# PERSPECTIVES OF APPLICATION OF INNOVATIVE RESOURCE-SAVING TECHNOLOGIES IN THE CONCEPTS OF GREEN LOGISTICS AND SUSTAINABLE DEVELOPMENT

Olga Ostapenko[1]
Nataliia Savina[2]
Leila Mamatova[3]
Antonina Zienina-Bilichenko[4]
Olha Selezneva[5]

1. Vinnytsia National Technical University, Ukraine
2. National University of Water and Environmental Engineering, Ukraine
3. State higher educational establishment «Priazovskyi state technical university», Ukraine
4. National University of Food Technologies, Ukraine
5. Odessa I. I. Mechnikov National University, Ukraine

**Abstract:** The paper considers the prospects for the application of innovative resource-saving technologies in the concepts of green logistics and sustainable development. Assessment of the perspectives of application of innovative resource-saving technologies in Ukraine was carried out with taking into consideration the main goals of sustainable development, tendencies of development of sustainable energy and fuel and energy complex of Ukraine in the direction of European integration, ensuring reduction of greenhouse gas emissions and increasing the use of non-traditional and renewable energy sources. The study illustrates the application of principles and objectives of the concept of green logistics in order to increase the level of energy-economic efficiency of the energy sector of Ukraine with the application of energy- and resource-saving, environmentally safe and cost-effective innovative technologies.

**Keywords:** innovative technologies, resource-saving technologies, green logistics, sustainable development.

## 1. INTRODUCTION

Sustainable Development is the basis for global international cooperation. The 2030 Agenda for Sustainable Development (2020), adopted in 2015, is defines the directions of development of humanity in the perspective to 2030. The Sustainable Development concept contributes to sustaining economic progress and protecting the environment in the long term. The Sustainable Development concept is the result of combining economic, social and environmental trends (Koval, Duginets, Plekhanova, Antonov, Petrova, 2019). The concept of Sustainable Development combines the optimal use of scarce natural resources with the application of environmentally friendly nature-, energy- and resource-saving technologies in the production of environmentally friendly products at all stages of the life cycle which also affects trade trends (Prystupa, Koval, Kvach and Hrymalyuk, 2019) and tourism (Koval, Mykhno, Antonova, Plekhanov, Bondar,

2019) as well as the safety and environmental protection (Koval, Petrashevska, Popova,Mikhno, Gaska, 2019). The concept of Sustainable Development is determinates the 17 Sustainable Development Goals (SDGs) of development of humanity. This SDGs are universal and may applied to all countries. The SDGs is defined the tendences of development of sustainable energy and fuel and energy complex of Ukraine in the direction of European integration, ensuring reduction of greenhouse gas emissions and increasing the use of non-traditional and renewable energy sources with the application of energy- and resource-saving, environmentally safe and cost-effective innovative technologies.

## 2. LITERATURE REVIEW

On August 18, 2017, the Government of Ukraine approved the Energy Strategy of Ukraine for the Period up to 2035 "Security, Energy Efficiency, Competitiveness". Ukraine's energy strategy will help ensure energy security and sustainable development of Ukraine's energy sector through 2035. The prerequisites for the development of a new Energy Strategy of Ukraine were: the need to ensure energy independence and energy security of Ukraine, changes in the energy policy of the European Union, the creation of an Energy Union in Europe and the signing by Ukraine of the Memorandum on the full integration of the energy markets of Ukraine and the EU, the signing of the Paris Agreement of Climate Change. Ukraine's energy strategy takes into account European achievements in the fields of energy production, energy efficiency improvement, aimed at ensuring the decarbonisation of the energy sector and reducing the amount of harmful emissions into the atmosphere. Ukraine's energy strategy will help to provide conditions for a gradual reduction in the use of traditional fossil fuels and increase the share of energy from non-traditional renewable sources. An energy strategy should ensure energy independence and energy security of Ukraine on the basis of maximizing the use of its own energy resources which requires a constant audit (Nazarova et al., 2019). Ukraine's new energy model should provide equal opportunities for the development of all types of energy generation, with particular emphasis on improving energy efficiency and implementing innovative resource-saving technologies for the use of energy from renewable and alternative sources (Kostetska, Khumarova, Umanska, Shmygol, Koval, 2020).

A number of investigations in recent years were devoted to the studying of efficiency of application of innovative resource-saving technologies in the world and Ukraine (Koval et al., 2019; Ciuła et al., 201; Shmygol et al., 2020; Ostapenko, *2019, 2020)*. The analysis of the interpretation and the essence of Green Logistics are given in (Omel'chenko et al., 2013; Melnikova and Yanchenko, 2018). According to (Melnikova and Yanchenko, 2018), “Green Logistics” is a new scientific area that involves the application of advanced logistics technologies and modern equipment to increase the efficiency of logistic resources and minimize pollution. The basic principles of green logistics are given in (Melnikova and Yanchenko, 2018; Gubanova et al., 2019; Popova, Koval, Antonova, Orel, 2019): 1) rationalization of the use of natural resources and resources of the enterprise; 2) maximum utilization of production, packaging and packaging waste; 3) reducing the consumption of raw materials and materials with low recyclability or safe disposal; 4) application of modern high technology and recycling technologies; 5) increasing the level of environmental orientation and responsibility of logistics personnel.

These principles of green logistics allow to implement green technologies and help to rationalize the use of material flows of the enterprise. According to above mentioned, the tasks of green logistics are presented in investigations (Melnikova and Yanchenko, 2018): 1) the use in the production of environmentally friendly and safe materials, as well as resource-saving technologies in order to minimize environmental pollution; 2) maximum utilization of industrial waste as secondary raw materials, materials and defective and defective goods; 3) optimization of waste disposal costs; 4) resource saving and energy saving in production; 5) increase of product competitiveness; 6) reducing the cost of production; 7) reducing the time for collection, differentiation and refining waste; 8) reduction of transport costs; 9) attraction of all production facilities, etc.

As it is noted in (Melnikova and Yanchenko, 2018), the above tasks of green logistics allow you to use the latest waste processing and recycling technologies, resource-saving technologies in production, and maximum recycling of production, packaging and packaging waste. *Aim of the research* is assessment of the prospects for the application of innovative resource-saving technologies in the concepts of green logistics and sustainable development in Ukraine, with taking into consideration the main goals of sustainable development, tendencies of development of sustainable energy and fuel and energy complex of Ukraine in the direction of European integration, ensuring reduction of greenhouse gas emissions and increasing the use of non-traditional and renewable energy sources. Study illustrates the application of principles and objectives of the concept of green logistics in order to increase the level of energy-economic efficiency of the energy sector of Ukraine with the application of energy- and resource-saving, environmentally safe and cost-effective innovative technologies.

## 3. METHODS

Energy statistics are an important component in determining the direction of competitive and sustainable economic growth. To achieve the Sustainable Development Goal 7 (SDG7), it is necessary to provide affordable, reliable, sustainable and modern energy for all by 2030 (Sustainable energy for all, 2020). In accordance with the Sustainable Development Goal 13, the 2015 Paris Climate Agreement was ratified, which foresees the reduction of global $CO_2$ emissions from 2020 (Paris Climate Agreement, 2020). Our research is based on the "Tracking SDG7" - resource, which uses the databases of the International Renewable Energy Agency (IRENA), the International Energy Agency (IEA), the World Bank, the United Nations Statistics Division (UNSD) and others (Tracking SDG7,2020; Rise, 2020, Esmap, 2020). We also used statistics from Eurostat and World Bank resources (Eurostat, 2020; WorldBank, 2020). The 20-20-20 goal package includes the following goals for 2020: a reduction in EU greenhouse gas emissions of at least 20% below 1990 levels; ensuring gross final energy consumption in the EU is at least 20% of renewable energy; ensure a 20% reduction in primary energy consumption by improving energy efficiency.

Fig. 1 shows the statistical data of greenhouse gas emission in 1990-2017 for 28 countries of European Union. Fig. 2 shows the statistical data of gross electricity generation from renewable sources in 1990-2015 for 28 countries of European Union. In Fig. 2 we see a gradual increase since 2004 in the share of electricity generation with the involvement of non-traditional and renewable sources.

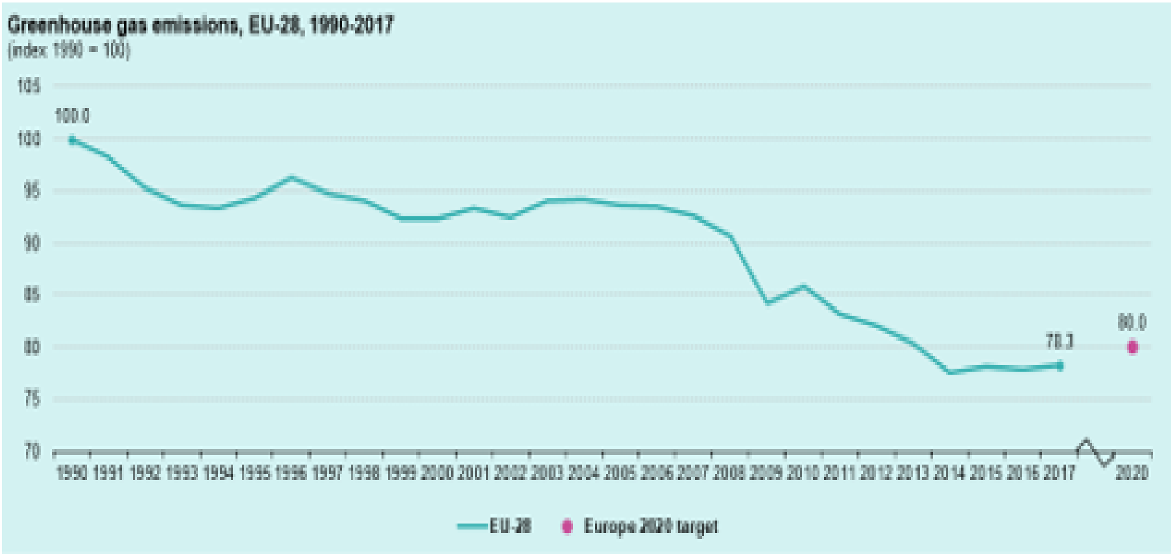



Fig. 1. Statistical data of greenhouse gas emission in 1990-2017 for 28 countries of European Union. Source: statistical data from Eurostat (2020)

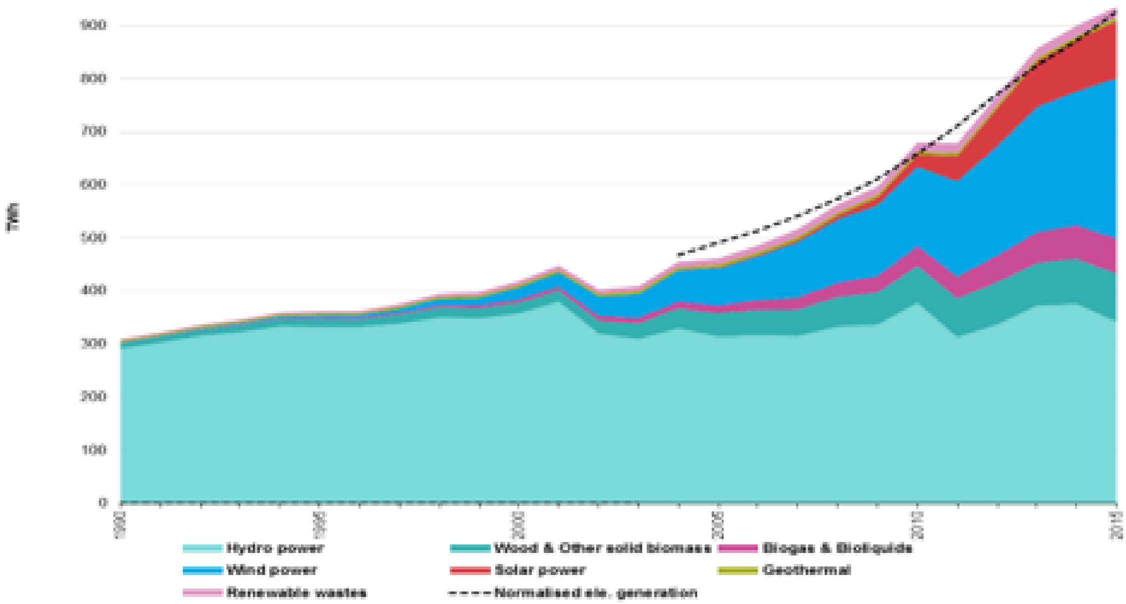
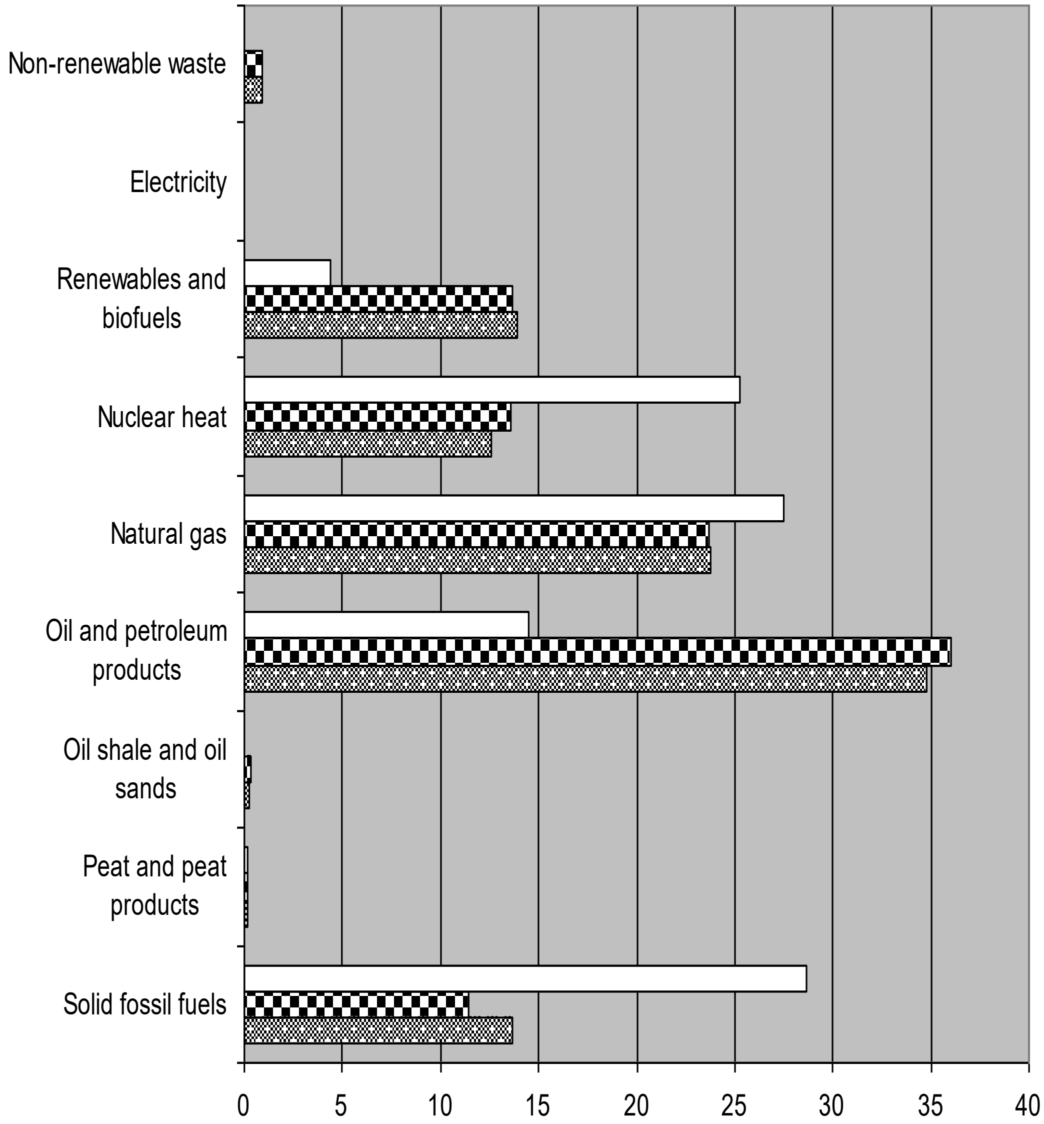



Fig. 2. Statistical data of gross electricity generation from renewable sources in 1990-2015 for 28 countries of European Union. Source: statistical data from Eurostat (2020).

As it is seen from Fig. 2, in 2015 the share of electricity generation from non-traditional and renewable energy sources in the EU countries has tripled compared to 2004. In Fig. 3 shows a comparison of gross inland energy consumption by fuel (in%) for 28 EU countries, 19 Euro area countries and Ukraine. From fig. 3 shows that in Ukraine, the percentage of usage of renewable energy and biofuels is 3…4 times lower than in the EU and the Euro area. This indicates the need to increase the share of non-traditional and renewable energy sources in the fuel and energy sector and in the energy sector of Ukraine.




| | Solid fossil fuels | Peat and peat | Oil shale and oil | Oil and petroleum | Natural gas | Nuclear heat | Renewables and biofuels | Electricity | Non-renewable waste |
|---|---|---|---|---|---|---|---|---|---|
| Ukraine | 28,7 | 0,1 | 0,0 | 14,5 | 27,5 | 25,3 | 4,4 | 0,0 | 0,1 |
| EA-19 | 11,4 | 0,2 | 0,4 | 36,1 | 23,7 | 13,6 | 13,7 | 0,1 | 0,9 |
| EU-28 | 13,6 | 0,1 | 0,3 | 34,8 | 23,8 | 12,6 | 13,9 | 0,1 | 0,9 |

EU-28 EA-19 Ukraine

**Fig. 3.** Comparison of gross inland energy consumption by fuel (in%) for 28 EU countries, 19 Euro area countries and Ukraine. Source: compiled by authors based on statistical data from Eurostat (2020).

Fig. 4 shows a comparison of the dynamics of change the share of renewable energy in total final energy consumption (%) in the world, countries of the Northern America and Europe, and Ukraine.

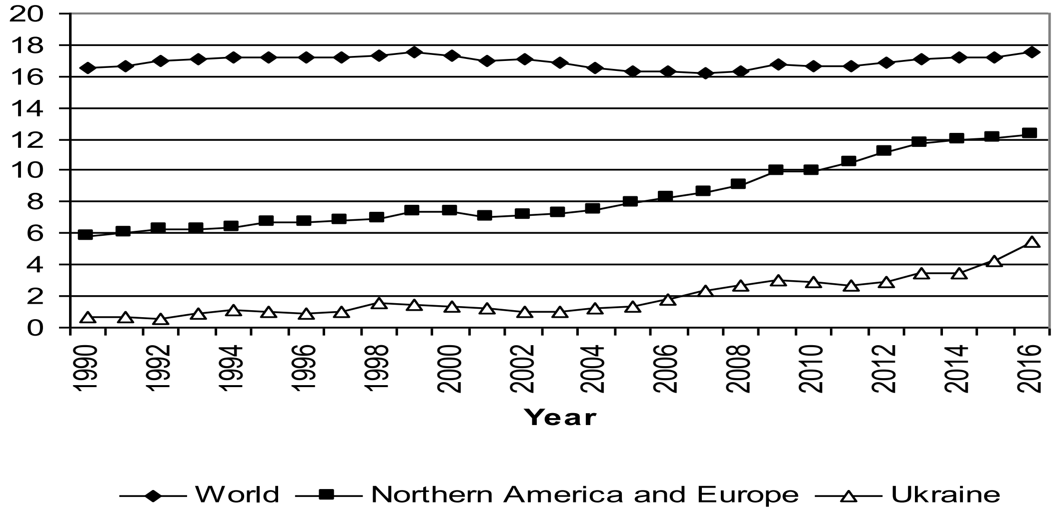



Fig. 4. Comparison of the dynamics of change the share of renewable energy in total final energy consumption (%) in the world, countries of the Northern America and Europe, and Ukraine. Source: compiled by authors based on statistical data from Eurostat (2020).

From Fig. 4 shows that Ukraine has substantially increased the share of renewable energy sources in the fuel and energy balance. However, the percentage of unconventional energy sources used is insufficient compared to the global level and the level of countries in Northern America and Europe. Fig. 5 shows the comparative dynamics of energy intensity change in the world, and in Northern America and Europe and in Ukraine.

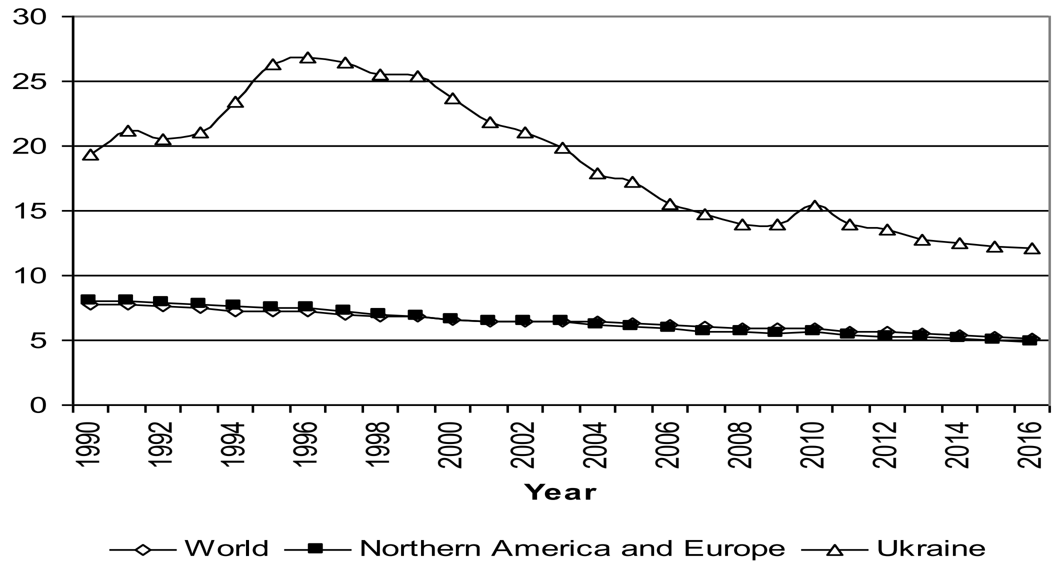



Fig. 5. Comparative dynamics of energy intensity (MJ/USD PPP 2011) change in the world, and in Northern America and Europe and in Ukraine. Source: compiled by authors based on statistical data from Eurostat (2020).

In Fig. 6 shows the dynamics of annual change in the percentage (increase) of national energy intensity in the world, Northern America and Europe and Ukraine.

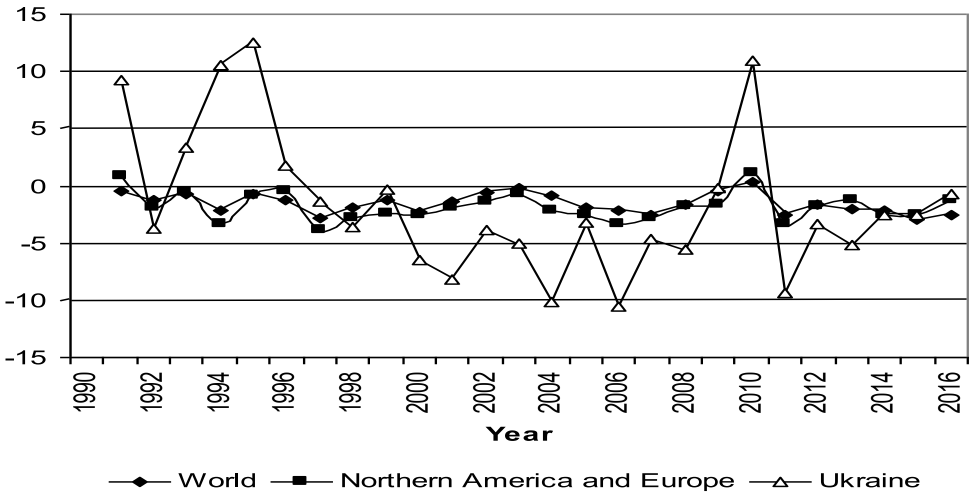



Fig. 6. Dynamics of Annual change in the percentage (increase) of national energy intensity in the world, Northern America and Europe and Ukraine. Source: compiled by authors based on statistical data from Eurostat (2020).

Based on the analysis of the research results, shown in Figs. 4 – 6, we can conclude that energy intensity in Ukraine tends to decline, but is too high compared to global and European and Northern American countries. This necessitates the widespread introduction of innovative energy- and resource-efficient high-efficiency technologies, including the use of non-traditional and renewable energy technologies.

## 4. RESULTS AND DISCUSSION

In our study we suggested to perform the comprehensive assessment of efficiency of application of energy- and resource-saving, environmentally safe and cost-effective innovative technologies, in the concepts of green logistics and sustainable development, with application complex generalized dimensionless criterion of energy-ecological-economic efficiency of innovative technologies:

$$K_{INN}^{compl} = \beta \cdot K_{RES} + \Delta E + \Delta EC + K_{REC}, \qquad (1)$$

where β – share of replacement the traditional technology by innovative technology; $K_{RES}$ – dimensionless criterion of relative energy- and resource-saving efficiency of innovative technology, which used for the determination of energy- and resource-saving operation modes and may be determined in the following manner:

$$K_{RES} = \sum_i \left( \frac{\Delta B_i}{B_i} \right), \qquad (2)$$

where $\Delta B_i$ – is economy of the *i*-th resource (and/or energy) of innovative technology, $B_i$ – are consumption of the *i*-th resource (and/or energy) of the replaced traditional technology; this criterion may be applied on condition that $K_{RES}$ > 0;

$\Delta E$ – is relative economic efficiency of innovative technology, which used for the determination of economically valid operation modes on condition that $\Delta E$ > 0, this criterion may be determined in the following manner:

$$\Delta E = \sum_i \left( \frac{\Delta E_i}{E_i} \right), \qquad (3)$$

where $\Delta E_i$ – are economy of operation costs for *i*-th operation mode of the innovative technology, $E_i$ – are operation costs for *i*-th operation mode of the replaced traditional technology;

$\Delta EC$ – is relative ecologic efficiency of innovative technology, that enables to determine ecologically safe operation modes of innovative technology on condition that $\Delta EC$ > 0; the relative ecologic efficiency (in shares) $\Delta \mathrm{EC}$ of innovative technology for *i*-th operation modes is determined in the following manner:

$$\Delta EC = \sum_i \left( \frac{\Delta EC_i}{EC_i} \right), \qquad (4)$$

where $\Delta EC_i$ – is the reduction of the amount of harmful emission in the atmosphere for *i*-th operation mode of innovative technology, $EC_i$ – is the amount of harmful emission in the atmosphere for *i*-th operation mode of replaced traditional technology;

$K_{REC}$ – dimensionless criterion of relative recycling (and/or utilization of the waste) efficiency of innovative technology, which used for the determination of recycling or waste utilization possibilities of innovative technology and may be determined in the following manner:

$$K_{REC} = \sum_i \left( \frac{\Delta U_i}{U_i} \right), \qquad (5)$$

where $\Delta U_i$ – is amount of recycling of utilization of the *i*-th resource (and/or energy) of innovative technology, $U_i$ – are consumption of the *i*-th resource (and/or energy) of replaced traditional technology; this criterion may be applied on condition that $K_{REC}$ > 0;

Thus, the justification of the application of the methods of green logistics and sustainable development for the analysis of perspectives of application of innovative technologies is presented in the given research. According to such approach, it is determined that: energy- and resource-saving, economically substantiated, ecologically safe and recycling (and/or utilization of the waste) efficient innovative technologies will be provided on conditions of: $K_{INN}^{compl}$ > 0 and $K_{RES}$ > 0 and $\Delta E$ > 0 and $\Delta EC$ > 0 and $K_{REC}$ > 0. The greater is the value of $K_{INN}^{compl}$ index, the more energy efficient, ecologically safe, economically efficient and competitive innovative technology will be. Application of the suggested approaches, aimed at determination of the areas of efficiency of application of energy - and resource-saving, environmentally safe and cost-effective innovative technologies will be demonstrated on the specific examples.

Figs. 7 and 8 show the results of comprehensive assessment of efficiency of application of energy- and resource-saving, environmentally safe and cost-effective innovative technology - cogeneration heat pump technology, in the concepts of green logistics and sustainable development. In our research the values of complex generalized dimensionless criterion of energy-ecological-economic efficiency of innovative technologies are determined on conditions of replacement share the traditional technology by innovative technology , which change in the range of $\beta$ = 0,125...1,0. Fig. 7 shows the area of efficiency of application of energy- and resource-saving, environmentally safe and cost-effective innovative cogeneration heat pump technology, using the heat of water recycling system with cogeneration heat pump installation (CHPI) of small power. Fig. 8 shows the area of efficiency of application of energy- and resource-saving, environmentally safe and cost-effective innovative cogeneration heat pump technology, using the heat of water recycling system with CHPI of large power. This areas are determined by the complex generalized dimensionless criterion of energy-ecological-economic efficiency of innovative technologies from the formula (1).

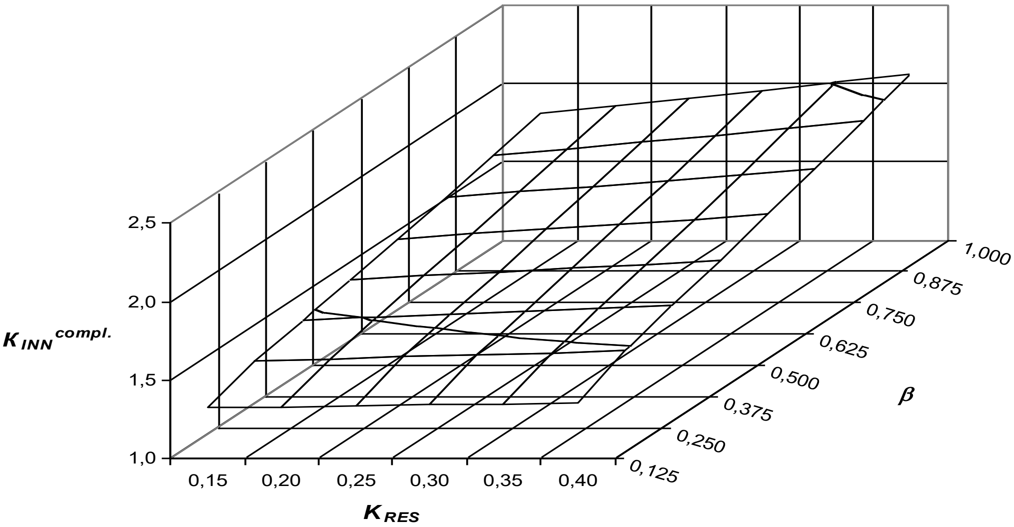



Fig. 7. Area of efficiency of application of innovative cogeneration heat pump technology of small power, using the heat of water recycling system. Source: authors research results.

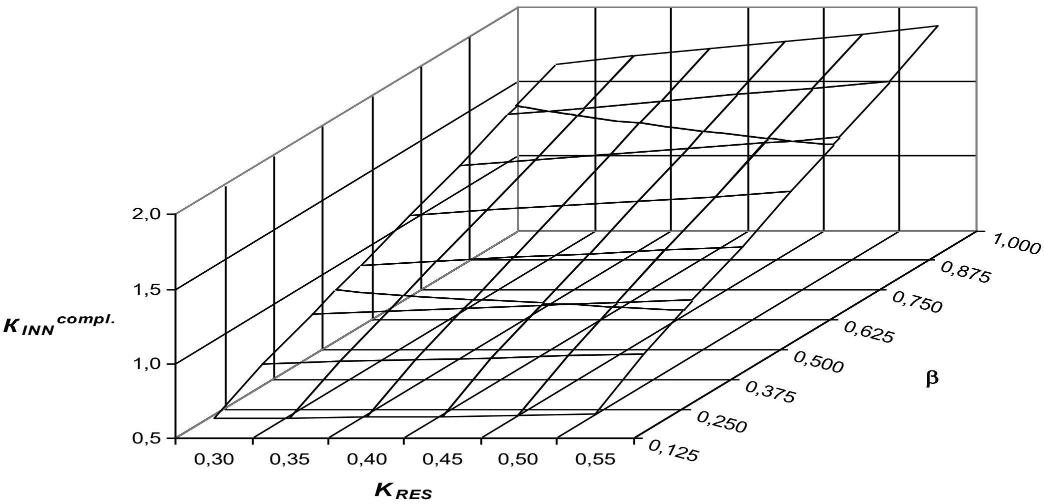



Fig. 8. Area of efficiency of application of innovative cogeneration heat pump technology of large power, using the heat of water recycling system. Source: authors research results.

As it is seen from Figs. 7 and 8, on conditions of $K_{INN}^{compl}$ > 0 and $K_{RES}$ > 0 and $\Delta E$ > 0 and $\Delta EC$ > 0 and $K_{REC}$ > 0, dependences, shown in Figs. 7 and 8, determine areas of efficiency of application of energy- and resource-saving, environmentally safe and cost-effective innovative cogeneration heat pump technology, using the heat of water recycling system. On such conditions, the above-mentioned innovative technology can be recommended as energy- and resource-saving, environmentally safe and cost-effective innovative technology.

## 5. CONCLUSIONS

The paper considers the prospects for the application of innovative resource-saving technologies in the concepts of green logistics and sustainable development. Assessment of the perspectives of application of innovative resource-saving technologies in Ukraine was carried out with taking into consideration the main goals of sustainable development, tendencies of development of sustainable energy and fuel and energy complex of Ukraine in the direction of European integration, ensuring reduction of greenhouse gas emissions and increasing the use of non-traditional and renewable energy sources. The study illustrates the application of principles and objectives of the concept of green logistics in order to increase the level of energy-economic efficiency of the energy sector of Ukraine with the application of energy- and resource-saving, environmentally safe and cost-effective innovative technologies. In study is suggested to perform the comprehensive assessment of efficiency of application of energy- and resource-saving, environmentally safe and cost-effective innovative technologies, in the concepts of green logistics and sustainable development, with application complex generalized dimensionless criterion of energy-ecological-economic efficiency of innovative technologies.

The justification of the application of the methods of green logistics and sustainable development for the analysis of perspectives of application of innovative technologies is presented in the given research. According to such approach, it is determined that: energy- and resource-saving, economically substantiated, ecologically safe and recycling (and/or utilization of the waste) efficient innovative technologies will be provided on conditions of: $K_{INN}^{compl}$ > 0 and $K_{RES}$ > 0 and $\Delta E$ > 0 and $\Delta EC$ > 0 and $K_{REC}$ > 0. The greater is the value of $K_{INN}^{compl}$ index, the more energy efficient, ecologically safe, economically efficient and competitive innovative technology will be. Application of the suggested approaches, aimed at determination of the areas of efficiency of application of energy- and resource-saving, environmentally safe and cost-effective innovative technologies is demonstrated on the specific examples. In research determined areas of efficiency of application of energy- and resource-saving, environmentally safe and cost-effective innovative cogeneration heat pump technology, using the heat of water recycling system. On conditions of $K_{INN}^{compl}$ > 0 and $K_{RES}$ > 0 and $\Delta E$ > 0 and $\Delta EC$ > 0 and $K_{REC}$ > 0, the above-mentioned innovative technology can be recommended as energy- and resource-saving, environmentally safe and cost-effective innovative technology. In this paper the prospects for the application of innovative resource-saving technologies in the concepts of green logistics and sustainable development has been performed; this method has in-depth approach to perform the comprehensive assessment of efficiency of application of energy- and resource-saving, environmentally safe and cost-effective innovative technologies, in the concepts of green logistics and sustainable development, with application complex generalized dimensionless criterion of energy-ecological-economic efficiency of innovative technologies. This approach enables to provide the substantiated determination of the perspectives of application of energy- and resource-saving, environmentally safe and cost-effective innovative technologies, in the concepts of green logistics and sustainable development, in order to increase the level of energy-economic efficiency of the energy sector of Ukraine.

**REFERENCES**

[1] Ciuła, J., Gaska, K., Siedlarz, D., Koval, V. (2019). Management of sewage sludge energy use with the application of bi-functional bioreactor as an element of pure production in industry. E3S Web Conference, 123, 01016. https://doi.org/10.1051/e3sconf/201912301016.
[2] Esmap (2020). Retrieved from: https://www.esmap.org/
[3] Eurostat (2020). Energy dependency. Retrieved from: https://ec.europa.eu/eurostat.
[4] Gubanova E., Kupinets L., Deforzh H., Koval V., Gaska K. (2019). Recycling of polymer waste in the context of developing circular economy. Architecture Civil Engineering Environment, 12(4), 99-108. doi: 10.21307/ACEE-2019-055.
[5] Kostetska K., Khumarova N., Umanska Y., Shmygol N., Koval V. (2020). Institutional qualities of inclusive environmental management in sustainable economic development Management Systems in Production Engineering, 28 (1), 15-22.
[6] Koval, V., Duginets, G., Plekhanova, O., Antonov, A., & Petrova, M. (2019). On the supranational and national level of global value chain management. Entrepreneurship and Sustainability Issues, 6 (4), 1922-1937.
[7] Koval, V., Mikhno, I., Hajduga, G., Gaska, K. (2019). Economic efficiency of biogas generation from food product waste. E3S Web Conference, 100, 00039. DOI: 10.1051/e3sconf/201910000039.
[8] Koval, V., Mykhno, Y., Antonova, L., Plekhanov, D., & Bondar, V. (2019). Analysis of environmental factors' effect on the development of tourism. Journal of Geology, Geography and Geoecology, 28(3), 445-456. https://doi.org/10.15421/111941.
[9] Koval, V., Petrashevska, A., Popova, O., Mikhno, I., & Gaska, K. (2019). Methodology of ecodiagnostics on the example of rural areas. Architecture Civil Engineering Environment, 12(1), 139-144. doi: 10.21307/ACEE-2019-013.
[10] Koval, V., Sribna, Y., Gaska, K. (2019). Energy Cooperation Ukraine-Poland to Strengthen Energy Security. E3S Web Conference, 132, 01009. https://doi.org/10.1051/e3sconf/201913201009.
[11] Koval, V., Duginets, G., Plekhanova, O., Antonov, A., & Petrova, M. (2019). On the supranational and national level of global value chain management. Entrepreneurship and Sustainability Issues, 6(4), 1922-1937.
[12] Melnikova, N., Yanchenko, N. (2018). The analysis of the interpretation and the essence of green logistics. Social Economy,56, 183–189.
[13] Nazarova, K., Hordopolov, V., Kopotiienko, T., Miniailo, V., Koval, V., & Diachenko, Y. (2019). Audit in the state economic security system. Management Theory and Studies for Rural Business and Infrastructure Development, 41(3), 419-430.
[14] Omel'chenko, I., Aleksandrova, A., Brom, A., Belova, O. (2013). Osnovnyye napravleniya razvitiya logistiki XXI veka: resursosberezheniye, energetika i ekologiya. Gumanitarnyy vestnik, 10. Retrieved from: http://hmbul.ru/articles/118/118.pdf. [in Russian].

[15] Ostapenko, O. (2019). Analysis of energy, ecological and economic efficiency of steam compressor heat pump installations, as compared with alternative sources of heat supply, with accounting the concept of sustainable development . Sustainable Development Under the Conditions of European Integration. Part II, (pp. 312 – 329). Ljubljana:Visoka šola za poslovne vede.

[16] Ostapenko, O. (2020). Estimation of energy-ecological-economic efficiency of energy supply systems with cogeneration heat pump installations in Ukraine, in the concepts of green logistics and sustainable development. Institutional Development Mechanism Of The Financial System Of The National Economy. (pp. 52 – 66). Batumi: Publishing House "Kalmosani".

[17] Paris Climate Agreement (2020). Retrieved from: https://unfccc.int/process-and-meetings/the-paris-agreement/the-paris-agreement.

[18] Popova, O., Koval, V., Antonova, L., & Orel, A. (2019). Corporate social responsibility of agricultural enterprises according to their economic status. Management Theory and Studies for Rural Business and Infrastructure Development, 41(2), 277–289. https://doi.org/10.15544/mts.2019.23.

[19] Prystupa L., Koval, V, Kvach, I. and Hrymalyuk, A. (2019). Transformation of cycles of state regulation in international trade. AEBMR-Advances in Economics Business and Management Research. Atlantis Press: France. 95, 277-280.

[20] Rise (2020). Retrieved from: https://rise.esmap.org/country/ukraine.

[21] Shmygol N., Galtsova O., Solovyov O., Koval V., Arsawan I. (2020). Analysis of country's competitiveness factors based on inter-state rating comparisons E3S Web Conferences, 153, 03001. https://doi.org//10.1051/e3sconf/202015303001.

[22] Sustainable development (2020). Retrieved from: https://sustainabledevelopment.un.org.

[23] Sustainable energy for all (2020). Sustainable Development Goal 7. Retrieved from: https://www.seforall.org.

[24] Tracking SDG7 (2020). Retrieved from: https://trackingsdg7.esmap.org/country/ukraine.

[25] WorldBank (2019). DataBank. Retrieved from: https://databank.worldbank.org.