues that Ukraine is currently facing, renewable energy sources remain one of the top priorities of the low-carbon development policy and one of the ultimate tools for reduction of carbon emissions into the atmosphere (Table 1). Taking all these points into consideration, in 2016 a total of 120,5 MW of power generating capacities entered into active operation [10].

Referring to table 1 it becomes evident that the capacities of renewable energy are growing year by year. In 2017 a total generating capacity of renewable energy plants increased more than by 10% – to 1,5 GW [9]. During the entire 2017 the growth in the volume of «green» energy generation comprised 260 MW. The leadership is held by the solar power – 99,1 MW and the wind power – 11,6 MW. Furthermore, in 2017 four wind farms became operational – in Kherson, Mykolaiv, Lviv and Ivano-Frankivsk regions.

Solar power is the «youngest» energy source among the renewable energy source in Ukraine, however it proves to be the most dynamic sector of renewable power generation in Ukraine. Solar electrical power in Ukraine is traditionally generated in the southern regions of the country (Figure 2).

Hence, the installed capacity of solar power plants in Ukraine in 2017 constituted 742 MW which showed a 211 MW growth in comparison to the previous year. Development of renewable energy from SPPs is considered to be efficient due to a high number of sunny days and moderate air temperatures in the territory of Ukraine. Despite SPP being a leader by installed capacities in Ukraine the share of solar energy generation in Ukraine compared to the EU remains extremely low.

Wind-energy generation as well proves to be a promising area for development of alternative energy in Ukraine (Figure 3). However, the wind power generation is growing significantly slower than the solar. This may be attributed to the fact that wind power plants are substantially more complex to install, more expensive and require more operational costs.

As may be seen from the figure, wind power in Ukraine is developing at a fairly steady rate with continuous growth. In 1 year, the overall capacity of solar power stations in Ukraine increased by 27 MW to constitute a total of 465 MW. It is to be noted that some of the researchers consider that Ukraine is among the four European countries that are best capable of generating electricity from wind power [13].

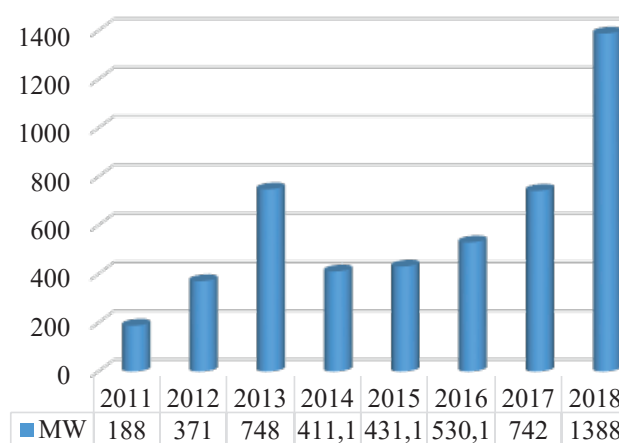
Furthermore, Ukraine possesses considerable amounts of biomass suitable for energy generation (Figure 4).

Possible supply of the biomass available is assessed at 27 mln. tons of fuel annually. According to the data by the State Statistics Service of Ukraine, the energy potential of the biomass accumulated by agricultural plants is evaluated at over 7,5 million tons of fuel per annum. This supply can provide for up to 10% of the total energy consumption in Ukraine [13].

Table 1

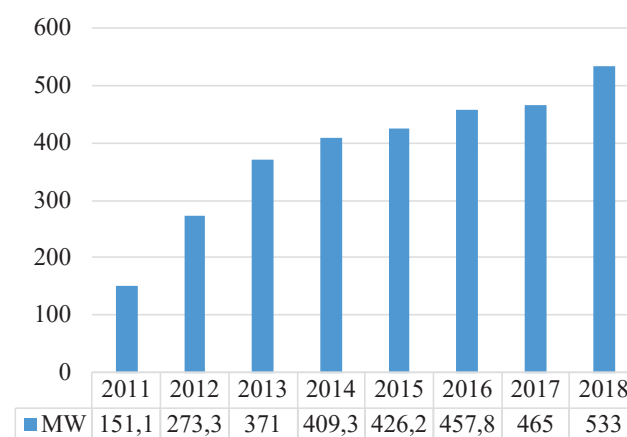
**Capacity of renewable energy sources by the forms of energy (MW) [10]**

	2015	2016	2017	2018
Wind	426	438	465	522
Solar	432	531	742	1097
Biomass	35	39	39	44
Biogas	17	20	34	41



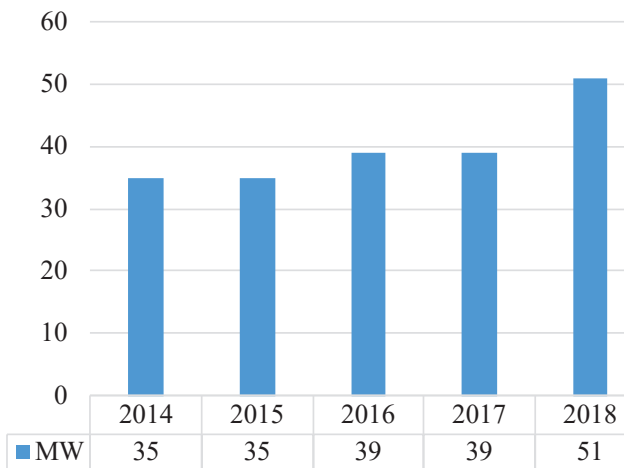
**Figure 2. Installed capacity of SPPs that operate by green tariff, MW**

Source: developed on the basis [9]



**Figure 3. Installed capacity of WPPs that operate by green tariff, MW**

Source: developed on the basis of [9]



**Figure 4. Installed capacity of renewable electrical energy plant (biomass) that operate by green tariff, MW**

*Source: developed on the basis of [9]*

It is worth noting that in 2018 additional capacities of 430 MW of power plants generating from solar, wind and biomass power as well as small hydropower plants entered into operation. A further growth of 83% of generated electricity from solar capacities, 13% growth from wind power plants and 4% growth of energy generated from biomass power plants was recorded. The share of renewable energy sources in the total energy generation capacity in Ukraine constitutes 1,8% while its share in value terms amounts to 8,3% [13].

An important fact to note is that in 2018 Ukraine acquired the status of the full-fledged member of the International Renewable Energy Agency (IRENA). This proved to be a confident step towards the improvement of investment climate of the country, the possibility to attract world leading technologies and to obtain subsidized loans for «green» projects [10].

In 2014 Ukraine signed a European Union Association Agreement with the purposes of enhancing the cooperation between Ukraine and the EU. Within the context of this Agreement, energy issues play a prominent role on the path to complete integration. Energy cooperation establishes an objective of contributing to the energy efficiency and energy saving in Ukraine, reforming and improving the energy markets, reducing CO<sub>2</sub> emissions and, most importantly, integrating Ukrainian energy sector into the European electrical energy network.

An objective need to incorporate the use of alternative energy sources into the activity of industrial enterprises is stipulated by energy, economic and political crises in Ukraine. Their consequences lie in the accelerated growth of prices for electricity and fuel; decrease in the quality of services related to supply of resources by energy service companies that are natural monopolists, etc. Such situation conduces to active development of «green energy» generation

market, emergence of competitive environment within the energy supply industry.

The energy strategy stipulates the setting of energy-related development goals by 2020 and by 2035. Key objectives of this strategy are, first and foremost, to form an economically secure and competitive environment, to increase the level of energy security, to reduce dependence on energy importation, the natural gas in particular. An overall effect of the implementation of the Strategy would be the transformation of the fuel and energy industry of the country from the problem sector that require continuous government support into modern, efficient, competitive sector of national economy capable of sustainable development and competitive activity in the European and global energy markets [11].

Presently, Ukraine is facing a range of issues related to the excessive use of overpriced imported fuel, ineffective markets and infrastructure. Apart from it, there occurs further deterioration of energy facilities in Ukraine, reduction of the domestic resource base, obstruction of power supply from the eastern regions [4–6]. These factors contributed to the emergence of new threats.

The primary method of neutralizing these threats lies in the diversification. Diversification is determined as one of the main directions for reduction of the energy dependence of the country. Moreover, diversification not only decreases the political risks related to the monopolistic energy supply but also services as a powerful contributor to decrease expenditures for purchase of fuel and energy resources due to the existing competition within the business environment. Countries of the European Union make extensive use of several directions for diversification of energy materials [3].

The first direction is a large-scale implementation of the liquified natural gas. The second direction for diversification includes the changes into the structure of consumption of energy resources which enables the country to increase its level of energy security by means of reducing the importation of energy resources [9]. In this respect Ukraine has a high potential of the bioenergy sector. It must be emphasized, that the future of bioenergy production is defined by the National Action Plan for Renewable Energy for the period until 2020. According to this plan bioenergy generation by 2020 must reach the level of substitution of the natural gas of 7,2 billion m<sup>3</sup> per year [9].

Ukraine's orientation towards European integration further envisages the harmonization of the national legislation in the sphere of energy efficiency and use of renewable energy sources with the legislation of the European Union. Such approach would ensure international competitive capacity of the Ukrainian economy, prerequisites for Ukraine's membership in international organizations and a further incentive to restore and reinvigorate the national energy sector.

The energy intensity of Ukraine's GDP is considerably higher in comparison to the economies of the European Union countries. It must be underlined that the high level of the GDP energy intensity is objectively conditioned by a high share of energy intensive sectors within the structure of Ukrainian economy such as metallurgical, chemical industry and mining operations. Simultaneously, low energy efficiency in the sectors of energy conversion and supply, high specific energy consumption for heating and hot water supply for households all serve to complicate the situation [9].

According to the research findings, the achievement of the objectives of the Energy Strategy of Ukraine with regard to the decrease of GDP energy intensity by 20% is realizable by means of gradual reduction of the total volume of primary energy by over 10% by 2020.

Ukraine remains one of the largest electrical energy consumers in Europe even after the economic downturn caused primarily by the armed conflict in eastern Ukraine. The total installed capacity of the country constitutes 55,3 GW. Thermal power plants still consume the overwhelming majority of the total installed capacity (24,5 GW), followed by nuclear power plants – 13,8 GW, while the share of electricity consumption by the installed capacities of hydropower plants constitutes 5,9 GW [9].

It should be also noted that in 2016 Ukraine was undergoing active reforms of the legal framework with regard to the gas market according to the obligations under a European Union Association Agreement and the Law of Ukraine «On the natural gas market». Further to it, the government of Ukraine continues to put every effort into improvement of oil products quality to match the EU standards. Since January 1<sup>st</sup>, 2016 a ban was implemented on the turnover of car petrol and diesel fuel belonging to Euro 3 emission standard [10].

Use of nuclear energy to satisfy the needs of the national economy and its stable functioning is a precondition for providing an appropriate level of energy security and sustainable development of Ukraine [11]. Hence the main efforts in reforming the nuclear sector were aimed at enhancing energy security and independence from the monopolistic supply of nuclear fuel and equipment in accordance with the experience and practices of the EU countries.

Apart from this, the European Union is the largest investor into the fund of construction of the new Shelter Structure over the destroyed 4<sup>th</sup> reactor of the Chernobyl Nuclear Power Plant [12].

**Conclusions.** In conclusion it is safe to say that Ukraine must make a greater effort in relation to its own energy independence. Currently, the percentage of renewable energy sources in Ukraine is one of the lowest in Europe. Ukraine's energy infrastructure, in particular electrical power plants, thermal power plants and gas pipelines, all require reconstruction.

However, despite all existing problems in the energy sector of Ukraine our country possesses every potential for accelerated economic growth and enhancement of its energy security. The energy security, in its turn, is an important constituent of the national security of the state. Therefore, the Ukrainian government implements strategic reforms into the sphere of energy supply, strengthening the energy security due to the realization of its energy strategy. Ukraine expands its cooperation with the countries of the European Union which provides the possibility to ensure Ukraine's protection, to create competitive energy resources market and facilitate sustainable social and economic development.

#### REFERENCES:

1. Bluszcz, A. (2017). European economies in terms of energy dependence. *Quality & Quantity*, 51(4), 1531-1548. URL: <https://link.springer.com/article/10.1007/s11135-016-0350-1>.
2. Boersma, T., & Goldthau, A. (2017). Wither the EU's Market Making Project in Energy: From Liberalization to Securitization?. In *Energy Union* (pp. 99–113). Palgrave Macmillan, London. URL: [https://link.springer.com/chapter/10.1057/978-1-137-59104-3\\_6](https://link.springer.com/chapter/10.1057/978-1-137-59104-3_6).
3. Bowden, N. & Payne, J. (2009). The casual relationship between U.S. energy consumption and real output: a disaggregated analysis. *J. Policy Model*, 2(31), pp. 180–188.
4. Gil'orme, T., Ryzhyk, Y., & Yaresko, A. (2016). Formation of the mechanism of energy efficiency management on the basis of 'predator-prey' concept. *Problems of development modern science: Theory and practice: Collection of scientific articles*. EDEX, Madrid, España, 107–110. URL: [http://conf.at.ua/27.07.2016\\_ispanija.pdf#page=107](http://conf.at.ua/27.07.2016_ispanija.pdf#page=107).
5. Gilorme, T.V. & Shachanina, Y.K. (2016). Corporate Social Reporting as a Dominant of Information Support for Enterprise Management. *Economics and Society*, (5), 672–677. URL: [http://www.economyandsociety.in.ua/journal/2\\_ukr/120.pdf](http://www.economyandsociety.in.ua/journal/2_ukr/120.pdf).
6. Hilorme, T., & Shachanina, Y. (2017). Staff development as an object of accounting of a social activity of the entity. *Economics and Finance*, 6, 14–20. URL: [http://econfin.at.ua/maket\\_ekonomika\\_i\\_finansy\\_06\\_2017.pdf](http://econfin.at.ua/maket_ekonomika_i_finansy_06_2017.pdf).
7. Matschoss, K., & Repo, P. (2018). Governance experiments in climate action: empirical findings from the 28 European Union countries. *Environmental Politics*, 27(4), 598–620. URL: <https://www.tandfonline.com/doi/full/10.1080/09644016.2018.1443743>.
8. Nasiritousi, N. (2017). Fossil fuel emitters and climate change: unpacking the governance activities of large oil and gas companies. *Environmental Politics*, 26(4), 621–647. URL: <https://www.tandfonline.com/doi/abs/10.1080/09644016.2017.1320832>.
9. Priority trends in ensuring the energy security of Ukraine in the terms of eurointegration. URL: [https://eeas.europa.eu/headquarters/headquarters-Homepage/4081/eu-ukraine-relations-factsheet\\_en](https://eeas.europa.eu/headquarters/headquarters-Homepage/4081/eu-ukraine-relations-factsheet_en).
10. Renewable energy in Ukraine. URL: [http://www.ukrexport.gov.ua/i/imgsupload/file/Renewable-energy-in-Ukraine\\_230\\_230\\_WWW.pdf](http://www.ukrexport.gov.ua/i/imgsupload/file/Renewable-energy-in-Ukraine_230_230_WWW.pdf)

11. Report on the implementation of the Association Agreement between Ukraine and the European Union in 2016. URL: <https://www.kmu.gov.ua/storage/app/media/zviti-pro-vikonannya/zvit-pro-assotsiatsiyu-2016.pdf>

12. Report on the results of the National Commission for State Regulation of Energy and Utilities in 2017. URL: [http://www.nerc.gov.ua/data/filearch/Catalog3/Richnyi\\_zvit\\_NKREKP\\_2017.pdf](http://www.nerc.gov.ua/data/filearch/Catalog3/Richnyi_zvit_NKREKP_2017.pdf).

13. The role and place of Ukraine's energy sector in global energy processes. URL: <http://razumkov.org.ua/uploads/article/2018ENERGY-ENG.pdf>.

14. Ukraine's new energy strategy until 2020: security, energy efficiency, competition. URL: [http://razumkov.org.ua/upload/Draft%20Strategy\\_00%20%287%29.pdf](http://razumkov.org.ua/upload/Draft%20Strategy_00%20%287%29.pdf).

15. Update of the Energy Strategy of Ukraine for the period up to 2030. URL: [mpe.kmu.gov.ua/minugol/doccatalog/document?id=222032](http://mpe.kmu.gov.ua/minugol/doccatalog/document?id=222032).