The solutions of the problems of energy and transport decarbonization in Russia

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Abstract. The article concerns the problems of fight against Climate Change and Global Warming. Decarbonization of energy industry is necessary condition for reducing greenhouse gas emissions. Development of renewable energy sources, such as sun, wind, water (except for large hydroelectric power plants), geothermal springs, biofuels is limited by specific problems. Paris climate agreement, accepted by Russia in 2016, implies the necessity to reduce emissions by 25-30% of 1990 levels to 2030. This process is impossible without the nuclear energy development. The purpose of the article is to consider the potential of nuclear energy in solving the problems of climate change. The article is based on complex and system theoretical method and contains review and analysis of scientific conferences thesis, devoted to key-problems of nuclear energy industry in Russia and world, materials of reports of UNECE and UNSC, articles published in scientific journals. The most key advantages and disadvantages of nuclear energy generation in terms of modern ecological problems are determined in the article to define the opportunities of nuclear energy integration to the system of "green" economy. The assumptions and forecasts of further development of modern energy industry are reflected in the conclusions of the article.

1. Introduction
The main priority of energy development nowadays is to create a fair, sustainable, environmentally friendly world, which means the reduction of greenhouse gas emissions, the decarbonization of energy and transport.

In 2015 186 countries, including Russia, have adopted the Paris climate agreement. According to the Paris climate agreement, the reducing of carbon footprint should be achieved by decrease of production and using volumes of fossil fuel, the reduction of the total volume of municipal solid waste and plastic packaging, the modernization of agriculture and cattle breeding techniques. Meanwhile, according to International Energy Agency, more than 40% of greenhouse gas's emission are produced by heat and power industry.

The decarbonization of energy and transport is very important condition of carbon footprint reduction. The emission of greenhouse gases can be reduced by development of renewable energy sources, such as sun, wind, water (except for large hydroelectric power plants), geothermal springs, biofuels. But there are substantial problems, hindering the global and ubiquitous use of these types of energy. So, solar battery, using for energy storage, contains lithium and cobalt, while the recycling technologies of this materials is still not perfected. The general disadvantages of renewable energy are high cost of engineering installations and relatively low power generation.
According to the report of The United Nations Economic Commission for Europe (UNECE), in most countries of the world, reducing greenhouse gas emissions is impossible without the development of nuclear energy. [1] The development and implementation of closed loop technologies in nuclear power industry are especially important from this point of view.

The Paris climate agreement can be considered as a step to recognition the nuclear energy as an integral part of the "green" economy. In the most of European countries nuclear projects and investments implemented at home and abroad fully comply with the UN Sustainable Development Goals (SDGs) (Figure 1) and the principles of ESG (E - environment, S – social, G — governance). (Figure 2)

Environmental, social and governance (ESG) criteria are the list of criteria for evaluation of company’s operations that socially conscious investors use to screen potential investments. It includes three main parts: the responsible attitude to the environment, high social responsibility, high quality corporate governance.

The concept of Sustainable Development, appeared in 1970-s in terms of UN conference, also consists of three main factors: ecological, economical and social. In 2015 United Nations General Assembly accepted Sustainable Development Goals (SDGs). These 17 interconnected and global goals, concerning world economy, ecology and social development. [2] Economical goals include the eradication of poverty, hunger, optimization of the labor market situation (reducing of unemployment, ensuring decent wages), implementation of the principles of responsible production and consumption, industrialization and economic growth.

The most important social goals are: reducing social inequality and liquidation all kinds of discrimination (gender, racial, national, etc); the creation of effective and reliable social security system, formation of objective, efficient and fair justice system, providing quality and available education. Among the most significant ecological goals of Sustainable Development must be called the combating climate change, the preserving land and sea ecosystems, the development of environmentally friendly and affordable ways of energy generation.

ESG criteria initially were formulated in correspondence with Sustainable Development Goals. [3] The purpose of these criteria is to develop a unified evaluation system and regulate the work of large corporations. Russian energy sector, just like global energy industry, need the comprehension and modernization in accordance with these standards.

The main purpose of the article is to analyze the potential of comprehensive and mutual development of nuclear energy and electric in solving the problems of climate change. This purpose includes several key objectives:

- To estimate the opportunities and perspectives of nuclear energy in terms of decarbonization of energy industry and the reducing greenhouse gas emissions.
- To determine innovative technologies of nuclear energy, which are the most promising for ecological goals, including the combating climate change.
- To consider the economical and ecological correlation between nuclear energy and electric transport development.

The relevance and scientific significance of the topic are determined by importance of energy and environmental issues and the necessity of it’s solution in correspondence with ESG criteria and Sustainable Development Goals.

2. Materials and methods

The research materials of the article includes thesis of scientific conferences, devoted to key-problems of nuclear energy industry, materials of reports of UNECE and UNSC, articles published in scientific journals.

The interdisciplinary and system research methodology is used in the article. Theoretical analysis of research literature and legal documents, which regulate the development and implementation of
3. Results

The absence of greenhouse gas emissions, the possibility of regeneration and reuse of nuclear fuel, the high energy intensity of nuclear fuel make nuclear energy more acceptable in terms of the principles of the “green” economy and promising as energy industry of the future. The main environmental problem of nuclear energy is the formation and accumulation of radioactive waste, which implies the risk of contamination of the biosphere. Possible resolve of the problem can be the transition to the closed nuclear fuel cycle [4].

Closed loop technologies is innovative technology of modern nuclear industry. Closed nuclear fuel cycle suppose the holding of spent nuclear fuel on the territory of the nuclear power plant during 3–10 years; temporary controlled storage of spent nuclear fuel in autonomous storage facilities at a radiochemical plant (for a period of up to 40 years), follow by processing of spent nuclear fuel with the release of fissile nuclides of uranium and plutonium from it, which are subsequently reused as fuel, solidification (vitrification) of the remaining waste and waste disposal. In comparison with open nuclear fuel cycle it has high efficiency and contributes to the conservation of natural uranium reserves (efficiency of open nuclear fuel cycle is estimated up to 3%). [5] Although nowadays the economic benefit from the introduction of a closed fuel cycle does not significantly exceed the costs of reprocessing, the need to develop safe and efficient nuclear fuel reprocessing technologies in future is obvious. The transfer to fast neutron reactors and thermal reactors is planned in Russia and some other countries, such as France. This transfer allow to spread nuclear fuel reprocessing, because the reactors of these types can run on the mixed-oxide fuel [6].

Another opportunity, related to nuclear energy, concerns the electric vehicles. Nowadays in Russia the project for the development of electric transport is implementing within the framework of the Digital Energy program. It is planned to create its own network of charging infrastructure, as well as create a software platform with the functionality of managing charging stations, interacting with consumers (including payment services), with the energy system (both in terms of optimizing electricity costs and issuing energy back to the network). [7] At the current stage of the development of the project, the main result is the development of technologies for the interaction of electric transport and the power system, and gaining experience in the operation of electric filling stations (figure 1) [8].
At the end of 2021, RENERA LLC, an industry integrator of energy storage systems, and AVTOTOR Holding LLC, the largest car manufacturer in the Kaliningrad region, entered into a cooperation agreement. The document defines the areas of cooperation on a long-term basis for the production in Russia of cars of various classes on electric traction, components for them (including an electric battery) and implies the use of products of LLC RENERA in electric vehicles that are planned to be produced at the production of AVTOTOR. Such a cluster approach to integrating nuclear generation and the transition of transport to electric and hydrogen traction seems to be the most effective systemic solution to the problem of reducing greenhouse gas emissions, decarbonization of energy and transport. [9]

The main purpose of the electric vehicle development in Russia include:

- The creation of unified standards for environmental well-being and quality of life of the population, taking into account the climatic, environmental, cultural, historical and other characteristics of the regions, the creation of unified energy, technological, infrastructural platforms for sustainable development.
- The development in regions of Russia tendencies of cooperation, innovative development and environmental well-being.
- Phased transition to predominantly nuclear generation of electrical energy and electric and hydrogen traction of the traffic flow, which will stimulate the development of surrounding territories [10].

As part of solving these problems, the system and cluster approach of nuclear energy and electric transport development should be implemented. The most important points of this cluster approach are:

- Cluster approach to addressing issues of environmental well-being and quality of life of the population of the Baltic region.
- Prospects for the development of nuclear energy as an integral part of the "green" economy in the Baltic region.
- Production and service of electric vehicles, development of a unified charging infrastructure in the countries of the Baltic region.

The purpose of the cluster is to create common standards for environmental well-being and quality of life of the population, taking into account the climatic, environmental, cultural, historical and other characteristics of the regions, the creation of common energy, technological, infrastructure platforms for sustainable development.

The project is expected to be implemented in two phases. At the first stage, the cluster will unite enterprises and organizations of St. Petersburg, Leningrad, Kaliningrad, Smolensk, Kursk and Tver regions of Russia, as well as Finland, Poland, Lithuania, Latvia, Estonia, Belarus. At the second stage, the cluster will unite enterprises and organizations from other regions of the north-west of Russia and the countries of the Baltic region.

In the future it is planned to phase out the use of hydrocarbon raw materials in energy and transport, and the arrival of electric vehicles on our streets.

The arrival of electric vehicles on our streets not only marks the beginning of a new environmentally friendly era, but also forms a huge new market for electric energy. For example, a reliable power supply of 1 million electric vehicles requires a capacity of at least 2.5 GW.

The production of modern electric vehicles is, first of all, the production of innovative batteries for electric power, electric motors and other high-tech products, in which the enterprises of the Russian nuclear industry are also interested (figure 2).
4. Discussion

Today, Russia needs the accelerated solution of legislative, technological and organizational issues of the arrival of electric vehicles on our streets. There is a new understanding of the prospects for the development of Russian nuclear energy and, in particular, the construction of the Baltic NPP.

Currently, more than 5 million vehicles with internal combustion engines are in operation on the territory of St. Petersburg, Leningrad and Kaliningrad regions. Replacing at least some of them with electric vehicles will require new power supply capacities. It is also necessary to resolve the issue of the production of components for electric transport (energy storage devices, electric motors, etc.), as well as to ensure their maintenance and recycling.

The special issue stays the problem of recycling of lithium-ion batteries of electric transport, which is implemented on the basis of nuclear industry enterprises. So, in November 2021 JSC Rusatom Greenway, an enterprise of the state corporation Rosatom, proclaimed about plans of construction of technical complex Center in Dzerzhinsk, Nizhny Novgorod Region, to process lithium-ion batteries for electric vehicles, mobile devices and uninterruptible power supplies.

5. Conclusion

Nowadays Russia strives for implementation of green economy principles and development of environmentally friendly types of energy. The decarbonization of energy industry and the reducing greenhouse gas emissions is impossible without the development of nuclear energy. Although there are certain problems of implementation and development of closed nuclear fuel cycle technologies in Russia, the technologies of nuclear waste processing and reuse of nuclear fuel will develop and become the basis of the energy of the future.

There are obvious economical and ecological opportunities of nuclear energy and electric transport mutual development. Growth of electric transport sector means the increase in electricity demand, which are produced by nuclear power plants. At the same time, the recycling of lithium-ion batteries for electric vehicles, mobile devices and uninterruptible power supplies proceeds on the base of nuclear industry enterprises. Thereby, the carbon neutrality of energy and transport, the implementation of Green economy principles in Russia and other countries could be achieved by further development of nuclear energy.

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