

CABINET OF MINISTERS OF UKRAINE

ORDER

**dated 13 July 2016 No. 552-p
Kyiv**

**On approval of the Program of hydropower development for the period
till 2026**

Approve the Program of hydropower development for the period till 2026, which is attached.

Prime Minister of Ukraine

V. Groisman

Ind. 37

Approved
by the Order of the Cabinet of Ministers of Ukraine
dated 13 July 2016, No. 552-p

**PROGRAM
of hydropower development for the period till 2026**

Objective of the Program

This program is aimed at implementation of measures to ensure sustainable hydropower development for the period till 2026.

The Program is aimed at energy security through effective hydropower development supported by maximum use of cost-effective hydropower potential, improving the management over hydropower objects and their safety, increasing regulatory maneuvering capacity of hydropower plants and storage power plants to increase the stability and reliability of the unified energy system of Ukraine as well as its integration into the European energy system, reducing the consumption of organic fuel resources and anthropogenic impact on the environment.

The United Energy System of Ukraine. The Role of Hydropower

Energy Strategy of Ukraine till 2030, which was approved by the Cabinet of Ministers of Ukraine on 24 July 2013, No.1071, provides for the implementation of large investment projects in the thermal energy sector (modernization of thermal power units). That assumes the extension of lifetime for nuclear power units and construction of new nuclear power plants.

Taking the shortage of regulation capacity of hydropower plants and storage power plants the use of thermal power aimed at regulation of both semi-peak and peak zone of load curves is non-relevant for this type of capacities and is provided by application of uneconomical and inefficient modes at thermal power plants.

Reliable and efficient operation of domestic power plants is impossible without their scale modernization. Ukraine's commitments set out in the Association Agreement with the European Union, the European Atomic Energy Community and its Member States, as well as in the Protocol on Ukraine's accession to the Treaty establishing the Energy Community, provide the bringing of

parameters of thermal energy in line with EU requirements regarding emissions of SO₂, NO_x and dust.

Estimated assessments show that the cost of modernization of thermal power units per 1 MW of installed capacity is comparable to specific capital costs for the Dniester HPSPP and Kaniv HPSPP. At that one should take into account that the strict compliance of operating parameters of storage plants to EU environmental standards, and environmental and climate obligations of Ukraine, including the Paris agreement signed by Ukraine in April 2016 within the United Nations Framework Convention on Climate Change, which includes limitations on emissions of greenhouse gases, as well as the fact that average lifetime of storage station equals to 100 years, which far exceeds the expected lifetime of reconstructed units of thermal power plants, which is normally as low as 15-20 years.

General trends in development of power generation capacity in the united energy system of Ukraine over the past years as well as the current plans for the construction of power energy objects demonstrate an increase of installed capacity of power plants due to those operating mainly in the area of the basic zone of the load curve of the united energy system of Ukraine (nuclear power plants, solar power plants, wind power), however the growth rate for maneuvering capacity is somewhat slower.

Temporary annexation of Autonomous Republic of Crimea by the Russian Federation and armed conflict in eastern Ukraine in 2014, which resulted in destruction of power generation facilities and electric networks, coal industry facilities, objects of transport and social infrastructure, led to changes in the operation modes of united energy system of Ukraine and necessity to optimize the fuel balance of Ukraine and appropriate changes in the structure of generating capacity in the mentioned grid.

Only 11 bln KW*h of the total economically efficient hydropower potential which totals about 17.5 billion KW*h, is used currently. Unused effective potential is about 6.5 bln KW*h.

In Ukraine, the share of economically efficient use of hydropower potential is over 60 percent, while the most developed countries reached higher levels of utilization, in particular, Italy, France and Switzerland - 95-98 percent, the United States - 82 percent.

Increased use of hydropower resources in the energy sector would reduce the fuel component and the country's dependence on imported fossil fuels.

Hydroelectric power plants are the most mobile group of generating capacity which effectively provides the reserve capacity to be used for the regulation of frequency and power.

Today the united energy system of Ukraine suffers from shortage of reserve power for automatic secondary regulation. An effective way to ensure the fast-starting reserve capacity for said system is in conversion of hydropower plants from a daily regulation to secondary regulation of frequency/capacity, which requires prospective construction of pumped storage power stations responsible for regulation of daily load curve in the grid.

According to the decision of the Council of Ministers of the Energy Community Ukraine undertook obligations to reach 11 percent share of energy produced from renewable energy sources in the general structure of energy consumption in the country till 2020, which fact has been reflected in the National Action Plan for Renewable Energy for the period till 2020 approved by the Cabinet of Ministers of Ukraine on 1, October, 2014 No.902.

According to the National Action Plan on renewable energy till 2020, the total capacity of power plants using renewable energy sources will reach 10.9 GW. This national Plan provides for the growth of total installed capacity of wind and solar power facilities, which are non-maneuvering capacities, by almost five times. At that, the increase in installed capacity of power plants using renewable energy sources should remain within the limits which are acceptable to ensure the reliable operation of the united energy system of Ukraine. In this regard, the use of pumped storage power plants is a universal mechanism for solving problems existing in the united energy system of Ukraine.

According to estimations, the commissioning of Dniester HPSPP (three hydraulic units) and Kaniv HPSPP during the launching of thermal power units will provide average monthly savings of natural gas in the amount of 9.3 million cubic meters, or USD 3.6 million, and 10.3 million cubic meters, or USD 4 million, accordingly.

In addition, in case of replacement of power plants with HPSPP the average operational savings of coal are expected at the level of 90.7 thousand tons or USD 8.2 million for Dniester HPSPP and 43.8 thousand tons or USD 3.9 million - for Kaniv PSP. In the course of operation of Kaniv HPSPP under the modes similar to regimes in 2014 for the Dniester HPSPP the savings of coal due to replacing the power units of thermal power plants will grow increasingly taking the volume of power generation.

Operation of the Dniester HPSPP and HPSPP Kaniv and replacement of units at thermal power plants in the daily load curve of the united energy system of Ukraine will significantly reduce emissions of pollutants produced by thermal power plants.

Under the results of preliminary estimations the reduction of emissions made by thermal power plants during operation of Dniester HPSPP (three hydropower units) is expected at the level of 181.1 thousand tons of CO₂, 2.3 thousand tons of SO₂, 0.6 thousand tons of NO_x and 0.7 thousand tons of dust on monthly scale. Substitution of the load of thermal power plants in daily load curve with hydro units of Kaniv HPSPP would result in monthly reduction of pollutants made by thermal power plants at the level of 104 thousand tons of CO₂, 1.2 thousand tons of SO₂, 0.3 thousand tons of NO_x and 0.4 thousand tons of dust.

Taking the above, commissioning of hydro units at HPSPP is crucial in solving the problem of shortage of highly maneuvering capacities in the united energy system of Ukraine and demonstrates positive economic effect for the said system.

The current state of hydropower industry

Hydropower capacity of the united energy system of Ukraine equals to 6,063.3 MW, including as follows:

Dnieper cascade hydropower plants - 3,660.8 MW;

Dniester hydroelectric cascade - 743 MW;

Kyiv HPSPP – 235.5 MW;

Tashlytska HPSPP (two units) - 302 MW;

Dniester HPSPP (three units) - 972 MW;

Small hydropower plants - about 150 MW.

Power generation at hydropower facilities in 2015 was about 11 billion KW*h, which was equal to 8.6 percent of total electricity produced in the united energy system of Ukraine.

The daily load curve of the united energy system of Ukraine is characterized by considerable unevenness. The average annual ratio of the minimum load at night to a maximum one in the evening peak hours is 0.76.

In such circumstances, the adjustment of significant part of daily load range (about 20 percent) is performed for the account of coal thermal power units with capacities of 200 to 300 MW by the method of daily disconnections of 10 or more units to overcome the night dips. These sophisticated "over-project" modes of basic coal thermal power units lead to early wearing of equipment, increased number of accidents and increased fuel costs, especially of gas and oil. According to fuel consumption norms about 60 tons of coal and 50 thousand cubic meters of natural gas are required to start-up the unit of 150 to 200 MW capacity.

To ensure reliability, stability and efficiency of the united energy system of Ukraine we must create a balanced structure of capacities by installation additional maneuvering capacities, complete the construction of pumped storage power plants and build new hydropower plants and pumped storage power plants. These measures will enable commissioning of 3300.5 MW in 2026,

while the share of hydropower will reach more than 15.5 percent of generating capacity of the system.

This would create favorable conditions for integration of the united power system of Ukraine into the European energy grid and would contribute into export of electricity.

Defining the role of the Dniester, Kaniv and Tashlyk pumped storage power plants to meet peak demand on the daily load curve, and improve operational modes of thermal and nuclear power plants

Maneuvering generation capacities are used in the United Energy System of Ukraine serve for regulation of the daily load curve, and include hydropower plants and hydroelectric pumped storage power plants and thermal power units. The facilities used to provide the balance in the united energy system of Ukraine are those of thermal power plants. Measures taken to adjust the daily load curve include, in particular, increasing of load for thermal power units in the hours of peak demand for electricity (by increasing the load of operating units of thermal power plants and putting into operation of reserve power capacities of 150-300 MW), as well as by unloading them in hours of minimum load for united energy system of Ukraine. Thermal power plants are intended for the basic and semi-peak load and are the balancing capacities in the united energy system of Ukraine, meeting peak demand on the daily load curve, which fact negatively affects their technical condition.

The dynamic analysis on attraction of power units with capacities of 150-300 MW for regulation of daily load curve of the united energy system of Ukraine shows as follows.

Units with capacity of 200 are of greatest demand in the industry. The share of their daily use during the period of concern has not been changed essentially and ranged from 72 to 80 percent compared to all power units with 150-300 MW capacity. It should be noted that the power capacity of 200 MW is not enough to ensure regulation of daily load curve, so units with capacity of 300 MW are systematically involved in regulation. Their share equals to 16 to 22 percent compared to all power units of 150-300 MW. The part of power units with capacities less than 200 MW, which are involved in regulation, may not be critical: 2 to 7 percent of the total number of power units of 150-300 MW, in particular, due to their small quantity in the united energy system of Ukraine.

Thus, the main regulating capacities on the daily load curve are 200 MW units and backup power units of 300 MW (including mono and double-hulled units).

It should be noted that in recent years the tendency to increase the installed capacity of the united energy system of Ukraine prevails for the account of energy facilities operating mainly in the core zone of load demand of the united energy system of Ukraine, i.e. base load is growing, while the growth rate of share maneuvering capacity is slower and does not meet the demands in these capacities for the united energy system of Ukraine for regulation of daily load curves.

The main development trends in hydropower industry. Prospective projects of new construction and renovation of hydrogenating facilities

Construction of Dniester PSPP - first stage

Dniester PSPP was designed as one of the largest pumped storage power plants in Europe. Its design capacity (seven units) will be 2,268 MW in generating mode and 2,947 MW in pumping mode. Location of the Station - Novodnistrovsk Chernivtsi region.

First stage includes three hydroelectric units with total capacity of 972 MW in generating mode and 1,263 MW in pumping mode.

Dniester PSP is designed to adjust the schedule of daily load overflows within the united energy system of Ukraine, the increase of electricity production in peak and semi-peak zones of load curve of the united energy system of Ukraine.

Adjusted cost of the project of the first stage for three units (reported by the State Enterprise "Ukrderzhbudekspertiza") totals UAH14.794 billion.

Putting into operation of Dniester PSPP will help to cover the peak power demand in the united energy system of Ukraine and improve the opportunity for energy overflows with neighboring power systems of European countries.

In connection with the construction of the Dniester PSPP social infrastructure objects appeared in the region (the project provides for the costs for the fixed contribution into financing of social objects in Sokyryany district and in the city of Novodnistrovsk).

Based on operation of pumped storage power plant during 330 days a year under the project mode, power output will total 2.252 billion. KW*h, while an annual income from the operation of the first stage of pumped-storage power plant will be UAH4.049 billion.

Further implementation of the project assumes the development of the design project for construction of the second stage of Dniester PSPP in number of the fourth hydroelectric set.

Construction of the Dniester HPSPP - second stage

The Ministry of Energy and Coal made decision in respect of feasibility of construction of the fourth hydroelectric set at Dniester PSPP.

Capacity of the fourth hydroelectric is planned to be 324 MW in generating mode and 421 MW in pumping mode.

The estimated cost of construction for the second stage for the fourth hydroelectric set will amount UAH 2,795,788.406 thousand (to be specified after drafting). The funding sources will be defined in the course of preparation and approval of the title.

Taking the requirements of construction technology, some of the works required for the second stage, were included into the first stage (upper and lower reservoirs, main facilities of water intake, water outlet, lower deck, etc.).

Construction project provides for the following measures:

- drafting of construction project for the second stage of the Dniester HPSPP, the State expertise of the project, approval of the project by the Cabinet of Ministers of Ukraine;
- provisioning of financing according to the construction schedule;
- implementation of the project - during 2017-2019.

Construction of the Dniester HPSPP - third stage

It is planned to include three hydroelectric sets (№ 5-7) with total capacity of 972 MW in generating mode and 1,263 MW in pumping mode to the third phase of construction of the Dniester HPSPP.

Construction of the Dniester HPSPP (seven generators) will be completed after execution of the third stage that would give significant systemic, economic and social effects.

The estimated cost of the project is expected to be UAH 8400000 thousand.

The decision on commencement the construction for the third stage of the Dniester HPSPP will be taken under the results of amendments to the design of joining the Dniester HPSPP and upon putting into operation of the third hydraulic unit with the prospect development up to seven hydroelectric units taking the measures envisaged in the development strategy for united energy system of Ukraine concerning construction of baseline networks. This work is carried out by the State enterprise "National Energy Company" Ukrenergo" and will be completed by the end of 2016

Construction of Kaniv HPSPP

Construction of Kaniv HPSPP (Buchak village, Kaniv district of Cherkasy region) with the capacity of 3600 MW was launched in 1986, and stopped in 1991. The updated draft with adaptation to the current state of the united energy system of Ukraine envisages the construction of pumped-storage power station with the decrease in capacity down to 1,000 MW and characteristics as follows:

number of hydroelectric sets - four with capacity 250 MW each;

upper reservoir - storage capacity of 17 mln. cubic meters with levee 10 meters width, the length of the forcing front - 4 km;

operational staff - 236 employees, the average number of workers involved into construction - 1900 persons;

Total time of construction - 6.5 years, launching of the first hydraulic unit is planned in 3.5 years from the start-up;

Cost of construction – UAH 11.98 billion including VAT (approximately USD 1.5 billion in prices as of 1 January, 2013)

In addition to the approved budget UAH 302 million has been envisaged for infrastructure development in Cherkasy region.

Facilities of dam and power station include upper and lower reservoirs, water pipes, building of the storage plant, drainage way, gas-insulated plant of 330 kV and other facilities:

upper reservoir is artificial one and located in side-hill semi-fill;

lower reservoir is the water storage of Kaniv hydropower plant;

water conduits shall be backfilled – four composite lines, internal diameter - 8 meters, total length - 950 meters;

drainage way has the length of 235 meters and variable width 91 to 125 meters;

on-surface structure includes water intake with inlet channel, building of Kaniv HPSPP, production facilities of the station, complete gas-insulated distribution plant of 330 kV

Implementation of the project requires as follows:

attracting of funds from international financial institutions (confirmation of participation in the project has been received from the World Bank and the European Investment Bank, expression of interest for joining the project has been declared by European Bank for Reconstruction and Development and Kreditanstalt für Wiederaufbau (KfW);

development of working design documentation for the construction site preparation;

works on preparation of construction site (primary works aimed at creation of construction infrastructure)

implementation of the project is scheduled in 2016-2023.

Construction of Tashlyk HPSPP- second start-up complex

Construction of Tashlyk HPSPP was launched in 1981 and halted in 1991 with about 80 percent readiness of two units

Completion of Tashlyk HPSPP was started under the revised project, which has been approved by the Cabinet of Ministers of Ukraine in 2002.

Start-up complexes including hydropower sets No. 1 and 2 were commissioned in 2006 and 2007 accordingly.

State Enterprise "National Joint Stock Energy Company "Energoatom" continues construction of the start-up complex consisting of hydro unit No. 3, readiness is about 58 percent. Rising of water

level in Alexandrivsk water storage was executed up to mark of 16 meters, hydraulic turbine was mounted, generator-motor was manufactured and supplied.

Second start-up complex of hydropower set No. 3 includes:

hydro power plant building with hydro power set No.3 itself, technological systems and building structures;

feed tunnel conduits;

330 kV overhead line from outdoor 330 kV switchgear of Tashlyk HPSPP to outdoor 330 kV switchgear of South-Ukrainian NPP;

outdoor switchgear 330 kV at separate subdivision of South-Ukrainian NPP, chambers No. 3 and 4 with new relay room;

cut-off dam at Tashlyk water storage;

rising the level in Olexandrivsk water storage up to the mark 16.9 meter (revised project envisages the rise up to 20.7 meter).

techno-economic performance indices of the first start-up complex of hydropower set No.3 is as follows:

installed capacity in turbine mode - 151 MW;

installed capacity in pump mode – 226.5 MW;

annual electricity production – 87.5 million kW*h;

annual electricity consumption - 119 million kW*h.

In view of revising the project for completion of three units of Tashlyk HPSPP and subsequent completion of four - six hydraulic units, including measures to improve the reliability and safety of hydraulic structures, basic hydropower and hydromechanical equipment, the cost of the project has been revised on the basis of current prices and adjustments to the project have been made. Re-approval of the project is expected in late 2016.

Construction of Tashlyk HPSPP - third – fifth start-up complexes (hydropower units No.4-6)

According to the Order of the Cabinet of Ministers of Ukraine dated 21 November 2007 No. 1036 "On approval of the project completion for Tashlyk HPSPP " taking the experience of operation of hydraulic units No.1-3 of Tashlyk HPSPP and results of environmental monitoring the decision on bringing back into service of hydraulic units No.4-6 was made.

Commissioning of hydropower units No. 4-6 with in turbine mode capacity of 453 MW and pumping mode capacity of 633 MW.

Description of parameter	Start-up complexes including 6 hydropower units
Number of hydropower units	6
Installed capacity, MW:	
In turbine mode	906
In pumping mode	1266
Annual electricity production, million kW*h	873
Annual electricity consumption, million kW*h	1178

Moreover, the project will provide additional emergency reserve power for the South-Ukrainian NPP's own needs.

Due to the fact that the project will have a positive impact and improve the safety of the South Ukrainian nuclear power plant, as well as due to lack of own funds the State Enterprise "National Joint Stock Energy Company "Energoatom" is currently exploring the feasibility of attracting the loan resources from international financial institutions required for implementation of the project.

Project implementation envisages the following measures:

- adjustment of project documentation, expertise and re-approval of the project;
- development of working design documentation;
- provisioning of sources for project financing;
- execution of procedures for purchasing the equipment;
- construction works and commissioning.

Construction of Kakhovka HPP-2

The Kakhovka HPP belongs to semi-peak hydroelectric plants. Increasing of capacity at Kakhovka HPP would allow its shifting into peak area of the load curve. The installed capacity: 250 MW, number of hydro power units: four (of 62.5 MW capacity each), location of the new station - Nova Kakhovka, Kherson region.

Growth of average long-term production of electricity after construction of Kakhovka HPP -2 is supposed to be conditioned by escapades. Following the installation of hydropower units of Kakhovka HPP-2 basic indicators are expected to be improved (i.e. installed capacity and average long-term production).

In 2010 the EU has allocated the grant funds assigned for the development of feasibility study for the project on expansion of Kakhovka hydraulic system. This work was executed by consulting company Fichtner (Germany).

Feasibility study defining the location, characteristics of future structures and layout of the main equipment has been developed by date. The scheduled cost of construction, according to preliminary estimates, totals about 420 mln. Euro.

European Investment Bank, European Bank for Reconstruction and Development and Kreditanstalt für Wiederaufbau (German state bank KfW) expressed their interest in financing the project.

Project implementation envisages the following measures:

- obtaining of expert conclusion from the state enterprise "Ukrderzhbudekspertiza" and approval of the feasibility study by the Cabinet of Ministers of Ukraine;
- drafting of construction design project for the second stage of Dniester HPSPP, obtaining the State expert conclusion for the project, approval of the project by the Cabinet of Ministers of Ukraine;
- attracting the funds from international financial institutions;
- implementation of the project during 2019-2024.

Reconstruction of HPPs of PJSC "Ukrhydroenergo" – second stage of reconstruction

Objectives of the project:

- reconstruction of 76 hydropower units including installation of new:
 - turbines and generators;
 - speed governors;
 - excitation systems;

- control and monitoring;
 - security systems;
 - generator circuit breakers and other equipment;
- reconstruction of hydromechanical equipment and hydraulic structures;
- application of systems for automatic dam safety monitoring;
- improvement of environmental situation in Dnepr River and Dniester river due to installation of turbines which exclude the ingress of oils into the river;
- creation of informational management system at JSC "UHE" and working conditions for the staff.

Project for reconstruction of HPPs of PJSC "Ukrhydroenergo" envisages the funding from several sources; in particular, own funds of PJSC "Ukrhydroenergo" received from production of electricity, and financing from international financial institutions (World Bank, European Bank for Reconstruction and development, European investment bank).

Upon completion of feasibility study for reconstruction in 1994, the World Bank has confirmed partial financing of the program of reconstruction. It was decided to conduct reconstruction in two stages (phases).

Within 1996-2002: the first stage of reconstruction of hydropower plants of Dniester cascade and Dniester HPP-1 was executed for the account of own funds, loan from the World Bank and grant of Swiss Government. As a result 16 hydropower units were reconstructed. The increase of capacity for 88.1 MW was obtained after first stage. First stage of reconstruction resulted in partial implementation of advanced automated control systems for hydroelectric power plant as well as in security control systems for hydraulic facilities of HPP and replacement of numerous electrical instruments. The second phase, due to various circumstances, began only in 2005. Thus the so-called intermediate stage of reconstruction occurred during which the repair and replacement of old equipment have been performed at the expense of PJSC "Ukrhydroenergo".

During the intermediate stage seven hydro units were reconstructed and this resulted in increase of capacity by 30 MW. In 2004 PJSC "Ukrhydroproekt" developed a feasibility study for the second stage of reconstruction of hydroelectric power plant.

During the second phase of reconstruction, which was actually the "technical retooling of equipment" the need in additional scope of works arose in order to include additional measures for improvement of reliability and safety of hydraulic structures, basic water-power part and hydraulic equipment. Also, given that the fire requirements and standards have been significantly changed in recent years, the need to revise the fire safety of all the buildings and structures of HPPs and replacement of fire alarm and controls of fire-fighting systems appeared. This developed into decision by PJSC "Ukrhydroenergo" in 2012 to adjust the project on the second stage of reconstruction.

In 2014 JSC "Ukrhydroproekt" completed the design draft "HPPs of Ukrhydroenergo. Reconstruction. 2nd stage. Adjustments" and obtained positive comprehensive conclusion from the State enterprise "Ukrderzhbudekspertiza". However, the delay in the consideration and approval of the project led to exceeding the deadline for application of the project and its approval by the Cabinet of Ministers of Ukraine. Therefore nowadays new requirements specification is being developed which are required for further adjustment of the project and its approval by the Cabinet of Ministers of Ukraine.

According to estimates the implementation of the project "HPPs of Ukrhydroenergo. Reconstruction. 2nd Stage. Adjustments" will allow increasing the capacity of reconstructed hydraulic units by 307 MW, creating additional 2000 jobs for the time of construction works at the site, and given that main manufacturers of electric power and hydraulic turbine equipment are Ukrainian enterprises – creating additional 5 thousand jobs at the factories, which along with equipment for HPSPP- Dniester would give 12 thousand additional jobs.

To implement the project of reconstruction the State expertise of the project and approval of the same by the Cabinet of Ministers of Ukraine are required.

Construction of Upper Dniester hydropower cascade

A significant and cost-effective untapped hydropower potential of Dniester River is located in Carpathian region which suffers from energy shortfall. In this region the most important challenges are related to acceleration of social and economic development, including development of generation from renewable sources, on the other hand is the problem of protection against floods causing great damage to local population, economy and environment.

Based on the preliminary design drafts performed by PJSC "Ukrhydroproekt" this project envisages the construction of cascade of six channel/derivative low water head (water head of 8-9 meters) hydropower plants with allocation of flood control reservoirs at water storage pools on the level which is far above normal headwater level.

At that, the daily discharge flow control is envisaged at water storage to cover peak zone of daily load curve of the energy system with the total capacity of 390 MW for all HPPs and average long-term production of about 710 million KW*h subject to measures for protection against flood.

The estimated cost of construction equals to 1100 million EUR (preliminary draft by PJSC "Ukrhydroproekt" as of 2014). Stations will be located at the site of the Upper Dniester in Ivano-Frankivsk, Ternopil and Chernivtsi regions from Dovhe village and till the pinch of water storage of Dniester hydrosystem with total length of about 220 kilometers.

In this area the average long-term discharge of Dniester River totals 200-230 cubic meters per second. Width of the stream canal reaches 100 meters; width of flood plain is up to 250 meters. In the course of consideration over the project for construction of Upper Dniester hydropower cascade preliminary calculations under design decisions relied on advanced approaches accepted worldwide:

- comprehensive use of storage reservoirs for hydropower, fighting against floods, as well as water supply, fisheries, and recreation;

- minimization of negative impact on the environment and improving of living conditions for population;

- providing the advanced principles of investment into construction through loans and private investment instruments;

- development of infrastructure in the areas of construction

Minimization of negative impact on the environment is one of the key conditions of the project. Therefore, Upper Dniester hydropower cascade the construction of which is currently under consideration is characterized by low water heads of 7 to 9 meters. Due to such low water heads the great part of the upper water storage will be located in the territory of wetlands within the borders affected by floods characterized by 1 to 5 percent risk (i.e. those occurring once in 100 and 20 years respectively). For floods with the risk of 1 percent and 5 percent the difference in plane area equals to about 10 percent, thus minimizing the flooding of the lands.

The complex protective measures includes dams, drainages, bank consolidation in order to protect settlements, farmlands against high water, flooding, impoundment and bank processing aimed at improving the living conditions of population in the zone of the water storage and tail-water.

According to the groundwork of PJSC "Ukrhydroproekt" allocation of flood control reservoirs with estimated volume of 147 million cubic meters is provided at water storage of Upper Dniester hydropower cascade, which will enable to control the discharge and transform floods of different risk, thus reducing the maximum flood discharges which are discharged from the Dniester water storage located below and having useful capacity of 2 bn. cubic meters, which in its turn is the main regulator of Dniester's discharge.

In addition, the creation of reservoirs would improve the conditions of water supply, fisheries, recreation, environmental conditions during low-flow periods of shallow rivers, and given the

favorable climatic and environmental conditions would increase the value of land in coastal zone of the water storage ponds.

Structures of Upper Dniester hydropower cascade envisage the arrangement of six highway bridge crossings over the Dniester River.

Construction of Upper Dniester hydropower cascade will enhance social and economic conditions of population due to:

- protection against floods and draughts;

- enhancement of water supply, electric supply, recreation conditions in adjusting settlements as well as environmental conditions in general;

- the use of construction infrastructure, enhancement of transport conditions by building access roads, bridge crossings via hydropower sets (provided the cost of one crossing over the Dniester of about USD250 million);

- investment inflows to the region;

- creation of new jobs for local population.

Implementation of the project would require the measures as follows:

- development of feasibility study and obtaining the conclusion of the State expertise;

- execution of the first phase of feasibility study - engineering survey and study on environmental protection, development of the main provisions of feasibility study, which will examine various options for cascade of Upper Dniester hydropower plants with storage ponds of complex use and specify the number of hydropower stations, determination of their location and key indicators, selection of the most efficient option for hydroelectric cascade system, discussion and approval of the selected option

- development of draft design and commencement of construction works.

Development plan for generating facilities of hydropower industry for the period till 2026 is contained in attachment 1.

Assessment of additional systematic effect

The functioning of the Dniester HPSPP in a number of one hydraulic unit (324 MW in turbine mode) makes it possible to carry out the replacement of two power plant units of 200 MW each or of one power unit with capacity of 200 MW and one thermal power unit of 300 MW capacity. Accordingly operation of two hydroelectric units of Dniester HPSPP (capacity 324 MW each) will enable to replace four power units of thermal power plants of 200 MW each or two power units of 300 MW each and one power unit of 200 MW, three hydraulic units (capacity 324 MW) would replace six hydro units 200 MW each or four units of 300 MW each.

The functioning of one hydraulic unit of Kanivska HPSPP enables to carry out a replacement of one unit of thermal power plant with capacity of 300 MW and respectively operation of Kanivska HPSPP in number of four hydroelectric units (250 MW each) would replace four hydro units of 300 MW.

Economy of natural gas consumption required for starting the power units at thermal power station as the result of replacement by Dniester HPSPP and Kaniv HPSPP of PJSC “Ukrhydroenergo” is presented in table 1 and table 2.

Table 1

Economy of coal and natural gas consumption as the result of replacement of power units at thermal power stations by Dniester HPSP

List of equipment (replacement of coal units with capacity 200 MW each)	Average annual economy of coal (anthracite and gas group)		Average annual economy of coal (anthracite group)		Average annual economy of natural gas	
	ton	Million UAH	ton	Million UAH	Thousand cubic meters	Million UAH
Hydraulic unit No. 1	367 889	551,8	341 469	512,2	37 826,5	214,7
Hydraulic units No.1 and 2	735 778	1103,7	682 938	1024,4	75 652,9	429,3
Hydraulic units No.1-3	1 103 668	1655,5	1 024 408	1536,6	113 479,4	644

Table 2

Economy of coal and natural gas consumption as the result of replacement of power units at thermal power stations by Dniester HPSP

List of main equipment (replacement of coal units with capacity 300 MW each)	Average daily production of electricity, thousand kW*h	Average annual economy of coal		Average annual economy of natural gas	
		ton	Million UAH	Thousand cubic meters	Million UAH
Kaniv HPSP (in number of four hydraulic units)	2 843,8	557 415	836,1	125 008	709,4

Price of the coal totals UAH 1500 per 1 ton exclusive VAT.

Price of natural gas totals UAH 5675 per 1000 cubic meters ton exclusive VAT.

Plan of actions on execution of the Program

Plan of actions on execution of the Program is presented in attachment 2.

Efficiency and estimated results from implementation of the Program

General estimated results of the program will be the improving of safety level, reliable and sustainable operation of hydropower industry and its effective development with maximum use of cost-effective hydropower potential, complete implementation of regulatory functions of united energy system of Ukraine, improvement of operation conditions of nuclear power plants and thermal power plants and ensuring the possibility for putting new nuclear power capacities into operation as well as reduction of organic fuels consumption and technological impact on environment and ensuring national energy security in general. Execution of set tasks and activities would provide significant positive energy, economic, environmental and social results.

General results from implementation of the program are as follows:

completion of the second stage of reconstruction at HPPs of PJSC "Ukrhydroenergo" followed by the extension of their operational life for 30-40 years, increasing of capacity for 245.2 MW and higher levels of operational safety.

Putting into operation the highly maneuvering capacities of HPPs and HPSPs in order to control daily and weekly load curve of the energy system.

Implementation of the project would allow to achieve the improvement of stability level, reliability and efficiency of the united energy system of Ukraine thanks to the balanced structure of capacities, to provide the necessary amount of maneuver capacity providing in full system services, to create conditions for permanent and quality satisfaction of the demand for electricity, and to reach the share of maneuvering capacities of HPPs and HSPP up to 15.5% in general balance of the industry till 2026, thus providing an optimal balance between different types of power generation capacities on Ukrainian electricity market and enabling for stabilization of prices for electricity at reasonable levels.

Additional effects of the Program are:

- increase of the quality of electricity;
- decrease of the costs for electricity production;
- reduction of combustion products from thermal power plants using fossil fuel;
- reduction of accident rate at thermal power plants due to the decrease of non-project maneuvering modes;
- improving of social and economic and environmental conditions by:
 - complex use of storage ponds, in particular for power generation, flood fighting, recreation and water supply to facilitate the prevention of emergency situations of natural character, and creation of more environmentally friendly and favorable conditions for population;
 - attracting the investments into the region during the construction of hydroelectric and pumped-storage power plants, in particular for the social and environmental needs;
 - more jobs through the construction of hydropower facilities;
 - improving of the safety of hydropower facilities and significant reduction of the risk of accidents; minimization of the risk of economic losses associated with emergency situations and elimination of the consequences of accidents

Due to the increase in hydroelectric power generation and operation of pumped-storage plant significant savings of fossil fuels will be obtained, including those through:

- reconstruction and commissioning of new capacities;
- partial charging of pumped storage power plants from nuclear power plants which will displace thermal power plants on the load curve;
- increasing the highly maneuvering capacities, which will replace the thermal power units that carry out daily regulation of load curves

Economic result will be in reduction of the cost of electricity:

- at the Dnieper HPP - after reconstruction;
- at coal power plants - by creating the conditions for operation within project mode and reduction of fuel consumption;
- at nuclear power plants - by creating conditions for operation in basic mode with increased utilization of installed capacity and improved electricity output

It should also be noted that Ukraine has almost completed cycle of manufacturing of basic water-power and auxiliary equipment for the construction and operation of hydroelectric and pumped-storage power plants i.e. turbines, water seals, consequently it became possible to provide orders for large companies, including OJSC "Turboatom", State Enterprise "Electrotyazhmash" (Kharkov), PJSC "Zaporizhtransformator" (Zaporizhzhya) and others that would provide work for almost 12 thousand workers.

In addition, construction of hydroelectric and pumped storage power stations will increase the number of jobs in the areas of construction up to 3,000 thousand in the course of works for at least

five - six years and provide about 300-400 jobs for a period of operation of hydropower plant, i.e. for almost 100 years (we mean only the jobs for highly qualified industrial staff).

Environmental and social results of the program will enable the reduction of anthropogenic impact on the environment and improvement of living conditions, reduction of harmful effects from emissions on human health through minimized use of fossil fuels and emissions of pollutants into the environment, including greenhouse gases.

Since the hydropower industry in Ukraine is effectively supported by the international financial institutions for already 20 years, this program should serve as a basis for interaction with such organizations for the medium-term period.

XXI Century highlights the problem of careful approach to drinking water resources. The urgency of this issue was confirmed in the “World Declaration of ICOD on Water Storage for Sustainable Development”, which, inter alia, provides for the need to achieve a balance between secure infrastructure, and active use of water resources. This document envisages the combined use of large and medium water storages with the glance at the necessity and priority of sustainable development of areas and minimization of negative effects and thus allows obtaining cheap, clean and essential energy necessary for the society.

PLAN
of development for generating capacities of hydropower industry for the period till 2026

[illegible]

[illegible]

	Financial organization	UAH																
	Own funds from VAT	thousand UAH					2 775 332		625 332	1 250 000	900 000							
4.	Construction of Kaniv HPSP																	
	Key indices		order of the Cabinet of Ministers of Ukraine of 11 December 2013 № 1050	11,98 bln. UAH														
	- Commissioning	MW	Title of construction		1000	1000						250	250	250	250			
	- financing of capital costs (design works)	thousand UAH	Title of construction															
	- financing of capital costs (construction) (separation made acc.estimated cost of the draft in prices as of 1 January 2013 in eq. 1.5 bln USD and average annual rate in 2012 7.99 UAH per1USD)	thousand UAH	Title of construction	Equiv. 1.5 bln.USD, rate 7.99 UAH/1USD			11 915 560	232 908	987 495	1 531 653	2 610 944	2 595 660	1 723 888	1 678 135	554 879			
	Including under the sources:																	
	Loans from international Financial organization	thousand UAH					10 593 253	30 500	512 925	1 221 224	2 503 366	2 497 569	1 679 229	1 633 476	514 964			
	Own funds from VAT	thousand UAH					1 322 307	202 408	474 570	310 429	107 578	98 091	44 659	44 659	39 915			
	- financing of social objects	thousand UAH					302 000				80 100	89 250	58 500	54 150	20 000			
5.	Construction of Kakhovka HPP-2																	
	Key indices		preliminary estimations PJSC «Ukrhydroproject» and Fichtner (Germany)	420 mln.Euro (exclusive VAT)														
	- commissioning of capacity	MW	preliminary estimations		250	250									62,5	187,5		

- financing of capital costs (design works)	thousand UAH	preliminary estimations				127 000	8 974	114 906	3 120								
- financing of capital costs (construction)	thousand UAH	preliminary estimations				13 453 013				918 661	1 493 801	2 037 002	2 960 443	3 082 663	2 960 443		
Including under the sources:																	
Loans from international Financial organization	thousand UAH					12 107 711				348 100	1 419 111	1 935 152	2 812 421	2 928 530	2 664 398		
Own funds from VAT	thousand UAH					1 345 301				570 561	74 690	101 850	148 022	154 133	296 044		
6. Construction of Upper Dniester hydropower cascade																	
Key indices		preliminary estimations PJSC «Ukrhydroproject»	20,185 bln. UAH														
- commissioning of capacity	MW	preliminary estimations		390	390							60	90	60	60	60	60
- financing of capital costs (design works)	thousand UAH	preliminary estimations				160 000	9 720	85 280	65 000								
- financing of capital costs (construction)	thousand UAH	preliminary estimations				20 185 000				804 000	2 215 000	3 554 000	3 504 000	3 254 000	3 254 000	2 450 000	1 150 000
Including under the sources:																	
Loans from international Financial organization	thousand UAH					18 166 500					2 084 130	3 390 860	3 295 120	3 093 390	3 093 390	2 290 980	918 630
Own funds from VAT	thousand UAH					2 018 500				804 000	130 870	163 140	208 880	160 610	160 610	159 020	231 370
PJSC “Ukrhydroenergo”, total																	
- commissioning of capacity	MW					2 422,9	331,5	9,8	16,5	347,1	273,3	331,5	362,0	375,3	250,3	62,8	62,8
- financing of capital costs (design works) total	thousand UAH					307 456	39 150	200 186	68 120								
- financing of capital costs (construction) total	thousand UAH					68 986 239	3 155 103	6 996 202	5 981 643	7 891 558	8 965 787	8 060 241	8 818 538	7 502 267	6 814 902	3 050 000	1 750 000
Including under the sources:	thousand UAH																
Loans from international	thousand					48 666	1 644	1 490	2 421	4 257	7 400	7 005	7 741	6 536	5 757	2 890	1 518 630

	Financial organization	UAH					039	551	969	808	974	198	241	017	884	788	980	
	Own funds from VAT	thousand UAH					20 320 200	1 510 552	5 505 233	3 559 835	3 633 584	1 565 588	1 055 000	1 077 521	965 383	1 057 113	159 020	231 370
7.	Construction of Tashlyk HPSP- start-up complex No. 3-5 (hydro units No. 3-6)		Design draft, approved by the order of the Cabinet of Ministers of Ukraine of 21 November 2007 № 1036 (adjustment under completion)	3,38 bln. UAH (14,9 bln. UAH)														
	Key indices		preliminary estimations PJSC «Ukrhydroproject»															
	- commissioning of capacity	MW	preliminary estimations		604	604					151		151		151			151
	- financing of capital costs (design works)	thousand UAH	preliminary estimations				115 764	13 579	12 500	12 500	8 221	11 000	11 988	11 000	11 988	9 000	9 000	4 988
	- financing of capital costs (construction)	thousand UAH	preliminary estimations				14 758 579	25 843	148 500	2 300 000	2 253 200	1 600 000	1 577 012	1 600 000	1 577 012	1 197 012	1 240 000	1 240 000
	Including under the sources:																	
	Own funds from VAT (outsourced financing under consideration)	thousand UAH					14 758 579	25 843	148 500	2 300 000	2 253 200	1 600 000	1 577 012	1 600 000	1 577 012	1 197 012	1 240 000	1 240 000
	Total																	
	- commissioning of capacity	MW					3 026,9	331,5	9,8	16,5	498,1	273,3	482,5	362,0	526,3	250,3	62,8	213,8
	- financing of capital costs (design works) total	thousand UAH					423 220	52 729	212 686	80 620	8 221	11 000	11 988	11 000	11 988	9 000	9 000	4 988
	- financing of capital costs (construction) total	thousand UAH					83 744 818	3 180 946	7 144 702	8 281 643	10 144 758	10 565 787	9 637 253	10 418 538	9 079 279	8 011 914	4 290 000	2 990 000
	Including under the sources:	thousand UAH																
	Loans from international Financial organization	thousand UAH					48 666 039	1 644 551	1 490 969	2 421 808	4 257 974	7 400 198	7 005 241	7 741 017	6 536 884	5 757 788	2 890 980	1 518 630
	Own funds from VAT	thousand UAH					35 078 779	1 536 395	5 653 733	5 859 835	5 886 784	3 165 588	2 632 012	2 677 521	2 542 395	2 254 125	1 399 020	1 471 370

ACTION PLAN
on execution of the Program of development of hydropower industry
for the period till 2026

Description of project		Description of measures	Terms	Responsible for execution
1.	Construction of Dniester HPSPP- 1 st stage in number of 3 hydro units	Completion of construction and commissioning of completed objects	2016-2018	Ministry of energy and coal PJSC «Ukrhydroenergo»(under agreement)
		Completion of financing for the 1 st stage	2018	Ministry of energy and coal NERC (under agreement) PJSC «Ukrhydroenergo»(under agreement)
2.	Construction of Dniester HPSPP- 2 nd stage in number of hydro unit No.4	Development and approval of design draft	2016	Ministry of energy and coal Ministry of economic development Ministry of regional development Ministry of finances Ministry of justice PJSC «Ukrhydroenergo»(under agreement) PJSC «Ukrhydroproject» (under agreement)
		implementation	2017-2019	Ministry of energy and coal PJSC «Ukrhydroenergo»(under agreement)
		Completion of financing for the 2 nd stage	2017	Ministry of energy and coal NERC (under agreement) PJSC «Ukrhydroenergo»(under agreement)
3.	Construction of Dniester HPSPP- 3 ^d stage in number of hydro units No. 5-7	Preparation of feasibility study	-“-	Ministry of energy and coal PJSC «Ukrhydroenergo»(under agreement) state company «National energy company «Ukrenergo» (under agreement) PJSC «Ukrhydroproject» (under agreement)
4.	Construction of	Initiation of project	2016	Ministry of energy and coal

	Kaniv HPSPP	according to the order of the Cabinet of Ministers of Ukraine dated 27 January 2016 No. 70		Ministry of finances Ministry of economic development PJSC «Ukrhydroenergo»(under agreement)
		Signing of loan agreements with international financial institutions	2016	Ministry of energy and coal Ministry of finances Ministry of justice PJSC «Ukrhydroenergo»(under agreement)
		Provisioning of financing, tender procedures and commencement of primary construction works	-“-	Ministry of energy and coal NERC (under agreement) PJSC «Ukrhydroenergo»(under agreement)
5.	Construction of Upper Dniester hydropower cascade	Development of feasibility studies	2018	PJSC «Ukrhydroenergo»(under agreement) PJSC «Ukrhydroproject» (under agreement)
		Expertise of feasibility studies, development and approval of design documents	-“-	Ministry of energy and coal Ministry of economic development Ministry of regional development Ministry of finances Ministry of justice PJSC «Ukrhydroenergo»(under agreement) PJSC «Ukrhydroproject» (under agreement)
6.	Reconstruction of the second stage of Dnipro cascade	Execution of works acc.to title of project	2026	Ministry of energy and coal Ministry of economic development Ministry of regional development Ministry of finances Ministry of justice PJSC «Ukrhydroenergo»(under agreement) PJSC «Ukrhydroproject» (under agreement)
7.	Construction of Tashlyk HPSPP	Adjustment of draft	2016	State company “National JS energy company “Energoatom” (under

				agreement) PJSC «Ukrhydroproject» (under agreement)
		Expertise of feasibility studies, development and approval of design documents	2016-2017	Ministry of energy and coal Ministry of economic development Ministry of regional development Ministry of finances Ministry of justice державне підприємство State company “National JS energy company “Energoatom” (under agreement) PJSC «Ukrhydroproject» (under agreement)
		Provisioning of financing sources	2017-2026	Ministry of energy and coal NERC (under agreement) State company “National JS energy company “Energoatom” (under agreement)
		Execution of construction and erection works	-“-	State company “National JS energy company “Energoatom” (under agreement)
8.	Research work " Utilization of water resources of Upper Dniester, in particular for the development of its hydropower potential"		2017	PJSC «Ukrhydroenergo» (under agreement)
9.	The development and approval of layouts of complex use of water and hydropower resources of Ukrainian rivers and specifying the amount of unused cost-effective hydropower potential		-“-	Ministry of energy and coal State agency for water resources PJSC «Ukrhydroenergo»(under agreement)
10.	Enhancement of management system of large hydropower objects to increase their efficiency and safety		Permanently	PJSC «Ukrhydroenergo»(under agreement)