Nachhaltigkeitsnarrative im Nuklearbereich (Sustainability narratives in the nuclear field)

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This report was financed by:

Wiener Umweltanwaltschaft /

Vienna Ombudsoffice for Environmental Protection

Vienna, 2025

Content

1 Summary

Sustainability has become an important part in nuclear narratives especially over the last years. The term “sustainable” keeps appearing in names of nuclear organisations and titles of nuclear conferences. But what is meant by “sustainability” in these contexts?

And, on the other hand, how is nuclear included in sustainability regimes? Do references to nuclear energy production and nuclear waste management in key documents of sustainability policies reflect problems and challenges in an adequate way?

This report gives an overview of both approaches and investigates the relationship of sustainability and nuclear from a critical perspective, focussing on nuclear power and nuclear waste management.

It can be summarised that nuclear topics slipped out of sustainability key documents over the decades. While there was a whole chapter in the Brundlandt report from 1987 engaging critically with risks of nuclear power, the Agenda 21 from 1992 concentrated only on radioactive waste issues. The sustainable development goals (SDGs) only refer to these old recommendations and are in the need of an update on nuclear issues. The Green Taxonomy offers sustainability criteria for nuclear, but the inclusion of nuclear in the Green Taxonomy is highly disputed, legal challenges are still ongoing.

At the core of argumentation of nuclear community actors is the narrative that nuclear power contributes on the one hand to greenhouse gas reductions (in comparison with fossil fuels), and on the other hand to energy security – and by this to economic welfare. What is kept out of this picture are the unsolved environmental consequences of nuclear power like uranium mining and milling residues, risk of severe impacts due to accidents, and the unsolved issues in the management of radioactive waste and spent fuel. Social consequences like the high costs taxpayers have to pay for NPP newbuild and RWM are also not discussed openly.

Summarizing, when outweighing the risks, shortcomings and economic problems of nuclear energy against its contribution to climate mitigation and sustainability goals, it becomes clear that the disadvantages weight more heavily. Nuclear energy is no sustainable technology.

Radioactive waste management can be made more sustainable by reducing burdens for future generations but in other ways than with the concept of burying and forgetting especially the high radioactive waste in deep geological repositories. Further development of four pillars could help to manage nuclear waste in a way to better reach sustainability goals - building on concepts of sustainability & society and make them applicable to radioactive waste management, fostering a shared culture for safety and security and sustainability, fostering participation of society in radioactive waste management and developing models for an intergenerational stewardship culture.

2 Zusammenfassung

Nachhaltigkeit ist vor allem in den letzten Jahren zu einem wichtigen Bestandteil der Nuklear-Narrative geworden. Der Begriff „nachhaltig“ taucht immer wieder in den Namen von Atomorganisationen und den Titeln von Konferenzen auf. Aber was ist mit „Nachhaltigkeit“ in diesem Zusammenhang gemeint?

Und wie wird andererseits die Kernenergie in das System der Nachhaltigkeit einbezogen? Spiegeln die Verweise auf die Kernenergieerzeugung und die Entsorgung nuklearer Abfälle in den Schlüsseldokumenten der Nachhaltigkeitspolitik die Probleme und Herausforderungen in angemessener Weise wider?

Dieser Bericht gibt einen Überblick über beide Ansätze und untersucht das Verhältnis von Nachhaltigkeit und Kernenergie aus einer kritischen Perspektive, wobei der Schwerpunkt auf der Kernenergie und der nuklearen Abfallentsorgung liegt.

Zusammenfassend lässt sich sagen, dass das Thema Kernenergie im Laufe der Jahrzehnte aus den Schlüsseldokumenten zur Nachhaltigkeit herausgefallen ist. Während es im Brundlandt-Bericht von 1987 ein ganzes Kapitel gab, das sich kritisch mit den Risiken der Kernenergie auseinandersetzte, konzentrierte sich die Agenda 21 von 1992 nur mehr auf Fragen der radioaktiven Abfälle. Die Ziele für nachhaltige Entwicklung (SDGs) beziehen sich nur auf diese alten Empfehlungen und bedürfen einer Aktualisierung in Bezug auf die Kernenergie. Die Grüne Taxonomie bietet Nachhaltigkeitskriterien für die Kernenergie, aber die Aufnahme der Kernenergie in die Grüne Taxonomie ist höchst umstritten, und die Rechtsstreitigkeiten sind noch nicht abgeschlossen.

Im Mittelpunkt der Argumentation der Nuklearindustrie steht das Narrativ, dass die Kernkraft einerseits zur Verringerung der Treibhausgase (im Vergleich zu fossilen Brennstoffen) und andererseits zur Energiesicherheit – und damit zum wirtschaftlichen Wohlstand – beiträgt. Ausgeblendet werden dabei die ungelösten Umweltfolgen des Uranabbaus, das Risiko schwerwiegender Auswirkungen durch Unfälle und die ungelösten Fragen der Entsorgung von radioaktiven Abfällen und abgebrannten Brennelementen. Auch die sozialen Folgen wie die hohen Kosten, die die Steuerzahler:innen für den Neubau von KKW und die Entsorgung von radioaktiven Abfällen und abgebrannten Brennelementen tragen müssen, werden nicht offen diskutiert.

Wenn man die Risiken, Mängel und wirtschaftlichen Probleme der Kernenergie gegen ihren Beitrag zum Klimaschutz und zu den Nachhaltigkeitszielen abwägt, wird deutlich, dass die Nachteile schwerer wiegen. Die Kernenergie ist keine nachhaltige Technologie.

Die Entsorgung nuklearer Abfälle kann nachhaltiger gestaltet werden, indem die Belastungen für künftige Generationen verringert werden, allerdings auf andere Weise als durch das Konzept des Vergrabens und Vergessens insbesondere der hochradioaktiven Abfälle in geologischen Tiefenlagern. Die Weiterentwicklung von vier Säulen könnte dazu beitragen, dass die Entsorgung nuklearer Abfälle die Ziele der Nachhaltigkeit besser erreicht – aufbauend auf dem Einbringen von Konzepten der Nachhaltigkeit und Gesellschaft in die Entsorgung radioaktiver Abfälle, auf der Förderung einer gemeinsamen Kultur für nukleare Sicherheit, nukleare Sicherung und Nachhaltigkeit, auf der Förderung der Beteiligung der Gesellschaft an der Entsorgung radioaktiver Abfälle und auf der Entwicklung von Modellen für eine generationenübergreifende Stewardship-Kultur.

3 Introduction

Sustainability has become an important part in nuclear narratives especially over the last years. The term “sustainable” keeps appearing in names of nuclear organisations and titles of nuclear conferences. But what is meant by “sustainability” in these contexts?

And, on the other hand, how is nuclear included in sustainability regimes? Do references to nuclear energy production and nuclear waste management in key documents of sustainability policies reflect problems and challenges in an adequate way?

This report gives an overview of both approaches – interpretation of sustainability by the nuclear community, and inclusion of nuclear in sustainability regimes.

In the last chapter, the report investigates the relationship of sustainability and nuclear from a critical perspective, focussing on nuclear power and nuclear waste management.

4 Concepts of sustainability and nuclear from sustainability policy's perspectives

For reviewing how nuclear energy is included in sustainability policies, key sustainability documents were analysed.

The **Brundtland report**, entitled Our Common Future (UN 1987) from the UN's Commission on Environment and Development, was the first internationally well-known report to use the terms of sustainable development. This report starts by defining sustainable development as *"development that meets the needs of the present without compromising the ability of future generations to meet their own needs"* (UN 1987, chapter 2, §1), and catches in a synthetic wording that *"in essence, sustainable development is a process of change in which the exploitation of resources, the direction of investments, the orientation of technological development; and institutional change are all in harmony and enhance both current and future potential to meet human needs and aspirations"* (UN 1987, chapter 2, §15). One key element of the core principles of sustainability is defined as the ability of communities and institutions to build up appropriate decisions aiming at sustainability thanks to an open and reflexive framework of decision making.

In the Brundtland report, a whole chapter (no 7) is devoted to energy, and a whole subchapter to nuclear energy. This subchapter III is called "Nuclear Energy: Unsolved Problems" and refers on five pages to the risk of nuclear accidents (the Brundtland report was released one year after the accident of Chernobyl), the problems of nuclear waste disposal and dismantling of reactors, and the dangers of proliferation.

After the UN Conference on Environment and Development in Rio de Janeiro, the so-called **Agenda 21** was adopted in 1992 by more than 178 governments. (UN 1992) The Agenda gives action recommendations for local, national and global levels. The document has four sections. In section I, social and economic dimensions of sustainable development are discussed. Nuclear power is mentioned as problematic: "[…] *urgent need to address the prevention and reduction of man-made disasters and /or disasters caused by, inter alia, industries, unsafe nuclear power generation and toxic wastes*." (UN 1992, §7.57) In section II on conservation and management of resources for development in the subchapter on transboundary atmospheric pollution, nuclear is mentioned in the objective" *to develop capabilities to assess and mitigate transboundary air pollution resulting from industrial and nuclear accidents […]*" (UN 1992, §9.27) In the subchapter on marine environmental protection, the safety of transport of fuel on ships is addressed. (UN 1992 §17.30) Radioactive waste was discussed in a separate chapter 22 on a little bit more than 2 pages. §22.3 defines: *"The objective of this programme area is to ensure that radioactive wastes are safely managed, transported, stored and disposed of, with a view to protecting human health and the environment, within a wider framework of an interactive and integrated approach to radioactive waste management and safety.*" While numbers on inventory and costs in this chapter are outdated, some aspects are already in that are still of importance, f.e. the call for minimizing and limiting generation of radioactive waste, the role of safety in radioactive waste management, a call for standards and guidelines that are internationally accepted, assisting developing countries, including environmental impact assessments (EIA), installing a ban on Sea dumping, no export to countries of the South, etc. To foster legal instruments and

mechanisms, in chapter 39 the Agenda 21 called for a nuclear safety convention in the framework of the IAEA[1]. (UN 1002 339.7)

Building on these sustainability key documents, several **three dimension-models of sustainability** became state-of-the-art. These dimensions are: economic, social and environmental. Different models had different perspectives of how the dimensions relate to each other, and what should be the role of the environmental dimension. Purvis et al (2019) show an overview figure of possible relationships of the dimensions:

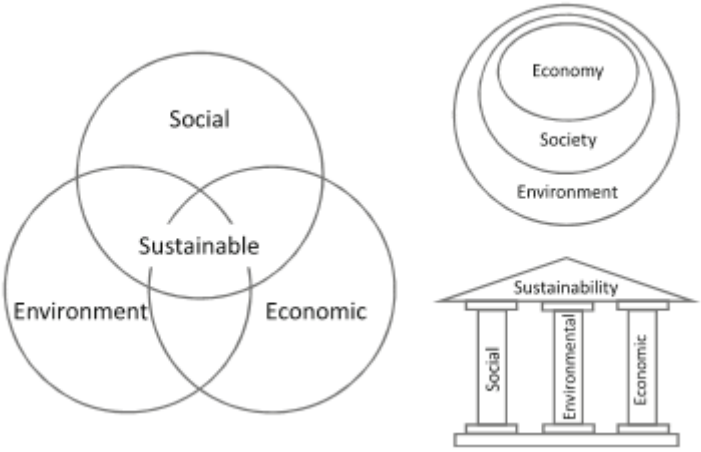

Figure 1 : Purvis et al. (2019)

In 2015, the **Agenda for Sustainable Development** was developed. 17 Sustainable Development Goals (SDGs) covering social, ecological and economic aspects have been defined, with 169 associated targets, to be reached by 2030. If an activity calls itself sustainable, it needs to address these sustainable development goals. The SDGs and their sub-goals address the connection between pollution, inequalities, poverty, production and consumption etc. Different problems need to be tackled everywhere and simultaneously.

[1] The Joint Convention on Nuclear Safety was adopted in 1994, the Joint Convention on the Safety of Spent Fuel Management and on the Safety of Radioactive Waste Management in 1997.

Figure 2: Sustainable Development Goals. https://www.un.org/sustainabledevelopment/news/communications-material/

SDGs are international goals; the European Commission is committed to implementing the SDGs in all EU policies and encourages EU countries to do the same. The SDGs are voluntary goals. They are not legally binding, but many states set them as benchmarks and make voluntary reports.

Radioactive waste is mentioned in the SDGs only in an outdated background information. SDG 12 (Ensure sustainable consumption and production[2]) includes chemicals and wastes, also radioactive waste. For radioactive waste, this SDG website cites as only source the above mentioned Agenda 21 (Rio Declaration 1992), chapter 22. Even though some trends were set in the Agenda 21 for safe radioactive waste management under the sustainability regime, this information is in need of an update.

The **Green Taxonomy** is a new financing instrument supporting the EU Green Deal by defining sustainable activities in much technical detail. An activity may call itself sustainable if it contributes significantly to reach at least one of the six defined environmental goals plus does not significant harm (DNSH) to the other goals. These goals are:

- Climate change mitigation
- Climate change adaptation
- The sustainable use and protection of water and marine resources
- The transition to a circular economy
- Pollution prevention and control
- The protection and restoration of biodiversity and ecosystems

Nuclear is dealt with in the Complementary Climate Delegated Act (Commission Delegated Regulation (EU) 2022/1214 of 9 March 2022 amending Delegated Regulation (EU)

[2] https://sdgs.un.org/topics/chemicals-and-waste

2021/2139 as regards economic activities in certain energy sectors and Delegated Regulation (EU) 2021/2178 as regards specific public disclosures for those economic activities). This CDA applies from 1 Jan 2023. Three types of nuclear activities are included

- 4.26: Pre-commercial stages of advances technologies with minimal waste from the fuel cycle
- 4.27: Construction and safe operation of new nuclear power plants, for the generation of electricity or heat, including for hydrogen production, using best-available technologies
- 4.28: Electricity generation from nuclear energy in existing installations

In Annex 1 and Annex 2 of the CDA, criteria for the substantial contributions of these three types of nuclear activities to the first two environmental objectives and DNHS to the other environmental objectives are defined.

All provisions the Member State has to fulfil, amongst others: The member state…

- has final disposals for low and intermediate level waste
- has enough funds for radioactive waste management and decommissioning, and this money will be available when needed
- has a documented plan with detailed steps to have in operation a high level waste (HLW) repository by 2050

The Green Taxonomy is the first instrument to give concrete criteria for nuclear for fulfilling environmental goals. These include, besides the above mentioned, for contributing to the goal of climate change mitigation protection a threshold for life-cycle greenhouse gas (GHG) emissions from the generation of electricity from nuclear energy of below 100 g CO_{2e}/kWh. For DNSH to the goal of climate change mitigation the direct GHG emissions of the activity have to be lower than 270 g CO_{2e}/kWh.

It is important to remark that the acceptance of nuclear into the Taxonomy is a very disputed decision. The first report of the so-called technical expert group (TEG) of March 2020 contained 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. After massive lobbying of pro-nuclear states and a report of the EC’s Joint Research Centre, nuclear was included in the Taxonomy legal system, even though several studies provided evidence that nuclear power does not comply with he DNSH criteria (see f.e. Stagl 2020). Several legal challenges followed, among them a legal challenge of Austria, which has not been decided yet.

It can be summarised that nuclear topics slipped out of sustainability key documents over the decades. While there was a whole chapter in the Brundlandt report engaging critically with risks of nuclear power, the Agenda 21 concentrated on radioactive waste issues. The SDGs only set a link to the Agenda 21 (from 1992) and did not mention nuclear power besides this link.

The Green Taxonomy offers sustainability criteria for nuclear, but the inclusion of nuclear in the Green Taxonomy as such is highly disputed, legal challenges are still ongoing.

5 Sustainability narratives in the nuclear field

In both nuclear organisations and networks, the term “sustainability” keeps popping up especially in the last years. This chapter reviews how organisations and important legal texts define and use sustainability in the nuclear field.

Nuclear Waste Directive and Nuclear Safety Directive

The two important EURATOM directives for nuclear safety and radioactive waste management were reviewed if and how sustainability is mentioned there.

The Nuclear Safety Directive 2014/87/Euratom does not mention sustainability at all.

In the Nuclear Waste Directive 2011/70/Euratom, sustainability is mentioned only once in recital 23: *“It is broadly accepted at the technical level that, at this time, deep geological disposal represents the safest and most sustainable option as the end point of the management of high-level waste and spent fuel considered as waste.”* No further explanation what is meant by a sustainable option is provided.

This reflects the distance of Euratom legislation to environmental discourses of the EU. Euratom sees itself outside of EU environmental legislation (see f.e. Veuchelen 2023).

International Atomic Energy Agency (IAEA)

Shortly after the Agenda for Sustainable Development and its 17 SDGs were issued in 2015, the IAEA published its publication **“Nuclear Power and Sustainable Development”** (IAEA 2016). The sustainability dimensions economy, environment and social were addressed and indicators were developed. With these indicators, the publication compares several energy production technologies concerning their sustainability (IAEA 2016, fig. 31 p. 101), Nuclear energy is assessed as favourable, only radioactive waste, water use and overnight investment costs are rated as (partly) unfavourable.

On its website, the IAEA claims that she **contributes with her work to nine of the 17 SDGs**.[3] The contribution comprises nuclear technologies that are offered to countries, amongst others for water analysis, assessment of soil erosion, breeding new plants, food and medical supply treatment, using nuclear and isotope technologies in medicine, industry and research, guiding on radioactive waste management (RWM), and in general fostering the use of nuclear energy.

In the **IAEA conference ”Radioactive waste management. Solutions for a sustainable future” in 2021**, sustainability was even prominently displayed in the title, while in the previous conference in 2016, it was not a topic at all. IAEA Director General Grossi said in the opening talk of this conference: *“For it is only when nuclear waste is managed successfully can nuclear science and technology contribute to a sustainable future for everyone.”* (IAEA 2023, p. 5) Continuing the optimization of RWM was named as important to society and supportive of the Sustainable Development Goals (IAEA 2023, p. V)

Besides this more general connection of RWM with sustainability in the opening talks of the conference, several aspects of sustainability were addressed by the participants:

[3] https://www.iaea.org/sites/default/files/22/08/iaea_and_the_sdgs.pdf

- Sustainable radioactive waste management would need to embrace the principles of the circular economy— avoid, minimize, recycle, reuse — with disposal as the last option.
- Economic sustainability was addressed in several contributions: securing an economically sustainable future for nuclear would result in robust and reliable national energy supply, long-term jobs and therefore significantly contributing to energy security. Creating (green) jobs was also mentioned as part of economic sustainability of nuclear.
- Sustainability was sometimes used in the meaning of sustaining, especially when talking about sustained financing needs for RWM, but also sustained knowledge keeping and sustained political support.
- RWM should be ensured without putting an undue burden on future generations, and by this being sustainable in the intergenerational perspective.
- The use of sustainable materials and a sustainable supply chain was addressed.
- Involvement of stakeholders, esp. host communities, could promote sustainability through social relationships (social dimension)
- A culture of equality, diversity and inclusion would be fundamental to the sustainability, growth, and improvement of organizations, leading to improvements of safety and security culture.

IAEA tries to fit nuclear energy, nuclear technologies and RWM into a sustainability scheme tackling all three dimensions. Making RWM as safe and secure as possible seems to count for being sustainable. But discussing risk and consequences of severe accidents is missing altogether in these debates.

Nuclear Energy Agency (NEA)

NEA' s publication **"Nuclear Energy in a Sustainable Development Perspective"** (NEA 2000) has the goal to help assessing the extent to which nuclear energy is compatible with the goals of sustainable development. It provides a review of specific characteristics of nuclear energy from the economic, environmental and social viewpoints of sustainable development, focusing on key issues of relevance for policy makers. As central for sustainable development NEA defines in its executive summary maintaining or even increasing overall assets for future generations. Nuclear energy is seen as such asset due to offering energy production and increasing human and man-made capital. It needs to be assured that nuclear energy use does not reduce irreplaceable natural assets significantly. Economic competitiveness is seen as a prerequisite for contributing to a sustainable development. Most NPPs are described as competitive in the NEA publication. One argument for competitiveness is that electricity consumers are paying for nuclear safety and insurance against accidents, decommissioning and radioactive waste disposal. NEA already in 2000 saw that competitiveness was to get more difficult. Uranium resources are discussed as being large enough for decades and the costs of nuclear fuel to be small. Recycling fissile material and development of advanced fuels could help broadening the resource basis. Furthermore, nuclear energy is praised as being essentially carbon-free. *"Including the nuclear energy option in the basket of tools aiming at addressing climate change issues is consistent with the precautionary principle and sustainable development objectives."* (NEA 2000, p. 8) Prevention of accidents is also discussed as being important. NEA argues that there are small volumes of radioactive waste from the nuclear energy sector that can be isolated from the biosphere at acceptable costs – the problem is seen only in public concerns. *"The implementation of repositories, in ways discussed with and accepted by the public, will be a major step towards meeting sustainable development goals."* (NEA 2000, p.

9) Nuclear energy is mentioned as providing employment, enhancing diversity and security of energy supply. To tackle the social dimension of nuclear, the public needs to be involved in decision-making. The role of OECD countries could be to promote nuclear energy in newcomer countries.

When searching for "sustainability" on NEA's website, this publication from 2000 is popping up and labelled as "most recently", even it is now a quarter of a century old. All in all, this publication focusses on economic dimensions of sustainability and energy security also for future generations. Now, a quarter of a century later than the time of the NEA publication, the competitiveness of NPP has decreased massively, and it has become clear that taxpayers will have to pay for radioactive waste management because what has been saved by radioactive waste producers will not be enough. The firm believe that nuclear technology can be handled safe and secure (which is seen as a precondition for being sustainable) needs to be reviewed under the current circumstances, when nuclear facilities are increasingly attacked by acts of war.

In a **video from 2021**[4], Diane Cameron from NEA is targeting the role of nuclear energy as a low carbon energy source and is lobbying for tripling the increase of nuclear power generation until 2050 to reach the Paris climate goals. There is no mentioning of sustainability, the focus lies on reaching net zero and avoiding carbon emissions.

This is also true for NEA's report on its activities at the COP29 in 2024, where NEA's focus was on nuclear financing, new technologies and engagement with young generation. NEA is concentrating on highlighting *"nuclear energy's potential as a key enabler of a sustainable transition"*[5].

The **SNETP – The Sustainable Nuclear Energy Technology Platform** was established in 2007 as a research and development platform for civil nuclear systems. Its goal is supporting and promoting the safe, reliable and efficient operation of nuclear systems. There are no definitions of or publications directly on sustainability available on the website. Information is presented on the website of projects or events dealing with nuclear energy as a driver for economic growth and sustainable transition.

Research projects and programmes under Euratom funding seemingly also work on sustainability. The project **HARPERS (Harmonised best practices, regulations and standards in waste management and decommissioning)** had a work package on "Conducting sustainability assessment in the field of nuclear decommissioning and waste management". In a recent presentation (Perko et al 2025), the authors tried to bring together the SDGs and NPP decommissioning examples and in the use of nuclear technologies. The approaches do not differ in essence from what has been discussed above: the focus is on economic effects and contributions to several SDGs by providing nuclear technologies and IAEA services. A special focus is put on circular economy as tool to support sustainability. Examples where circular use of radioactive materials is not sustainable are given, like recycling that needs high energy input, keeps toxic material in the loop, exploits workers, or has a rebound effect. Repurposing of nuclear sites is being discussed, this means that a site after decommissioning could be used for so-called small modular reactors or other industrial

[4] https://www.youtube.com/watch?v=m_-T8-MamIU
[5] https://www.oecd-nea.org/jcms/pl_98194/nea-at-cop29-focus-on-nuclear-financing-new-technologies-and-engagement-with-young-generation

enterprises, but also for community and recreation. (see also [6]) HARPERS made an effort to define circular economy and sustainability goals for decommissioning. The definition that was elaborated in the project is: *"Circular economy in nuclear decommissioning represents a model of production and consumption based on the efficient use of available resources in all phases; this by retaining assets and materials in circulation at their highest value for as long as possible, and minimizing waste, through processes like sharing, maintenance, repairing, reuse, refurbishment, remanufacturing, recovering, and recycling."*

At the core of argumentation of these nuclear community actors is the narrative that nuclear power contributes on the one hand to greenhouse gas reductions (in comparison with fossil fuels), and on the other hand to energy security – and by this to economic welfare.

What is kept out of this picture are the increasing environmental consequences of nuclear power like uranium mining and milling residues, risk of severe impacts due to accidents, and the unsolved issues in the management of radioactive waste and spent fuel.

Social consequences like the high costs taxpayers have to pay for NPP newbuild and RWM are also not discussed openly.

The approach of the SITEX.Network seems to be more useful for exploring connections of RWM with sustainability.

The **SITEX.Network** (**Sustainable network for Independent Technical EXpertise on radioactive waste management)** evolved from two research projects (Sitex I and II) and focusses on radioactive waste management. Three colleges work together in this network, representing three different functions: the technical expert function, the regulatory function and the civil society function. There is no elaborated definition of sustainability in the SITEX.Network yet besides having a sustainable network in the meaning of a stable, ongoing network that is no longer dependent on external funding. The societal function, on the other hand, is already recognised strongly in the SITEX.Network through solid collaborations between all SITEX.Network members.

Only recently, a working group was installed to develop the so-called 5S-concept. The 3S-concept is widely known as the relation between safety, security and safeguards. SITEX.Network works on integrating sustainability and society into this concept. The development of this 5S-approach is still ongoing. (see more in chapter 6)

[6] https://www.iaea.org/bulletin/moving-forward-repurposing-nuclear-facilities-after-decommissioning

6 Sustainability and nuclear from a critical perspective

Why is the question of the relationship of nuclear and sustainability important?

It has to be kept in mind that sustainability policies and goals are voluntary, they are not legally binding, even though many states set them as benchmarks. Nevertheless, the SDGs address important connected goals for society to reach, like no other policy instrument does. If nuclear energy can establish itself as sustainable, this will help its promotion in respective European policies like the Green Deal. The debates on nuclear in the Taxonomy showed that for nuclear countries it is not only important on a symbolic level that nuclear is now labelled "sustainable", but also on a financial level – sustainable activities should receive better financing conditions.

When discussing sustainability and nuclear, two perspectives have to be considered:

1) Can nuclear energy be sustainable at all?
2) How can radioactive waste management become more sustainable?

These two aspects need to be addressed differently.

6.1 Can nuclear energy be sustainable at all?

The main arguments from the nuclear community why nuclear is sustainable concern nuclear power's production of low-carbon energy and its contribution to energy security and economic wellbeing.

But these arguments are too narrow to see the whole picture. In the last years, many studies have analysed this in detail (see f.e. Wealer et al. 2021, Stagl 2020), which are summarized here:

Nuclear technologies have a risk for severe accidents that cannot be neglected, which the history of major accidents shows. The risk for future severe accident increases with ageing of the reactor fleet, with climate change becoming worse and resulting in extreme weather events posing risks to nuclear facilities, and with increasing security threats due to terror and war acts on nuclear facilities.

The management of spent fuel and radioactive waste is in wide parts not solved in a safe and secure manner. No final storage for high radioactive waste is in operation yet, sometimes waste that has already been disposed of in final repositories has to be recovered (Asse II in Germany). Large volumes of (legacy) radioactive waste often have an unknown inventory and need to be characterized and re-conditioned. Interim storage facilities and containers that were designed only for decades now are facing lifetime extensions up to more than a hundred years with unknown consequences.

Financing of the management of spent fuel and radioactive waste is not secured. The polluter pays principle will not be sufficient to cover the immense costs, taxpayer will have to step in for generations – which will put undue burden to future generations, who might not get nuclear energy any longer but still would have to care for the nuclear waste.

With radioactive material there is a constant proliferation risk, which becomes even more important in times of war and global crisis.

Nuclear power has become a very expensive energy option, no longer competitive without state aid to renewables like wind and solar.

Building new NPPs takes too much time to have an effect on climate mitigation. A new NPP needs decades before it can start operation – this is far too late for replacing fossil fuels; on the contrary, the very long building times of new NPPs could result in longer operation of fossil plants.

Moreover, by investing into nuclear it comes to a lock-in effect, the funds that would be needed for renewables, energy storage and efficiency will be bound to nuclear energy for decades. Nuclear energy is no transition technology.

If a severe accident happens, liability is not covered to a sufficient extent. In the end, taxpayers will have to pay if another accident happens.

Nuclear energy is not a “best-in-class” approach, even if it is low-carbon.

Uranium mining and its residues does significant harm to the environment in many places on this planet.

The nuclear community likes to speak of the nuclear cycle. But the nuclear cycle is in reality a nuclear chain: Even if spent fuel can be reprocessed, in the end it will become radioactive waste and will need a final repository for up to a million years.

Repurposing of nuclear sites is basically not a new idea, as decommissioning to the green field should allow for all types of use after the area was released from nuclear control; it is new that this is now labelled as circular economy and that future uses should be anticipated early in the decommissioning process. From 213 NPP that were closed worldwide as of July 2024, 23 have completed decommissioning, but out of those only 9 have been released to the greenfield (5 in USA, 1 in Japan and 3 in Germany). (WNISR 2024, table 12) It is not clear how many of the nuclear sites can be re-used at all.

Nuclear energy has a high demand of water for cooling. This can lead to increased competition for water in times of drought, but also to heating up rivers beyond the limits that might still be acceptable for the water fauna and flora (see example of Paks NPP that is now allowed to heat up the Danube for even more than 30°C[7]) – both aspects could contribute to significant harm on water and biodiversity.

The argument that nuclear technologies help countries, esp. developing countries, in environmental and health issues, does not automatically make these technologies sustainable. In their production (f.e. isotope production, sources) also reactors are needed, and waste occurs that needs to be managed and can cause significant harm.

A basic problem is that nuclear safety regulations are not linked with EU environmental law. Therefore some principles and procedures do not come to action. This results in less democracy in the nuclear sector, less transparency and public participation.

[7] https://www.joint-project.org/2024/07/28/npp-paks-allowed-to-heat-up-the-danube/

Summarizing, when outweighing the risks, shortcomings and economic problems of nuclear energy against its contribution to climate mitigation and sustainability goals, it becomes clear that the disadvantages weight more heavily. Nuclear energy is no sustainable technology.

6.2 How can radioactive waste management become more sustainable?

Radioactive waste has come to stay. There is no option to not manage it. But it can be managed in a more or less sustainable way.

Safety and security are without doubt important prerequisites for a sustainable nuclear waste management. But a safe and secure nuclear waste management does not automatically mean it is sustainable. One of the key aspects of sustainability is not to burden future generations.

In chapter 5, the work of the SITEX.Network has been mentioned, trying to implement sustainability and societal aspects into the 3S-concept of safety-security-safeguards. From the first inputs of a subgroup working on it, four pillars were defined that are of relevance for implementing sustainability and societal aspects into radioactive waste management:

1. Building on concepts of sustainability & society and make them applicable to radioactive waste management
2. Fostering a shared culture for safety and security (and sustainability)
3. Fostering participation of society in radioactive waste management
4. Developing models for an intergenerational stewardship culture

Building on concepts of sustainability & society and make them applicable to radioactive waste management

Nuclear law under Euratom is sort of a separate world in the EU. Euratom sees itself often outside EU environmental law. For example, many EU member states did not subject their national waste management programme (developed under Directive 2011/70/Euratom) to a Strategic Environmental Assessment under SEA-Directive 2001/42/EC with the argument that the SEA Directive was not applicable to Euratom.

To make their radioactive waste management more sustainable, EU member states would have to recognize the relevance and legitimacy of sustainability concepts and better introduce them in their national nuclear legislation. Especially all legal requirements on SEA and EIA, also in a transboundary context (Espoo Convention) and in the frame of access of the public to information, decision-making and justice in environmental matters (Aarhus Convention) should be fulfilled, and good practice should be the target. Applying the precautionary principle in RWM, esp. when dealing with uncertainties, needs also to be fostered.

On the other hand, the SDGs could benefit from an update on radioactive waste management in the respective articles, as the information given is already decades old and partially outdated (see chapter 3).

Concepts of society need also to be taken into better focus. While participation of the public is today more or less obligatory (even if it is often not as effective as necessary), the role of democratic bodies like Parliaments in nuclear is often inadequate, as decisions on radioactive waste management are not always brought into Parliament.

Fostering a shared culture for safety and security and sustainability

As mentioned before, safety and security of radioactive waste management are a prerequisite for sustainability. In addition to nuclear laws, to establish, keep and continuously improve a culture for safety and security is essential for ensuring a safe radioactive waste management.

In the frame of the SITEX projects, the term “shared” has been introduced in this debate, meaning that civil society should also have a say and participate in the culture for safety and security. SITEX.Network implemented this by opening up its organisation to civil society and allowing for a continuous reflection and cooperation of the work of the technical support organization and regulators engaged in SITEX.Network with civil society actors. This is a good example how civil society could contribute to the shared culture of safety and security.

Sustainability needs to be introduced in this concept in a meaningful way.

Fostering participation of society in radioactive waste management

Transparency and participation are crucial for including the public in RWM. While in former times the public did not have much say in decision-making on nuclear, nowadays it is widely recognized that the public does have the democratic right to participate in nuclear topics. Nevertheless, transparency and participation in RWM need improvements on many levels.

Transparency and participation in the nuclear sector are enshrined in international, European and national law: the Aarhus Convention, the Espoo Convention, the Environmental Impact Assessment and Strategic Environmental Assessment laws, national legal participation regimes, Euratom Directives (Nuclear Safety, Nuclear Waste), etc..

Information for the public on RWM needs to be easy to find, understandable, complete, up-to-date and openly dealing with conflicting opinions and uncertainties. Informing is not the same as participating, but a necessary precondition.

Participation should cover a broad range of measures: from environmental impact assessments to technical dialogues, from legally secured to voluntary instruments, from local to transboundary levels etc.

While all kinds of participation instruments are needed, it needs to be recognised that voluntary participation instruments cannot replace legally secured instruments.

Creating and keeping trust and enabling fruitful interactions between different actors are key aspects. Fruitful interactions aim at creating and maintaining relations between a plurality of actors, institutional or not, with the capacity to conduct a variety of inquiries (scientific, moral, social) and to address the complexity of radioactive waste management. The perspective of decision-making processes grounding on the capacity for actors to constitute the appropriate means for making decisions pave the path for the definition of a long-term vision of pluralistic decision-making, grounding then a pillar of sustainability.

Developing models for an intergenerational stewardship culture

The backend concept for RWM that is foreseen in most European countries is final disposal in a national or multinational facility (neither is yet in operation for high radioactive waste). Final repository in these concepts mean that the high radioactive waste is disposed of in a deep geological repository, where the canister material, the backfilling of the tunnels and the host rock would ensure safety into eternity. This concept is also called concept of passive

safety, as no human interventions should be needed after closure, or at least after a period of post-closure active monitoring. Furthermore, the tendency goes to “bury and forget”, as no memory keeping over hundreds or thousands of years is foreseen in some countries. Most countries believe that it would be more secure if the nuclear waste would be forgotten in its host rock.

It is highly disputable if this concept of passive safety and no memory keeping really guarantees to cause no burden to future generations.

An alternative is the so-called intergenerational stewardship culture. This describes an approach that nuclear waste will not be buried and forgotten, but memory will be kept alive and final repositories will be constructed that allow for retrieving the waste for a long period if necessary. Such models could orient themselves on the long-term stewardship concept that the USA uses for toxic waste sites. Research is needed to develop such stewardship models and establish an intergenerational stewardship culture.

Concluding, RWM can be made more sustainable by reducing burdens for future generations but in other ways than with the concept of burying and forgetting especially the high radioactive waste in deep geological repositories. The above presented four pillars can help to manage nuclear waste in a way to better reach sustainability goals. What is needed is to work in earnest on these four pillars and develop them further.

7 References

IAEA (2016): Nuclear power and sustainable development. Vienna.

IAEA (2023): Radioactive Waste Management. Solutions for a Sustainable Future. Proceedings of an International Conference. Vienna, Austria, 1-5 November 2021.

NEA (2000): Nuclear Energy in a Sustainable Development Perspective. OECD.

Perko, T., Geysmann, R., Turcanu, C. (2025): Conducting sustainability assessment in the field of nuclear decommissioning and waste management: Basic principles and focal points. Presentation. HARPERS, 19th May 2025.

Purvis, B., Mai, Y., Robinson, D. (2019): Three pillars of sustainability: in search of conceptual origins. In: Sustainability Science (2019) 14:681–695.

Stagl, Sigrid (2020): Does Nuclear Power Comply With the DNSH Criteria of the EU Taxonomy for Sustainable Activities? A Literature Review. On behalf of the Federal Ministry for Climate Action, Environment, Energy, Mobility, Innovation and Technology Directorate General VII – Climate Action & Environment Directorate 10 – General Coordination of Nuclear Affairs GZ 2020-0.417.529.

TEG Report (2020): Taxonomy Report. Technical Annex. Updated methodology & Updated Technical Screening Criteria. EU Technical Expert Group on Sustainable Finance.

UN (1987): Report of the World Commission on Environment and Development. Our Common Future. United Nations.

UN (1992): United Nations Conference on Environment & Development. Rio de Janerio, Brazil, 3 to 14 June 1992. AGENDA 21. United Nations Sustainable Development.

Veuchelen, L. (2023): The failure of Euratom to harmonize the EU nuclear safety and environmental regulation. Can a recent ECJ judgment become a breakthrough, beneficial for EU's quest for a sustainable, renewable-driver future? In: Elgar online, Vol. 11, Issue 4, p. 117-139. https://doi.org/10.4337/relp.2023.0003.

Wealer, B., Breyer, C., Hennicke, P., Hirsch, H., von Hirschhausen, C., Klafka, P., Kromp-Kolb, H., Präger, F., Steigerwald, B., Traber, T., Baumann, F., Herold, A., Kemfert, C., Kromp, W., Liebert, W., Müschen, K. (2021). Kernenergie und Klima. Diskussionsbeiträge der Scientists for Future, 9, 98 pp. doi: 10.5281/zenodo.5573719.

WNISR (2024): World Nuclear Industry Status Report. Schneider, M., Froggatt, A., Hazeman, J. et al. https://www.worldnuclearreport.org/The-World-Nuclear-Industry-Status-Report-2024-HTML

8 Glossary

CDA	Complementary Delegated Act
DNSH	Do no significant harm
EC	European Commission
EIA	Environmental Impact Assessment
EU	European Union
GHG	Greenhouse gases
HLW	High level waste
IAEA	International Atomic Energy Agency
NEA	Nuclear Energy Agency
NPP	Nuclear power plant
RWM	Radioactive waste management
SDG	Sustainable Development Goals
SEA	Strategic Environmental Assessment
UN	United Nations

9 List of figures