# THE DEVELOPMENT OF HYDROPOWER IN UKRAINE TO ENSURE THE SUSTAINABLE DEVELOPMENT OF ITS THE ENERGY SYSTEM

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**Summary**

Modern energy issues are one of the key global topics, and Ukraine is no exception. With the growing energy needs and the deterioration of the environmental situation in the world, ensuring the sustainable development of the energy system becomes an extremely important task. One of the possible solutions to this problem is the development of hydropower, which is an important source of renewable energy. The relevance of the research is determined by a number of factors. First, Ukraine depends on coal and gas imports, which creates energy security risks. Secondly, global obligations in the field of reducing greenhouse gas emissions require a transition to more ecologically clean sources of energy, including hydropower. Third, the development of hydropower can stimulate regional development and create new jobs. The purpose of the study is to determine the potential of hydropower in Ukraine and to assess its possibilities for ensuring the sustainable development of the energy system. The subject of the study is the current state of hydropower in Ukraine, the advantages and limitations of this type of energy.

The research methodology is based on the analysis of available data on hydropower, assessment of its potential, identification of economic and environmental prospects, as well as analysis of modern legislative regulation.

**Key words:** hydropower, sustainable development, energy independence, renewable energy, environmental sustainability.

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## 1. Introduction

Energy is a necessary driver of the modern world, and the development of the national energy sector is crucial to ensuring the sustainable development of society. Ukraine, as a sovereign country with great industrial potential and a rather complex situation in the energy sector, experiences all the challenges and opportunities associated with the generation, supply and use of energy.

The development of energy has a decisive influence on the state of the economy in the country and the standard of living of the population. That is why reliable, economically justified and ecologically safe satisfaction of the needs of the population and the economy in energy products is a priority task of the state's energy policy. At the same time, ensuring the sustainable further development and effective functioning of the fuel and energy complex of Ukraine is the basis for the successful implementation of such a policy.

In this context, hydropower is important not only from the point of view of electricity production, but also a whole set of additional functions that ensure the stability of the functioning of the energy system and the economy of Ukraine. Hydropower is the most technologically

developed method of electricity production, which is widely used in the world and is a guaranteed energy resource.

Today, hydroelectric power plants are operated in 159 countries and provide the production of 16.3% of all electricity produced in the world. Hydropower provides the most efficient process of obtaining electricity, with low operating costs and a long service life. Hydropower plays an important role in ensuring the stability of the unified energy system (UES) of Ukraine, as it provides the energy system with highly maneuverable capacities in regulating daily load schedules with coverage of the peak part and filling of night dips, and also performs the function of an emergency power reserve.

Hydropower is also a complex water management system that solves the problems of water supply to the population and industry, water transport, irrigation, fisheries, recreation, etc. Protection of the population and national economic objects from floods is also an important additional function of hydropower, which is capable of regulating the flow of water, and the development and maintenance of hydrotechnical structures of power plants at an appropriate level contributes to the creation and provision of transport connections.

Ukraine has a developed hydropower complex. The domestic machine-building complex provides production of equipment both for reconstruction and restoration, as well as construction of hydroelectric power plants of various sizes. Today, the existing capacity of large hydropower plants is about 9% of all generating capacity of UES of Ukraine, but there is potential for further growth to 15–20%. A separate direction of hydropower development in Ukraine is the development of small hydropower on existing reservoirs, main canals, as well as the reconstruction of small hydropower facilities that perform the function of protecting adjacent territories from floods.

## 2. Presentation of the main material

In 2023, the installed capacity of hydroelectric power plants and hydroelectric power plants in the UES of Ukraine is about 5500 MW. Most of them, more than 4922 MW, belong to PJSC "Ukrhydroenergo", whose annual electricity production exceeds 10 billion kWh.

The total hydropower potential of Ukraine is more than 44 billion kWh. (including small hydropower plants of approximately 3.0 billion kWh). Today, the economically effective potential is about 17.5 billion kWh, of which about 11 billion kWh is already being used. (more than 60%) 5. Thus, the unused effective potential is about 6.5 billion kWh. At the same time, it should be noted that the hydropower potential of the Dnipro is largely exhausted *(Sydorchuk, 2020)*.

In addition, the intensive operation of the Dnipro HPP for tens of years has its consequences. Physically and morally outdated equipment has a low (compared to modern) efficiency factor (Efficiency), does not support the necessary regulation parameters, has a significant impact on the environment. Therefore, increasing the potential of the Dnipro cascade of hydroelectric power stations is possible and necessary, mainly due to the rehabilitation of the existing and installation of new hydro and electrical equipment with higher productivity.

Currently, it is hydropower that is mainly the main source of the highly mobile reserve. However, today in the balance of capacities of the UES of Ukraine, the capacity of the hydroelectric plant is about 10%, against the optimal 16%. To solve the problem, it is necessary to build additional hydraulic and hydraulic storage capacities.

It is assumed that the reconstruction with the extension of the service life for more than 3.2 GW of hydroelectric power plants and the construction of new capacities will allow to

achieve a significant increase in the total capacity of hydroelectric power plants of the UES of Ukraine. Thus, according to the forecast of the Energy Strategy of Ukraine for the period until 2030, the installed capacity of hydroelectric power plants and hydroelectric power plants will reach 16% of the total capacity of UES of Ukraine, which will ensure an adequate level of maneuvering and reserve capacities *(Kovalenko, 2019)*.

Along with the priority areas of using the potential of large hydropower, there is an opportunity to use the potential of small rivers of Ukraine. The development of small hydropower will also contribute to the decentralization of the general energy system, which will remove a number of problems both in the energy supply of remote and hard-to-reach areas of the countryside, and in regional electricity networks, which will reduce not only the loss of electricity during electricity supply, but also increase the overall economic efficiency of the operation of Ukraine's UES. According to the Institute of Renewable Energy of the National Academy of Sciences of Ukraine, the hydro potential of small rivers is about 12.5 billion kWh, which is about 28% of the total hydro potential of Ukraine

The priority direction of the development of the hydro potential of small rivers is the construction of hydroelectric power stations with small and medium-sized hydroelectric power plants8, based on the approaches accepted in world practice with the integrated use of reservoirs, ensuring protection against floods, minimizing the area of flooding and damage to the environment *(World Bank, 2019)*.

Another priority for attracting the hydro potential of small rivers is the reconstruction of small and medium-sized hydroelectric power plants on the plain rivers of Ukraine. To date, more than 170 small hydroelectric power stations (MHPs) have been preserved in Ukraine, of which 90 MHPs with a total capacity of 70–80 MW are operating. Most of the MHPs, especially non-operating ones, are in a neglected state, with an unclear form of ownership. Hydraulic structures are in a state of emergency or completely destroyed. All this leads to the need for significant investments for the reconstruction and modernization of small and medium-sized hydroelectric power stations. Along with the priorities for the development of Ukraine's hydro potential, the relative advantage of the industry, namely its self-sufficiency, should be emphasized. Ukraine has sufficient scientific and technical potential and considerable experience in the field of hydropower potential research, hydroelectric power plant design, design development and production of hydroturbine and electric power equipment, solving water management and environmental problems during the construction and operation of hydroelectric power plants. Ukrainian enterprises have the necessary production potential to create domestic equipment for small hydropower plants.

## 3. Advantages and prospects of hydropower development in Ukraine

Hydroelectric power stations represent the most mobile group of power equipment in terms of providing power reserve, which should be used in the frequency and power regulation system of UES of Ukraine. From the point of view of economic efficiency, they are the most favorable for use in the regulation process, since the requirements for the technical condition of the equipment are mainly applied only to the turbogenerator, in contrast to the technologically more complex power unit of the HPP. At the same time, the work of the gas power plant is especially important for the purposes of increasing the stability of the system. The gas station can be connected to the network from zero within 1–2 minutes, and the transition time from generator mode to pump mode does not exceed 5.5 minutes. In addition, unlike hydroelectric power

plants, the operation of the gas power plant does not depend on the water level of the year. HPPs can use almost the entire volume of water accumulated in reservoirs (except for the non-drainable part) to ensure peak load. In world practice, the number of start-ups of hydrounits of GAES in generator and pump mode often reaches 400 per month, and sometimes it is 30 starts per day *(SDG, 2021)*.

Hydroelectric power plants of Ukrhydroenergo OJSC operate in the System of Automatic Regulation of Frequency and Flows of Active Power (ASRCP) of the UES of Ukraine. Regulation of frequency and active power is carried out by means of automatic transmission of commands by the SCADA/AGC system to station control systems for changing power at hydroelectric power units of the UES of Ukraine.

The reconstruction and development of the hydropower industry of Ukraine will ensure the stability, reliability and efficiency of the operation of the UES of Ukraine, increase the economy of organic fuel due to the increase in the share of electricity produced at hydroelectric power stations in the country's energy balance. And the presence of unused hydro potential and hydro storage reserves near the western borders creates additional advantages (opportunities) in the implementation of electricity export programs, as well as joint work with the European Union ENTSO-E *(United Nations, 2015)*.

In addition to the above, the need to ensure the completion of the construction of a number of projects for the development of hydroelectric power plants and gas power plants of Ukraine is due to: the acute shortage of maneuverable capacities in the UES, in connection with the prospective introduction of new nuclear power plant capacities and renewable renewable energy sources (RES); the high efficiency of these objects in comparison with alternative options; significant freezing of huge funds invested in unfinished construction; wear and tear of the equipment of the Dnipro Cascade HPP, which is the main power regulator in the UES and ensures its stability; high results of the 1st stage of reconstruction of the Dnipro Cascade HPP. As a result of the implementation of all measures, the hydropower capacity should increase to 11,000 MW (16–20% of the total power system capacity), which is necessary to meet the needs of the UES of Ukraine in regulating the load schedule, frequency, and creating an emergency reserve in the power system *(MEEPU, 2020)*.

In addition, the reconstruction of the hydropower potential will make it possible to significantly increase the reliability of existing stations by improving the technical condition of the technological equipment of hydroelectric power stations, to introduce automated systems for monitoring the safety of hydrotechnical structures and emergency response, and to reduce possible environmental risks from the operation of station equipment.

At the same time, with an increase in the capacity and volume of electricity production, the goals of increasing the reliability and safety of operation of stations, meeting environmental protection requirements, and creating modern working conditions in accordance with current regulatory documents are being achieved. Technical reconstruction measures are carried out using 16 environmentally friendly technologies (replacing turbine impellers with environmentally friendly ones), eliminating the possibility of lubricants (turbine and transformer oil, oil products) entering the Dnipro, etc.

The development of small hydropower, in turn, in addition to providing its own energy resources, will contribute to the acceleration of socio-economic development due to the influx of investments, the creation of new jobs, the use of reservoirs for fish breeding, recreation and tourism. The construction of new small and medium-sized hydropower plants, primarily in the Carpathian region on the Tisza and Dniester rivers (with a total capacity of 1,200 MW and electricity production of about 3,000 billion kWh) is conditioned by: the practical absence

of own electricity producers in the Transcarpathian region (only 5–6%), which reduces guarantees of reliable energy supply; the presence of its own significant reserves of hydropower, located in close proximity to the western borders, which opens up favorable opportunities for the export of electricity; the necessity and possibility of a joint solution to energy problems and protection against floods, which is also a task of state importance and ensures the saving of state funds. In the Carpathian region, the development of small hydropower, in addition to providing own energy resources, will contribute to the acceleration of socio-economic development due to the influx of investments, the creation of new jobs, the use of reservoirs for fish breeding, recreation and tourism.

The overall priority values for the development of small hydropower in Ukraine, determined on the basis of concrete developments, are estimated at the end of 2030 at the level of 1,247 MW of power with an annual electricity production volume of 3.75–4.2 billion kWh/year, which will allow saving organic fuel in volumes equivalent to 1.5 million tons. p./year, or 1.3 billion cubic meters. m of natural gas.

## 4. Stimulating the development of small hydropower plants

Since 2009, the Cabinet of Ministers of Ukraine has increased attention to the development of renewable energy sources in Ukraine, including small hydropower. The Law of Ukraine "On Amendments to the Law of Ukraine “On Electric Power” on Stimulating the Use of Alternative Energy Sources" and on Establishing a “Green” Tariff was adopted. The latest amendments to the legislation stimulate the development of primarily small hydropower through the introduction of a “green” tariff incentive for small and micro-HPPs. In particular, changes were made to the Law “On Electric Power”, which determine: a new classification of small hydropower plants by introducing the terms “microhydroelectric power plant” (MHP with a capacity of up to 200 kW), “mini hydroelectric power plant” (MHP with a capacity of 200–1000 kW) and “small hydroelectric power plant” (MHP with a capacity of 1000–10000 kW); appropriate coefficients for each class to the approved NERC are introduced in the established order of the size of the “green” tariff 2.0; 1.6 and 1.2, respectively (before the adoption of this law, this coefficient was equal to 0.8 for all MHPs); the requirement to comply with the size of the local component, i.e. the norms of the cost of the components of Ukrainian origin used in the creation of the electric power facility, has been removed for all categories of MHPs. This really provides additional opportunities to attract investors; separate provisions of the law also determine the legal basis for operation of MHPs on the wholesale electricity market and provide state guarantees for the purchase of electricity produced by micro-, mini-, and small HPPs.

The priority task of the state policy in the field of hydropower of Ukraine should be to determine the expansion of the use of the potential of both large and small hydropower to meet the energy needs of the national economy. An appropriate organizational form for ensuring the coordination of actions and a clear sequence of implementation of the strategy for the reconstruction and development of Ukraine's hydro potential is the development of the sectoral program “Development of hydropower of Ukraine for the period until 2050”, for determining the priorities of the activities of state authorities and state enterprises, as well as establishing benchmarks and requirements for activities economic entities, in particular in terms of planning the development of the machine-building industry, research organizations and the system of education and training of personnel for the hydropower industry.

## 5. Conclusions

Hydropower can play a key role in the development of sustainable and independent energy in Ukraine, contributing to the reduction of gas emissions and providing reliable sources of energy for the country.

Prospects for the development of hydropower in Ukraine were studied in order to ensure the sustainable development of the country's energy system, and the necessity of diversifying energy sources, reducing greenhouse gas emissions and ensuring energy independence was determined. A promising solution to this problem is the study and implementation of hydropower technologies, which can play a key role in the modern energy system of Ukraine. An analysis of the current state of hydropower in Ukraine was made, the possibilities of its development were identified and the impact on the sustainable development of the energy system was determined. The study also covers the analysis of legislative regulation and financial aspects of hydropower. An analysis of the economic benefits, social benefits and environmental aspects of hydropower in Ukraine has been carried out.

## References

*1. Zhukova, M. G. (2021). "Development of hydropower in Ukraine: trends and prospects". Energy Research, 12(2), 45–62.*
*2. Sydorchuk, O. V. (2020). "Ecological and social aspects of hydropower in Ukraine: analysis and recommendations". Ecology and Sustainable Development, 8(1), 30–46.*
*3. Kovalenko, I. I. (2019). "Legal regulation of hydropower in Ukraine: problems and prospects". Law and Society, 7(3), 12–28.*
*4. "Energy strategy of Ukraine until 2030: principles and tasks". Bulletin of Energy, 3(4), 22–39. World Bank. (2019).*
*5. "Analysis of the hydropower market in Ukraine: opportunities and challenges". Ministry of Energy and Environmental Protection of Ukraine. MEEPU (2020).*
*6. "Strategy for the development of hydropower in Ukraine until 2030" United Nations. (2015).*
*7. "Sustainable Development Goals by 2030: A Report on Achievements and Challenges" SDG (2021).*
*8. European Commission. (2017). "Directive on the use of energy from renewable sources: Regulations and requirements".*