Opinion of the

Group of Experts referred to in Article 31 of the Euratom Treaty

on the Joint Research Centre's Report

Technical assessment of nuclear energy with respect to the 'do no significant harm' criteria of Regulation (EU) 2020/852 ('Taxonomy Regulation')

(Adopted by the Group of Experts referred to in Article 31 of the Euratom Treaty at the meeting on 28 June 2021 by vote, with 28 votes in favour[1], one against, and three abstentions).

The European Commission has requested an Opinion under Article 31 of the Euratom Treaty on "A technical assessment by JRC on nuclear energy under the 'do no significant harm' criterion of the Taxonomy Regulation". The request is presented in Annex 1 of this Opinion.

The European Commission distributed the report "Technical assessment of nuclear energy with respect to the 'do no significant harm' criteria of Regulation (EU) 2020/852 ('Taxonomy Regulation'), hereinafter "The JRC Report", to the Article 31 Group of Experts on 26.3.2021.

The Article 31 Group of Experts reviewed the JRC report in accordance with the European Commission's request. The review was conducted with respect to the Group's overall mandate and competence, namely the protection of workers, members of the public and the environment against the dangers arising from exposure to ionising radiation.

The below text is structured in the following manner. It starts with the summary of the Opinion of the Article 31 Group of Experts (in the form of a list of points). This is followed by explanations of the observations leading to each point of the Opinion, presenting first the observations based on a set of key points (1-5) included in the European Commission's request, and then followed by other observations made by the Article 31 Group of Experts.

The summary of the Opinion of the Article 31 Group of Experts is as follows:

- The European legal framework provides an adequate system of protection of workers, members of the public and of the environment, as well as, for the management of any risks in a manner that the residual risk remains acceptable.

- The provisions of the Euratom legislation regarding the protection of humans against harmful effects of ionising radiation are in line with relevant international recommendations and standards such as those of the International Commission on Radiological Protection (ICRP) and the International Atomic Energy Agency (IAEA). Compliance with the provisions of the Euratom legislation, which also require appropriate regulatory control to ensure the implementation of the requirements, provides sufficient confidence that the impact of the back end of the nuclear fuel cycle to humans remains acceptable.

- The Article 31 Group of Experts agrees with the JRC report conclusion that deep geological repositories (DGR) are considered, at the state of today's knowledge, appropriate and safe

[1] 26 members were present and 2 excused members sent their agreement with the Opinion in writing

means of isolating spent fuel and other high-level waste (HLW) from the biosphere for very long time scales and the necessary technologies are now available.

- As stated in the JRC report, the ICRP continues to believe that the standards of environmental control needed to protect the members of the public are likely to be sufficient to ensure that other species are not put at risk. The Article 31 Group of Experts shares this view and concludes that compliance with the provisions of the Euratom legislation provides sufficient confidence that the potential environmental consequences and inherent risks of long-term nuclear waste management, in particular the potential impact of long-term disposal of nuclear waste on the environment, remain acceptable.

- The current system of radiation protection and the requirements for nuclear and waste safety, as adopted in the relevant Euratom legislation, are outcomes of decades long continuous global international co-operation for establishing appropriate criteria and mechanisms to appropriately manage related uncertainties and risks. The basic principles of radiation protection, the general principles for nuclear and waste safety, as established and specified through more detailed requirements of the relevant Euratom legislation, are managing related uncertainties and risks in a manner consistent with the precautionary principle enshrined in Article 191 of the Treaty on the Functioning of the European Union (TFEU). The Euratom legislation also provide for the establishment of appropriate regulatory frameworks to ensure the implementation of the requirements.

- The conclusions of the JRC report are based on well-established results of scientific research, reviewed in detail by internationally recognised organisations and committees. Current requirements for radiation protection, as adopted in the EU Basic Safety Standards Directive (BSS Directive), and for limiting doses to workers and members of the public during normal operation as well as in emergency situations are considered sufficiently conservative. In addition, during the development of these requirements the precautionary principle has been applied. It is unlikely that some gaps in the scientific knowledge would significantly change the present assessment of the impact of ionising radiation on human health and the environment.

- However, like within any other field of technology, further research is needed, and is already being required by the relevant EU Directives, to increase knowledge, to maintain and develop competence and to improve safety and reduce related risks. Such need for continuous improvement cannot be seen as an indication of some gap in scientific knowledge and data that could affect the determination of the risks addressed by the report.

- The Article 31 Group of Experts agree that the Technical Screening Criteria (TSC) general requirements for compliance with the Euratom legislation regarding radiation protection, nuclear safety and safe management of radioactive waste and spent fuel including more specific derived requirements (e.g. releases of radioactive substances), as well as, other internationally accepted safety criteria such as the safety reference levels established by the Western European Nuclear Regulators Association (WENRA), are the necessary fundamentals in the proper and adequate protection of exposed workers, members of the public and the environment. Therefore, the requirements in the TSC regarding protection of humans and the environment from harmful effects of ionising radiation are automatically satisfied in the EU if a licence can be issued. The licensee must have a sufficient level of knowledge and competence to demonstrate compliance with all regulatory requirements to the regulatory authorities in order to obtain a licence.

- Sufficient competence, legal powers and resources of the national regulatory authority issuing a licence for any activity of nuclear energy is paramount in obtaining proper protection and safety. The regulatory authority must be able to review and assess licence applications and related safety assessments, set up licensing conditions, and to supervise the operations

during all its phases and to enforce regulatory requirements whenever noncompliance is observed. The competence of the regulatory authorities is thus paramount in obtaining proper protection. In that respect, it is the clear view of the Article 31 Group of Experts that the regulatory authorities in EU Member States – when and where needed – have a sufficient level of competence.

- For nuclear fuel cycle activities outside the EU, compliance with the International BSS (IAEA GSR Part 3), which has also been endorsed by the European Atomic Energy Community, provides for the same level of protection of workers, members of the public and the environment as is provided by the EU BSS Directive within the EU. Regarding radiation protection, the TSC should require compliance with the International BSS for activities outside the EU instead of making a general reference to the ICRP Recommendations.

- The JRC report demonstrates that the fatality rate caused by severe accidents is for nuclear energy comparable to, and for the Gen III NPPs lower than, that of any other electricity production technologies and that the maximum consequences of a single event are rather high but still comparable with some other electricity production technologies.

- In order to use the estimates for maximum consequences in a single event presented in the JRC report in any evaluation of risks, it is imperative to look at the associated probability of such an event, which for modern nuclear power plants is extremely low. In addition, the predicted increase in the risk of cancer for low doses has low relative confidence and, therefore, the dose response model that has been used in the calculation of fatalities is likely to overestimate the number of fatalities.

- The Article 31 Group of Experts notes that no off-site mitigation measures are taken into account in the calculation of the maximum consequences of nuclear accidents and emphasizes that emergency preparedness and response are comprehensively incorporated in the Euratom legislation addressing nuclear safety and radiation protection.

- The Article 31 Group of Experts notes that apart from the fatality rate and the maximum consequences, the assessment of other direct and indirect impacts of very severe and rare accidents is not within the scope of the JRC report, as such impacts have not been assessed for any economic activities falling under the EU Taxonomy Regulation. The Article 31 Group of Experts shares the JRC report's view that such impacts might be more difficult to assess but can be important for understanding the broader health implications of an accident.

Observations and Opinion of the Article 31 Group of Experts based on specific key points presented in the European Commission's request:

Whether the legal framework established under the Euratom Treaty provides an adequate system of protection of workers, members of the public and of the environment and whether there are any residual risks.

<u>JRC report findings</u>

The legal and regulatory background is referred to in the JRC report and is comprehensively described in the Annex I of the report. This annex contains a list of principal international agreements, standards, conventions, tools and EU Directives relevant to the issue.

With regard to the legal framework, the JRC report provides the following principal conclusions:

The international community has agreed and implemented several international treaties in order to ensure that the benefits of nuclear energy, like electricity production (with a low-carbon footprint), medical and industrial/agricultural uses, can be realised while the risks that it poses to human health and the environment are controlled and maintained within acceptable levels. Therefore, countries developed an international legal framework for conducting activities related to nuclear energy and ionising radiation in a way that adequately protects individuals, property and the environment.

Licensees of nuclear installations have to demonstrate, prior to obtaining a licence, and ensure during operation, that the effective dose to the most affected members of the public are within strict legal limits. These limits correspond to a level of dose below which no significant harm is caused to the population.

With regard to the protection of the environment, the JRC report states the following:

The International Commission on Radiological Protection (ICRP) recognized in its latest Recommendation (ICRP Publication 103) that as a result of the increased interest in the protection of the environment from human activities, there was a growing need for advice and guidance on matters related to the protection of the environment from the effects of ionising radiation, even though such needs have not arisen from any new or specific concerns about effects of ionising radiation on the environment.

While it can be expected that future recommendations and guidance from the ICRP will contain advice on the protection of plants and animals in the natural environment, it is important to note that the ICRP reiterated its continued belief that the standards of environmental control needed to protect the members of the public are likely to be sufficient to ensure that other species are not put at risk.

Review comments

The Article 31 Group of Experts confirmed the findings of the JRC report related to the legal framework under the Euratom Treaty and agreed that also another European legislation (not only under the Euratom Treaty) is relevant and necessary to take into account – as for example Directives under the Treaty on the Functioning of the European Union (TFEU) related to the protection of the environment and referred to also in the JRC report.

In addition, all referred international standards, conventions, recommendations and guidance are relevant for providing a full and comprehensive picture of the framework within which nuclear safety and radiation protection is ensured in Europe.

The Article 31 Group of Experts confirms that the current European legal framework provides for a system of protection of workers, members of the public and of the environment which is in line with international conventions, safety standards and recommendations for nuclear safety and radiation protection and provides for the mechanisms to address risks and uncertainties through the internationally widely accepted radiation protection principles of justification, optimization of protection and dose limitation. The adequate protection of workers and members of the public is ensured also by establishing relevant dose limits, authorised limits for discharges to the environment, reference levels, dose constraints, etc.

The secondary legislation in the form of Directives and Regulations is legally binding to all EU Member States and mechanisms are established for ensuring its appropriate transposition and practical implementation (such as notification to the European Commission of national legislation transposing the Directives, and legally binding international peer reviews).

The legal system covers all lifecycle phases of nuclear energy including long-term treatment and storage of spent fuel and other radioactive waste, gives provisions for safety measures in the facilities, enforcement and control of those safety measures and also provides for transparent

reporting of matters related to safety of facilities including the results of surveillance programmes. It further requires the establishment of a comprehensive and effective control system.

In relation to the protection of the environment, special attention must be paid to the locations where humans are not normally present, seas and oceans for example. Special EU legislation focusing on these aspects is presented in Annex I of the JRC report.

Opinion of the Article 31 Group of Experts

- **The European legal framework provides an adequate system of protection of workers, members of the public and of the environment, as well as for the management of any risks in a manner that the residual risk remains acceptable.**

The potential impact of the back end of the nuclear fuel cycle on human health

JRC report findings

The JRC report describes and explains the different steps of the back end of the nuclear fuel cycle, which comprises the steps that the nuclear fuel (and activation and fission products) goes through after being taken out of the reactor. The steps are storage at the reactor site, interim storage, possible reprocessing, conditioning of radioactive waste (e.g. encapsulation) for final disposal and final disposal. Generation of radioactive waste, the different categories of waste, management strategies, and the contents of radionuclides in the waste are included in the account.

The legal framework including conventions related to radiation protection and nuclear and waste safety (all to provide for proper protection of humans) is reviewed and found to be adequate.

The impacts from the various steps of the back end of the fuel cycle are examined. The radiological impact to human health (both health of exposed workers and of members of the public) from the above-mentioned steps is found, taking into account available operating experiences, to be low during normal operation and in accordance with the requirements of EU BSS Directive.

It is stated in the report that a final repository for high-level waste is not in operation anywhere in the world, but after several decades of research and technological development the construction and operation of several repositories is expected in the present decade. The process for the design, licensing, construction, operation and final closure of deep geological repositories is regulated by national law, based on international standards and European Directives (for the EU Member States); this means that there is a common ground shared by all programmes based on the best available principles and concepts. The very long process to build a deep geological repository is stepwise and reversible to various extents to ensure that the best available technology is used and that the radiological risks are and will be as low as reasonably achievable. There is broad consensus in the scientific, technological and regulatory fields that final disposal in a deep geological repository is considered, at the state of today's knowledge, the most effective, safest and feasible solution for the long-term management of spent fuel and high level waste ("waste") in order to ensure that no significant harm is caused by the waste to human life and the environment (because contact with the biosphere is avoided). The most advanced European approaches (in Finland, Sweden and France) are reported. The impact to humans from a deep geological disposal is expected to be low for all future generations aiming to achieve the basic ethical requirement that the activities of today shall not cause negative impacts and shall not impose undue burdens on future generations. Long-term experience of a deep geological repository cannot be obtained (time frame up to 100000 years or more), but some knowledge on the behaviour can been derived from "natural reactors".

The JRC report provides the following overall statements regarding reprocessing, storage, and disposal of waste:
"*In the light of the above analysis it can be concluded that industrial activities associated with reprocessing of spent nuclear fuel do not represent significant harm to human health or to the environment."*

"In the light of the above analysis it can be concluded that activities related to the storage & disposal of technological & radioactive waste, as well as spent nuclear fuel do not pose significant harm to human health or to the environment."

Review comments

The report's description of the steps in the back end of the nuclear fuel cycle is very comprehensive and based on up to date data as well as gives good insight into the management of radioactive materials and the processes that are involved.

The radiological impact (expressed as radiation dose) from these steps to workers and the members of the public is well assessed and based on reliable references. The radiological impact can be denoted low under normal operating conditions and is in accordance with the requirements of the BSS Directive.

The emphasis in the report is on the impact from normal operating conditions, however the provisions and measures for keeping the probability of and impact from envisaged incidents and accidents at acceptable low levels are addressed.

The development and construction of a final repository for high-level waste is a long process, which can take several decades from first conception to realisation. The report gives a proper description of the methods that are used in order to safely dispose of the waste for a period in the order of 100000 years, for example through natural and engineered barrier systems between the radioactive waste and the biosphere.

The final repository will undergo several lifetime phases, i.e. construction, operation, closure with control and finally closure without any institutional control. The management of risks associated with such a repository is by nature getting more difficult for large time spans where uncertainties in predictions/assumptions regarding e.g. the development of society, human behaviour and capabilities are leaving room for residual risks.

As no final repository for high-level waste is in operation, no demonstrations have been made yet of the short-term performance. The performance over time spans of thousands of years cannot be demonstrated by observations, however the operator will only get a licence if the competent licensing authority, based on a professional line of arguments, is convinced that the impact to humans will be low and remain to be low for the predicted lifetime of the repository. In relation to that, it can be mentioned that the Radiation and Nuclear Safety Authority of Finland (STUK) has recently accepted the documentation presented for the future final repository in Finland. Regulatory control and supervision of a final repository for high-level waste will be in place from the start of such a repository and extend long into the period after closure.

Opinion of the Article 31 Group of Experts

- **The provisions of the Euratom legislation regarding the protection of humans against harmful effects of ionising radiation are in line with relevant international recommendations and standards such as those of the ICRP and the IAEA. Compliance with the provisions of the Euratom legislation, which also require appropriate regulatory control to ensure the implementation of the requirements, provides**

sufficient confidence that the impact from the back end of the nuclear fuel cycle on humans remains acceptable.

- **The Article 31 Group of Experts agrees with the JRC report conclusion that deep geological repositories (DGR) are considered, at the state of today's knowledge, appropriate and safe means of isolating spent fuel and other high-level waste (HLW) from the biosphere for very long time scales and the necessary technologies are now available.**

The potential environmental consequences and inherent risks of long-term nuclear waste management, in particular the potential impact of long-term disposal of nuclear waste on the environment

JRC report findings

The JRC report came to the following conclusions. The disposal of low-level waste in surface and near-surface disposal facilities is an industrial reality with facilities being operated in several countries, while some of them have entered the institutional control phase. The respective safety demonstration includes evidence that the disposal facility will contain the radionuclides in the waste for as long as they remain hazardous and that the doses or risks to the exposed individuals will remain below the established limits ensuring that no significant harm is caused to humans and the environment.

With regard to this key point presented in the European Commission's request, the report states that the long-term potential impacts of radioactive waste relevant to the DNSH criteria, are of radiological nature and that in terms of radioactivity, the main contributors are spent fuel and high-level waste.

The report acknowledges the main goal of radioactive waste management, which is to ensure that the radioactive waste materials are contained and isolated from the biosphere throughout all stages of waste management so as to protect workers, members of the public and the environment from the harmful effects of ionising radiation. This poses a scientific and technological challenge for spent fuel and high-level waste containing long-lived radionuclides.

The report states that the solution to this challenge is the disposal of spent fuel and HLW in a remote (deep) and stable geological formation (DGR), which is based on a multi-barrier combination including both engineered and natural barriers meant to isolate the radioactive material.

The report states that presently, there is broad scientific and technical consensus that disposal of long-lived HLW in deep geologic formations is considered, at the state of today's knowledge, considered as an appropriate and safe means of isolating it from the biosphere for very long time scales and that it is generally acknowledged, that the necessary technologies for geological disposal are now available. The operational safety of DGRs is provided by engineered systems and operational controls while after closure the repository remains passively safe so that the exposure resulting from potential radioactive releases in the far future remain well below the dose constraints set by the relevant regulations, which in turn are orders of magnitude below the natural background dose levels, and which ensure that no significant harm will be caused to humans or the environment.

The report also states, that even though the dose limits are typically established to protect human health, the ICRP continuously believes that the standards of environmental control needed to protect members of the public are likely to be sufficient to ensure that other species are not put at risk.

The report states, that safety in the post-closure phase is demonstrated by a robust and reliable process which confirms that dose/risk to the public, and thus also the risk to the environment, are

kept below the established limits under all circumstances during the time scales of interest and in the absence of human control. A challenging feature of these studies is the very long timeframe and the complexity of the phenomena that govern the safety functions, as well as the treatment of uncertainties in the scenarios, in the models, and in the data. The safety demonstration provides quantitative indicators that are compared to the requirements of the regulations.

The report also acknowledges, that to ensure that waste does not harm the public and the environment, the implementation of a DGR is a stepwise process reversible to various extents, including technical solutions and strong regulatory framework. This is to ensure that the best available technology is used and that the radiological effects are and will be as low as reasonably achievable. In addition, the process for the design, licensing, construction, operation and final closure of DGRs is regulated by national law, and based on international conventions/European Directives, which constitutes a common ground based on the best available principles and concepts. Thus the radiological impact of nuclear energy lifecycle activities, including radioactive waste management and disposal, is regulated by setting dose constraints for members of the public as well as by defining maximum allowed effluent releases into the environment.

Opinion of the Article 31 Group of Experts

- **As stated in the JRC report, the ICRP continues to believe that the standards of environmental control needed to protect the members of the public are likely to be sufficient to ensure that other species are not put at risk. The Article 31 Group of Experts shares this view and concludes that compliance with the provisions of the Euratom legislation provides sufficient confidence that the potential environmental consequences and inherent risks of long-term nuclear waste management, in particular the potential impact of long-term disposal of nuclear waste on the environment, remain acceptable.**

To comment on the level of uncertainty and the level of scientific consensus with respect to the report's findings, in particular with a view to the precautionary principle enshrined in Article 191 TFEU (and referred to in Art.19.1(f) of the Taxonomy Regulation.

<u>JRC report findings</u>

The findings of the JRC report are based on the conclusion that the current legal and regulatory frameworks provide an appropriate management of uncertainties and risks.

The current system of radiation protection and the requirements for nuclear safety and radioactive waste management, as adopted in the relevant EU Directives, are outcomes of decades-long continuous global international co-operation, establishing appropriate criteria and mechanisms managing related risks and uncertainties.

Extensive research activities are being performed at both national and international levels, financially supported by the European Commission and national funding with the aim to decrease possible uncertainties in all phases of implementation of radioactive waste management programmes, to ensure the highest level of safety in radioactive waste management and to demonstrate the feasibility of a technical solution with respect to radiation protection of humans and the environment.

Opinion of the Article 31 Group of Experts

- **The current system of radiation protection and the requirements for nuclear and waste safety, as adopted in the relevant Euratom legislation, are outcomes of decades-long continuous global international co-operation for establishing appropriate criteria and**

mechanisms to appropriately manage related uncertainties and risks. The basic principles of radiation protection, the general principles for nuclear and waste safety, as established and specified through more detailed requirements of the relevant Euratom legislation, are managing related uncertainties and risks in a manner consistent with the precautionary principle enshrined in Article 191 TFEU. The relevant Euratom legislation also provide for the establishment of appropriate regulatory frameworks to ensure the implementation of the requirements.

Are there existing gaps in scientific knowledge and data that could affect the determination of the risks addressed by the report?

JRC report findings

The report's findings are that after decades of research done the existing knowledge and data provide confidence that the risks can be managed so that they remain sufficiently low also with very long timeframes.

According to the JRC report, the impact of ionising radiation on human health and the environment is assessed in line with well-accepted international recommendation and reports, which are based on regularly reviewed results of scientific research. In particular, these are the summaries of scientific findings published by the United Nations Scientific Committee on the Effects of Atomic Radiation (UNSCEAR) and the recommendations derived based on these findings by the ICRP, which is an independent, well-recognized international organization that advances for the public benefit the science of radiation protection. Globally, international and national regulations in the field of radiation protection are almost exclusively based on the ICRP recommendations. Scientific findings are partly based on results of research projects financed by the Euratom Framework Programmes. IAEA safety publications and the Euratom Basic Safety Standards Directive implement the principles and dose limits recommended by the ICRP. The JRC report underlines that these regulations and recommendations represent today the state-of-the-art of radiation protection measures and protocols.

The JRC report stresses the fact that the current policy for radioactive waste management is entirely based on the results of long-term, extensive research and development (R&D) programmes, performed within national programmes or in research supported by the European Commission. Already in the 1970's, systematic studies on geological disposal as the reference option for the long-term management of high level and/or long-lived radioactive waste have been performed in Europe and are still continued. The report lists more than 30 Euratom Research and Training projects which supported (since the 5th Framework Programme) the introduction of innovative options for the back-end of the nuclear fuel cycle. Currently, R&D activities mostly support process optimisation efforts aimed at improving process efficiency and standardisation, minimising dose to workers and members of the public, and establishing shared grounds for exchanges of experience and best practices, and for training and education in several ongoing Euratom research projects. An essential role is played by international organisations such as the IAEA and the Nuclear Energy Agency of the Organisation for Economic Cooperation and Development (OECD/NEA) to maintain and develop a global dimension of R&D, thus extending cross-referencing and review beyond Europe. The report underlines the fact that research activities on radioactive waste management support all technology areas and waste typologies, which are currently applied or proposed for future use. The scope of research programmes supporting radioactive waste management includes basic knowledge, pre-disposal stages, disposal in geological repositories as well as decommissioning and remediation.

The JRC report points out that there is a need to provide adequate education and training and to maintain R&D activities in order to ensure the availability of the necessary expertise and skills to cover the needs of the national programmes on spent fuel and radioactive waste management.

"Compared to other domains, the case of nuclear energy and radioactive waste management is somewhat special. On the one hand, the timescale affected by radioactive long-lived waste management tasks will encompass many generations, requiring a strong, robust knowledge transmission system; on the other hand, nuclear technologies have been implemented for a relatively short time span since their inception, corresponding to only one or two generations until now. Thus the education and training, and the knowledge management dimensions are considered key complementary components of R&D programmes at national, European and global level. "

Opinion of the Article 31 Group of Experts

- **The conclusions of the JRC report are based on well-established results of scientific research, reviewed in detail by internationally recognised organisations and committees. Current requirements for radiation protection, as adopted in the EU BSS Directive, and for limiting doses to workers and members of the public during normal operation as well as in emergency situations are considered sufficiently conservative. In addition, during the development of these requirements the precautionary principle has been applied. It is unlikely that some gaps in the scientific knowledge would significantly change the present assessment of the impact of ionising radiation on human health and the environment.**

- **However, like within any other field of technology, further research is needed, and is already being required by the relevant EU Directives, to increase knowledge, to maintain and develop competence and to improve safety and reduce related risks. Such need for continuous improvement cannot be seen as an indication of some gap in scientific knowledge and data that could affect the determination of the risks addressed by the report.**

Other observations and opinions

Technical screening criteria

JRC report findings

The JRC report concludes based on impact analyses of the different life cycle activities of nuclear energy that mining and processing of uranium ore, power production (including construction and decommissioning of power plants), reprocessing, and interim storage and final disposal of high-level radioactive waste (HLW) can have significant potential radiological impacts on the environment and on human health. Related analyses demonstrate that such impacts can be mitigated and reduced to 'do no significant harm' levels if specified minimum criteria are fulfilled. These criteria have been, together with criteria to mitigate non-radiological impacts, compiled into proposed preliminary and illustrative technical screening criteria (TSC). This was done in order to demonstrate the usability of the screening process for determining whether a nuclear activity is environmentally sustainable in accordance with the EU Taxonomy Regulation.

Key element in the TSC regarding radiological impacts is compliance with the EU legal framework (if within the EU) or an equivalent framework (if outside of the EU) regarding radiation protection, nuclear safety, safe management of waste and protection of the environment, as well as, other internationally accepted safety criteria such as the safety reference levels established by the Western European Nuclear Regulators Association (WENRA). A key element in the TSC for the disposal of HLW is the requirement for disposal in a deep geological facility in a stable geological

formation in which the waste is isolated from the biosphere by multiple barriers for the necessary timespans.

Opinion of the Article 31 Group of Experts

- **The Article 31 Group of Experts agrees that the TSC general requirements for compliance with the Euratom legislation regarding radiation protection, nuclear safety and safe management of radioactive waste and spent fuel including more specific derived requirements (e.g. releases of radioactive substances), as well as, other internationally accepted safety criteria such as the safety reference levels established by the Western European Nuclear Regulators Association (WENRA), are the necessary fundamentals in the proper and adequate protection of exposed workers, members of the public and the environment. Therefore, the requirements in the TSC regarding protection of humans and the environment from harmful effects of ionising radiation are automatically satisfied in the EU if a licence can be issued. The licensee must have a sufficient level of knowledge and competence to demonstrate compliance with all regulatory requirements to the regulatory authorities in order to obtain a licence.**

- **Sufficient competence, legal powers and resources of the national regulatory authority issuing a licence for any activity of nuclear energy is paramount in obtaining proper protection and safety. The regulatory authority must be able to review and assess licence applications and related safety assessments, set up licensing conditions, and to supervise the operations during all its phases and to enforce regulatory requirements whenever noncompliance is observed. The competence of the regulatory authorities is thus paramount in obtaining proper protection. In that respect, it is the clear view of the Article 31 Group of Experts that the regulatory authorities in EU Member States – when and where needed – have a sufficient level of competence.**

Nuclear fuel cycle activities outside EU

<u>JRC report findings and review comments</u>

For nuclear fuel cycle activities outside the EU, especially those related to mining and milling, the JRC report refers to the need to comply with the recommendations of the ICRP with the aim to ensure similar requirements for radiation protection as within the EU. However, in this respect the report does not refer to the IAEA Safety Standards and especially to the “Radiation Protection and Safety of Radiation Sources: International Basic Safety Standards, General Safety Requirements GSR Part 3" (hereinafter the “International BSS”). The JRC report does not explain the relevant roles and the specific relation between the ICRP recommendations, the EU BSS Directive and the International BSS in the sense that the latter two are providing (within the EU and globally, respectively) the regulatory and practical means for implementing the ICRP Recommendations for radiation protection.

The EU BSS Directive and the International BSS are fully comparable (substance requirements and the level of protection offered) and, therefore, the International BSS has also been endorsed by the Euratom Atomic Energy Community. It should also be noted that the IAEA requires compliance with the International BSS for any country receiving its technical support.

Opinion of the Article 31 Group of Experts

- **For nuclear fuel cycle activities outside the EU, compliance with the International BSS (IAEA GSR Part 3), which has also been endorsed by the European Atomic Energy Community, provides for the same level of protection of workers, members of the public and the environment as is provided by the EU BSS Directive within the EU. Regarding radiation protection, the TSC should require compliance with the International BSS for activities outside the EU instead of making a general reference to the ICRP Recommendations.**

Severe accidents

JRC report findings and review comments

The JRC report addresses consequences of severe accidents using two risk indicators, i.e. a fatality rate and a maximum credible number of fatalities in a single event. The report demonstrates that the fatality rate, i.e. fatalities/GWh caused by severe accidents is for nuclear energy comparable to, and for the Generation (Gen) III NPPs lower than, that of any other electricity production technologies. On the other hand, the maximum consequences are high for nuclear energy based on both Gen II and III NPPs, but comparable with some other electricity production technologies such as hydropower in non-OECD countries. The maximum consequences for non-nuclear electricity production is based on real historical accident data reflecting the officially registered number of casualties (e.g. after a major hydropower-dam accident). For nuclear energy, the maximum credible number of fatalities is based on probabilistic safety assessments (PSA) which allow for calculations of events with extremely low frequency of occurrence (order of 10^{-10}/GW·y). This frequency is much lower than the frequency for the maximum consequences for the fossil and hydro electricity production. Moreover, accidents at Gen II and Gen III nuclear power plants having frequencies corresponding to the maximum consequences for the fossil and hydro electricity production would not result in any fatalities. For a nuclear accident, the calculation of the maximum credible number of fatalities based on some highly conservative assumptions (dense population in the 100 km radius region around the plant and no off-site mitigation measures).

The Article 31 Group of Experts wishes to point out that where arrangements for emergency preparedness are in place as required by the EU BSS Directive, the doses for members of the public caused by severe accidents are likely mainly lower than 100 mGy. For such levels of doses UNSCEAR states: “Conditional predictions can be made to estimate the risk of cancer in exposed populations. Uncertainties are much larger and more debatable and any predicted increase in the risk of cancer should be regarded as having low relative confidence and be no more than notional.” and “there is insufficient evidence to be able unequivocally attribute health effects to ionizing radiation” and addresses further research needs in this respect. (Sources, effects and risks of ionizing radiation, UNSCEAR 2012- Annex A).

The JRC report concludes that operating nuclear power plants are subject to continuous improvement and as a result, of lessons learned from operating experience, the development of scientific knowledge, or as safety standards are updated, reasonably practicable safety improvements are implemented at existing nuclear power plants. This is a requirement of the EU Nuclear Safety Directive, and is also incorporated in WENRA’s safety reference levels for existing reactors. The JRC concludes that the result of this continuous improvement is that the calculated frequency of severe accidents reduces over time and is already reflected in the fatality rate given in the report, and that further reductions may be expected in the future, although they may become more marginal as the most important safety improvements have probably been made already, including those following the EU nuclear stress tests, defined in the light of the Fukushima accident to cover extraordinary triggering events like earthquakes and flooding.

The JRC report acknowledges that very severe nuclear accidents, as well as non-nuclear severe accidents, can lead to other direct and indirect impacts that might be more difficult to assess. The report states that evaluating the effects of such impacts is not in the scope of the present JRC report, although they can be important for understanding the broader health implications of an accident.

Opinion of the Article 31 Group of Experts

- **The JRC report demonstrates that the fatality rate caused by severe accidents is for nuclear energy comparable to, and for the Gen III NPPs lower than, that of any other electricity production technologies and the maximum consequences of a single event are high but still comparable with some other electricity production technologies.**

- **In order to use the estimates for maximum consequences in a single event presented in the JRC report in any evaluation of risks, it is imperative to look at the associated probability of such an event, which for modern nuclear power plants is extremely low. In addition, the predicted increase in the risk of cancer for low doses has low relative confidence and, therefore, the dose response model that has been used in the calculation of fatalities is likely to overestimate the number of fatalities.**

- **The Article 31 Group of Experts notes that no off-site mitigation measures are taken into account in the calculation of the maximum consequences of nuclear accidents and emphasizes that emergency preparedness and response are comprehensively incorporated in the Euratom legislation addressing nuclear safety and radiation protection.**

- **The Article 31 Group of Experts notes that apart from the fatality rate and the maximum consequences, the assessment of other direct and indirect impacts of very severe and rare accidents is not within the scope of the JRC report, as such impacts have not been assessed for any economic activities falling under the EU Taxonomy Regulation. The Article 31 Group of Experts shares the JRC report's view that such impacts might be more difficult to assess but can be important for understanding the broader health implications of an accident.**

28 June 2021

Electronically signed by

Mika Markkanen

Chair of the Group of Experts

Annexes:

Annex 1: Request for an Opinion under Article 31 of the Euratom Treaty on "A technical assessment by JRC on nuclear energy under the 'do no significant harm' criterion of the Taxonomy Regulation"

Annex 2: Opposing opinion (Claudia Engelhardt, Germany)

Annex 1: Request for an Opinion under Article 31 of the Euratom Treaty on "A technical assessment by JRC on nuclear energy under the 'do no significant harm' criterion of the taxonomy regulation"

EUROPEAN COMMISSION
DIRECTORATE-GENERAL FOR ENERGY

Directorate D - Nuclear energy, safety and ITER
D.3 - Radiation protection and nuclear safety

GROUP OF EXPERTS REFERRED TO IN ARTICLE 31 OF THE EURATOM TREATY

Request for an Opinion under Article 31 of the Euratom Treaty on

"A technical assessment by JRC on nuclear energy under the 'do no significant harm' criterion of the taxonomy regulation"

(Approved by the Article 31 Group of Experts during the November 2020 meeting**)**

1. Background and Rationale

Regulation (EU) 2020/8521 ('Taxonomy Regulation') establishes a framework for the development of an EU classification system ("EU Taxonomy") of environmentally sustainable economic activities for investment purposes. While the Regulation provides the general framework for an economic activity to qualify as environmentally sustainable, it empowers the European Commission to set the actual performance criteria (technical screening criteria) to determine under what conditions an economic activity qualifies as environmentally sustainable.

The Regulation determines that in order to qualify as environmentally sustainable, an economic activity must: (1) make a substantial contribution to one of six environmental objectives[2]; (2) do no significant harm (DNSH) to the other five objectives; (3) meet minimum social and governance safeguards; and (4) comply with certain technical screening criteria, specifying the conditions of 'substantial contribution' and DNSH for economic activities that are selected and addressed by the taxonomy.

While there are indirect references in the Regulation to the issue of nuclear energy (including to nuclear waste), co-legislators ultimately left the assessment of nuclear energy to the Commission, as part of its work on the delegated acts establishing the technical screening criteria. A Technical Expert Group on Sustainable Finance (TEG) was tasked with advising the Commission on the technical screening criteria for activities substantially contributing to the climate change mitigation and adaptation objectives. As part of this task, the TEG undertook an analysis of the impact of nuclear energy on the other four environmental objectives that are addressed by the taxonomy.

The TEG acknowledged that the *"evidence on the potential substantial contribution of nuclear energy to climate mitigation objectives was extensive and clear. The potential role of nuclear energy in low*

[2] The six environmental objectives are: (1) Climate change mitigation, (2) climate change adaptation, (3) sustainable use and protection of water and marine resources, (4) transition to the circular economy, (5) pollution prevention and control, (6) protection and restoration of biodiversity and ecosystems

carbon energy supply is well documented" and that *"nuclear energy generation has near to zero greenhouse gas emissions in the energy generation phase and can be a contributor to climate mitigation objectives"*. However, the TEG could not *"conclude that the nuclear energy value chain does not cause significant harm to other environmental objectives on the timescales in question"* and indicated further assessment of the 'do no significant harm' aspects of nuclear energy would be necessary. With the Taxonomy likely to act as guiding framework for significant proportions of the (short-term) funding that will be disbursed under the updated MFF and Next Generation EU, the issue has acquired additional importance and urgency.

The Joint Research Centre (JRC) has been invited to carry out such analysis and to draft a technical assessment report. The aim is to analyse the DNSH aspects of nuclear energy, assessing its environmental risks with respect to the Taxonomy environmental objectives with particular attention to water, circular economy, pollution prevention, and ecosystems/biodiversity objectives. This should support the Commission's decision if nuclear energy can meet the criteria under the Taxonomy Regulation, and if so, what DNSH technical screening criteria could be associated *(full terms of reference of the JRC mandate attached in annex).*

Specifically, the JRC has been asked to:

A) Conduct a review of the state of the art to assess nuclear energy generation under the "do no significant harm" (DNSH) criterion. The assessment should consider the effects of the whole nuclear life cycle on the existing and potential environmental impacts across all objectives. As per the TEG recommendations, special attention should be given to impacts on the objectives relating to circular economy, pollution and biodiversity criteria, but also ensuring the protection of water and marine resources.

B) Conduct a specific assessment on the current status and perspectives of long-term management and disposal of nuclear waste. The final comments of the TEG rely among other things on the consideration that there is no robust evidence regarding the DNSH criteria concerning high-level radioactive waste.

The JRC technical assessment will gather and present evidence that helps to evaluate existing and proposed solutions, with a specific focus on the risks and nature of potential environmental impacts of long-term nuclear waste management, treatment and storage.

The period of execution of the assessment by the JRC is six months (to be completed by end-December 2020). The JRC technical report will be reviewed by two independent group of experts, who will be invited to provide their opinion: the Scientific Committee on Health, Environmental and Emerging Risks (SCHEER), and the Group of Experts referred to in Article 31 of the Euratom Treaty.

2. Terms of reference

Within this process, the Group of Experts referred to in Article 31 of the Euratom Treaty is asked to review the JRC technical assessment report and provide an independent Opinion on the findings and recommendations of the report and on the completeness and robustness of the assessment that underpins them.

The main focus of the review of the JRC report should be with respect to the level of protection of workers, members of the public and the environment against the dangers arising from exposure to

ionising radiation in relation to the nuclear fuel cycle and, in particular, in relation to long term high-level radioactive waste treatment and storage technologies and risks.

In doing so, the Article 31 Group of Experts should consider the following key points:

- Whether the legal framework[3] established under the Euratom Treaty provides an adequate system of protection of workers, members of the public and of the environment and whether there are any residual risks.
- The potential impact of the back end of the nuclear fuel cycle on human health.
- The potential environmental consequences and inherent risks of long-term nuclear waste management, in particular the potential impact of long-term disposal of nuclear waste on the environment.
- To comment on the level of uncertainty and the level of scientific consensus with respect to the report's findings, in particular with a view to the precautionary principle enshrined in Article 191 TFEU (and referred to in Art.19.1(f) of the Taxonomy Regulation).
- Are there existing gaps in scientific knowledge and data that could affect the determination of the risks addressed by the report?

3. Deadline

The Group of Experts referred to in Article 31 of the Euratom Treaty is asked to provide its Opinion 3 months after receiving the final JRC report.

Annex

Terms of Reference for a technical assessment implemented by JRC on nuclear energy under the 'do no significant harm' criterion[4]

[3] Council Directive 2011/70/Euratom; Council Directive 2014/87/Euratom; Council Directive 2013/59/Euratom; Council Directive 2013/51/Euratom;

[4] Available via this link: https://ec.europa.eu/health/sites/default/files/scientific_committees/scheer/docs/scheer_q_020_rd.pdf

Annex 2: Opposing opinion (Claudia Engelhardt, Germany)

The main reasons for the opposing opinion are as follows:

- The mandate of the Article 31 Group of Experts (GoE) reviewing the JRC report is rather narrow. The review of the JRC report was carried out in accordance with the request of the European Commission and the general mandate and competence of the GoE. Further environmental aspects such as the *polluter pays principle*, the *principle of not imposing an undue burden on future generations*, costs as well as proliferation and (nuclear) security were not covered by the review of the GoE. In order to give a serious answer to the question of whether nuclear energy is environmentally sustainable, these other aspects have to be taken into account.
- The Commission asked the GoE "Whether the legal framework established under the Euratom Treaty provides an adequate system of protection of workers, members of the public and of the environment and whether there are any residual risks?" As was stated in the opinion, the European legal framework provides an adequate framework system of the protection of workers, members of the public and of the environment. Nevertheless, there will always be a residual risk that can never be excluded. The aim of the legal framework and its implementation is to manage the risks in a manner that ensures the residual risk is as low as possible. The decision whether the remaining risk is acceptable or not is a sovereign decision of each individual EU Member State. The acceptance of the residual risk does not mean that the corresponding technology can be classified as sustainable.
- Severe accidents play only a minor role in the JRC report. Apart from the number of fatalities, other direct and indirect impacts of severe accidents are not assessed by the JRC. However, actual severe accidents have demonstrated that potential radiological consequences, for example, vast contaminated areas, evacuation and long-term relocation of members of the public, restrictions on food and drinking water supplies, land use restrictions for agriculture and housing, as well as non-radiological consequences, e.g. adverse psychological, societal or economic consequences, have harmful impacts on humans and the environment for decades or even centuries. These consequences affect the host country, but potentially also neighbouring countries. Against this background, nuclear energy clearly does not satisfy the *do no significant harm* (DNSH) criterion and the answer to the question of whether nuclear energy is environmentally sustainable is very clearly no.
- The JRC does not include other direct and indirect impacts of severe accidents in the scope of its assessment as such impacts have not been assessed for any other economic activity covered by the EU Taxonomy Regulation. The use of nuclear energy, however, is not comparable to other economic activities. Risk assessment and defence-in-depth including physical barriers, redundant and various key safety functions as well as emergency response measures are fundamental elements in the use of nuclear energy due to the potential consequences associated with its use. Comparable safety features are not required for any other technology covered by the EU Taxonomy Regulation. It stands to reason, therefore, that the consequences of severe accidents potentially caused by human factors, natural events, but also by terrorist attacks must be fully included in the assessment.
- According to current knowledge, deep geological repositories are considered appropriate and safe for depositing high-level radioactive waste for very long periods. However, the necessary large time spans leave room for uncertainties. Aside from the lack of practical experience, uncertainties exist among other things with regard to future changes in the climate, future societal developments (e.g. human intrusion), social behaviour as well as long-term information and knowledge retention. Furthermore, implementation requires a social consensus that must be maintained over a longer period of time.

- The JRC report considers the DNSH criterion for nuclear power activities to be fulfilled if the regulatory requirements are met. From this, the GoE concluded that the requirements in the Technical Screening Criteria (TSC) on the protection of humans and the environment from the harmful effects of ionising radiation are automatically satisfied in the EU if a licence can be issued. However, against the background of the aforementioned severe accidents and the residual risk, an assessment framework that goes beyond the regulatory requirements seems indispensable in order to adequately answer the question as to whether nuclear energy is environmentally sustainable.