UDC 338.27+338.242.2 DOI: https://doi.org/10.18664/338.47:338.45.v0i64.144728

EVALUATION OF EV MARKET EXPANSION ON THE PERSPECTIVES OF ELECTRIC POWER ENGINEERING DEVELOPMENT IN UKRAINE

Krutsyak M., PhD student (National Technical University of Ukraine «Igor Sikorsky Kyiv Polytechnic Institute»)

The analysis of factors that lead to the changes in the market situation for electricity and changes of the development vector of electric power industry in Ukraine, respectively, is carried out. The state and condition of Ukrainian power industry in the coordinates of technology development are determined.

Established in the conditions provided by the current New energy strategy of Ukraine, it should be expected the deficit of electricity in the market and the increasing of the consumption by electric vehicles to the domestic consumers level. The potential influence of the rapid growth of the Ukrainian market of electric vehicles on the general situation in the power industry is determined. The works of the world-renowned experts in the field of energy economy, the statistical data and a number of basic legislative acts concerning the electricity market in Ukraine were analyzed.

The methodological basis to conduct the research is chosen and grounded. The structure of electricity consumption, main fuel, energy resources of the fuel and energy complex of Ukraine is presented. The dynamics of the electric power industry and the market of cars and

electric vehicles in the period from 2012 to 2017 is determined with the help of the graph-analytical method and the method of polynomial extrapolation of data using the approaches of complex and system analysis. The forecast of their development in the perspective up to 2035 are prepared. The separate indicators, which determine the further development of the power industry and the market of electric vehicles are analyzed.

It has been established that the Energy Strategy of Ukraine until 2035 "Safety, Energy Efficiency and Competitiveness" is no longer relevant for today, and therefore it is proposed to reconsider it taking into account the current state of technology development that leads or can lead to significant changes in the electricity market. It is proved that long-term planning and forecasting of the development of the electric power industry has lost its expediency in connection with the accelerated development of technologies. It is proposed to change forecasting and planning on a smaller horizon.

Key words: electric vehicles, car market, electricity, consumption, generation, fuel and energy complex.

ОЦІНЮВАННЯ ВПЛИВУ ЕКСПАНСІЇ РИНКУ ЕЛЕКТРОМОБІЛІВ НА ПЕРСПЕКТИВИ РОЗВИТКУ ЕЛЕКТРОЕНЕРГЕТИКИ В УКРАЇНІ

Круцяк М. О., аспірант (НТУ «КПІ імені Ігоря Сікорського»)

Здійснено аналіз факторів, які призводять до зміни кон'юнктури ринку електричної енергії та зміни вектору розвитку електроенергетики в Україні, відповідно. Визначено стан і положення електроенергетики України в координатах розвитку технологій.

Встановлено, що за умов подальшого розвитку ринку електричної енергії в Україні, передбаченими чинною Новою енергетичною стратегією України, слід очікувати настання дефіциту електричної енергії на ринку та зростання споживання її електромобілями до рівня, співставного із споживанням побутовими споживачами. Визначено потенційно можливий вплив стрімкого зростання ринку електромобілів України на загальну ситуацію в електроенергетиці. Опрацьовано роботи визнаних у світі експертів у галузі економіки енергетики, а також проаналізовано статистичні дані та низку базових законодавчих актів щодо функціонування ринку електроенергії в Україні.

Обрано та обґрунтовано методологічну основу проведення дослідження, що надає можливість врахувати вплив одного крупного споживача електричної енергії на увесь ринок. Приведено структуру споживання електроенергії та основних паливно-енергетичних ресурсів ПЕК України. За допомогою графо-аналітичного методу і методу поліноміальної екстраполяції даних із використанням підходів комплексного і системного аналізу визначено динаміку розвитку електроенергетики та ринку автомобілів і електромобілів у період з 2012 по 2017 роки, а також надано прогноз їх розвитку у перспективі до 2035 року. Проаналізовано окремі показники, що визначають подальший розвиток електроенергетики та ринку електромобілів.

Встановлено, що Нова енергетична стратегія України вже не є актуальною на сьогоднішній день, а тому запропоновано її переглянути з урахуванням сучасного стану розвитку технологій, які призводять або можуть призвести до значних змін на ринку електричної енергії. Доведено, що довгострокове планування і прогнозування розвитку

електроенергетики втратило свою доцільність у зв'язку з пришвидшеним розвитком технологій. Запропоновано змінити горизонт прогнозування і планування на менший.
Ключові слова: електромобілі, ринок автомобілів, електроенергія, споживання, генерація, ПЕК.

ОЦЕНКА ВЛИЯНИЯ ЭКСПАНСИИ РЫНКА ЭЛЕКТРОМОБИЛЕЙ НА ПЕРСПЕКТИВЫ РАЗВИТИЯ ЭЛЕКТРОЭНЕРГЕТИКИ В УКРАИНЕ

Круцяк М. О., аспирант (НТУ «КПИ имени Игоря Сикорского»)

Осуществлен анализ факторов, сильно влияющих на конъюнктуру рынка электрической энергии и на изменение вектора развития электроэнергетики в Украине, соответственно. Определено состояние и положение электроэнергетики Украины в координатах развития технологий.

Установлено, что при дальнейшем развитии рынка электрической энергии в Украине в условиях, предусмотренными действующие Новой энергетической стратегией Украины, следует ожидать наступления дефицита электрической энергии на рынке и рост потребления электромобилями до уровня, сопоставимого с потреблением бытовыми потребителями. Определено потенциально возможное влияние стремительного роста рынка электромобилей Украины на общую ситуацию в электроэнергетике. Обработаны работы признанных в мире экспертов в области экономики энергетики, а также проанализированы статистические данные и ряд базовых законодательных актов, касающиеся функционирования рынка электроэнергии в Украине.

Избрана и обоснована методологическая основа проведенного исследования, дающая возможность учесть влияние одного крупного потребителя электрической энергии на ситуацию на всем рынке. Приведена структура потребления электроэнергии и основных топливно-энергетических ресурсов ТЭК Украины. С помощью графо-аналитического метода и метода полиномиальной экстраполяции данных с использованием подходов комплексного и системного анализа определена динамика развития электроэнергетики, а также рынка автомобилей (в том числе, электромобилей) в период 2012-2017 гг. Предоставлен прогноз их развития в перспективе до 2035 года. Проанализированы показатели, определяющие дальнейшее развитие электроэнергетики и рынка электромобилей.

Установлено, что Новая энергетическая стратегия Украины уже не является актуальной на сегодняшний день, поэтому предложено ее пересмотреть с учетом современного состояния развития технологий, которые приводят или могут привести к значительным изменениям на рынке электрической энергии. Доказано, что долгосрочное планирование и прогнозирование развития электроэнергетики утратило свою целесообразность в связи с ускоренным развитием технологий. Предложено изменить горизонт прогнозирования и планирования на менее длительный.

Ключевые слова: электромобили, рынок автомобилей, электроэнергия, потребление, генерация, ТЭК.

Background. Electricity is one of the main branches of the national economy. Moreover, the normal functioning of the industry is a prerequisite for the functioning of other, not so important for the economy, industries. Its role and place can hardly be

underestimated, as there is a close relationship with socio-economic relations, with the environment, with economic security, and with resources support, etc. Therefore, the changes in the power industry have their impact on the related industries. That is why managing of changes in the electric power industry requires careful and prompt actions in order to avoid possible negative consequences.

The accession to the ENTSO-E (European network of system operators of electricity transmission), accession to the Paris climate agreement, and new-fashioned distribution of crypto currency mining closely interconnected with the increase in the share of electric vehicles in the Ukrainian automotive market, and the general decrease in electricity generation, which in the future may lead to the deficit of the latter. Till now we have not felt the negative effects of such changes. But it is important to pay attention to the study of the developing situation and create a set of measures to manage changes in the field of power energy.

Analysis of recent research and publications. Within last years many scientists, not only economists study the interconnections of power engineering as a component of the fuel and energy complex with related branches of the national economy. Particular attention was paid to the study of the relationships between electricity and other sectors of the economy in the context of sustainable development. V. Vernadsky [1], N. Georgescu-Rogan [2], K. Boulding [3], L. Kohrsen [4], and P. Weavermade [5] a significant influence on the development of research in this field. Their ideas were picked up by contemporaries, among which: Y. Paton [6], V. Heets [7], M. Zgurovsky [8], S. Voitko [9], B. Serebrennikov [10], R. Podolets [10], T. Stephens [11], M. Kaplan [12] and many others. Nevertheless the scientific researches of the above-mentioned experts in the field of energy economics are fundamental; the author provides an applied research that taking into account the impact of modern technologies development only on the one component in the triune concept.

The ***aim*** of the article is to determine the impact of the dynamic expansion of the domestic electromotive market on the electric power industry in Ukraine.

Previously unresolved parts of the general problem. Taking into account Ukraine's aspiration for entering to the European Union as an energy independent member, and in the future to become a key player in the European electricity market, attention should be paid to a comprehensive analysis of the factors that may lead to a deterioration of the situation in the domestic electric power engineering, as well as to carry out a detailed analysis and to evaluate the potentially consequences. As result, propose ways to solve the problems identified in the prospects for the development of electric power engineering, which has a large significance for the future of economy and its security.

Results. In Ukraine, following the constant changes in politics, economy, exchange rates, state borders, social and economic well-being, as well as transformations in the fuel and energy sector and in the power industry, in particular, raising the level of energy efficiency of the economy, environmental requirements and raising tariffs, while the industry's downturn is followed by a tendency to reduce the consumption of electricity, and, through the "supply-demand" chain, to reduce the generation of electricity, respectively (Fig. 1) [13].

However, such a decrease is not expected for a long term, as the rapid development of the Ukrainian electromotive market may lead to a significant increase in electricity consumption, first of all, by ordinary citizens (at the moment most of them have all the electric vehicles in the country) and then by state and non-state organizations that are more inertial and conservative with respect to technology development.

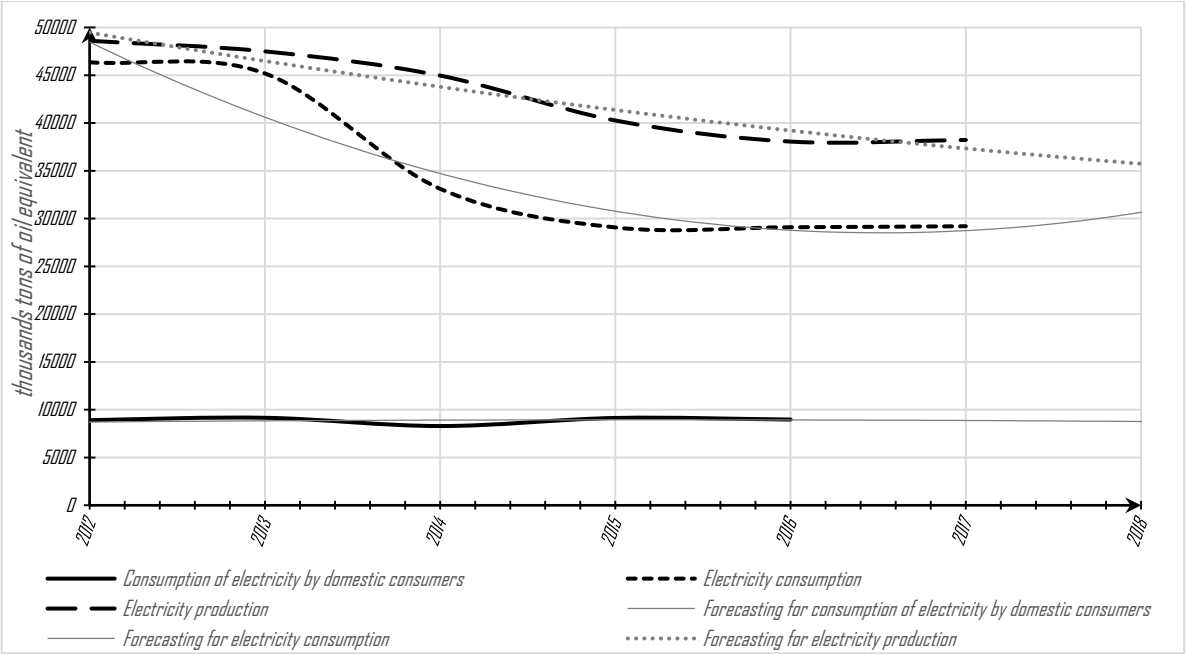

Figure 1. Volumes of total electricity production, total consumption and consumption by household consumers in 2012-2017, thousands tons of oil equivalent [14; 15; 16]

In Ukraine, the market of electric cars has gained considerable development over the last few years (Fig. 2). In the end of 2017, 6.9 million passenger cars were registered in Ukraine [17; 18; 19], among them 4,861 electric motors, which is about 0.07% of their total number. Thus, the average consumption for one electric vehicle is about 37 kWh per day (excluding the efficiency of charging devices), or for all existing cars by electric traction by the end of 2017 is about 65,647.8 thousand kWh (16,149.36 hereinafter tons of oil equivalent, calculated according to methodology of Horticulture business development project) during the year. If we compare the obtained data with the data that the average Ukrainian consumer of electric energy used in 2012 (when there were only 7 cars of this type in the electric vehicles market) is was about 2,200 kWh per year for all their needs (including heating, air conditioning, cooking, etc.) or about 6 kWh per day (calculated by the author on the basis of sources presented by The National Commission for state regulation in the energy and utilities). Thus, taking into account that the number of electricity consumers in recent years has not changed significantly (16,528,043 people in 2017 compared to 16,556,258 people in 2012), and only 4,861 of them have been purchased electric vehicles for the everyday use, this led to an increase in the electricity consumption of an average Ukrainian consumer by more than 0.5% compared to 2012.

Taking into account the growth rates of the electric vehicles market and decreasing the consumption of electricity by the average consumer, in 2035 it should be expected that the consumption of electricity by the same consumer on the daily fueling of an electric motor vehicle will be compared with electricity consumption for all other consumer needs (Fig. 3). In other words, in 2035 the increase in electricity consumption of the average domestic consumer is expected to double, which is related exclusively to the expansion of the market of electric vehicles.

However, on the one hand, it should be noted that this forecast is pessimistic, since the statistics provides data of the cars number that are not vehicles with internal combustion engines (hereinafter ICEs) in the traditional sense, that is: auto and electric motors, and with a hybrid power plant (cars of this type are charged from their own electrical grids on

board that are not part of the United Energy Grid), and on the other hand, it is rather optimistic, since this forecast does not take into account the consequences of state policy, aimed to accelerate the development of the domestic market of electric vehicles (tax benefits, the right to travel by lane for public transport, the abolition of import duties etc.).

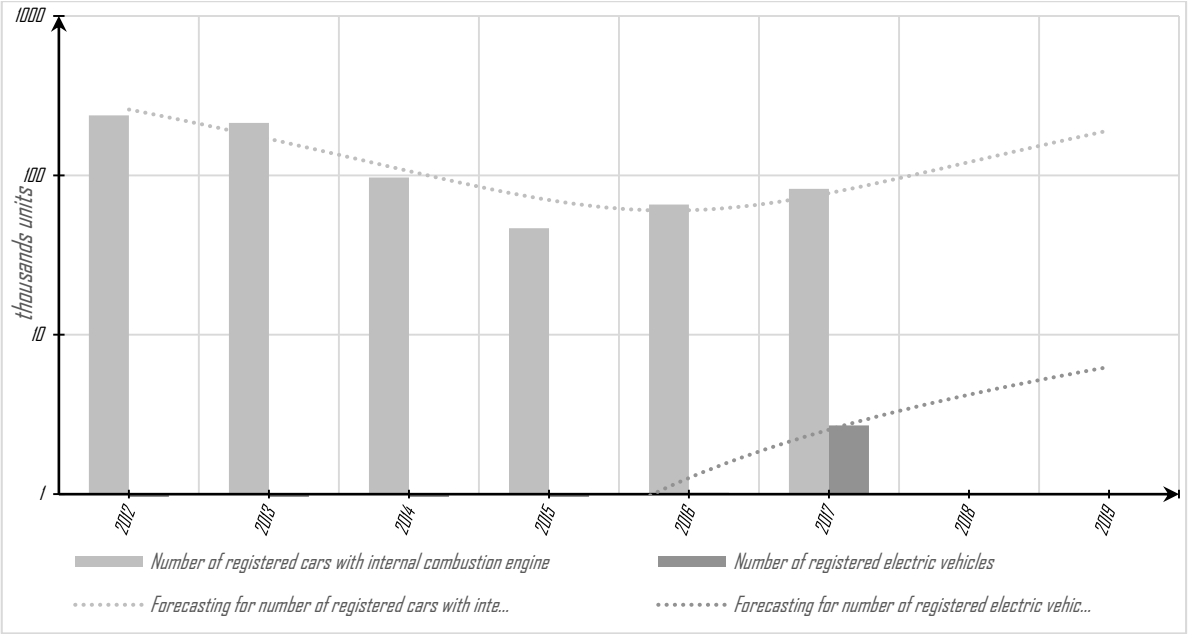

Figure 2. Dynamics of the development of the market of cars and electric vehicles in Ukraine for 2012-2017, thousands units

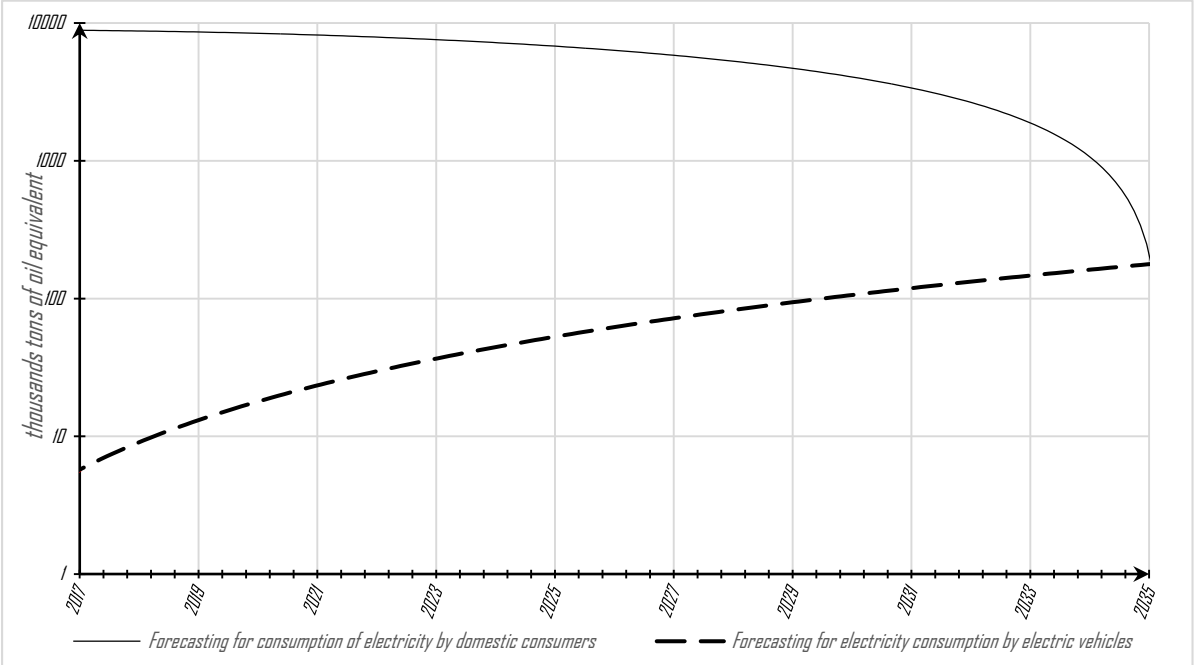

Figure 3. Forecast of total electricity consumption by household consumers in Ukraine taking into account the development of the market of electric vehicles for 2018-2035 years, thousands tons of oil equivalent [20]

In the end, it can be assumed that the majority of Ukraine's automobile fleet with traditional ICEs will be replaced by similar electric motors over the next few decades. As a result, the market feels faster and more rapid increase in electricity demand, which will have to be met.

There are several ways to solve this problem: to increase our own generating capacities or to increase the import of electricity [21]. And taking into account the time run (as well as the rush development of technologies), the solution of this problem will have been already given, and the author believes that therefore the current New Energy Strategy of Ukraine until 2035 (August 18, 2017) should already contain a number of amendments.

In addition, the rapid development of the market of electric vehicles, of course, influence on other sectors of the fuel and energy complex of Ukraine. In the future the decrease of demand and consumption of traditional fuel for cars with ICE is expected. In the short term it is not predicted, because it is directly connected with the high popularity of cars with ICE at the present and with high consumption of refined products for military purposes (Fig. 4), which is practically not influenced by simultaneous increase of prices for petroleum products and reduction of fuel consumption by each new unit of vehicle per mileage.

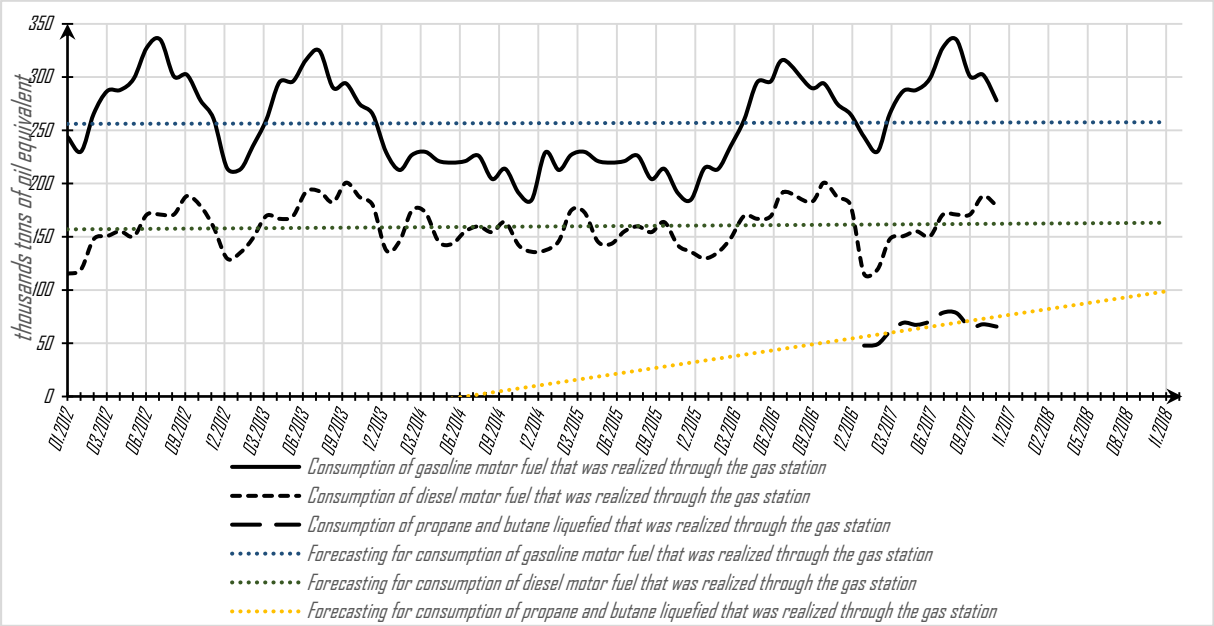

Figure 4. Volumes of consumption of main types of fuel by motor transport in Ukraine in 2012-2017, thousands tons of oil equivalent [22]

Conclusions. Summing up, it can be argued that the current New Energy Strategy of Ukraine until 2035 (August 18, 2017) is not relevant for today. The electricity consumption is under the threat of the rapid development of the electric vehicle market. It should ultimately lead to a sharp increase in its generation and disproportions in the domestic energy balance. In addition, this Strategy has not been taken into account the possible consequences, too.

The scientific novelty of the research connected with the creation of a methodological approach for determining the dynamics of the electric power industry development (in our case, in the retrospective of 2012-2017 and in the perspective up to 2035) and with the implementation of a comparative analysis not only taking into account the state of the industry but also taking into account the changes in indicators its potentially possible large consumers (in our

case, the market of electric vehicles). This provides an opportunity to explore more deeply the development of the electricity industry, as well as draw conclusions on how much the vector of its development is rightly set by the Cabinet of Ministers of Ukraine.

The practical significance of the research. The formation of the domestic fuel and energy sector and the electric power industry, in particular, can only take place if appropriate strategies are adopted taking into account the current state of the technologies development. And the adequate results of assessing their impact on the explored related industries can be provided. As technological progress of the present day proceeds at an accelerated pace, the need to formulate long-term strategies for the development of industries loses its significance and acquires more and more insights, acquaintances, and not predictive signs. That is why it is recommended to change the planning horizon and review the New Energy Strategy of Ukraine taking into account the development of the market for electric vehicles and technologies.

REFERENCES

1. Vernadskij V. I. Biosfera i noosfera / Predislovie R. K. Balandina. — M. : Ajris-press, 2004. — 576 p.
2. Nicholas Georgescu-Roegen. Energy and Economic Myths / Southern Economic Journal. Vol. 41, No. 3. — Jan., 1975. — pp. 347-381.
3. William Boulding, Markus Christen. Sustainable Pioneering Advantage? Profit Implications of Market Entry Order / Marketing Science. Vol. 22, No. 3. — 2003.
4. Jens Koehrsen. Boundary Bridging Arrangements: A Boundary Work Approach to Local Energy Transitions / Sustainability. Vol. 9, No. 3. — 2017. — 424 pp.
5. Weaver P., Jansen L., Grootveld G., Spiegel E., Vergragt P. Sustainable Technology Development. / Routledge : London. — 2000.
6. Paton B., Baryaxtar V., Bakaj A., Neklyudov I. Budushhee atomnoj energetiki. Gazeta «Kievskij telegraf». — Vol. 22. — 2–8 June 2016. — 316 pp.
7. Heiets V. M. Ekonomika Ukrainy : Kliuchovi problemy s perspektyvy. // Naukovyi Visnyk Dyplomatychnoi Akademii Ukrainy, Vol. 23, No. 3. — 2016. — pp. 164-176.
8. Zghurovskyi M. Z., Pereverza K. V., Pereverza E. V. Metodyka Pobudovy Stsenariiv Rozvytku Ukrainy Z Vykorystanniam SWOT-Analizu // M. Z. Zghurovskyi, K. V. Pereverza, E. V. Pereverza. — Kyiv : Polytechnica. — 2009.
9. Voitko S. V., Shatkovskyi O. V. Indykatyvnyi pidkhid otsiniuvannia investytsiinoi pryvablyvosti krain. Sfera vidnovliuvanoi enerhetyky. // Biznes Inform. Vol. 7. — 2013. — pp. 141-148.
10. Diachuk A. A., Podolets R. Z., Serebrennykov B. S. Politika energoeffektivnosti v Ukraine: veritas momentum. // Ekonomika Ukrainy. Vol. 4. — 2015. — pp. 58-69.
11. Kamguia Simeu, S.; Brokate, J.; Stephens, T.; Rousseau, A. Factors Influencing Energy Consumption and Cost-Competiveness of Plug-in Electric Vehicles. // World Electr. Veh. J. Vol. 23, No. 9. — 2018.
12. Mehmet Efe Biresselioglu, Melike Demirbag Kaplan,Barbara Katharina Yilmaz Electric mobility in Europe: A comprehensive review of motivators and barriers in decision making processes // Transportation Research Part A: Policy and Practice. Elsevier. — March 2018.
13. The National Commission for state regulation in the energy and utilities (NKREKP) [Electronic resource] : [Web-site]. – Annual electricity consumption report 2016. — Kyiv. — Mode of access: URL: http://www.nerc.gov.ua/data/filearch/elektro/pobytovi/spozhyvannia_elektro/2016/spozhyv-elektro-Ukraine_2016.pdf (viewed on November 15, 2018). — Title from the screen.
14. The National Commission for state regulation in the energy and utilities (NKREKP) [Electronic resource] : [Web-site].

— Annual report 2016. — Kyiv. — Mode of access: URL: http://www.nerc.gov.ua/data/filearch/Catalog3/Richnyi_zvit_NKREKP_2016.pdf (viewed on November 15, 2018). – Title from the screen.

15. Ministry of Infrastructure of Ukraine [Electronic resource] : [Web-site]. – Annual report 2017. – Kyiv. – Mode of access: URL: https://mtu.gov.ua/content/statistichni-dani-v-galuzi-aviatransportu.html (viewed on November 15, 2018). – Title from the screen.

16. Web-portal "EcoAutoInfo.com" [Electronic resource] : [Web-site]. — EV development in Ukraine 2017. — Kyiv. — Mode of access: URL: http://ecoautoinfo.com/statti/v-ukraini-kilkist-elektromobiliv-za-2016-rik-zbilshilasya-v-4-razi.html (viewed on November 15, 2018). – Title from the screen.

17. Ukrainian Motor Vehicle Manufacturers Association " [Electronic resource] : [Web-site]. — Statistics 2017. — Kyiv. — Mode of access: URL: http://ukrautoprom.com.ua/statistika (viewed on November 15, 2018). – Title from the screen.

18. Horticulture business development project [Electronic resource] : [Web-site]. — Power units and ratios between different units of measurement heat and power in 2010. — Kyiv. — Mode of access: URL: https://uhbdp.org/images/uhbdp/pdf/library_sabo/odynyci_kilkosti_teploty_ta_potuzhnosti.pdf (viewed on November 15, 2018). — Title from the screen.

19. Melnyk L. Ekonomika enerhetyky [text] / L. Melnyk, I. Sotnyk. — Sumy : University book, 2015. — 378 p.

20. Ministry of Energy and Coal Industry [Electronic resource] : [Web-site]. — New Energy Strategy of Ukraine until 2035: "Security, Energy Efficiency, Competitiveness". — Kyiv. — Mode of access: URL: http://mpe.kmu.gov.ua/minugol/doccatalog/document?id=24521112/ (viewed on November 15, 2018). – Title from the screen.

21. State statistics service of Ukraine [Electronic resource] : [Web-site]. — Use of energy materials and oil refining products. — Kyiv. — Mode of access: URL: http://www.ukrstat.gov.ua/operativ/operativ2017/energ/vmp/vmp_u/arh_vmp2017_u.htm (viewed on November 15, 2018). – Title from the screen.