ROSATOM

THE EU TAXONOMY REQUIREMENTS FOR NUCLEAR ENERGY

VVER TECHNOLOGIES AND NUCLEAR INDUSTRY INNOVATIONS

Brief Analysis

October 2022

Introduction

In 2021, the Intergovernmental Panel on Climate Change (IPCC) stated in its report that greenhouse gas emissions at the current level would lead to disruption of environmental balance and irreversible climate change over the next decade. This fact defines the need to take urgent practical actions to combat climate change without delaying such actions until 2050-2060. At the moment, the primary issue is the lack of practical mechanisms for implementing national declarations on climate goals, which necessitates the "urgent climate actions."

While certain circles keep debating whether nuclear energy indeed qualifies as green energy, it is an undeniable fact that reaching global climate goals is impossible without nuclear. The low-carbon nature of nuclear power is not disputed by international experts, nevertheless, when implementing such projects, it is necessary to pay attention to such aspects as uranium mining, water consumption, safe operation of nuclear power plants and radioactive waste management.

Experts around the world have come to a consensus that nuclear power is one of the low-carbon sources of energy and is a necessary tool needed to meet the challenges of global energy transition and the challenges of combating climate change. This view was explicitly articulated, also at the UN Climate Change Conference in Glasgow (United Kingdom) in 2021.

In order to support and promote actions aimed at combating climate change, both at the national and international levels, green regulation is being developed. Among the international standards that classify nuclear power as green, the financial taxonomy developed under the guidance of the international non-profit organization "Climate bonds initiative (CBI)" is noteworthy.

An important example of recognition of nuclear power as green on a national level is the Chinese Green Bonds Endorsed Projects Catalogue, first published in 2015. In July 2021, its updated version was approved, where nuclear power is included in the list of green projects. In September 2021, a Taxonomy of green projects was adopted in Russia - it qualifies nuclear power as green without any additional criteria. The CBI head, Sean Kidney, praised the Russian Taxonomy noting that its advantage was recognition of nuclear energy as green.

In July 2022, nuclear power was officially included in the EU Sustainable Taxonomy for sustainable activities (EU Taxonomy). After numerous discussions, the Complementary Climate Delegated Act (CDA) to the EU Taxonomy came into force, which defined specific criteria for qualifying nuclear power projects as sustainable activities. CDA is to be implemented from January 1, 2023.

The inclusion of nuclear in the EU Taxonomy is certainly an encouraging signal and a positive influence on the reputation of nuclear power and, among other things, increases interest in nuclear technologies (construction of new NPPs and extension of lifespan of the existing NPPs, as well as construction of SMRs in future).

As part of the implementation of nuclear power projects and innovation developments in the industry, it is absolutely crucial to strictly comply with international and national requirements and standards. Thus, the analysis of the criteria of the CDA to the EU Taxonomy is of practical interest.

Rosatom performed analysis of the CDA requirements for nuclear power using the example of VVER technologies and innovations in nuclear industry in April-July 2022.The report contains cases, practical examples and technological solutions of the Rosatom projects and experience.

Summary and key conclusions

The EU Taxonomy, as other green taxonomies, qualifies activities as green considering its climate and ecological efficiency – that is, broader than strictly climate impact (incl. “do no significant harm” principle), but more narrow than sustainable development in the classical sense of ESG (incl. social and governance aspects).

In the CDA, criteria for the qualification of nuclear power projects as sustainable are defined. It is important that nuclear energy is classified as a transitional activity named a low-carbon stable energy source, contributing to an effective and credible transition towards climate neutral economy, considering the economic lifetime of the projects.

Confirmation of compliance with the criteria of the EU Taxonomy is an essential factor contributing to the effective promotion of products and services in the field of nuclear power in different countries of the world. It is important to note that the CDA contains a large number of detailed criteria for nuclear technologies, some of which are not clearly defined or have no valid confirmation mechanisms. Also, a part of the CDA criteria relates to the area of responsibility of a country at which territory the nuclear power projects are implemented – such criteria relates to nuclear infrastructure as opposed to requirements to nuclear technologies.

The following activities are considered in the EU Taxonomy: construction of nuclear power plants (obtaining a license until 2045), extension of the lifespan of nuclear power plants (obtaining a license until 2040) and innovation technologies (Generation IV reactors). The established criteria can be grouped into several areas: general technological requirements (key requirements for analysis), requirements for specific projects and requirements for the legislation/infrastructure (necessary to consider when evaluating potential projects).

The Rosatom experts analyzed the main criteria of the EU Taxonomy for nuclear power, which were divided into four main groups.

Minimum level of greenhouse gas emissions, including the following key criteria:

- **Life-cycle greenhouse gas (GHG) emissions from the generation of electricity from nuclear energy are below the threshold of 100 g CO2e/kWh**
- **Life-cycle GHG emission savings are calculated using EU Recommendation or, alternatively, using ISO standards**

The requirement for GHG lower than 100 g CO2 eq/kWh is universal for all types of electricity generation in the EU Taxonomy. Nuclear power fulfills this requirement by default because its direct emissions are zero, similar to the GHG emissions generated by renewable energy sources.

According to the UN IPCC Report (2014), the levels of life-cycle GHG emissions on average are: 12 g CO2 eq/kWh for nuclear, 11 g CO2 eq/kWh for wind, 24 g CO2 eq/kWh for hydro and 48 g CO2 eq/kWh for solar, meaning that nuclear power is one of the cleanest types of energy generation. For comparison, similar indicators for gas and coal generation are 490 and 820 g of CO2 eq/kWh, respectively.

The thesis regarding the low-carbon nature of nuclear energy was explicitly voiced by experts during the preparation of the first edition of the EU Taxonomy in 2020, which read as "confirmation of the potential significant contribution of nuclear energy to the achievement of climate change mitigation goals is sufficient and clear."[1]

Safety criteria for the NPP operation stage include resistance to extreme external impacts (natural hazards), minimizing negative effects of NPPs on the environment, and undesirable influence on the climate goals

Nuclear industry has one of the most stringent systems of safety standards in the world, which are established by the IAEA and enshrined in the national legislation of the countries implementing nuclear power projects. The nuclear safety

1. EU Technical Expert Group on Sustainable Finance, Taxonomy Report: Technical Annex, March 2020

regulation system determines, among other things, the procedure for the construction, operation and other stages of the life-cycle of NPP, the management of spent nuclear fuel and radioactive waste.

Modern standards of the safety NPP operation were developed also based on previous experience of the first two generations reactors operation. Operational safety of current nuclear energy is sufficient, provided that outdated reactors would be substituted with reactors of Generation III and newer ones.

Nowadays, Generation I and II reactors are technologically obsolete, they are no longer being built and are being gradually decommissioned.

The first-Generation III reactors appeared in Japan at Kashiwazaki 6 and 7 reactors (ABWR) in 1996 and 1997. In 2016, the first Generation III+ reactor (VVER-1200 at Novovoronezh NPP-2) was put into operation in Russia. The core advantage of Generation III+ reactors is the passive safety systems introduced into the reactor design after the events at the Fukushima Daiichi NPP in 2011. Currently, nuclear industry determinedly works on development of Generation IV reactors. The main objective of such reactors is closing the nuclear fuel cycle.

The improvement of the safety system and the efficiency of the VVER technology has been taking place since the very first commissioning of this type of reactor. Modern Russian-designed reactors are based on a combination of active and passive safety systems, which minimizes the likelihood of an accident and eliminates the risks of damage in the event of a hurricane, floods, earthquakes and other extreme external hazards.

International cooperation is a significant instrument for experience and information sharing, as well as improving nuclear safety in terms of technologies and procedures. The IAEA regulatory documents note the importance of peer review missions and advisory services in the field of nuclear safety. The main expert missions are: The Operational Safety Review Team (OSART) and the Technical Safety Review (TSR) mission. Since 1983, the key countries operating NPPs – France, China, Russia, the USA and the UK – have been receiving OSART missions and the review missions most regularly.

The IAEA Member States submit national reports on the implementation of obligations arising from the Convention on Nuclear Safety (in accordance with the Article 5 of the Convention on Nuclear Safety, 1994) regularly. The reports provide updated information on nuclear safety and are subject to expert peer review, which allows for a higher level of safety.

In addition to the IAEA, there are other frameworks for the exchange of best practices and cooperation in the area of safety assessment, for example, the organization of the major European electricity producers conduct certification according to the European Utility Requirements (EUR), and the multinational program for the evaluation of new NPP projects under the auspices of the OECD Nuclear Energy Agency.

The safety criteria are formulated in sufficient detail in the CDA and for the most part is presented as references to the existing EU directives and the IAEA and Western European Nuclear Regulators' Association (WENRA) standards.

Strict regulatory framework for NPP construction and operation ensure the compliance with abovementioned criteria during implementation of nuclear projects, as it also includes requirements for compliance with international standards and required reporting to supervisory national and international bodies (in particular, the Russian Federation regularly submits national reports on the implementation of its obligations for "peer review" at the IAEA meetings, according to Article 5 of the Convention on Nuclear Safety, 1994).

The criteria for the nuclear fuel cycle include the concept of Accident Tolerant Fuel (ATF), the goals of closing the nuclear fuel cycle and minimization of radioactive waste production within the nuclear fuel cycle (transition to Generation IV reactors).

The criteria related to nuclear fuel cycle are, on the one hand, aimed at projects for the construction of new NPPs and for extending the life of existing NPPs but on the other hand, they can also be applied to specific contracts of fuel supplies.

The CDA criteria in terms of nuclear fuel include the requirement to fully apply ATF from 2025, with its mandatory certification and approval by the national safety regulatory authority. At the same time, as of today, there are no universally accepted definition of ATF or its specific technical parameters.

The term accident tolerant fuel has become firmly entrenched in the nuclear energy agenda after the accident at the Fukushima Daiichi NPP (Japan) in March 2011. As a result of the reactor core heating, the temperature of the cladding of zirconium alloy fuel elements rose significantly. Zirconium cladding rapidly reacted with water steam at high temperature and was accompanied by release of hydrogen gas, what resulted in a steam explosion. Since then, the term accident tolerant fuel has been used to refer to nuclear fuel resistant to accidents. Such fuel must remain operational not only under normal conditions, but also in the conditions of loss-of-coolant accidents.

Three main approaches to the ATF development across the globe are: advanced coating of fuel pellets, advanced coating of fuel cladding and replacement of uranium dioxide fuel with silicide and/or nitride one. Experts agree that full-scale technological or even regulatory readiness for the use of accident tolerant fuel is not achievable by 2025 in any of these areas.

In addition, it remains uncertain how to prove the compliance with the use of ATF from 2025 requirement – obtaining a license for lead test/ partial/ full loading, partial/ full actual loading of ATF or completing the full qualification of the new fuel in accordance with the requirements of each national regulatory authority.

There is no clear procedure for recognizing fuel as accident-tolerant. Similarly, with any changes in the parameters of nuclear fuel, such recognition, evidently, should be carried out through the certification (licensing) procedure in accordance with the requirements of the national legislation.

Additional criteria specified in the CDA, which is directly related to the nuclear fuel cycle, is the transition to a closed-cycle economy, meaning the mandatory (organizational, financial, technological) accounting in terms of the management of spent nuclear fuel, including spent ATF. Hence, the issue of spent nuclear fuel management should be considered when developing ATF technologies, as well as reflected in the national requirements for ATF and its licensing procedure.

Together with this group of CDA criteria, it is necessary to consider generation IV reactors aiming at closure of the nuclear fuel cycle (specifically fast neutron reactors). As the current edition of the CDA characterizes nuclear power as a transitional activity with a project implementation period of new NPP construction and existing NPP life extension until 2045 and 2040 respectively, it is reasonable to assume the possibility of development of other complementary delegated act with green criteria along with the advancing and commercialization of generation IV reactor technologies for the deployment of large-scale construction of such NPPs after 2045.

Rosatom places attention to the development of technologies for the complete closure of the nuclear fuel cycle, including the development of all necessary elements of infrastructure. In this area of work, Rosatom is implementing the “Proryv” project and offers the concept of "Balanced nuclear fuel cycle", which currently combines products and solutions aimed at closing the fuel cycle of light-water reactors.

The goals of Balanced nuclear fuel cycle are achieved by introducing fast neutron reactors in the nuclear fuel cycle, thereby creating a so-called dual-component nuclear energy system, which includes not only traditional reactors on thermal neutrons, but also new generation IV reactors. Balanced nuclear fuel cycle is a combination of four main components: spent nuclear fuel reprocessing with high-level waste fractioning; long-term storage systems for spent nuclear fuel and high-level waste; fuel from reprocessed nuclear materials; of minor actinide transmutation in fast reactors. The transition to dual-component nuclear energy system will increase the efficiency of uranium raw materials use and minimize the generation of radioactive waste.

There are certain difficulties with the CDA criteria interpretation in the field of closing the nuclear fuel cycle, as the definitions of spent nuclear fuel and radioactive waste are also not unified. In some of the EU member states, spent nuclear fuel is considered to be a resource, what implies the possibility of its reprocessing.

In a number of countries, due to the lack of reprocessing technologies, spent nuclear fuel is qualified as radioactive waste and belongs to storage. EU documents allow the classification of spent nuclear fuel both as recyclable products and as radioactive waste, which makes it difficult to apply the CDA requirements. As Rosatom has spent nuclear fuel reprocessing technologies, Russian legal framework, unambiguously qualifies spent nuclear fuel as a resource, which corresponds to the CDA requirement of transition to a closed-cycle economy.

The criteria for the back-end of the nuclear fuel cycle are related to the radioactive waste management and NPPs decommissioning

Consideration of the back-end issues is a necessary condition for the safety of the environment, human life and health, as well as for the "do no significant harm" principle.

Most of the CDA criteria in terms of the back-end relate to the legislation/infrastructure of the country where the NPP is located and require compliance with existing EU directives and the IAEA safety standards. There are no definitions and specific guidelines in CDA. Again, the difference in approaches to spent nuclear fuel and radioactive waste significantly affects the interpretation of the CDA criteria.

Radioactive waste management has two areas – its minimal formation and its safe management. There are no detailed requirements in terms of radioactive waste management in the CDA, such requirements may be further specified in the EU regulations or reflected in the national legislation. Rosatom is developing technologies for the closing of nuclear fuel cycle, which makes it possible to minimize the formation of radioactive waste via reprocessing and further use of valuable nuclear materials from spent nuclear fuel cycle. In Russia, the state recognizes the ownership of the accumulated radioactive waste, and thus its exclusive responsibility, including financial, for the further management of such waste.

Another focus of attention is the reduction of the risk of radioactive waste. Separation of short-lived and long-lived fractions of high-level radioactive waste, process of extraction and after-burning of minor actinides can significantly improve the efficiency of disposal. This will significantly reduce the period of potential danger and allow to avoid the need to construct geological repositories by placing short-lived fraction of radioactive waste near-surface and mid-depth disposal facilities. This approach makes it possible to manage the risks associated with the absence of favorable geological conditions, as well as to reduce the total costs of spent nuclear fuel management.

Decommissioning, as well as the radioactive waste management requires the establishment of an integrated system. First, it is necessary to develop a regulatory framework that sets the basic principles and specific limits, parameters. Secondly, technological infrastructure is required, such as facilities for physical and radiological characterization, site decontamination, dismantling, materials management, and disposal of radioactive waste, as well as specialized equipment. Thirdly, financial support for decommissioning and radioactive waste management should be provided. Fourthly, regulatory bodies should be created or granted appropriate authority, which will be responsible for issuing licenses (other official permits) and monitoring (inspection, sanctions).

As regards handling radioactive waste and decommissioning, the CDA criteria relate mainly to the national infrastructure, that is, the infrastructure of the country where the NPP project is to be implemented, including the requirements for the financial reserves for the efficient decommissioning of nuclear facilities.

One of the most important requirements is the minimization of radioactive waste production within the nuclear fuel cycle using the best available technologies – that is, in fact, the transition to closing the nuclear fuel cycle.

Conclusion

It can be argued that the existing approaches in the field of nuclear energy meet the green criteria and comply with the requirements for the safe and reliable technological solutions. At the same time, certain efforts are required from the nuclear community to scrutinize the green criteria and regularly and explicitly confirm the compliance with them.

Considering the historical regulatory and technological autonomy of the nuclear industry, this task presents a certain challenge due to the need for detailed analysis of relevant requirements, calculations and justifications, detailed reports for regulatory and qualifying bodies.

At the same time, these efforts are very likely to lead to a positive effect for the nuclear industry, both in increasing demand for nuclear technologies and gaining access to traditionally limited financial resources for technical re-equipment of existing and construction of new nuclear power plants using green financing instruments.

> “Nuclear power generation needs to double if we are to reach our energy and climate goals”
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> Fatih Birol,
> International Energy Agency

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