Nuclear energy and the EU Taxonomy

Position Paper
for the Consultation on the Draft Delegated Act

Gabriele Mraz, Austrian Institute of Ecology

Patricia Lorenz, Nuclear Campaigner, Friends of the Earth Europe

December 2020

Table of Contents

1 Introduction

The European Commission is currently establishing an EU-wide classification system, the so-called "taxonomy", which will be used in the future to classify economic activities on the basis of their ecological sustainability. Within this framework, the question of whether an investment in nuclear power can be classified as sustainable is being debated. The final report of the technical expert group (TEG) of March 2020 contains the following nuclear energy assessment in the Annex: **„[…] it was not possible for TEG, nor its members, to conclude that the nuclear energy value chain does not cause significant harm to other environmental objectives on the time scales in question. The TEG has therefore not recommended the inclusion of nuclear energy in the Taxonomy at this stage."**(TEG Report Annex 2020, p. 211) Among other issues the unsolved nuclear waste issue was cited by the TEG as a reason for this assessment.

While the quoted TEG statement makes clear that nuclear energy has not been assessed as a sustainable activity in the sense of the taxonomy, it is the declared aim of some Member States and lobby organizations to have this science-based decision revised. On 20 November 2020, the public consultation for the draft delegated act started, open until 18 December 2020.

Independent experts and the interested public want to engage in the debate. This Position Paper examined the status of key nuclear issues to support informed comments. Under the key criteria to be applied – contribution to the environmental objectives and do no significant harm (DNSH) – the following issues were identified as most problematic: Insufficient nuclear waste management programmes, unsolved technical issues of spent fuel, lack of societal acceptance and creating unmanageable risks for future generations. Also of importance is to take into account the risk of severe accidents of nuclear power plants. Nuclear energy cannot make any contribution to the key demand of establishing a circular economy. Also rather underrepresented in the discussion, but brought back by the 2014 IPCC 1.5 degree report, is the issue of nuclear proliferation.

2 What is the Taxonomy?

This position paper is examining the question, whether the conclusion of the TEG experts, which have not included nuclear power for a number of reasons, was correct and which additional facts and considerations need to be taken into account to show that this decision was correct. Therefore this paper is not explaining the EU taxonomy and would refer the interested reader to the Supplementary TEG Report[1].

How is the taxonomy connected to the Green Deal and other European sustainable finance initiatives? See: https://ec.europa.eu/info/business-economy-euro/banking-and-finance/sustainable-finance_en

[1] Using the Taxonomy: Supplementary Report 2019by the Technical Expert Group on Sustainable Finance: https://ec.europa.eu/info/sites/info/files/business_economy_euro/banking_and_finance/documents/190618-sustainable-finance-teg-report-using-the-taxonomy_en.pdf.

Chronological overview

March 2018	The European Commission presented its Action Plan for Financing Sustainable Growth to redirect capital flows towards sustainable investment. The **EU Taxonomy Regulation proposal** should achieve EU criteria to determine which economic activity is sustainable. This classification ("taxonomy") set out following key criteria: To be included in the proposed EU Taxonomy, an economic activity must **contribute substantially to at least one environmental objective** and **do no significant harm to the other five**, as well as **meet minimum social safeguards**. Technical screening criteria set requirements for determining substantial contribution and doing no significant harm. **The six taxonomy environmental objectives:** I. climate change mitigation; II. climate change adaptation; III. sustainable use and protection of water and marine resources; IV. transition to a circular economy, waste prevention and recycling; V. pollution prevention and control; VI. protection of healthy ecosystems. The Taxonomy will be developed gradually. The Technical Expert Group (TEG) report covers activities that make a substantial contribution to climate change mitigation and adaptation. More activities will be added in the future, including activities that contribute significantly to other environmental objectives.
May 2018	The European Commission published the proposal for a regulation on the establishment of a framework to facilitate sustainable investment (**Taxonomy Regulation**).
July 2018	The European Commission established the **Technical Expert Group (TEG) on sustainable finance** to prepare expert information as a basis for the EU taxonomy. Experts from finance, academia, civil society and industry were appointed[2]. The TEG developed recommendations for technical screening criteria for economic activities that can make a substantial contribution to climate change mitigation or adaptation, while avoiding significant harm to the four other environmental objectives.
June 2019	EC presented a first version of the TEG Report[3]; **in this report the TEG experts already stated that it was not possible for them to conclude that the nuclear energy value chain did not cause significant harm**, followed by
June 18, 2019	**Stakeholder conference** and **public consultation**
September 13, 2019	End of public consultation
September 25, 2019	EU Council agrees to not exclude nuclear energy

[2]TEG group members are listed here: https://ec.europa.eu/info/sites/info/files/business_economy_euro/banking_and_finance/documents/180613-sustainable-finance-press-release_en.pdf.

[3]https://ec.europa.eu/info/sites/info/files/business_economy_euro/banking_and_finance/documents/190618-sustainable-finance-teg-report-taxonomy_en.pdf

December 2019	The EU Council and the European Parliament reached a political agreement on the Taxonomy Regulation.
March 2020	The TEG published its **final report on EU taxonomy.** It contained implementation guidance on how companies and financial institutions can use and disclose on the basis of the taxonomy. The report is supplemented by a technical annex containing also technical screening criteria for 70 climate change mitigation and 68 climate change adaptation activities, including criteria for 'do no significant harm to other environmental objectives'.
April 15, 2020	The EU Council adopted by written procedure its position at first reading with respect to the Taxonomy regulation[4]. However, **Member States could not agree on nuclear energy** being part of the taxonomy or not.
June 18, 2020	The European Parliament approved the regulation text; after the text was published in the Official Journal it will enter into force 20 days later.
June 22, 2020	The **Taxonomy Regulation 2020/852** was published in the Official Journal of the European Union and **entered into force on July 12, 2020[5].** The Taxonomy Regulation tasks the Commission with establishing the actual list of environmentally sustainable activities by defining technical screening criteria for each environmental objective. These criteria will be established through delegated acts.
November 20, 2020	EC presents the **first delegated act** which is covering climate change mitigation and climate change. **Public consultation** lasting four weeks started.[6]

[4]European Council: https://data.consilium.europa.eu/doc/document/ST-5639-2020-INIT/en/pdf
[5]https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=CELEX:32020R0852
[6]https://ec.europa.eu/info/law/better-regulation/have-your-say/initiatives/12302-Climate-change-mitigation-and-adaptation-taxonomy#ISC_WORKFLOW

3 Arguments why nuclear energy does not fulfil the taxonomy goals

3.1 Spent fuel and radioactive waste

The most important fact why nuclear energy cannot fulfil the taxonomy goals is the unsolved problem of nuclear waste management, in particular of the very long-lived high level waste (HLW). As of yet, no final repository for HLW such as spent fuel from nuclear reactors is in operation. The Finnish final repository, the only one under construction, is in limbo due to worrisome results of copper research experiments (see chapter 3.1.1).

Currently, spent fuel and HLW are kept in spent fuel pools in the reactor buildings, in interim storage facilities, and a small part has been reprocessed and the resulting HLW is also stored in interim facilities. Neither the storage in the spent fuel pools nor the long-term interim storage is safe for long-term use.

Also interim storage and final disposal of low and intermediate level waste (LILW) is not solved by any means. A very prominent example is the Asse LILW final repository in Germany that where insufficiently made safety cases resulted in serious problem to such an extent that the disposed waste has to be retrieved, costing several billion euros.

In this chapter we draw attention to the most pressing points of nuclear waste management – points that need to be solved before nuclear waste management can be seen as safe and secure enough to do no significant harm to humans and environment in the short and long-term.

3.1.1 Open technical and geological research issues in the backend management of spent fuel and high radioactive waste

The Myth of the Deep Geological Disposal

Merriam-Webster's definition of 'myth', as **'**a popular belief or tradition that has grown up around something or someone' gives a good idea about the Deep Geological Disposal. While nobody has seen one, attempts to find one went void and research is full of uncertainties and unsolved problems concerning the usable material, geological host rocks and issues of proving safety up front and monitoring it for up to one million years later. A close-knit community believes in Deep Geological Disposal (DGD) to solve one of nuclear power's biggest problems while independent scientists and large parts of Civil Society are not convinced of the safe feasibility of such concepts.

Among the leading myth founders is the IGD-TP, the **Implementing Geological Disposal of radioactive waste Technology Platform.** This platform was initiated to carry out European strategic initiatives to facilitate the stepwise implementation of safe, deep geological disposal of spent fuel, high-level waste and other long-lived radioactive waste. It aimed to address the remaining scientific, technological and social challenges, and supports European waste management programmes. It was launched on 12 November 2009, initiated by the European Commission and waste management organizations. NGOs with a knowledge and standing in the field of nuclear power such as Greenpeace were invited, however, when they refused to sign up to the "IGD-TP Vision", they were not accepted and forced to leave. The 2011 IGD-TP Strategic Research Agenda (SRA) states that *"by 2025, the first geological disposal facilities for spent fuel, high-level waste, and other long-lived radioactive waste* *will be operating safely in Europe"* (Vision 2025). This is clearly an approach that was based on political but not scientific grounds.

EURAD: EU Joint Research into Waste Management

Another sign that not everything is on the road yet, are the big amounts that are spent for research on EU level, e.g. in the **EURAD Project - European Joint Programme on Radioactive Waste Management.** This five-year research project started in 2019 and gives an impression of the open issues in the field of waste management. EURAD is not laboratory research yet: It was designed to identify the most important topics for research. The European Commission sees the EURAD project's goals as a way to find answers to "*the challenges in the field of radioactive waste management*" in Europe. One question EURAD deals with is how to manage uncertainties – based on the insight that nuclear waste management can never be free of uncertainties. In an Introductory Course held in Sept. 2020[7] the key importance of uncertainty management was highlighted, research has to be done to reduce, avoid or mitigate uncertainties. In consequence it is clear that the notion of "safe" will have to be switched to "as safe as possible", which is in the end the result of negotiations between different stakeholders.Moreover, in this Introductory Course it became clear that the Safety Case concept has been not defined in the Nuclear Waste Directive, because all countries use it differently.

In another Introductory Course presentation, the timeline for planned operation of a DGD was presented. The first three projects are already delayed, and the other Member States seem to have taken refuge in postponing their plans as long as possible to avoid early failures.

Research questions that are dealt with in the EURAD project are amongst others: Will the interaction between materials have an impact, for example on integrity of the waste package? What will happen to the organics in the waste package, and to their degradation forms? How can the chemical evolution in large structures and over long times be assessed, and this not only in laboratories? What research results can be upscaled from waste packages to disposal cell scale? Is adsorption a reversible process? In reality, many components at the same time will compete for adsorption; but in studies normally only one component is researched.

This shows that a vast amount of research is still necessary and might take decades. Large-scale experiments are needed, but not even in the framework of the large research project EURAD, the EC or the Member States can provide sufficient funding for those experiments in tests.

[7] https://www.ejp-eurad.eu/events/one-day-course-introductory-course-eurad-and-radioactive-waste-management

High Level Waste repository projects

Industry and several research projects try to make the public and politicians believe that the "solution" or the "final disposal" is only a stone throw away and quotes almost-ready repository projects. Th~~h~~e following very short overview shows the actual status over the almost-there-solutions of the past forty years in countries with large commercial nuclear programmes after decades of preparation. However, not even the US with nearly one-third of the worldwide total of radioactive waste has managed to license the much needed national repository Yucca Project or any other site; an alternative technology – Deep Isolation in Borehole Repositories – is still in early R&D. Another idea the industry has been setting their bets on was silently killed when the authorities in South Australia abandoned the publicly unpopular plans for an international repository for high level waste from the whole world.

Realistic and proven costs are obviously unknown, since no repository exists, however, costs are certainly high and a have a tendency towards increasing. The GPF 2019 report gives tentative numbers ranging from €35 billion for France, for Belgium €10 billion, Japan with €29 billion, US €100 billion and UK €12.6 billion.

Final repository in Sweden and Finland: Copper dreams not coming true

One of the key safety features for the final repositories are the canisters to keep the spent fuel waste from leaking into the surrounding host rock. However, materials sufficiently resistant to radiation, toxic impacts, involved heat production, etc. have not been identified in the past 50 years. The material the industry has put its biggest hope on for use in a granite based deep geological disposal is copper – or rather was.

An overview of the Swedish/Finnish spent fuel repository situation[8]: The research on the KBS(-3) method with copper as canister material started as early as 1975. The scientific hypothesis was that oxygen-free water does not corrode copper in a repository, where there is no oxygen after closure. SKB, the private Swedish company responsible for finding a solution to nuclear spent fuel, kept presenting this concept as the much needed solution. In 2011, SKB submitted a license application for its spent fuel repository system. It went under review by the regulator, the Swedish Radiation Safety Authority (SSM). During the review, problems with the copper canisters were raised.

In 2017, the Swedish Environmental Court refused to accept the regulator's (!) attempt to postpone the copper corrosion issue until after a government permission for the repository. During the court proceedings, leaks to media showed that the regulator SSM's experts had doubts, when their own corrosion expert was against the go ahead for copper, because science meanwhile found out that water can directly corrode copper even when there is no oxygen. This means that copper in a KBS-repository may corrode at much faster rates than acceptable and release radioactivity from the canisters already after only around 1,000 years of storage time.

On January 23, 2018, the Environmental Court made its recommendation to the government and did not support the application, primarily because the uncertainties regarding the long-term safety of the planned repository due to possible copper canister problems. The Swedish NGO MKG said in October 2019[9]: *"The two test packages were secretly taken up by the nuclear waste company in the autumn of 2019. When this was revealed the company did not want to report any copper corrosion results until after the government had approved the licence to start building the repository for spent nuclear fuel in Forsmark. The company then changed its mind and said that copper corrosion results*

[8] http://www.nuklearsymposium.at/images/2020/2020_wns_Swahn_MKG.pdf, http://mkg.se/en/scientifically-inferior-skb-report-on-copper-corrosion-in-lot-project-shows-that-copper-is-not

[9] http://mkg.se/en/scientifically-inferior-skb-report-on-copper-corrosion-in-lot-project-shows-that-copper-is-not

would be reported both for the copper pieces (coupons) that were in the test packages, but also for the central copper tube that has been heated to significantly higher temperatures. The Swedish Radiation Safety Authority SSM then decided to start a project to ensure that the copper corrosion results that the company reports will be quality assured."

Then finally the regulator SSM took this issue up and started a quality assurance programme.[10] It has to be understood that the very basis of the repository project is at stake here: SKB's claim that the corrosion is caused by entrapped air and thus will not proceed over the next years or storage has not been proven to date. SKB also is an example – together with the state's regulator SSM – showing that safety is not their first priority. The scientific community is worried about SSM's attitude. E.g. the KTH Royal Institute of Technology listed several serious problems with the SKB report 20 years copper corrosion test[11] by saying that '*SKB has excluded scientific facts concerning microbial activity in the ground water and used flawed thermodynamics (…) omitted to study the most corroded parts of the central copper tubes and the bottom plates*` and concluded with a short statement *'This LOT-study shows, under all circumstances, that the anoxic **copper corrosion rate in Swedish groundwater is catastrophic with respect to the KBS-3 model'*** , whereby explaining that those catastrophic copper corrosion rates resulted from circumstances with the additional stress under actual repository conditions consisting of *`radiation induced corrosion (radiolysis), stress corrosion cracking and hydrogen embrittlement.'*

The issue of corrosion is now, in December 2020, still under investigation and far from certain and could derail the entire project in Sweden and Finland. SKB refuses to make test reports on copper corrosion available – even to the regulator SSM. SSM will deliver a report on the repository in March 2021 to the Swedish government. With a view to more scientific insecurities, the government is advised by several stakeholders (including academic and from Civil Society) and could refuse a go ahead for this repository project.

What is important to understand: The Onkalo final repository in Finland, which according to some industry organisations would be only months away from being granted an operational license, is supposed to use the very same Swedish copper canister system. The current status of research and licensing in Sweden however makes such fast procedures impossible. Even if Finland would manage a granite/copper system, this has no real value for other countries, because they have to find their own site, start investigations of site-specific geological conditions in their own host rock and design and approve their own adequate container system and ensure local acceptance at the chosen repository site.

"We need to develop a new model for storing nuclear waste"[12]

This was the alarming message from a piece of the most recent corrosion research: Xiaolei Guo, a deputy director at Ohio State University continues by saying: *"Current planned methods for storing high-level nuclear waste are 'severely' unsafe"*. Researchers at Ohio State University discovered that long-term plans to store radioactive waste from nuclear arms production are unsustainable and would result in radioactive materials being released into the environment. The materials proposed to store the hazardous waste corrode far more quickly than previously thought, researchers write in a

---

[10]https://www.stralsakerhetsmyndigheten.se/contentassets/b8881783acf14def9409d9d48789a0e2/201922-technical-note-ssms-external-experts-reviews-of-skbs-report-on-supplementary-information-on-canister-integrity-issues.pdf

[11]http://mkg.se/uploads/Appendix_3_Szakalos_&_Leygraf_The_most_important_comments_to_the_SKB_LOT-report%20_TR-20-14_201123.pdf

study published in scientific journal *Nature Materials* with details of their findings[12].The study is very clear on some important issues which obviously have been neglected until now: *"The complex corrosion behavior of materials over large time scale can be expected. The effects of corrosion products scale formation, radiation and bacteria etc. in the repository may all play a role in the corrosion process. Much work needs to be done to get a clearer scenario of corrosion development over geological time scale."* And continues: *"Corrosion is accelerated by the interface interaction between dissimilar materials could profoundly impact the service life of the nuclear waste packages (…). Once the container is damaged due to corrosion, surface waters and underground waters play a role in the transportation of radionuclides in water bodies, causing harm to humans. So the waste container serving as the first barrier to prevent HLRW from migrating into biosphere is of great importance. Corrosion effect of HLRW container is one of the most important problems needing to be solved in the HLRW disposal. Apart from corrosion effect, many problems influencing HLRW disposal are to be solved. For example, radiation damage of radioactive waste forms can result in changes in volume, leach rate, stored energy, structure/ microstructure and mechanical properties.*" (Nature 2018).

Corrosion is more and more becoming a serious problem also at the French repository site, Cigeo/Bure. The site with clay as a host rock poses an additional problem, because "*Radiation will break down water in the rock and cause corrosion of metal structures, leading to the release of explosive hydrogen gas, says biologist and engineer Bertrand Thuillier, an associate professor at the University of Lille. ANDRA plans to ventilate the tunnels, but that could exacerbate fires by providing oxygen, he says. A failure could be catastrophic, Thuillier warns: The area around Bure helps provide eastern Paris with water and is close to one of the world's most cherished wine regions, Champagne"[13].*

3.1.2 Not in my backyard and nowhere else: society's non-acceptance of offered solutions for nuclear waste disposal

Transparency and participation (T&P) are key to solve the nuclear waste problems. While they might not be technical criteria per se, experience of the last decades shows that in no region in the world the search for a final repository goes smoothly and without public protests. In peripheral regions of the world with poor democratic ethics it might still be possible to keep the population uninformed and to repress divergent opinions. The EC has included in its Nuclear Waste Directive Art. 10 a strict demand for transparency and effective participation of the public.

But:

- Many EU Member States did not conduct a Strategic Environmental Impact Assessment (SEA) of their national waste management programme. A SEA is in most countries the **only legal option to ensure an assessment of environmental impacts of different nuclear waste management options**, and to enable effective public participation, also transboundary.
- In many countries there is no right to veto for the hosting communities.

Cross-border conflicts

[12]Independent.co.uk on 20 01 27. Accessed on December 15 2020.

[13]https://www.thefreelibrary.com/Reports+raise+concerns+about+France%27s+nuclear+waste+tomb.-a0506829286.

Conflicts kept arising in the past decades around potential sites for storage, not only final disposals for spent nuclear fuel, but also low and intermediate level wastes.

Belgian spent fuel disposal plans at Luxembourg's borders

Belgium started in April 2020 a two-month public consultation on its plans for a Deep Geological Repository. Interestingly, Belgian nuclear waste authority ONDRAF stated that all OECD and EU countries already decided for a DGR as if this would be a matter of yes/no for a standard technical project and the only option. However, here too, the sites preliminarily proposed for the Belgium final repository triggered local concern. One of the sites is only five kilometres from the border to Luxembourg. Severe protests from the Luxembourg government followed because the geological layers chosen reach into Luxembourg territory. The Minister of the Environment replied that this could threaten drinking water supplies. She also said that the data used were not objective and that the scoping lacked alternatives. (Gouv Lux 2020) The harsh words from the side of Luxembourg were met by similarly undiplomatic words from the Belgian side, calling Luxembourg "irresponsible". Similar conflicts exist between the Czech Republic's plan and Austria, when most candidate sites are close to the Austrian border, and between the Czech Republic and Germany.

A common feature of all those projects is the highly intransparent preparation, trying to cover up uncertainties and missing knowledge concerning safety and geological conditions. Usually, concerns about the quality of planning procedures proved right, as in the above listed examples; with growing pressure for the industry to solve this problem, there are ample reasons to expect future attempts to find a site for nuclear waste disposal to be met with mistrust and protest.

This is one of the factors that will keep driving up costs of all solutions for several generations to come. Some experts are already assuming that the attractive idea of a final repository where nuclear waste would disappear forever is an illusion. Reality will consist of re-packing the waste over and over again for a long period to come, wasting resources *forever* to keep the most toxic substance on earth from contact with the environment.

The need to increase the safety of surface interim storage in operation adds on the pile of nuclear industry's To-Do but Don't-Know-How-To list, because this period of "interim-storaging" could take much longer than the buildings of thin concrete walls were built for in the first place.

Also, research is largely in the hands of the proponents of nuclear power, resulting in critical points, knowledge gaps and uncertainties being kept out of the public debate. The benefit for the nuclear industry is the possibility to pretend that there will be a sound solution soon, while suppressing critical voices. However, it proves difficult to hide reality: Worldwide no final repository method exists and neither any reliable assessment of when and how there might be one. It is clear that the issue of nuclear waste is, on the basis of its unsolved issues, enormous uncertainties, and multi-generational perspective, in sharp contrast with the Do No Significant Harm principle. Hence, any attempt to consider taking up nuclear power into the taxonomy, should include considerations in this light.

3.1.3 Creating unmanageable risks for future generations – unsolved long-term aspects of final disposal

Spent fuel and other highly radioactive nuclear waste has to remain isolated from the environment for one million years or longer – an unimaginably long period. The human species might not even exist this long. Nuclear authorities and states will have ceased to exist much earlier during this time-span. This burdens authorities and civil society alike to to take responsibility for the long term. Such a responsibility means maximal avoidance of further production of radioactive wastes.

The nuclear waste Directive 2011/70/Euratom Art. 12 (1) (e) defines that EU countries have to include concepts in their waste management programmes how to ensure the safety of their repositories also after end of operation. Only a few countries engage in research on knowledge preservation while most countries neglect the topic altogether.

Currently most scientist and politicians promote a concept of passive safety – sealing the final repository, dismantling the above ground facility (resulting in a so-called green field) and relying on the technological and the geological safety barriers, without any need for human action. But such a passive safety concept is not helping when unintended intrusions like potential drilling activities. An example: In the region of the WIPP[14]/USA New Mexico, a drilling rate of 148 boreholes per square kilometre over a 10,000 year period is predicted; drilling into the repository and after that in a brine pocket can result in a mobilization of radionuclides due to a reaction of the brine with the radioactive waste, radioactive fluid can spread through the borehole into the groundwater and above ground level [15].

To preserve memory over generations, all types of warning mechanisms have to be updated regularly. The US Department of Energy created the so-called Human Interference Task Force (HITF) in 1980 with the aim of developing a method to warn future generations for up to 10,000 years to not intrude in a nuclear waste site. In 1984, HITF published its results in a technical report[16]. The risks of war or terrorism were also included in this HITF assessment, resulting in the recommendation that "[r]epositories should, therefore, be unattractive targets for war, sabotage, or terrorism." With the terrorism experiences of today, this recommendation sounds very outdated.

What was proposed since the 1980ies to warn and inform future generations[17]? Warning signs, warning messages and symbols, building immense markers and dangerous looking monuments, creating an artificial moon, engineering mathematical code on biological matter due to the assumption that only biology but not culture will survive, genetically manipulated cats which shall change their skin colour when getting into contact with radioactivity, dissemination of myths, fairy tales and legends, a nuclear priesthood and artificially created rituals and legends, to be renewed from time to time and passed on between endless new generations of these priests…

A research project by the Nuclear Energy Agency NEA concluded that no single mechanism or technique exists which by itself is likely to achieve Preservation of Records, Knowledge and Memory (RK&M) over all timescales. The project therefore created a toolbox which consists of a set of 9

---

[14] WIPP = Waste Isolation Pilot Plant. The WIPP is located in New Mexico, USA. It is a repository in a salt bed for military transuranic waste like Plutonium. In 2014, an accident occurred at WIPP (the so-called cat-litter accident). The WIPP was planned to be closed in the early 2030ies, which was postponed to 2050 or even beyond.

[15] Tracy, Cameron L.; Dustin, Megan K.; Ewing, Rodney C. (2016): Policy: Reassess New Mexico's nuclear-waste repository. Comment. In: Nature 529, 149-151 (14 Jan 2016).

[16] HITF (1984): https://www.osti.gov/servlets/purl/6799619

[17] Read more: http://www.ecology.at/wua_endlager_wissenserhalt.htm

approaches, comprised of a set of 35 mechanisms. Two of these mechanisms are called novel concepts: 1) the key information file, designed to be a summary file (about 40 pages) for wide dissemination and use; and 2) a set of essential records (SER) , with the selection based on anticipated future needs.

The European mega-research project EURAD mentioned earlier, is focusing its research only up to the closure phase of a Deep Geological Disposal. But after closure the risk of environmental contamination or security breaches will not have vanished. The very difficult question of how to protect future generations in the very long term is not tackled at all in this flagship nuclear waste research project.

The safety of future generations is at stake. Decisions have to be made for how long nuclear waste can be recovered after a final repository has been sealed, which is an important criterion for choosing geology and technology and not only a simple question to be decided sometime in future.

The preservation of knowledge, data and memory are~~is~~ not solved, needing much and continuous effort, also long after nuclear power production will be over – another clearly not sustainable aspect of nuclear energy.

3.1.4 *"More needs to be done":* Insufficient national waste management programmes

Until the first Nuclear Waste Directive (Directive 2011/70/Euratom) came into force, many Member States did not even try to establish a proper nuclear waste management plan. When forced by cthe European Commission with the Directive, every Member State had to produce a national waste management programme that fulfils the conditions of the Nuclear Waste Directive. The first national programmes had to be submitted in 2015, followed by two national reports to describe their implementation progress in 2015 and 2018.

Almost not a single EU Member State has fulfilled this task within the time-frames set by the Directive. Firstly, most Member States did not communicate or notify their transposition of the Nuclear Waste Directive into national law in time. Secondly, most Member States did not notify their national waste management programmes to the EC in time. And thirdly, a set of infringement procedures has been started since 2018 due to the fact that **all Member States but five were unable to transpose all aspects of the Nuclear Waste Directive in a correct manner**.

The EC conducted two reviews of the submitted national waste management programmes. In its second report from end of 2019, the EC stated that progress has been made, but **"[H]owever, more needs to be done" (EC Report 2 2019, p. 17).** The EC presented a long list of necessary remedies to be delivered by the Member States:

- Swift decisions on national policies, concepts and plans should be taken, especially for intermediate level waste and high level waste.
- Member States that consider shared solutions should cluster up and take practical measures, including on site-specific matters.
- Member States have to ensure adequate funding for the costs of the national programmes.
- Classification schemes have to be harmonised.
- Many countries report delays in the implementation of the programmes. Clear key performance indicators are needed for monitoring progress to avoid further delays
- The inventory projections have to be improved.
- The independency of the nuclear waste regulator has to be demonstrated or established in the first place, including sufficient financial and human resources.

- Outcomes of peer reviews and self-assessments should be shared, and a transparent dialogue with stakeholders is necessary
- Research, development and training also remain important in delivering long-term solutions for high-level and intermediate-level waste and spent fuel management.
- Many Member States need to improve the quality of their national reports.
- The EC will follow up the work of the Member States and take legal action if necessary.

Moreover, in most countries, **an assessment of environmental impacts of the nuclear waste management programmes is missing.** This should have been done in a Strategic Environmental Assessment (SEA) for the national programmes, but because most countries have not undertaken a SEA, no environmental impacts have been assessed and taken into account.

This conclusion list of the EC Report from 2019 shows the overall poor status of the Member States national nuclear waste management programmes. But without a clear concept how to deal with nuclear waste, progress cannot be expected soon. When financing, regulatory structures, inventory data and transparency regimes are not available or in a poor status, decades of improvement have to follow before a sufficiently or acceptably safe nuclear waste management programme can result.

3.2 Risk of accidents and emissions of NPPs: the precautionary principle and residual risk

On top the unsolved problems of nuclear waste, there are more factors in which nuclear energy can do significant harm, in particular to the sustainability goal of "pollution prevention and control". Radioactive emissions cause environmental pollution and are posing a risk to human health, even in the low dose range.

The consequences of historical severe nuclear accidents are an ongoing, everyday business of our nuclear generation. The debris and molten core material in Chernobyl and Fukushima are still there. An enormously expensive shelter was recently installed in Chernobyl, but the consequences of the 1986 accident continue being a threat for people and environment. The situation is far from safe. **Forest fires** in spring 2020 unleashed radionuclides that were bound in woods resulting in possible further contamination.

Also the 2011 Fukushima accident is still out of control, not even robots can work in this environment to start clean-up. The pollution of the environment is still an everyday reality. There are plans to release contaminated water from storage tanks into the ocean, because no other solution seems to be viable. This water does not only contain the radioactive isotope Tritium, but also numerous other harmful radioactive isotopes, including long-lived isotopes such as Cesium-137, Strontium-90 and others. More details can be found on the website of the plant operator TEPCO[18]. The Japanese government's plan (!) intends the release of 1.19 million cubic meters, with 65.000 m³ which are **100 to 19.909 times above the legal limit**, 161.700 m³ are **10 to 100 times above the legal limit**, 207.500 m³ are 5 to 10 times above the legal limit and 346.500 m³ are up to 5 times above the legal limit.

As the Comprehensive Test Ban Treaty Organization (CTBTO) clearly states, Tritium (^{3}H) with a half-life of 12 years is "easily ingested. Can be inhaled as a gas in the air or absorbed through the skin.

[18] www.tepco.co.jp/en/decommission/progress/watertreatment/index-e.html

Enters soft tissues and organs. Exposure increases risk of developing cancer. Beta radiation emitted by tritium can cause lung cancer."[19]

A short reminder: During their entire operational time, all nuclear power plants and all other nuclear facilities **constantly emit radioactive and toxic materials and substances** into the hydrosphere and atmosphere and these keep accumulating in the environment in dependence on their half-lives.

Radioactive pollution **increases the risk for cancer and other health effects**: The effects of high radiation doses on humans (like acute radiation sickness) are documented quite well. But the effects of low doses are still disputed among experts and nuclear lobby groups. Low doses result from nuclear installations during normal operation, from accident situations in nuclear facilities for workers and the public, from the nuclear bombs on Hiroshima and Nagasaki and thousands of nuclear weapon tests in the atmosphere, under sea or underground, but also from medical exposure and natural background. In a report from 2018, new studies on the risk of low dose radiation were compiled[20]. The conclusion remains that there is no safe level of radiation exposure and that the Linear No Threshold model remains the best estimate for radiation health effects.

Radioactive pollution after the accident of Chernobyl lead to **permanent loss of agricultural and forestry areas**: In Belarus, after Chernobyl 18,000 km^2 of agricultural area were contaminated, more than 2,600 km^2 had to be abandoned, also 1,900 km^2 of forest[21]. A quarter of the Belarus wood was too contaminated fur further use, also parts of the country's minerals and sand[22]. In Ukraine, 31,000 km^2 of agricultural land, 15,000 km^2 pastures und 35,000 $km^2$of forest (these are 40% of the total Ukrainian forest) were contaminated; 1,800 km^2 agricultural land had to be abandoned (Cs-137 > 1,480 kBq/m^2).[23]

The following figure shows the risk for Europe to be contaminated with more than 1,480 kBq Cs-137/m^2, a contamination that would result in abandonment of those areas for habitation, agricultural or forestry use like the respectively high contaminated areas in Belarus and Ukraine after Chernobyl. The figure shows that nearly all countries have a risk to be contaminated this highly when a severe accident occurs in Europe. The risk might not be high (e. g. for Austria the maximum risk is 5.7E-06 (0.00057%), but nevertheless exists and has to be taken seriously. The only way to reduce it is a fast phase-out of nuclear energy production, no lifetime extension and no new build.

---

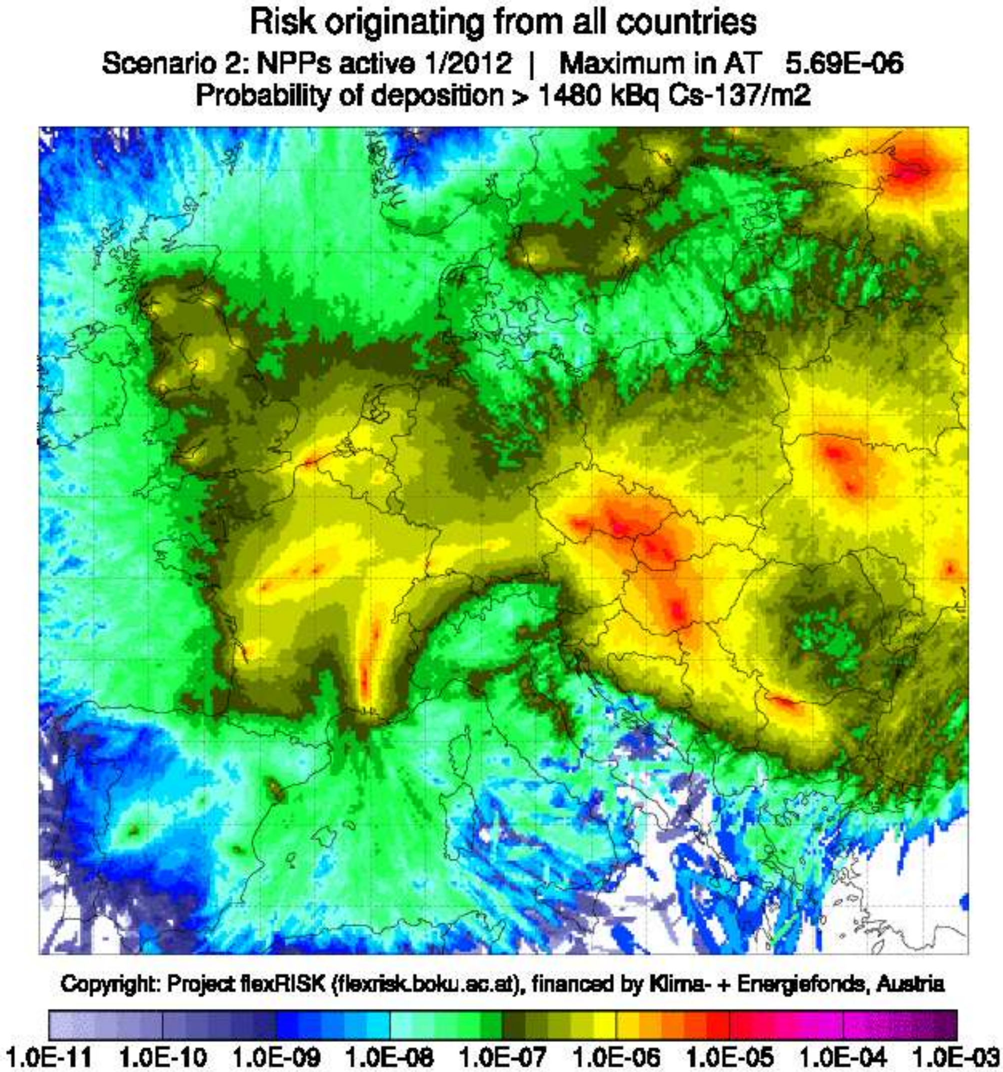
[19] (www.ctbto.org/nuclear-testing/the-effects-of-nuclear-testing/general-overview-oftheeffects-of-nuclear-testing/page-3-general-overview/?textonly=1)

[20] http://www.joint-project.org/upload/file/Health_effects_and_radiation_protection_study.pdf

[21] IAEA (1996a): One Decade after Chernobyl: environmental impact and prospects for the future - working material.

[22] Ministry for Emergencies and Population Protection from the Chernobyl NPP Catastrophe Consequences, Academy of Sciences of Belarus (1996): The Chernobyl Catastrophe. Consequences in the Republic of Belarus - National Report.

[23] IAEA (1996b): Social, Economic, Institutional and Political Impacts. Report for Ukraine



Radioactive pollution after a severe accident can result in **significant agricultural impacts**, even for beyond-design basis-accidents in newly planned NPP which are claimed to result “only” in a low contamination.

Example: Recent Environmental Impact Assessment Reports of NPP Operators in Bohunice III or Dukovany II[24] show that a beyond-design-basis accident in their planned new NPP could easily result in a contamination that will lead to significant impacts on agriculture up to 100 kilometres. In detail: Austria and Germany use a Catalogue of Countermeasures[25] for radiological protection measures. According to this catalogue, ad-hoc harvesting of agricultural products has to start even if a low contamination of 650 Bq Cs-137 per $m^2$is expected. This is by far lower than the average contamination in Austria resulting from Chernobyl fallout (21,000 Bq Cs-137/m^2), but nonetheless it can lead to exceeding acceptable EU food levels (Council Regulation Euratom 2016/52). Such contaminated food would no longer be marketable. But also food that may be contaminated below the food levels might not be marketable any longer, especially in countries without NPPs, causing massive image problems for their agricultural sectors. We see this also in the COVID crisis: If people fear that some activities might not be safe, they will not do them, even if they are not forbidden.

[24]https://www.umweltbundesamt.at/fileadmin/site/publikationen/rep0661.pdf

[25] Austrian Catalogue of Countermeasures: https://www.bmlrt.gv.at/umwelt/strahlen-atom/notfallplanung/behoerdliche-vorkehrungen/notfallvorsorge.html

The **risk of another severe nuclear accident like Chernobyl or Fukushima** with at least 20 million USD in damages has been recently recalculated. Swiss, Danish and UK researchers made an analysis of 216 nuclear energy accidents and incidents. (Wheatley et al. 2016) The authors assess a 50% chance that such a severe accident occurs every 60-150 years, that is once or even twice in a century. Smaller accidents like Three Mile Island/USA could even happen every 10-20 years according to this statistical assessment.

Nuclear energy is inextricably intertwined with the risk of creating significant harm for humans and the environment: the risk of chronic illness due to a severe accident, of loosing agricultural areas due to severe contamination, disastrous social and economic impacts for people having to live in contaminated territories. These risks are by no way negligible, especially in the light of the study from Wheatley et al (2016) assessing a 50% chance that a severe accident occurs every 60-150 years.

3.3 Nuclear energy as a part of the circular economy

Transition to a circular economy is one of the environmental objectives of the Taxonomy Regulation (Art.13). Organisations such as the IAEA or NEA/OECD readily point out the so-called nuclear cycle, from uranium mining, uranium milling, fuel processing all the way to burning the fuel elements in a NPP, taking it out of the reactor, followed by reprocessing – or in New Speak 'recycling' for re-use as MOX-fuel. In this narrative, important information is missing:

- Nuclear energy produces huge amounts of nuclear waste of which at least 99% cannot be recycled or re-used.
- Reprocessing does not eliminate high level waste to zero, rather the contrary because the extensive use of toxic chemicals during reprocessing results in even more waste types. Moreover, only a part of the reprocessed transuranic elements can actually be used for the production of fresh fuel. One of the two reprocessing plants in Europe, Sellafield, had to be closed down – amongst other reasons – due to declining orders; NPP operators prefer to dispose of their spent fuel directly in a final repository (to be built yet).
- Uranium tailings, resulting from uranium mining, need to be stored safely to avoid contamination of the environment and ground water.. Recycling or re-use are impossible.
- Industry's promise of future technologies which produce less nuclear waste with shorter disposal time due to lower half-lives and fuel recycling to be developed as Generation IV reactors is misleading – the remaining wastes still have heat output and will require a very long-term final repository, too. Also significant Low and Intermediate Radioactive Waste amounts are expected. Furthermore, the development of those 'magic' reactors is delayed and might come too late to ever be deployed in the energy systems before 2050.

A circular economy is characterized as an efficient use of resources followed by recycling or re-use; waste is minimized. None of this is true for the nuclear energy sector: from the very beginning, uranium mining, enormous amounts of all types of nuclear wastes are produced and have to be stored ad disposed of for up to a million years, despite efforts of reprocessing spent fuel, which is being abandoned for lack of efficiency and cost. A solution for radioactive waste has not been found during the 70 years of existence of nuclear power; chapter 3 describes that no progress is likely for several more years or even decades.

3.4 CO_2 along the whole nuclear life cycle

Nuclear energy is certainly not CO_2-free. Its CO_2 emissions are slightly higher than those of renewable energies like solar and wind – but only as long as the uranium ore grade is high. When uranium has to be produced from ore with a low grade, which will be the case within this century, CO_2 emissions are going to rise significantly. The range seems to be differing widely, however one of the few companies who ever mentioned this was EDF by stating that their fleet produces around 57 CO_2eq/kWh currently.

A study that is very often quoted when looking at CO_2 emissions from nuclear power is Sovacool (2008). Sovacool compared 103 lifecycle studies of greenhouse gas-equivalent emissions for NPPs. The range he found was 1.4 to 288 g CO_2eq/kWh, with an average of 66g. He explains that nuclear power is not directly emitting CO_2 but emits it via its life cycle, including the construction of the plant, uranium mining and milling and decommissioning. Sovacool's results have been confirmed by other studies (Beerten et al. 2009, Warner and Heath 2012).

In the Draft Delegated Act's Annexes, for several energy technologies a level of 100 g CO_2e/kWh is given. If the same level would be used for assessing nuclear energy, most recent data on CO_2 from uranium have to be included to avoid underestimation of nuclear energy's emissions.

3.5 Nuclear Proliferation

Nuclear proliferation, the spreading of nuclear weapons, fissionable material, and weapons-applicable nuclear technology and information is often ignored, because the debate usually centres on energy production. However, proliferation was brought back into the discussion by the authors of a task similar to the taxonomy effort, the 2018 IPCC report: *Nuclear energy, the share of which increases in most of the 1.5ºC-compatible pathways (see Chapter 2, Section 2.4.2.1), can increase the risks of proliferation (SDG 16), have negative environmental effects.*

The authors of the 2012 study Global Energy Assessment – Toward a Sustainable Future summarized the situation in this way: *"An important societal debate is still ongoing. Do the potential environmental benefits from low-carbon nuclear power outweigh the risks inherent in the technology? These risks occur in reactor operation and possibly in disposal facilities, but, in the view of the authors of this chapter, the most important risk from nuclear power is that its technology or materials may be used to make nuclear weapons. [...]That nuclear weapons may spread with nuclear power technology is therefore a danger that must be taken seriously."*

The argument that EU Member States where the taxonomy will be implemented are highly unlikely a typical proliferator or trying to acquire nuclear weapons is not valid, since

- The EU hopes to `export' the taxonomy to countries which are doing trade with EU member states
- It would be difficult to stop NPP sales to countries outside the EU by insisting that they are suspected of acquiring civil nuclear technology with the hidden agenda of preparing a nuclear weapon programme
- When looking at the IAEA list of countries considering to start nuclear programmes, the so-called 'new-comers' are largely not the safest and politically most stable countries (IAEA 2017): "*Since the last report in 2014, Belarus and the United Arab Emirates (UAE) have progressed in building their first NPPs and four countries have decided to postpone or scrap their plans for nuclear power. Several countries in Africa have moved forward with their plans after hosting Integrated Nuclear Infrastructure Review (INIR) missions conducted by the Agency. Some, such as Bangladesh and Turkey, have ordered their first NPP and have initiated the site and construction licence processes. Others, such as Egypt and Jordan, are in the contractual negotiation phase, or are about to take a knowledgeable decision or*

prepare for contracting, such as Ghana, Kenya, Nigeria, Poland, Saudi Arabia and the Sudan, although national decisions reflecting broad political support are still pending in some cases."

At this point, the international non-proliferation regime steps into the focus. The key piece is the **NPT, the Non-proliferation Treaty** from 1968. The IAEA then gained the authority of watching its member states to ensure they will not acquire nuclear weapons; except those who already own them (officially).

Some, of course, doubt this concept as such, because the NPT is not a solution to proliferation, only an effect of it. Sagan refers to countries like South Africa and Israel who simply didn't join the NPT as long they have or had nuclear weapon programmes or countries such as Iraq or North Korea who joined the NPT but continued their nuclear weapon programs secretly.

However, the question for the taxonomy discussion is whether also civil nuclear programs already pose a proliferation risk, mainly when keeping in mind that only ten states have the necessary uranium enrichment facilities (as of 2010). More recently, leading experts in the field of non-proliferation highlighted "*that the spread of all types of peaceful nuclear technology, not just "sensitive" nuclear technology, increases the likelihood of proliferation" (Sagan 2011)*

Scott D. Sagan gives an interesting insight into this discussion, as the following quote from his paper The Causes of Nuclear Proliferation (2011) shows: "'*The conventional wisdom is wrong—and dangerous. All types of civilian nuclear assistance raise the risks of proliferation. Peaceful nuclear cooperation and proliferation are causally connected because of the dual-use nature of nuclear technology and know-how. Fuhrmann acknowledges that the vast majority of states that have received civil nuclear assistance agreements have not acquired weapons (in 99.77% of country-year observations, states receiving civilian nuclear assistance did not acquire the bomb), but he also insists that there is a strong statistical and causal link between the number of nuclear cooperation agreements (NCAs) and the likelihood that a country will initiate a nuclear weapons program and eventually acquire the bomb. Fuhrmann asserts that "nuclear cooperation strongly influences whether a country goes down the nuclear [weapons] path. Participation in at least one nuclear cooperation agreement increases the likelihood of beginning a bomb program by about 500%*".

Fuhrmann is also quoted with his central insight "that a state may acquire dual-use technology with only peaceful intent, but then succumb to the temptation to initiate weapons research when international threats emerge."

Non-proliferation is a risk which the NPT has not been able and will not be able to constrain. The NPT regime as such is under increasing pressure. The 10th NPT Review Conference was scheduled for April 27 to May 22 2020, however, postponed due to the corona pandemic. As the much respected Pugwash experts put it in their May 2020 statement: "The risks for the Conference and, ultimately, for the Treaty itself, have been multiplying. There is a large list of serious worries and problems: the renewal of the nuclear arms race; the crisis in the architecture of nuclear arms control treaties; the crisis in the relations among nuclear weapon powers; new setbacks with regard to the Iranian nuclear deal and the proliferation crisis in North-East Asia; and growing antagonisms between nuclear-weapon-possessor and non-possessor states."[26]

The following reflection in The Bulletin[27] on the Turkish President's speech when he said that "Nuclear [military] power should be forbidden for all or should be permissible for all." serves as conclusions of this chapter: "Over the years, the Nuclear Non-Proliferation Treaty (NPT) has taken

[26] https://thebulletin.org/2020/05/the-postponement-of-the-npt-review-conference-antagonisms-conflicts-and-nuclear-risks-after-the-pandemic/
[27] https://thebulletin.org/2019/11/taking-erdogans-critique-of-the-nuclear-non-proliferation-treaty-seriously/

heavy fire both from enemies and friends, but recently there has been nothing so sharp as the criticism that Turkish President Recep Erdogan delivered September 24 in a UN General Assembly speech. It deserves much more attention than it got because it reflects a continued loss of respect, on the part of key NPT-member states, for the treaty's no-nuclear-weapons pledge (…) Of course, Turkey is only just constructing its first nuclear power reactors—but we should not underestimate Turkey's industrial abilities once engaged. And we should not take Erdogan's criticism of the NPT arrangement as idle talk."

The atom bomb as such, nuclear proliferation, the spreading of nuclear weapons, fissionable material and weapons-applicable nuclear technology and information is often ignored, because the debate usually centres on energy production. However, proliferation was brought back into the discussion by the authors of a task similar to the taxonomy effort, the 2018 IPCC report: ***Nuclear energy, the share of which increases in most of the 1.5ºC-compatible pathways (see Chapter 2, Section 2.4.2.1), can increase the risks of proliferation (SDG 16), have negative environmental effects.*** The end of the bipolar world order and the rise of regional powers leads to states starting a nuclear power program (e.g. Turkey) without excluding possible interest in acquiring nuclear weapons.

4 Calling on the European Commission to give the process legitimacy

The TEG Report assessed known climate change mitigation opportunities and tested possible climate change adaptation activities for inclusion in the EU Taxonomy. Many of the TEG's recommendations have been implemented into the Annexes of the Draft Delegated Act that shall be adopted by the European Commission in the end of 2020 or early 2021.

Changes and future economic activities which are not included in the Delegated Act can be assessed by the experts of the already established Platform on Sustainable Finance[28] at a later point in time. Some activities were not included in the Taxonomy if they could not make a substantial contribution or did not meet the do no significant harm (DNSH) criteria. In the field of energy production, coal was excluded, but also nuclear energy was not deemed sustainable, namely due to the waste problem. However, strong political pressure was exerted to include nuclear energy. Therefore the European Commission mandated[29] the **Joint Research Centre** to conduct a review to assess nuclear energy under the DNSH criteria, and to conduct a specific assessment on the current status and perspectives of long-term management and disposal of nuclear waste.

The nuclear industry is looking forward to the JRC assessment, believing that `the assignment of the JRC decided by the EC is a guarantee for a robust, science-based assessment of nuclear`.[30] The JRC is expected to deliver a draft version of the report by end of 2020/first quarter of 2021. In the next step, this report will be submitted to two more committees: The Group of Scientific Experts referred to in Article 31 of the Euratom Treaty and SCHEER[31] will be tasked to provide an assessment of the JRC report. And later in the process, also the Platform on Sustainable Finance will review this report. What is clear at this point: Nuclear power is treated in a special manner and might enter the taxonomy through a hidden back-door based on an assessment by the known pro-nuclear Joint Research Centre.

We call upon the Commission to ensure that

1. When the JRC presents its draft report for review, it should be made available also to the public and submitted to public consultation, not only to the committees which are bound by secrecy and whose members are not necessarily known for their expertise in sustainability.
2. Public and independent experts and NGOs can comment on the draft report and the report by the JRC as they did on the regulation covering all issues except nuclear and each of the delegated acts.
3. The JRC report will be submitted to the other two committees and the Platform on Sustainable Finance together with comments from the public and other independent experts.
4. All statements and recommendation will be made public, including the SCHEER committee's Scientific Opinion and the opinion of the Euratom Art. 31 Group.

[28]https://ec.europa.eu/info/files/members-eu-platform-sustainable-finance_en

[29]https://ec.europa.eu/health/sites/health/files/scientific_committees/scheer/docs/scheer_q_020_rd.pdf

[30]https://ec.europa.eu/info/law/better-regulation/have-your-say/initiatives/12302-Climate-change-mitigation-and-adaptation-taxonomy/F1303056

[31]https://ec.europa.eu/health/sites/health/files/scientific_committees/scheer/docs/scheer_q_020.pdf, Members of SCHEER: https://ec.europa.eu/health/scientific_committees/scheer/members_committee_en

5 References

Beerten, J., Laes, E., Meskens, G., D'Haeseleer, W. (2009): Greenhouse gas emissions in the nuclear life cycle: a balanced appraisal. In: Energy Policy 37: 5056-5068.

EC Report 2 (2019): Report from the Commission to the Council and the European Parliament on progress of implementation of Council Directive 2011/70/EURATOM and an inventory of radioactive waste and spent fuel present in the Community's territory and the future prospects. Second Report. COM(2019) 632 final. Brussels, 17.12.2019.

EGU (2020): EGU2020 Assembly online meeting and presentations May 2020.https://meetingorganizer.copernicus.org/EGU2020/session/34732

Gouv Lux (2020): Avis de la Ministre de l´Environnement, du Climat et du Développement durable du Grand-Duché de Luxembourg suite à l´information du lancement de la procédure d'évaluation des incidences du plan de gestion des déchets radioactifs en Belgique. https://environnement.public.lu/dam-assets/actualites/2020/06/AVIS-GDL-SEA-stockage-geologique.pdf

GPF (2019): The Global Crisis of Nuclear Waste. Report commissioned by Greenpeace France. 2019. https://cdn.greenpeace.fr/site/uploads/2019/01/REPORT_NUCLEAR_WASTE_CRISIS_ENG_BD-2.pdf

IAEA (2017): Report by the Director General. International Status and Prospects for Nuclear Power 2017. 28 July 2017. http://large.stanford.edu/courses/2018/ph241/holland1/docs/iaea-gc-61-inf-8.pdf

IPCC(2018): Global warming of 1.5°C An IPCC Special Report on the impacts of global warming of 1.5°C above pre-industrial levels and related global greenhouse gas emission pathways, in the context of strengthening the global response to the threat of climate change, sustainable development, and efforts to eradicate poverty p. 461.https://www.ipcc.ch/site/assets/uploads/sites/2/2019/06/SR15_Full_Report_High_Res.pdf

Nature (2018): Long term corrosion estimation of carbon steel, titanium and its alloy in backfill material of compacted bentonite for nuclear waste repository. https://www.nature.com/articles/s41598-019-39751-9.pdf

Sagan (2011): The Causes of Nuclear Weapons Proliferation. Scott D. Sagan. Annual Review of Political Science 2011 14:1, 225-244

SOTEC-radio Konzepte und Maßnahmen zum Umgang mit soziotechnischen Herausforderungen bei der Entsorgung radioaktiver Abfälle - Forschungsergebnisse (2018). https://www.polsoz.fu-berlin.de/polwiss/forschung/systeme/ffu/forschung-alt/projekte/laufende/17_sotec_radio/SOTEC-radio-Jahresbericht-2018.pdf

Sovacool, B. (2008): Valuing the greenhouse gas emissions from nuclear power: A critical survey. In: Energy Policy 36: 2940-2953

SRA (2011): IGD-TP Implementing Geological Disposal of Radioactive Waste Technology Platform Strategic Research Agenda 2011. https://igdtp.eu/wp-content/uploads/2017/09/SRA-Complete-web-version_July-14_2011.pdf

TEG Report (2019):Supplementary Report 2019 by the Technical Expert Group on Sustainable Finance. June 2019.

https://ec.europa.eu/info/sites/info/files/business_economy_euro/banking_and_finance/documents/190618-sustainable-finance-teg-report-using-the-taxonomy_en.pdf

TEG Report (2020): Taxonomy: Final report of the Technical Expert Group on Sustainable Finance. March 2020. https://knowledge4policy.ec.europa.eu/publication/sustainable-finance-teg-final-report-eu-taxonomy_en

TEG Report Annex (2020): Taxonomy Report: Technical Annex. Updated methodology & Updated Technical Screening Criteria. March 2020. https://knowledge4policy.ec.europa.eu/publication/sustainable-finance-teg-final-report-eu-taxonomy_en

Warner, E., Heath, G.A. (2012): Life Cycle Greenhouse Gas Emissions of the Nuclear Electricity Generation. In: Journal of Industrial Ecology Vol 16: S73-S92.

Wheatley, S., Sovacool, B.K., Sornette, D. (2016): Reassessing the safety of nuclear power. In: Energy Research & Social Science 15: p. 96–100.