

Ministry of Education and Science of Ukraine

ODESA NATIONAL UNIVERSITY OF TECHNOLOGY

International Competition of
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BLACK SEA SCIENCE 2023

PROCEEDINGS



ODESA, ONUT 2023

Ministry of Education and Science of Ukraine

Odesa National University of Technology

International Competition of Student Scientific Works

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Proceedings

Odesa, ONUT
2023

HYDROPOWER INDUSTRY OF UKRAINE: CURRENT STATE, PROSPECTS AND FISCAL INSTRUMENTS TO STIMULATE ITS DEVELOPMENT

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Abstract. *The aim of this work is to determine the main features of the current state, problems and prospects for the development of hydropower in Ukraine, as well as to analyze the potential for using fiscal instruments to stimulate this industry. The structure, location, generated capacities of the largest HPPs and PSHs of Ukraine are characterized. The dynamics of hydropower consumption in Ukraine is presented. Political, economic, socio-cultural and technological factors of the external environment for the development of hydropower are identified. The role and risks of the hydropower industry in supporting the energy balance in the conditions of a full-scale invasion of the Russian Federation into Ukraine are determined. The necessity of post-war modernization of hydropower in the context of the principles of sustainable development is shown. The potential effectiveness of the use of fiscal instruments (environmental tax) to stimulate the post-war development of the hydropower industry is substantiated, taking into account the principles of environmental responsibility of industry.*

Keywords: *hydropower, hydropower potential, renewable energy sources, fiscal instruments, environmental tax, environmental taxation, full scale invasion, PEST analysis.*

I. INTRODUCTION

One of the modern directions of sustainable development of the world economy is an active transition to renewable energy sources. Such energy sources contribute to the maximum limitation of the impact of human activity on the environment. One of the branches of renewable energy is hydropower, which generates electricity from the kinetic energy of water movement. The active development of this branch of the energy system has long been the norm for modern developed countries. In Ukraine, powerful hydropower complexes have also been operating for a sufficient amount of time, however, a relatively small share of hydropower in the total electricity generation by the United Energy System of Ukraine, a weak level of development of the investment environment, current political and socio-economic challenges (full-scale invasion of the Russian Federation into Ukraine) actualize the need for a more detailed studying the current state and prospects for the development of hydropower in Ukraine. Fiscal instruments were chosen as the object of study of the instruments of post-war stimulation of the development of this industry due to their effectiveness and significance for the economy of modern developed countries.

II. LITERATURE ANALYSIS

The hydropower industry of Ukraine has been developing for quite a long time, therefore, researchers have already prepared a sufficient number of scientific papers on the problems of the state and prospects for the development of this area. Of course, the hydropower industry is constantly evolving, so it makes sense to analyze only newer scientific works and other sources of information.

Vlasyuk Yu. S. and Stefanyshyn D. V. conducted a number of studies, the subject of which were the problems and prospects for the development of small hydropower in Ukraine. Sukhodolya O. M., Sidorenko A. A., Behun S. V. and Bilukha A. A. analyzed the current state and main risks, key tasks for the development of the hydropower industry in Ukraine. Obodovskyi O. H., Danko K. Yu., Pochaiyevets O. O., Obodovskyi Yu. O. proposed a method for determining the hydropower potential of rivers. Petrakov Ya. V. and Hnedina K. V. developed a methodology for the integral assessment of the impact of alternative energy on the environment.

The issue of the impact of the full-scale invasion of the Russian Federation on the hydropower sector is completely new, because so far it is precisely investigative journalism that has been carried out most of all in this area. Interesting analytical materials were prepared by Butsko D., Konev V., Harasym A. and Kelm N.

Separately, it should also be noted scientific research on the problems of environmental taxation. This topic has also repeatedly become the subject of research by scientists from various countries. The impact on ecotaxes on carbon dioxide emissions was studied by Runst P., Höhle D. The evolution and development prospects of environmental taxation were studied by Barde J. P., Owens J. In Ukraine, environmental taxes were studied by Nikola S. O., Husiev A. O., Suchek S. I. and other scientists.

Despite a fairly wide base of scientific research on the problems of hydropower and environmental taxation, the problem of using environmental taxes as fiscal instruments to stimulate the hydropower industry remains insufficiently studied. And in the context of the prospective postwar modernization of the entire industrial complex of Ukraine, this topic is of particular relevance.

III. OBJECT, SUBJECT, AND METHODS OF RESEARCH

The aim of the study is to determine the main features of the current state, problems and prospects for the development of hydropower in Ukraine, as well as to analyze the potential for using fiscal instruments to stimulate this industry.

The object of the study is the current state and prospects for the development of the hydropower industry in Ukraine as a renewable energy sector.

The subject of the study is a general description of the current state, principles, conditions, prospects, threats, as well as fiscal instruments to stimulate the development of the hydropower industry in Ukraine.

Research methods: during this study, general scientific and special research methods were used, including: analysis and synthesis, abstraction, a systematic approach to the phenomena and processes under consideration, induction and deduction, concretization, analogy, comparison, grouping, PEST-analysis.

IV. RESULTS

4.1. Hydropower industry of Ukraine: current state, problems and development trends

Hydropower is "a branch of renewable energy, as well as a set of large natural and artificial subsystems that serve to convert the kinetic energy of water into electrical energy" [1]. This definition of hydropower, formulated by PJSC "Ukrhydroenergo", emphasizes a very important feature of the hydropower segment of the Ukrainian energy industry – its renewable nature. Compared to traditional energy sources based on the use of fossil fuels (gas, oil, coal, etc.), such energy sources pollute the environment much less and do not exploit very limited fossil resources. At the same time, there are factors that limit the pace of development of energy sectors based on the use of renewable energy sources: the dependence on climatic conditions of many areas of such energy (the presence of rivers, wind power, and so on), the need to invest significant funds in building and supporting the operation of appropriate energy complexes. Due to the above factors, at the moment, the share of hydroelectric power plants and pumped storage power plants in the total electric power industry of Ukraine is very limited – 6.7% as of 2021 [2].

Here are the general characteristics of the hydropower industry in Ukraine [3]:

- the basis of the functioning of the hydropower industry in Ukraine is the river system, represented by almost 63 thousand rivers with a total length of more than 200 thousand km, of which 113 have a length of more than 100 km, while the river flow of fresh water reaches 87.14 billion m³;
- the hydropower sector of the Unified Energy System of Ukraine is represented by 10 high-capacity hydroelectric power plants (more than 10 MW), about 50 small-capacity hydroelectric power plants (less than 10 MW), 4 pumped storage power plants;
- the total capacity of generated hydropower reaches 5350 MW, while the share of high-capacity hydropower plants is 97.2%;
- the largest HPPs of the energy system: Dnipro HPP, Dniester HPP, Kremenchuk HPP, Kaniv HPP, Kyiv HPP, Kakhovka HPP, Seredniodniprovska HPP; the largest PSHs: Dniester PSH, Kaniv PSH, Tashlyk PSH.

Information about the largest HPPs in Ukraine and a map of their location are presented in Figure 1.

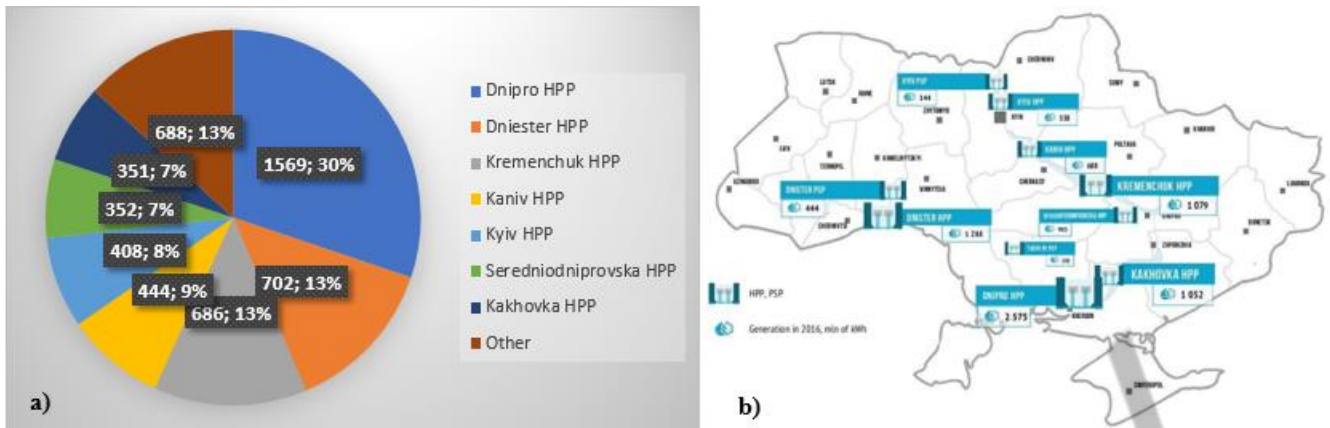


Fig. 1. Structure and location of the largest HPPs in Ukraine:
 a – absolute and relative indicators of the capacity of hydropower produced by HPPs*, b – map of the location of the largest HPPs and PSHs in Ukraine**
 *source: built by the author based on [4]
 **source: [5]

The total consumption of hydropower in Ukraine is characterized by an unstable trend, depending on both external and internal factors. The largest drop in the indicator of hydropower consumption (by 2.56 times over the period 2013-2015) is associated with a crisis period for the economy – the annexation of the Crimean Peninsula and the outbreak of war in the East of Ukraine. The period 2015-2018, on the contrary, demonstrates a stable positive growth trend of the indicator – from 464 thousand toe to 897 thousand toe. The dynamics of hydropower consumption in Ukraine is shown in Figure 2.

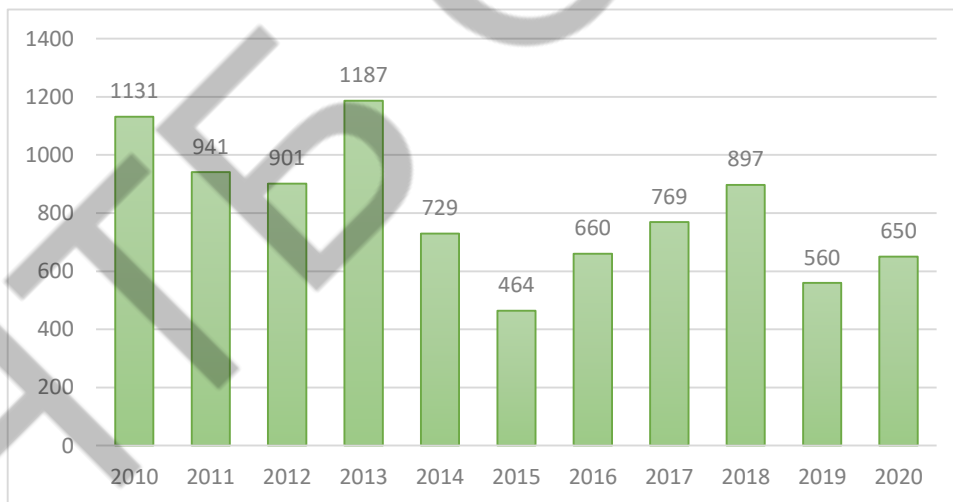


Fig. 2. Dynamics of hydropower consumption in Ukraine, thousand toe *
 *source: built by the author based on [4]

The share of the total installed capacity of HPPs and PSHs in the energy complex of Ukraine (6.7% as of 2021) is significantly less than the share of hydropower in the entire world's electricity (16.8% as of 2020) [6]. This situation can be caused by independent unchanging factors (insufficiency of the country's water resources, typical, for example, for some states of the African continent) or a number of external and internal reasons related to the insufficient development of the industry (for example, limited funding for projects related to the hydropower complex). Both groups of factors

are characteristic of the Ukrainian hydropower industry. The provision of Ukraine's own water resources is quite low – only 1 thousand m³ (this indicator is one of the lowest in Europe) [3]. But even the potential inherent in Ukraine is not fully used. To characterize the potential of water resources as a possible source of hydropower generation, the concept of hydropower potential is used. That part of the hydropower potential, the use of which is economically justified, is called the economic hydropower potential [7]. In Ukraine, the calculated economic hydropower potential reaches 17.5 billion kWh, and the actually used one is 11 billion kWh. Thus, the Ukrainian hydropower industry uses only 62.86% of the economic hydropower potential. This indicator is significantly lower than that of other developed countries: 95% in France, 85% in Switzerland, and 84% in Italy [3].

It should be noted that reaching the level of utilization of the entire economic hydropower potential is not justified from an environmental point of view. Here it is important to pay attention to the fact that although hydropower belongs to renewable energy sources, hydropower *is not* absolutely ecological kind of industry. The environmental damage from overexploitation of water resources is as follows [8]:

- destruction or damage to river ecosystems;
- flooding and erosion of surrounding soils;
- flooding of individual ecological biotopes;
- violation of the oxygen regime and hydrogen sulfide concentrations in rivers.

Accordingly, the concept of ecological hydropower potential is sometimes considered as an environmentally friendly part of the economic hydropower potential [9]. A country that follows the principles of sustainable development should limit the development of the hydropower industry precisely at the level of maximum use of the ecological hydropower potential. However, in Ukraine, the use of hydropower potential does not even reach the ecological level, as evidenced by the lagging behind the corresponding indicators of developed Western countries.

Thus, it can be confidently stated that the hydropower industry of Ukraine has the potential for development. However, the questions of principles, conditions and prospects for the development of the hydropower industry remain open. Let's consider them in more detail.

To analyze the conditions for the development of the hydropower industry in Ukraine, we will conduct a PEST analysis, its results will be presented in Table 1 [1, 3, 10].

Table 1. PEST analysis of the hydropower industry in Ukraine

P (Political)		E (Economic)	
Positive Factors	Negative factors	Positive Factors	Negative factors
1) Legal and regulatory support for the activities of the hydropower industry has been developed (Law “About the Electricity Market”, Energy Strategy of Ukraine, Hydropower	1) The war situation in the country (targeted attacks by the enemy on the energy facilities of Ukraine, the capture of the Kakhovka hydroelectric power station, and so on)	1) Growing demand for renewable energy 2) Tax incentives for producers of alternative energy industries	1) Limited presence of foreign investors in the Ukrainian hydropower market 2) Insufficient funding for projects to develop the hydropower industry

<p>Development Program) 2) All the largest HPPs and PSHs belong to one company – PJSC "Ukrhydroenergo" (signs of a natural monopoly) 3) State participation in the capital (the state is the main and sole shareholder of PJSC "Ukrhydroenergo") contributes to the sustainable development of the industry</p>	<p>2) Non-transparency of the national economy, high level of corruption in many areas 3) Inefficient systems of state control over the allocated financing of energy industry enterprises</p>		<p>3) Inflationary processes, rise in price of resources</p>
S (Socio-cultural)		T (Technological)	
Positive Factors	Negative factors	Positive Factors	Negative factors
<p>1) The proportion of the working population, attitudes towards work, social mobility 2) The policy of maximum support and development of engineering education, the introduction of the concept of dual education</p>	<p>1) "Brain drain" – many specialized specialists, including those in the field of hydropower, leave Ukraine for other, more economically developed countries 2) Negative public perception of many projects for the construction of new stations and, accordingly, the expansion of land flooding 3) Insufficient level of development of ecological consciousness of the general population in Ukraine</p>	<p>1) The possibility of further development of the industry remains due to the expansion of the use of ecological hydropower potential 2) Separate components of hydropower complexes are quite mobile and can be relatively easily replaced / repaired separately 3) A significant number of small and medium-sized rivers in Ukraine provides an opportunity for further integrated development of the system of small hydropower plants</p>	<p>1) Insufficient experience in the use of foreign advanced technologies for the improvement, support and repair of components of the energy complexes of HPPs and PSHs 2) Scientific and technical research in the field of hydropower in Ukraine is quite limited 3) Weak communication between research teams dealing with new technologies in the field of hydropower and representatives of the business sector of the relevant industry</p>

Separate attention should be paid to what is considered the most important negative factor of the modern environment – the full-scale invasion of the Russian Federation into Ukraine. In the context of this war, the hydropower industry has its own special prospects and risks.

In the context of a total shortage of electricity in the Ukrainian energy system, caused by constant enemy shelling and missile attacks on Ukrainian energy infrastructure facilities, it is the hydropower industry that helps to stabilize the situation and avoid a complete blackout. Of course, HPPs and PSHs at this level of development are not able to replace nuclear and thermal power plants, but during the hours of peak voltages on the power system, the hydropower complex helps to smooth out power surges [11].

The main risks of hydropower in wartime conditions are related to two main aspects:

- rocket strikes and shelling of Ukrainian hydropower facilities;
- occupation of technical complexes (HPPs and PSHs) of the hydropower industry.

As for the first group of risks, it is important to note here that the facilities of the hydropower industry are less prone to large-scale destruction, unlike other energy sectors of Ukraine. The dams of HPPs and PSHs are designed and developed in such a way as to take into account the high water pressure. Rocket warheads, whose weight rarely reaches half a ton, cannot cause total damage to several million tons of stone, from which hydroelectric and pumped storage dams are built. More risks are posed by possible hits in the control centers of hydropower facilities, but for this it is necessary to have high-precision missiles, the insufficiency of which the enemy has repeatedly confirmed by intelligence and practice data [12].

The second group of risks is more significant, since Ukraine cannot exercise control over the objects seized by Russian troops. And in this case, various unfavorable development scenarios can take place: from cutting off the supply of electricity to Ukraine to blowing up the dams of captured objects (unlike missile strikes, such an undermining can be carried out by planting explosives). The most famous example of a hydropower facility seized by the invaders is the Kakhovka HPP, which remains seized as of the end of January 2023. At the moment, this HPP continues to supply a certain amount of electricity to Ukraine (30-40% of its installed capacity), but at the same time cannot participate in voltage stabilization in the Ukrainian energy system at peak times, unlike other industry facilities that are under control of Ukraine [13].

Thus, the sphere of hydropower during the war has its own special prospects and risks of use. However, any war does not last forever and there is a natural question of the development of the hydropower industry in Ukraine in the medium and long term.

Based on the adopted development strategies and scientific research [3, 14], the following principles for the further development of the Ukrainian hydropower industry can be determined:

- adherence to the principles of sustainable development;
- expanding cross-border cooperation;
- construction of new energy facilities in the industry (in particular, small hydropower plants);
- improvement of the regulatory framework for the activities of the hydropower industry in Ukraine, the implementation of the relevant norms of European legislation;

➤ development of state systems of control and environmental monitoring of the hydropower industry in Ukraine.

The main problems of the development of the hydropower industry (risk of man-made disasters, negative impact on the environment, low level of investment activity, development of international cooperation, and so on) and possible ways to solve them are defined in [3].

One of the most important areas for the development of hydropower in Ukraine is to stimulate activities in this industry. To this end, organizational, economic and fiscal incentives can be used. The environmental tax is recognized in international practice as a fiscal instrument for regulating the activities of companies in the context of sustainable development. Let's consider the features and prospects of using this tool in order to develop the hydropower industry in Ukraine.

4.2. Using the environmental tax as a tool to stimulate the development of the hydropower industry in Ukraine

Environmental taxation, as defined by S. O. Nikola and A. O. Husev, is “a set of payments (taxes and fees) levied from legal entities and individuals aimed at stimulating rational environmental management by collecting a certain amount of funds in proportion to the negative impact on the environment ...” [15]. The main element of environmental taxation is the environmental tax. This concept refers to a tax levied on activities that have a negative impact on the environment. Of course, not all objectively non-environmental activities are considered subject to environmental taxation – a clear list is determined separately in each country.

According to the generally accepted classification in the EU countries, environmental taxes on the basis of taxation are divided into energy taxes, transport taxes, taxes on environmental pollution, taxes on the extraction and use of natural resources.

In EU countries, energy taxes are several times higher than other groups. The dynamics of collected taxes in the EU countries as a whole is shown in Figure 3.

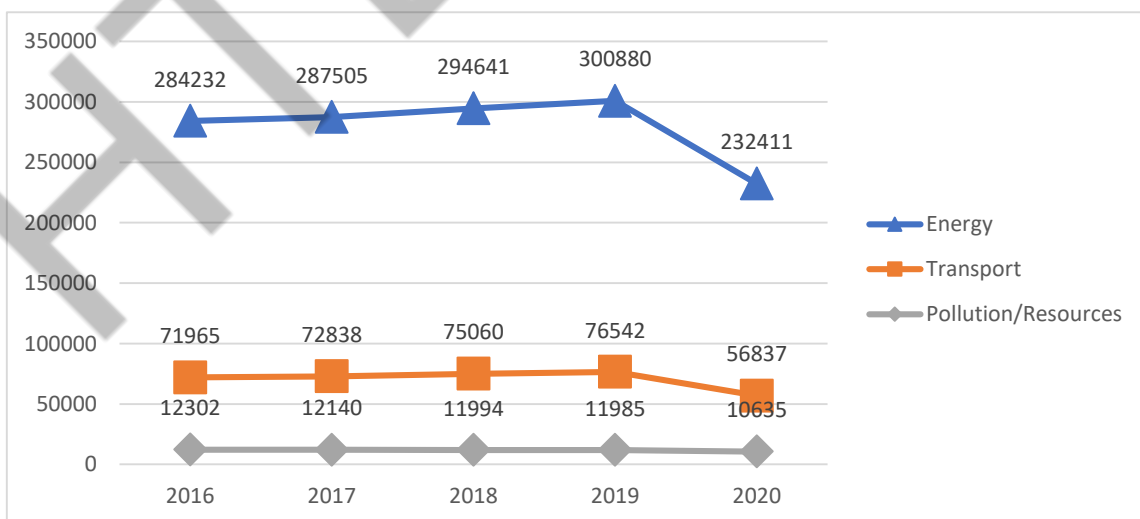


Fig. 3. Dynamics of collected environmental taxes in EU countries, million euros*

*source: developed by the author according to [16-17]

In Ukraine, official statistics give a slightly different grouping of ecotaxes into the following categories: for the amount of harmful emissions into the atmosphere (except for carbon dioxide), for discharges of pollutants into water bodies, for waste disposal, for the formation and storage of radioactive waste, for emissions of carbon dioxide into the atmosphere.

The dynamics of environmental taxes collected in Ukraine is shown in Figure 4. It can be seen that the largest part is formed by taxes equivalent to European energy taxes (harmful emissions into the atmosphere + CO₂ emissions). At the same time, transport taxes in Ukraine do not belong to environmental taxes at all, which may be inappropriate, because the exhaust gases of non-environmental cars have a direct negative impact on the environment. Also, it should be noted that the total amount of collected ecotax in Ukraine on average (2016-2020) is 1.703 times less than the European average, which is definitely a negative manifestation of the domestic fiscal system.



Fig. 4. Dynamics of collected environmental taxes in Ukraine, UAH billion*

*source: developed by the author according to [18]

One of the reasons for the lower volume of ecotaxes collected in Ukraine is their low rate. So, back in the first half of 2021, the tax rate on carbon dioxide emissions was only UAH 10 per ton (for comparison, the similar tax rate in Poland is 1 euro/ton, the UK is 24 euro/ton, France is 36 euro/ton, Sweden – 140 euro/ton) [19]. Under such conditions, the ecotax actually ceased to perform regulatory, stimulating and fiscal functions. But according to the adopted amendments to the Tax code [20], as of January 1, 2022, the ecotax on carbon dioxide emissions is approximately UAH 30/ton and further, by January 1, 2025, this tax will gradually increase to UAH 96.99/ton [21]. The situation is similar with other groups of ecotaxes.

Another reason for the insufficient volume of collected ecotaxes is the weak system of state regulation. The regions – the largest eco-tax payers in Ukraine include the city of Kyiv (1820 million UAH) and the regions: Dnipropetrovsk (857 million UAH), Donetsk (791 million UAH), Lviv (721 million UAH), Zaporizhzhia (434 million UAH), Poltava (262 million hryvnia) – Figure 5. At the same time, the leading regions in terms of harmful emissions into the atmosphere (the tax on this type of pollution occupies the main share of Ukrainian environmental taxation) are the regions (in decreasing order of emissions): Donetsk, Dnipropetrovsk, Ivano-Frankivsk,

Zaporizhzhia, Kharkiv. The incomplete coincidence between the largest polluters and the largest payers of the environmental tax gives grounds to assume that some enterprises are evading the payment of the environmental tax.

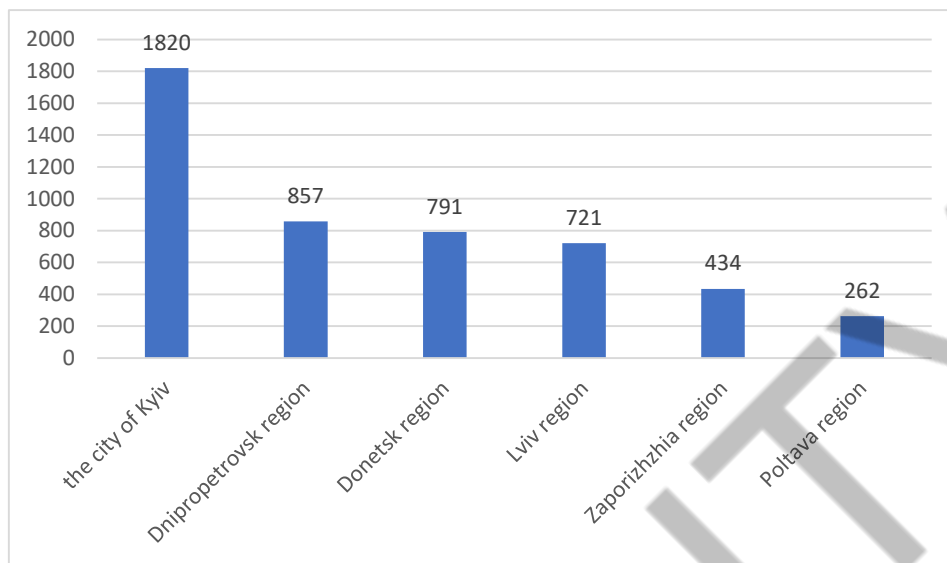


Fig. 5. Dynamics of collected environmental taxes in Ukraine, UAH billion*
*source: developed by the author according to [22]

The problem of misuse of collected funds is also relevant. According to [22], the total revenues from the environmental tax to the state budget for 2021 amounted to 2.8 billion UAH, but only 0.4 billion UAH of which were directed to the implementation of environmental protection measures. It is not clear how other means were used.

Thus, the main directions of development of the national system of environmental taxation are:

- ✓ changing the structure of environmental taxes, allocation of transport taxes in their structure; introduction of environmental taxes related to the non-environmental use of alternative energy sources;
- ✓ development of a regulatory framework, strengthening state control over the collection of environmental taxes;
- ✓ formation of a transparent system for the targeted use of the collected funds for the needs of the organization of environmental protection measures.

The expediency of using the ecotax as a fiscal tool to stimulate the development of hydropower is determined precisely by the described directions for improving the system of environmental taxation. As already noted, the development of hydropower is possible in two aspects:

- stimulating the transition from traditional non-environmental energy to alternative sources, in particular, hydropower;
- limiting the use of hydropower potential within its environmental component.

Gradual provision of the first direction is possible with the full implementation of the regulatory and stimulating function by the environmental taxation system. Choosing for themselves the most economically viable development option, some potential enterprises in the energy industry, with significant environmental tax costs for companies using traditional energy sources, would opt for alternative sources, in

particular, hydropower. To ensure the fulfillment of the regulatory and stimulating function of the environmental taxation system, it is necessary to establish the appropriate amount of the environmental tax rate and contribute to strengthening state control over the relevant area. And if the necessary legal and regulatory changes are made regarding the size of the tax rate, then the following modernization should be undertaken to strengthen state control:

- ❖ strengthen liability for environmental tax evasion;
- ❖ determine the mechanisms of communication between the sanitary and environmental services for assessing the impact on the environment and law enforcement agencies;
- ❖ improve technologies for detecting harmful emissions from enterprises;
- ❖ organize the sequence and frequency of inspections for compliance with environmental taxation standards.

Such decisions will stimulate the development of hydropower in Ukraine.

At the same time, non-environmental development of large HPPs and PSHs that destroy river ecosystems should also be limited. Preference should be given to SHPPs, which affect the state of water bodies to a lesser extent. In this context, it is possible to introduce certain additional articles of the environmental tax in the context of pollution of water bodies – the specified group of ecotax can be expanded to “negative impact on water bodies”. But the problem is to determine fair criteria for assessing the impact of hydropower facilities on water resources, as well as their boundary values, the appropriate tax rate. Possible criteria for the environmental impact of hydropower facilities on the environment:

- volumes of additional greenhouse gas emissions caused by the retention of organic matter in water bodies;
- change in biodiversity indices (Shannon index, Simpson index, etc.) before and after the construction of hydropower facilities;
- volumes of reduction of fresh water reserves;
- increase in the water level of water bodies.

Currently, there are almost no technological proposals on the methodology for evaluating these criteria. Their development is one of the promising areas for the development of modern "green" technologies.

Therefore, the environmental tax can act as an effective fiscal tool to influence the development of hydropower. Actualization of the regulatory and stimulating function of ecotaxes will contribute to the development of new hydropower facilities, and the expansion of the environmental taxation system through taxes on the harmful impact of hydropower facilities on the environment can limit the non-environmental development of new hydropower facilities.

V. CONCLUSIONS

This paper examines the current state, conditions, principles, problems and threats to the development of Ukrainian hydropower, as well as the use of fiscal instruments to stimulate the development of this industry. Based on the results of the study, the following conclusions were made:

1. Hydropower is an area of renewable energy, as well as a set of large natural and artificial subsystems that serve to convert the kinetic energy of water into electrical energy. Represented by the United Energy System of Ukraine in the field of hydropower, including 10 HPPs (total capacity 5200 MW), 4 PSHs, 50 SHPPs (total capacity 150 MW). Hydropower actively uses and develops the hydropower potential of Ukraine, which refers to the amount of electricity that can be obtained through the use of water resources. In Ukraine, the hydropower potential has been used only by 62%, but its further expansion should be carried out exclusively within the framework of the environmental component of the hydropower potential.

2. The development of hydropower in Ukraine is influenced by a number of political, economic, socio-cultural and technological factors. One of the most significant among these factors is the functioning of the industry in the context of a full-scale Russian invasion of Ukraine. Under the conditions of a total shortage of electricity in the Ukrainian energy system, caused by constant enemy missile attacks and shelling of Ukrainian infrastructure, the hydropower industry helps to smooth out voltage peaks in the energy system as much as possible and thus avoid a complete blackout. At the same time, the risks of the functioning of the hydropower industry itself in the conditions of war also increased significantly. And if missile attacks on hydropower facilities are capable of causing limited harm to the industry, then the capture of hydroelectric power plants and pumped storage power plants by enemy troops can significantly destabilize the development of the entire industry.

3. An important aspect of the post-war development of the Ukrainian hydropower industry is the stimulation of its activities, which can be carried out through the use of fiscal instruments – environmental taxes, which can be understood as a tax levied on activities that have a negative impact on the environment. The tightening of state control over environmental taxation will contribute to the actualization of the regulatory and stimulating function of the environmental tax, therefore, to an increase in the share of economic entities of alternative energy (in particular, hydropower). At the same time, the development of a system of environmental taxes on water pollution may limit the activities of non-environmental hydropower enterprises.

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