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# Prospects for the rational use of the resource potential of the Russian hydropower engineering

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**Abstract.** The following aspects of development have been identified based on the introspective approach: conditions for the sustainable development of hydropower, hydropower and ecology, hydropower and scientific and technical development, development of the social environment and human capital. On this basis, the conditions and principles of sustainable long-term development of the industry are determined. The analysis made it possible to formulate recommendations on targeted long-term proposals for the development of the industry in the areas analyzed.

In 2017 in Russia, the Parliamentary Assembly of the Collective Security Treaty Organization formulates a model law on energy security. Energy security (hereinafter EB) assumes the desire to protect citizens, society, the state, the economy from the threat of a deficit in providing their energy needs with affordable energy resources of acceptable quality, from threats of disruptions in the continuity of energy supply. It is becoming urgent to study the role of hydropower in the provision of these conditions. The study of the basic principles of the provision of energy security makes it possible to highlight the consideration of environmental safety requirements, which implies the development of the fuel and energy complex (FEC) in accordance with increasing environmental requirements, the prevention of irrational use of energy resources (the relationship with the energy efficiency policy), the continuity of the process of ensuring energy security[1].

## Conditions for sustainable development of hydropower

The main threats to energy security include the deterioration of the state of the fuel and energy base. This parameter is positively influenced by the increase in the share of non-carbon generating capacities, which include hydropower. The regions of Siberia and the Far East should now occupy a special place in the development of the hydropower industry of the Russian Federation. This was said by the President of the Russian Federation V.V. Putin in his messages to the Federal Assembly in 2012: "In the 21st century, the development vector of Russia is the development in the East of Siberia and the Far East. This is our colossal potential. " The President's address to the Federal Assembly on December 12, 2013 contains a direct instruction: "Russia, with its huge hydro resources, uses its potential for less than 20%. It is necessary to begin the construction of large hydroelectric power stations, primarily in Siberia and the Far East[2]. "

Among the threats to energy security is the lack of competitiveness of certain types of fuel resources and, as a consequence, the lack of the necessary diversification of the structure of the fuel and energy balance of the regions and the state as a whole.

Sustainable energy development is determined by the balance of production (availability) and



consumption of energy resources. Sustainable development, with regard to hydropower, is predetermined by the fact that reproduction of the mineral and raw materials base is in a stable state, which ensures a sustainable long-term development of the industry. This is the fundamental difference and advantage of hydropower from all other types of power in the factor of subsoil use .

In the context of assessing the future development of the electric power industry, this fact should be paid special attention. The document "Forecast of the scientific and technological development of the fuel and energy sector up to 2035" states: "According to the available forecasts, for the entire period until 2035 the main areas for the growth of continental oil and gas reserves will remain the West Siberian , Leno-Tunguska , Timano-Pecherskaya and Volga -Ural oil and gas bearing provinces[3]. However, in the main areas of oil and gas production, the available reserves and resources of a distributed subsoil fund will be able to ensure the reproduction of the mineral resource base in the medium term by about half. "

Under the new conditions of development, the existing balance of hydropower and subsoil use is a balance that is of strategic importance for the electric power industry and for the country's economy as a whole. Therefore, today the task should be to increase the efficiency of using the available resource potential of hydropower.

Positive conditions for the development of generation in hydropower include the existence of a stable and significant reserve of water and energy potential, reserves for energy saving and energy efficiency of the industry , development of small hydropower, which will provide an opportunity to increase hydrocarbon exports, and through this, indirectly, an increase in the country's budget. Hydropower development and construction of pumped storage stations will significantly expand the market for renewable energy, based on the wind - and the photogeneration, remove their negative impact on the unified energy system of Russia.

The shortcomings include: low innovative potential, significant development of the park resource of generating equipment and, as a consequence, the technical backwardness of the industry development, the risk of making the wrong decision about the prospects of hydropower development.

The role of hydropower in the future of Russia's energy industry can not be underestimated. So, for example, one of the promising areas of energy development that allows solving ecology problems and partial replacement of natural hydrocarbon fuel at the same time in the future is the production of hydrogen on the basis of large hydrogenerating objects.

All of the above dictates the need to develop a long-term comprehensive program for the rational use of Russia's existing resource potential with the active development of carbon-free energy, including through the development of hydropower as its main part. This program should be built on the basis of the unity of energy production with the resource potential of Russia in the future for a period up to 2050. Such a temporary landmark is dictated by the stability of the resource potential of hydropower and the forecast of the development of the energy resource base. After 2050, a profound transformation is possible, both in the economy and in the direction of energy development. By this time, the resource potential of hydropower as a stable and stabilizing branch of energy supply should be realized. This strategy should not only become the general direction of hydropower development as an industry, but it should also be implemented in the interests of developing the energy sector in general and the country's economy in general.

### **Hydropower and ecology**

The domestic experience of hydropower construction testifies to the possibility of solving acute environmental problems that periodically occurred at various stages of the use of hydropower resources. Until now, a one-sided approach to environmental impact assessment, which is provided by the construction of hydrotechnical facilities on the environment, prevails. This view requires rethinking.

The overall ecological effect to date has not been fully appreciated by the scientific community and deserves a separate study.

Environmental problems associated with the development of hydropower in recent decades are constantly attracting the attention of various specialists and are the subject of discussions at numerous

international and domestic sites, which marked the ongoing massive construction of hydroelectric power stations in the world and an increase in the scale of the impact on nature[4]. The need was recognized for using hydropower resources, shifting priorities towards environmental protection, in analyzing environmental problems, in recognizing the urgent adoption of environmental measures, in finding the most accessible ways to implement them.

By the end of the eighties of the last century, a set of normative and methodological documents on environmental protection for the ecological and economic justification of hydropower and water management facilities was prepared in our country[5]. Despite a sharp reduction in the rate of hydropower construction in modern Russia, environmental studies are continuing and the necessary sectoral documents are being prepared in the following key areas:

- analysis and assessment of the impact of hydropower facilities on the environment;
- modeling of impacts;
- forecast of environmental consequences;
- management of the impact of hydropower facilities on the environment and the rationale for environmental protection measures.

This contributes to a qualitative consideration of environmental issues in the design of new and reconstruction of existing hydropower facilities, justification of the implementation of affordable measures to ensure environmental safety of hydropower facilities.

Currently, in connection with global climate change, the issue of reducing greenhouse gas emissions becomes acute. In view of the contradictory nature of the assessments, it has become necessary to conduct large-scale studies at reservoirs in order to determine their impact on the ecological environment. There is a place for the existence of opposing points of view, justifying the contribution of reservoirs in creating or improving the ecological situation in the developed territory.

It should be borne in mind that the hydropower industry of Russia annually saves about 50 million tons of equivalent fuel. It should be noted and the life-saving function of hydroelectric power stations. Thus, the development of each bln. KW • h hydro instead of coal-fired CHP leads to a reduction in mortality at 110-220 people. in year. In general, the operation of the HPP allows avoiding damage to Russia by reducing the environmental impact of industry on a person . The recreational effect of HPP reservoirs is estimated by reducing the incidence rate for 10 days per year per person as a result of a month's recreational recreation near water bodies [6].

Obviously, in order to preserve and develop hydropower, it is necessary to develop a concept aimed at preventing negative phenomena in the natural environment during the life cycle of the facility[7]. It can be based on the idea of Academician M.P. Fedorov providing rational use of natural resources in hydropower through the creation of natural-technical systems, which served as the beginning of the formation of an appropriate scientific direction. The increase of the ecological and economic effect in the development of hydropower, carried out on the basis of innovative and resource potential, is critically important.

The existing impact of hydropower, as well as all areas of energy, on the environment and the livelihoods of the population is assessed negatively by society. It should be noted that with the unique utility of each of the energy sectors for society, the manifestation of negative consequences for each of them has its own specifics, and therefore each of them has its own tasks and ways to improve environmental and economic efficiency.

The overall goal for energy is formulated in the "Report on the Sustainable Development Goals, 2017" by the United Nations, which identifies 17 goals as an independent goal - Goal 7: Low- cost and clean energy.

According to the Environmental Policy of JSC RusHydro , the main challenges associated with the technical and technological features of the Company's production activities are the operation of existing ones, the design and construction of new hydroelectric power stations in the field of environmental protection are as follows:

1. Insufficient orientation of the existing and accessible design (technical and technological) solutions for the environmental aspects of hydrogeneration limits the possibilities of increasing

environmental efficiency and minimizing environmental risks in the design, construction and operation of HPPs. There are technical and economic limitations in the implementation of modern requirements in the direction of ensuring environmental protection at existing HPPs built and commissioned in previous periods.

2. The most promising sections of the possible (expedient) deployment of new hydroelectric power plants are located in the least developed areas that have preserved their natural natural wealth. The construction of new hydroelectric power plants under such conditions inevitably affects the habitat of rare species of animals and plants, including those listed in the Red Books of different levels.

3. Construction of hydropower plants and reservoirs inevitably leads to the formation of a new water ecosystem, which is primarily determined by the use of water resources in the technological cycle of electricity production.

Ways of increasing the ecological and economic effect in the development of hydropower are as follows:

1. Necessity of confirming the status of hydro generation as the most environmentally friendly form of electricity generation.

For this, it is necessary to conduct an objective socio-ecological and economic assessment of the projected and economic activity of all types of energy generation based on the foresight methodology : a single end-to-end system of indicators that comprehensively assesses the performance of all activities. Based on the results of this foresight methodology , a comparative assessment of the consequences - positive and negative characteristics of the analyzed energy generation trends - should be made. This will help to get away from the magic of calculations in one direction or another. Using the opportunities that opens up the work with data , dast the possibility of this is really done. An expert evaluation of the foresight methodology should be carried out throughout the life cycle of energy generation: the invasion of nature-production-waste.

2. It should take a strategic decision on the intensive transfer of hydropower from traditional large- scale facilities to small hydropower. Small hydropower is one of the most promising sources of energy in the future, economically feasible and environmentally justifiable. Feasibility is determined by a wide range of indicators based on the foresight methodology .

3. The best world practices should be disseminated and implemented in the field of hydropower.

4. According to the results of the expert evaluation of the foresight methodology , an order should be made for the development of innovative technologies of domestic production to solve existing problems in hydropower.

Hydropower projects, taking into account the innovative and resource potential, should become a model of ecological security: how resources are used -such is the ecology. The increase in environmental safety is measured in economic terms ( RUR , \$ ) and directly leads to an increase in the economic effect in hydropower.

### **Hydropower and scientific and technological development**

The Russian Federation, having the largest resource base capable of meeting the needs of the country and foreign markets in energy resources, traditional and promising fuels for the coming decades, should actively participate in the process of energy conservation and the formation of a future energy sector that meets the criteria of energy and economic efficiency and environmental safety. It is necessary now to create all the conditions and prerequisites for building such energy, which in the short term could provide competitive advantages for our industry and create the prerequisites for energy expansion into international markets. A key role in this should be played by hydropower.

Hydropower is a branch of industry and energy that unites the possibility of developing the branches of the national economy that are under the jurisdiction of the Ministry of Energy, the Ministry of Transport, the Ministry of Natural Resources and the Ministry of Industry and Trade [8]. All this proves the need for a comprehensive approach and consideration of all the facts that affect the development of the state when developing the hydropower potential of Russia.

Taking into account the necessity to build horizontal inter-branch relations, the scientific and technological and resource capacity of hydropower construction, we can talk about the advisability of creating a digital polygon based on this energy sector. The transition to a new technological level of planning, construction, operation of energy facilities will not only improve the reliability and safety of generating facilities, but also have a positive impact on their investment attractiveness, increase financial transparency for the entire life cycle of the facility. It is possible to realize this by creating a single information space that links both the resource flow and the entire technological cycle of the creation and operation of a hydroelectric power facility based on domestic software and technological developments. The expediency of initiating the construction of a new technological digital system based on hydropower, among other things, is due to the fact that hydropower still retains full technological independence from imported equipment and technologies. While the scientific-design and laboratory-experimental base is preserved, the experience and qualification of the personnel are preserved. We believe that this will contribute to the achievement of the set goals for the development of not only the energy industry, but also the state.

The industry has the potential and understanding of the need to build close cooperation between related industry companies, science and higher education, and certain steps are taken independently in this direction. The task is to preserve the human potential, to involve young people in active scientific and practical work, including, within the framework of the program "From individual abilities of man to an efficient economy"[9].

However, in the hydropower industry today, there are certain negative trends in reducing the activity of construction of new generating facilities, which has already begun to negatively affect the training of personnel for the industry, the degradation of education, the loss of qualified personnel, retirement or redirection of industry organizations. This process must be stopped already in the short term, otherwise this technological key direction of the energy sector will be irretrievably lost for Russia and will become completely dependent on Western companies and, first of all, China[10].

The problem is that when assessing the investment attractiveness of hydropower facilities, only the direct economic effect from the sale of electricity is taken into account, without assessing the complex impact of hydrotechnical facilities on the national economy. With a direct account because of the technical peculiarities, the resource capacity of hydropower facilities they will always lose thermal generation at the initial payback periods. Here, of course, it is necessary to change the methodological basis for calculating the economic efficiency of hydroelectronics and take into account the need for state participation.

The design of new facilities should be carried out on new principles:

- increase the role of science in making decisions to justify constructive and layout decisions, the main task for which should be to ensure the introduction of the most modern technical and technological solutions that are not inferior to, and superior to foreign ones, and for this as long as there are all conditions;
- ensuring the implementation of a new project in the format of a single information space created for all key stakeholders of the process;
- ensuring the possibility of a comprehensive solution of the issue of development of territories and industry;
- reduction of environmental impact and more rational use of non-renewable resources.

According to a total or partial implementation of the HS energy security rises inevitably leads to destabilization of functioning fuel systems - and the power that can slow down economic development, as well as the aggravation of problems of social and environmental protection of the state.

### **Development of the social environment and human capital.**

The development of the hydropower sector can not be achieved without the accelerated development and effective use of human capital in hydropower.

To ensure development and effective use of human capital in hydropower, the following tasks must be solved:

1. Development and wide discussion of the long-term strategy of hydropower development for 50-100 years as a sustainable perspective direction of the present and future development of the country's energy and economy. Formation of the image of the future hydropower.

2. Development and implementation of long-term strategies in the field of human capital management by hydropower structures, ensuring an effective level of investment in human capital from hydropower structures and creating attractive high-performance jobs.

3. Creation of tracking and anticipating branch trends in the system of vocational education and training of specialists and workers, ensuring systematic development and implementation of innovations and development of breakthrough technologies in hydropower.

4. Development and distribution of new forms and programs of state and corporate training, training, retraining and advanced training based on the integration of production, science and education, including the creation of industry competence centers for hydropower.

Effective creation of human capital should be supported by appropriate social measures and social programs, both public and corporate, ensuring:

- Creation of a system of retaining competences (accumulated experience and special knowledge) in the case of a change of generations;

- worthy social benefits, guarantees and compensation to employees of hydropower based on social standards, enshrined in sectoral agreements between employers of the industry and trade unions of workers[11].

The solution of the set tasks will contribute to the increase of labor productivity and the qualification of personnel in the traditional and "breakthrough" technological areas.

As a result, a new generation of future-oriented workers is formed, with sufficient competence to work on high-performance and high-tech jobs in hydropower, capable of developing, mastering and exploiting new technology and technologies that are responsibly related to the future of future generations.

Thus, the development of hydropower in the context of human capital acts as:

- the source of investment demand for new innovative knowledge and technology,
- Environments for the introduction, use and dissemination of new scientific knowledge and technologies

Both these aspects are realized on the basis of developed human capital.

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