UDC 338.1:656.615.003



Nina Yarova
PhD (Economics), Associate Professor,
Odesa National Maritime University
32 Mechnikov Str., Odesa, 65000, Ukraine
nina.yarovaya@onmu.Odesa.ua
ORCID ID:
http://orcid.org/0000-0002-9703-3305

Olga Vorkunova
PhD (Economics), Associate Professor,
Odesa National Maritime University
32 Mechnikov Str., Odesa, 65000, Ukraine
o.vorkunova@onmu.Odesa.ua
ORCID ID:
http://orcid.org/0000-0003-2451-5853

Natalia Khoteyeva
PhD (Economics), Associate Professor,
Odesa National Maritime University
32 Mechnikov Str., Odesa, 65000, Ukraine
natkhoteyeva@gmail.com
ORCID ID:
http://orcid.org/0000-0002-3858-6540

Economic assessment of the alternative energy sources implementation for port enterprises

Abstract. The purpose of this article is to explore specific features of the implementation of alternative energy sources used to ensure activities of Ukrainian port companies. A considerable development of the alternative energy industry in Ukraine is connected to a relatively loyal legislation, state support and tax benefits for companies which employ it. Diversification of energy sources contributes primarily to decreasing risks, however, from the economic point, the choice of concrete sources appears to be more efficient for port companies. Thus, it is suggested to install solar collectors and wind stations to facilitate port activities. According to our calculations, the implementation of the innovative investment project regarding solar panels is justified. The economic effect of installation of solar collectors and wind stations is estimated at UAH 3,107,667.00 (USD 194,230.00) and UAH 1,022,093.00 (USD 63,880.00), respectively. The use of both options is economically feasible in the modern conditions. However, the economic benefit from the wind stations is significantly less. It can be explained by the fact that equipment for wind stations is much more expensive, and its installation and maintenance are more sophisticated and costly. A much bigger quantity of solar panels is needed to provide electricity for the whole port, yet the cost of their installation and maintenance is considerably lower.
Keywords: Sea Port; Maritime Activity; Alternative Energy Sources; Renewable Energy Sources; Wind Power; Solar Power
JEL Classification: O14; Q29; Q43
DOI: https://doi.org/10.21003/ea.V166-09

Ярова Н. В.
кандидат економічних наук, доцент, кафедра економіки морського транспорту,
Одеський національний морський університет, Одеса, Україна
Воркунова О. В.
кандидат економічних наук, доцент, кафедра економіки морського транспорту,
Одеський національний морський університет, Одеса, Україна
Хотєєва Н. В.
кандидат економічних наук, доцент, кафедра фінансової економічної безпеки, обліку і аудиту,
Одеський національний морський університет, Одеса, Україна
Економічна оцінка впровадження альтернативних джерел енергії на підприємствах портової діяльності
Анотація. Метою роботи є дослідження особливостей впровадження альтернативних джерел енергії для забезпечення діяльності портових підприємств України, а також аналіз світового досвіду у використанні альтернативних джерел енергії в портах. Розглянуто різні види відновлюваних джерел енергії та виокремлено основні з них, використання яких для підприємств портової діяльності є більш ефективним з економічного погляду, а саме: сонячна та вітрова енергія.
Ключові слова: порт; альтернативні джерела енергії; відновлювані джерела енергії; вітроенергетика; сонячна енергетика.

Яровая Н. В.
кандидат экономических наук, доцент, кафедра экономики морского транспорта,
Одесский национальный морской университет, Одесса, Украина
Воркунова О. В.
кандидат экономических наук, доцент, кафедра экономики морского транспорта,
Одесский национальный морской университет, Одесса, Украина
Хотеева Н. В.
кандидат экономических наук, доцент, кафедра финансово-экономическая безопасность, учет и аудит,
Одесский национальный морской университет, Одесса, Украина
Экономическая оценка внедрения альтернативных источников энергии на предприятиях портовой деятельности
Аннотация. В статье рассмотрены особенности внедрения альтернативных источников энергии, а также мировой опыт в использовании альтернативных источников энергии в портах. Рассмотрены различные виды возобновляемых источников энергетики и выявлены основные из них, используемые для предприятий портовой деятельности, а именно: солнечная и ветровая энергия.
Ключевые слова: порт; альтернативные источники энергии; возобновляемые источники энергии; ветроэнергетика; солнечная энергетика.

1. Introduction

Efficient development of transport companies is one of the top priorities of the state policy aimed to create conditions for the country's economic growth, take advantage of its geopolitical position, improve the quality of transport service, achieve cost reduction in freight transportation at the expense of comprehensive computerisation of transport companies and revision of transport technologies [1].

The adoption and entry into force of the Law «On Sea Ports of Ukraine» contributes to the development of the Ukrainian sea port infrastructure, which is aimed at enhancement of the competitive ability of Ukrainian sea ports in the global market, which implies improvement of prospects for investment in the Ukrainian economy in general and of the country's port sector in particular. At the same time, many problematic issues have come up in the process of implementing the port reform caused by the imperfection of the national legislation and the need to change the means of management in the port sector. The use of modern equipment and brand new technologies plays a key role when taking onto account various means of economic management [2].

In countries like Ukraine, there is an urgent need to promote renewable energy sources. On this account, the country will obtain a number of benefits, such as a decrease in the consumption of traditional fuel, for example oil and gas, in the short-term perspective, the reduction of greenhouse gas emissions, the termination of the use of traditional fuels in production of electricity and heat by 2040 and the avoidance of the use of oil and gas in the transport sector of Ukraine by 2050.

Today, there is an urgent need to invest in the development of renewable energy technologies. If we neither invest in the sector nor take advantage of natural advantages, we cannot exclude that the deficit of traditional resources may cause a global catastrophe [3], which determines the relevance of the consideration of this issue.

2. Brief Literature Review

The studies by Y. V. Makogon and G. E. Kudenko are dedicated to the explanation of the essence of alternative energy sources [12]. Alternative energy sources are those which are renewable. We will have to refuse from traditional exhaustible resources that provide us with thermal energy in the nearest future. There are several reasons that point to the need for a soonest transition to alternative energy sources. Everyone knows that the technologies used to produce traditional energy have led to the global climate change. Meanwhile, the use of alternative energy sources is aimed at resolving global environmental problems. A deep and comprehensive overview of the works devoted to the global environmental assessments practises and approaches as well as challenges of the modernity has been realised by J. Jabbour and Ch. Flachsland (2017) [7].

The problem of usage of alternative energy sources is widely discussed by the experts, both from the point of view of technical particularities and from the position of efficiency of use. We may mention only few works relevant to our research out of the wide field of studies devoted to the topic field. O. Soskin and N. Matviychuk-Soskina (2013) [6] have studied the impact of traditional and alternative sources of energy on the environment. A. Arteconi, E. Ciarrocchi, Q. Pan, F. Carducci, G. Comodi, F. Polonara and R. Wang (2016) [8] have researched the storage of the thermal energy coupled with photovoltaic (PV) panels to manage the demand side of industrial building. T. Rajaseenivasan, R. Prakash, K. Vijayakumar, and K. Srithar (2017) [9] have conducted a mathematical and experimental investigation on the influence of basin height variation and stirring of water by solar PV panels in solar still.

3. The purpose of the study is to evaluate the effectiveness of the implementation of alternative energy sources for port enterprises. The main objectives of the study are to explore the ways to produce renewable (alternative) energy and the use of this energy by Ukrainian port companies.

4. Results

The continuous growth of the cost of oil, gas and related raw materials forces many countries to pay close attention to the methods for receiving the so-called renewable (alternative) energy, which undoubtedly will soon be needed in order to gain energy independence and compensate the lack of traditional fuel resources. It is obvious that our country has great prospects for the implementation of this very important and vital source in the consumer market with regard to individuals and large companies, plants and enterprises. The main advantage of such technologies is their environmental friendliness, ease of operation, long operational life, minimum service and maintenance [5]. By using renewable energy sources, we deliver a significant effect on the environment and energy crisis in the world, as well as gain independence from traditional types of energy, save significant cost and become confident in the future.

Renewable energy is a complex of technological solutions for the production of traditional electrical or heat energies from wind or solar energy. Basing on the chosen technology of energy production, the alternative resources can be divided into solar, wind, geothermal, hydropower, as well as those where biofuel production technologies are applied.

In May 2015, Germany set a world record for the production of solar energy per hour; German solar power plants produced 22 GWh of electric power. Moreover, German plans switch to renewable resources of energy.

The energy of falling water is used to rotate the turbines of water power plants. About 20% of the world's electricity is obtained from this source. Norway, Russia, China, Canada, the USA and Brazil are leaders in utilising the water power plants.

The first geothermal steam power plant was opened in the Italian city of Larderello in 1904. It still functions. By the end of 2004, the worldwide use of geothermal energy has reached 57 TWh/yr of electricity and 76 TWh/yr for direct use [24].

In Brazil, the majority of vehicles are fuelled with ethanol. Biodiesel made from vegetable oils, animal fats and waste oils from restaurants replaces completely the conventional diesel fuel. Such fuel can also be used in admixture. The largest producer and consumer of biodiesel is Germany. Germany, the USA, Denmark and Spain are among the leading countries using this type of energy; India and China have launched into the wide using of wind energy as well.

Despite the accidents at the power plants, nuclear power remains a reliable source of energy for many regions [10]. Due to the latest update, «there are over 440 commercial nuclear power reactors operable in 31 countries, with over 390,000 MWe of total capacity. About 60 more reactors are under construction. They provide over 11% of the world's electricity... 55 countries operate a total of about 250 research reactors, and a further 180 nuclear reactors power some 140 ships and submarines» [25].

Ukraine is one of the top five countries in Europe in terms of the development of alternative energy sources. According to the Ministry of Energy and Coal Industry of Ukraine, electricity generation from renewable energy sources (RES), except for large hydroelectric power stations, in 2013 has doubled (by 608,400,000 kWh) compared to 2012 - to 1.247 billion kWh/yr. Despite slight decline in 2016 compared to 2015, during 9 months of 2017, the generation of electricity by alternative sources (WPS, SPS, biomass) compared to the corresponding period of 2016 increased by 294.8 million kWh, or 25.6%, and was 1.444 billion kWh [26].

In 2016, 120.6 MW of alternative energy capacities was introduced, of which:

- wind energy objects - 11.6 MW;
- solar power objects - 99.1 MW;
- small hydropower objects - 3.3 MW;
- energy objects producing biomass electricity - 3.5 MW;
- objects of power generation, producing electricity from biogas - 3.1 MW [27].

In general, the balance of energy production from alternative energy sources in Ukraine in 2015 was at the level 3% with wind and solar power having a share of 0.1% [28].

SE Odesa Commercial Sea Port (SE OCSP) is one of the largest ports of the Black and Azov Seas basins. Located in the north-western part of the Black Sea region, the port is a leader among the ports of Ukraine in handling cargo volumes and the largest passenger port on the Black Sea. The technical capacities of the port allow it to handle of more than 25 million tons of dry and 25 million tons of bulk cargoes annually.

Container terminals provide handling of over 900,000 twenty-foot equivalent units (TEU) per year. The passenger terminal is capable to serve up to 4 million tourists a year [21].

SE OCSP has been applying technologies to use alternative energy sources. The results of the first year of the operation of the heating substation were announced; its process chain includes solar collectors and a heat pump system to collect low-grade heat of sea water.

The economic effect of the use of the unit producing thermal energy from alternative sources amounted to UAH 120,000 (USD 7,500). The exchange rate as for January 2015 has been chosen for the calculations in this research: USD 1 = UAH 16. Altogether, the share of heat energy from non-traditional resources is about 5% of the total production for the needs of the enterprise.

The implementation of the program for energy saving technologies began in 2007. Today, a number of heating units in the port is equipped with solar collectors. The installed equipment has operated effectively. But the efficiency of the solar cells can be recognised mostly in summer, whereas in winter the effect is much lower.

A project of modernization of the heating unit has been implemented in the port; it provides heating and hot water for the administrative and welfare buildings in the area of Berth 28 (Androsovsky lane). The integrated use of the solar collectors and the heat pump system covers from 30% to 90% of the needs of 3 buildings in thermal energy depending on the time of the year and weather conditions [21].

It should be noted that SE OCSP runs additional measures for energy-saving and optimisation of the energy-consumption regimes [21], provision of the alternative and renovating energy sources with the aim of setting-up the conditions of energy-safety of the enterprise, in particular:

1. Optimisation of the structure of the energy-saving service, deletion of duplicating function, namely the fulfilment of similar and yet different tasks from the point of professional training.
2. Uploading the electrical laboratory of the port with work, provision of all necessary measures for the objects of the port, which may be under construction, reconstruction or modernisation.
3. Development of an innovative approach to distribution of technical conditions and technical tasks to execute operations regarding the construction of new objects and modernisation of existing facilities:
- wide use of the energy-saving lamps;
- devices of the pointed light with zonal on-off switches;
- use of the transmission-type switches and options of switching off the particular zones in the absence of people there;
- usage on the staircases of the switches supplied with move-detectors and with pause in the time functions;
- installing of the toilet tanks with two-regime functions (saving and regular);
- installing the taps with photovoltaic elements or taps with a portion-delivery of water function in shower cabins.
4. Realisation of the monitoring of the port territory in order to discover new possibilities to install alternative or renewable energy resources.
5. Installation of the warm-water pump and solar collectors for partial heating and warm water supply to the building of the port service office with the use of low potential warmth as a source: a water pipe and the solar collectors under 50 kilowatt of capacity.
6. Warm water supply on the basis of flat or vacuum collectors where it is possible to place them under the roof of the building.
7. Setting up the combined system of heating and warm water supply along with external light under the roof of the two-storey administrative building. The main source of energy is obtained from flat solar collectors. Electrical heating is the additional source (due to the absence of the other sources of thermal energy). The target percentage of the use of solar energy within the object is 75% per year. The systems functions automatically and does not require the presence of service personnel.
8. Dispatch control of the system of heat input of the port. For this purpose, it is necessary to buy appropriate software. The provision of such a system will provide real-time control over the heat consumption of the port. The demo model can already be seen.
9. Use of the power-saving technologies and facilities:
- electrical engines with the regulating frequency of shift units fixed on the electrically powered pump aggregates in the port (pump stations, heating stations, cranes etc.);
- contemporary systems of regulated expenditures and temperature of the coolant;
- pressure regulators and balancing taps on the water-pipes system of the port.
10. Study of the possibilities to use wind energy on the territories of Odesa port and Zmiinyi island, as far as the potential of wind energy of the island is very high. The average speed of wind there is around 10 m/s at an altitude of 50 meters.
11. Realisation of a full energy audit and, basing on the results of it, elaboration of an energy strategy for the development of the Odesa Marine Trade Port over the next 10-15 years.
12. Launch of the system of commercial audit of energy provided by installation of a new generation of high accuracy devices.
13. Implementation of energy-saving policies reflected in separate organisational and technical decisions which are essentially aimed at the reduction of consumption of all types of energy sources while keeping intact the quality of the goods produced and the overall production.

The purpose of the development and realisation of energy-saving measures lies in the implementation of modern technologies aimed at reduction of expenses and modernisation of the overall production process. However, the reverse process is also possible: the modernisation of production generally increases energy efficiency of enterprises.

The economic essence of energy saving lies in forming of external and internal relational systems at an enterprise, which, in turn, facilitates rational usage of energy resources. The practical outcome of energy-saving measures at the enterprise is reduction of energy consumption and expenses on energy resources. Therefore, the enterprise gains a possibility to increase the overall production, reduce the primary costs and, as a result, increase the share of the market [14].

The classification of factors which influence the implementation of alternative energy projects in seaports, is given in Table 1. It may serve as a basis for the assessment of economic effectiveness of innovative investment projects regarding alternative energy supplies.

The overall production of energy from alternative or renewal energy sources shows a permanent increase in the seaports of Ukraine.

The biggest progress in the solar batteries for energy generation has been noticed only during the recent decades. New technologies that facilitate the production of batteries with a higher efficiency factor play a key role in the promotion of solar energy. It has been disclosed that the dependence function of efficiency factor (EF) of the solar batteries increases from the year of their introduction (T) into mass production [14]:

$$EFsb(T) = 10^7 - 20e^{0,0243*T}, \quad (1)$$

where: $EFsb(T)$ is efficiency factor of the useful output of solar panels depending on the year of their introduction.

The main aim of the research is to estimate the efficacy of introduction of alternative energy sources at port enterprises. We suggest to calculate the annual economic effects from launching solar collectors and wind stations, then compare them and make a conclusion about the most optimal and beneficial source of alternative energy.

The calculations are done basing on the example of the container terminal of the SE Odesa Commercial Sea Port. We suggest launching the solar collectors «Kvazar-250» (or photovoltaic modules «Quasar-250») made in Ukraine [22]. Specifications of the solar collector module «Kvazar-250» are given in Table 2.

Now, let us put the values in the formula of the annual economical benefit from launching the solar panels (Esb) [14]:

$$Esb = Epr - \frac{\left(\frac{N * Ins(st) * Pm2}{Ins(f) * Nm2} + Edl + Ei\right) * r}{100} - \frac{\frac{N * Ins(st) * Pm2}{Ins(f) * Nm2} + Edl + Ei}{Ta} - Eser - Etr, \quad (2)$$

where: Epr - presented expenses on traditional energy sources, UAH;

N - required capacity of solar panels, W;

$Ins(f)$ - insolation for the region, W/m²;

$Ins(st)$ - insolation under standard conditions, W/m²;

$Nm2$ - capacity of solar panels with regard to1 m², W/m²/year;

$Pm2$ - cost of solar panels per 1 m², UAH;

Edl - delivery expenses, UAH;

Ei - installation expenses, UAH;

Ta - amortisation period, years;

$Eser$ - service expenses (wiping the dust, wiping the snow, maintenance of the equipment etc), UAH;

Etr - training expenses, UAH/year;

r - profit rate, %.

The annual economic benefit from launching and functioning of the solar panels is UAH 7,334,094 (USD 458,380.00).

To achieve this, we suggest launching Ukrainian wind stations *EuroWind-10* in the functioning of the container terminal SE OCSP [23].

Specifications of the wind station *EuroWind-10* are given in Table 3.

Now, let us put the values in the formula of the annual economical benefit from launching the wind stations *EuroWind-10* (Ews) [14]:

$$Ews = Epr - \frac{(P + Edl + Ei) * r}{100} - \frac{P + Edl + Ei}{Ta} - Eser - Etr, \quad (3)$$

where: Ews - annual economic benefit from launching the wind stations *EuroWind-10*, UAH;

p - price of the wind stations, UAH;

Edl - delivery expenses, UAH;

Ei - installation expenses, UAH;

$Eser$ - service expenses (the equipment installed, it is necessary to carry out the regular procedures to check out the puling of straining ties, absence of vibrations and noises, the security of fixations, safety of electrical connections), UAH/year;

Etr - training expenses, UAH/year.

The annual economic benefit from launching and functioning of the wind stations is UAH 2,412,139.00 (USD 150,759.00).

According to the calculations, launching of solar collectors is assumed to be the most economically effective and innovative, investment project.

The economic benefit from launching and functioning of solar panels is UAH 7,334,094.00 (USD 458,380.00).

The economical benefit from launching and functioning of wind stations is UAH 2,412,139.00 (USD 150,759.00).

It is economically beneficial to implement both projects under the current conditions. However, the economical benefit from the wind stations is considerably lower. It is so due to the higher cost of the equipment, the higher fees for its installation and further service. At the same time, there is a need in a bigger number of the solar panels to provide the terminal with electrical energy in full, yet their cost and the expenses on the service and maintenance are lower.

5. Conclusions

Ukraine is able to meet the demand for energy needs by means of alternative energy sources. Nevertheless, the

Tab. 1: **Classification of factors influencing implementation of alternative energy projects in seaports**

Classification characteristics of the group	Factors
Climate conditions	– wind speed (m/s); – class of open terrain – insolation (W/(m/s)); – presence of natural and artificial water flows; – presence of geothermal sources; – other.
Technical and economical characteristics	Cost of installation, cost of transportation and installation, terms of usage of devices, cost of the environmental safety, condition of energy devices, efficiency factor; electricity tariffs for energy obtained from traditional sources etc.
Ecological characteristics	Influence on animals and birds from the wind devices, influence on the marina life from electrical and magnetic fields, the volume of the harmful emissions and greenhouse effect from traditional energy resources etc.
Geographical Characteristics	Distance from the centralised system of energy supply, distance from providers of organic fuels, minimal distance from the instalment to the inhabitant locality etc.

Source: Compiled by the authors based on [4-8; 15]

Tab. 2: **Specifications of the solar collector «Kvazar-250» and its economic effect on the container terminal of SE OCSP**

Specifications	Value
Price in USD	357
Capacity, kW/year	2,200
Given expenses, UAH	6,147,357 (USD 384,210)
Energy tariff, UAH/kW	1.36 (USD 0.09)
Module size, m³	1.65×1.00×0.05
Delivery fee, USD/m³	100.00
Installation price, USD	20.00% from the general cost
Service personnel	20: 4 technicians and 16 workers
Salary, UAH/month	5,000.00 and 2,000.00 (USD 312.00 and USD 125.00)
Training expenses, UAH/person	2,200.00 (USD 138.00)
Economic effect of solar collectors on the container terminal of SE OCSP	
Quantity of required items	6,147,357.00/1.36/2,200.00=2,055.00 pieces
Area occupied	1.65*1.00*2,055.00=3,390.00m²
Required capacity	Nm²= 2,200.00/1.65=1,333kW/m²/year
Price per 1m²:	Pm²= 375.00*26.00*2,055.00/3,390.00=5,627.00 UAH/m² (USD 352.00)
Delivery expenses	Edl=1.65*1.00*0.05*2,055.00*100.00*26.00=440,797.00 UAH (USD 27,550.00)
Installation expenses	Ei=2,055.00*375.00*26.00*0.20=3,814,902.00 UAH (USD 238,431.00)
Service expenses	Eser=(4.00*5,000.00+16.00*2,000.00)*12.00=624,000.00UAH/year (USD 39,000.00)
Training Expenses	Etr=20,00*2,200.00= 44,000.00UAH/year (USD 2,750.00)
Amortisation period, years	T_a=20.00 years
Profit rate, %:	r =20.00%

Source: Own research and calculations

Tab. 3: **Specifications of the wind station *EuroWind-10* and its economic effect on the container terminal of SE OCSP**

Specifications	Value
Price in USD	357
Capacity, kW/year	2,200
Given expenses, UAH	6,147,357 (USD 384,210)
Energy tariff, UAH/kW	1.36 (USD 0.09)
Module size, m^3	1.65×1.00×0.05
Delivery fee, USD/m^3	100.00
Installation price, USD	20.00% from the general cost
Service personnel	20: 4 technicians and 16 workers
Salary, UAH/month	5,000.00 and 2,000.00 (USD 312.00 and USD 125.00)
Training expenses, UAH/person	2,200.00 (USD 138.00)
Economic effect of solar collectors on the container terminal of SE OCSP	
Quantity of required items	6,147,357.00/1.36/2,200.00=2,055.00 pieces
Area occupied	1.65•1.00•2,055.00=3,390.00m^2
Required capacity	Nm^2= 2,200.00/1.65=1,333kW/m^2/year
Price per 1m^2:	Pm^2= 375.00•26.00•2,055.00/3,390.00=5,627.00 UAH/m^2 (USD 352.00)
Delivery expenses	Edl=1.65•1.00•0.05•2,055.00•100.00•26.00=440,797.00 UAH (USD 27,550.00)
Installation expenses	Ei=2,055.00•375.00•26.00•0.20=3,814,902.00 UAH (USD 238,431.00)
Service expenses	Eser=(4.00•5,000.00+16.00•2,000.00)•12.00=624,000.00UAH/year (USD 39,000.00)
Training Expenses	Etr=20,00•2,200.00= 44,000.00UAH/year (USD 2,750.00)
Amortisation period, years	T_a=20.00 years
Profit rate, %:	r =20.00%

Source: Own research and calculations

consumption of renewable energy in Ukraine is at the initial stage. Unfortunately, however attractive and humane alternative energy could look, its cost-effectiveness is significantly lower than the standard schemes, because the payback period of such innovations, as we have seen, is from 7 to 36 years at best, however, the price of alternative energy decreases as a result of introduction of new technologies. Hence, it is very likely that renewable energy will be both efficient and economically feasible in years to come.

The activities of port enterprises should be focused on achieving a common goal, which is a radical change in the whole port business of Ukraine and, consequently, the country's entry to the international market of port services on equal terms [1]. Undoubtedly, not only new production technologies, but also information technologies, management, and, which is utterly important, the introduction of alternative energy sources must play a special role in this process.

References

1. Vorkunova, O. V., & Khoteeva, N. V. (2011). Factors of competitiveness of the enterprises and port activity. *Ekonomichni innovatsii. Transport (Economic Innovations. Transport), 20,* 225-234. Retrieved from http://dspace.nbuv.gov.ua/bitstream/handle/123456789/67323/23-Khoteeva.pdf?sequence=1 (in Russ.)
2. Vorkunova, O. V., Yarovaya, N. V., & Ryabovolenko, N. V. (2014). Controlling - coordination instrument for managerial decision-making on pricing. *SWorld Scientific Works, 1,* 7-11.
3. Korobkyn, V. I. (2002). *Ecology in questions and answers.* Rostov: Feniks (in Russ.).
4. Andrizhievsky, A. A. (2005). *Energy saving and energy management.* Moscow: Vysshaya shkola (in Russ.).
5. Bastman, T. N. (1995). *The crisis of the environment.* Saint Petersburg: Progress-pogoda (in Russ.).
6. Soskin, O. I., & Matviychuk-Soskina, N. O. (2013). The influence of traditional and alternative energy sources on the environment in the context of a new economic development model. In V. Kravtsiv, & W. Wierzbiniec (Eds.), *Poland-Ukraine: Border regions development and cross-border cooperation.* Jaroslaw: The Bronisław Markiewicz State Higher School of Technology and Economics. Retrieved from http://soskin.blogspot.sk/2013/10/blog-post_11.html (in Russ.)
7. Jabbour, J., & Flachsland, Ch. (2017). 40 years of global environmental assessments: A retrospective analysis. *Environmental Science & Policy, 77,* 193-202. doi: https://doi.org/10.1016/j.envsci.2017.05.001
8. Arteconi, A., Ciarrocchi, E., Pan, Q., Carducci, F., Comodi, G., Polonara, F., & Wang, R. (2016). Thermal energy storage coupled with PV panels for demand side management of industrial building cooling loads. *Applied Energy, 185*(2), 1984-1993. doi: https://doi.org/10.1016/j.apenergy.2016.01.025
9. Rajaseenivasan, T., Prakash, R., Vijayakumar, K., & Srithar, K. (2017). Mathematical and experimental investigation on the influence of basin height variation and stirring of water by solar PV panels in solar still. *Desalination, 415,* 67-75. doi: https://doi.org/10.1016/j.desal.2017.04.010
10. Syusyukin, A. I., & Tarasovsky, V. G. (2009). The concept of creating a system of rational consumption and energy saving in the enterprise. *Elektrika (Electrics), 6,* 33-39 (in Russ.).
11. Panevchyk, V. V. (2007). *Basics of energy saving: workshop.* Minsk: Belarus State Economic University (in Russ.).
12. Makogon, Yu. V., & Kudenko, G. E. (2006). *Some aspects of implementation of energy saving policy in Ukraine: a monograph.* Donetsk: DonNU-DonF NISI (in Russ.).
13. The Verkhovna Rada of Ukraine (2012). *On Sea Ports of Ukraine.* The Law of Ukraine from 17.05.2017 No. 4709-VI (in edition as for 11.08.2013). Retrieved from http://zakon2.rada.gov.ua/laws/show/ru/4709-17 (in Ukr.)
14. Sysoeva, M. S. (2011). Perfection of the methodical apparatus for assessing the economic efficiency of innovative investment projects for the introduction of alternative energy sources. Dissertaation thesis. Tambov (in Russ.).
15. Wang, W., Katipamula, S., Ngo, H., Underhill, R., Taasevigen, D., & Lutes, R. (2013, July). *Advanced Rooftop Control (ARC) Retrofit: Field-Test Results.* Richland: PNNL. Retrieved from http://www.pnl.gov/main/publications/external/technical_reports/PNNL-22656.pdf
16. Alliance to Save Energy (2017). *Official website.* Retrieved from: http://www.ase.org
17. Hungarian Energy Efficiency Centre (2017). *Official website.* Retrieved from http://mehi.hu/en
18. Renewables 2010 (2010). *Renewable Energy Policy Network for the 21st Century. Global Status Report.* Retrieved from: http://www.ren21.net/Portals/0/documents/activities/gsr/REN21_GSR_2010_full_revised%20Sept2010.pdf
19. The Efficient Lighting Initiative (2017). *Official website.* Retrieved from http://www.efficientlighting.net
20. Wallenius Wilhelmsen Logistics (2017). *Official website.* Retrieved from http://www.2wglobal.com/www/environment/castorGreenTerminal/index.jsp
21. Odesa Sea Port Authority (2017). *Official website.* Retrieved from http://www.port.odessa.ua/en
22. Kvazar Group (2017). *Official website.* Retrieved from http://www.kvazargroup.com.ua (in Ukr.)
23. ECO-ST (2017). *Official website.* Retrieved from http://ecost.lviv.ua/ua/about_us.html (in Ukr.)
24. Fridleifsson, I. B., Bertani, R., Huenges, E., Lund, J. W., Ragnarsson, A., & Rybach, L. (2008, January 20-25). The possible role and contribution of geothermal energy to the mitigation of climate change. In O. Hohmeyer, & T. Trittin (Eds.), *IPCC Scoping Meeting on Renewable Energy Sources, Proceedings, Luebeck, Germany* (pp. 59-80). Retrieved from http://grsj.gr.jp/iga/iga-files/Fridleifsson_et_al_IPCC_Geothermal_paper_2008.pdf
25. World Nuclear Association (2017, August). *Nuclear Power in the World Today.* Retrieved from http://www.world-nuclear.org/information-library/current-and-future-generation/nuclear-power-in-the-world-today.aspx
26. Ministry of Energy and Coal Industry of Ukraine (2017, October 17). *Information reference on the main indicators of development of branches of the fuel and energy complex of Ukraine for September and 9 months of 2017 (according to the operational data).* Retrieved from http://mpe.kmu.gov.ua/minugol/control/uk/publish/article;jsessionid=70C6D2A5476CF8401B0B0ACB6D76FA38.app2?art_id=245243421&cat_id=35081 (in Ukr.)
27. State Agency on Energy Efficiency and Energy Saving of Ukraine (2017). *Information on capacity and volumes of electricity production by renewable energy companies operating under the «green» tariff (as of 01.01.2017).* Retrieved from http://saee.gov.ua/sites/default/files/Renewable_power_Ukraine_01_01_2017.pdf (in Ukr.)
28. State Statistics Service of Ukraine (2017, January 18). *Renewable Energy Consumption for 2007-2015.* Retrieved from http://www.ukrstat.gov.ua/operativ/operativ2016/sg/ekolog/ukr/esp_vg_u.htm (in Ukr.)

Received 15.04.2017