SMR and AMR Radioactive Waste: A Comparative Legal Analysis[1]

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Acronyms used:

- AMR: Advanced Modular Reactor
- ARN: Autoridad Regulatoria Nuclear (Argentina)
- BAT: Best Available Techniques
- CNEA: Comisión Nacional de la Energía Atómica (Argentina)
- CoRWM: Committee on Radioactive Waste Management (United Kingdom)
- DGR: Deep Geological Repository
- DOE: Department of Energy (USA)
- EPR: European Pressurized Reactor
- GDA: Generic Design Assessment
- HLW: High Level Waste (*)
- LILW: Low and Intermediate Level Waste (*)
- LWR: Light Water Reactor
- NRC: Nuclear Regulatory Commission (USA)
- PWR: Pressurized Water Reactor
- SMR: Small Modular Reactor
- VLLW: Very Low Level Waste (*)
- SF: Spent Nuclear Fuel

(*) Note on the waste categories HLW, LILW, VLLW: generic concepts not corresponding to any particular national definition.

A. INTRODUCTION: REASONS FOR DRAFTING THIS REPORT. THE CURRENT SITUATION REGARDING SMR AND AMR DEVELOPMENT WORLDWIDE

The interest of INLA WG5 in the waste generated by SMR dates back to February 2023. At that time, an online meeting was organized with members of Working Group 5, and within the context of discussions on the work program for the next two years, a list of topics of interest for joint analysis was put to a vote. Compared to other topics such as "societal participation in site selection of repositories" or "legal considerations on the possible development of multinational repositories," the topic of SMR waste caught the group's significant attention. A clarification suggested by the UK member is included here: the

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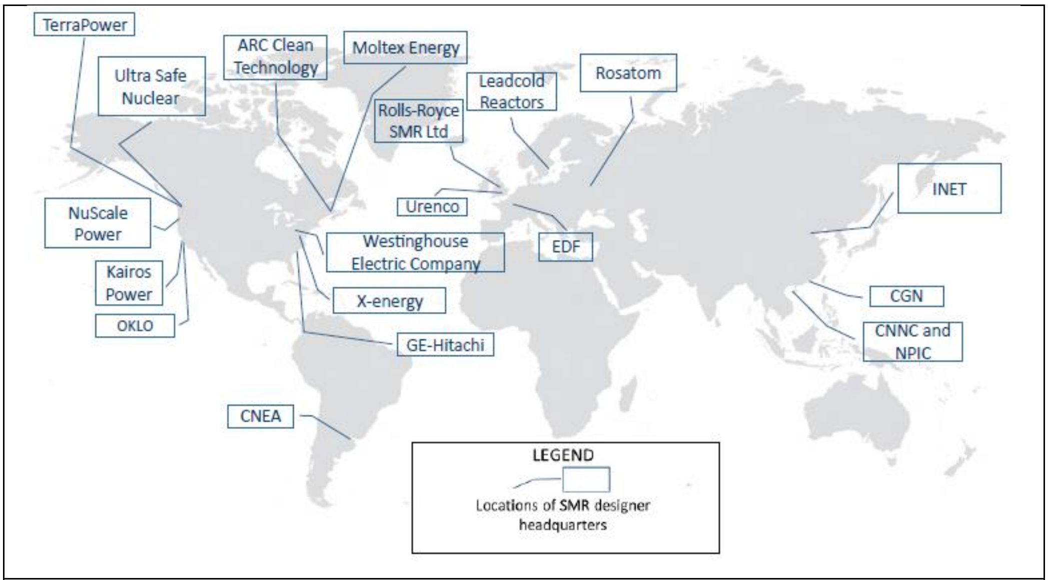
scope of study not only covers radioactive waste and spent fuel arising from SMR but also that arising from advanced reactors as defined by “AMR” in this country[4].

It is no surprise that the WG is interested in this topic. Currently, there are more than 50 SMR technologies in development worldwide, with 98 technologies identified at various stages of development. These projects are distributed across 18 countries. In particular, the second edition of the 2024 NEA SMR Dashboard includes 56 SMR under active development. The countries with organizations developing these technologies include the United States, Canada, France, Japan, China, and Russia, among others[5]. The first SMR will be built this decade, with accelerated deployment in the 2030s.



Location of SMR designers headquarters of a selection of SMR
NEA Small Modular Reactor Dashboard, N 20 EA No. 7650, © OECD 2023

International organizations are closely monitoring this evolution. Within the OECD-NEA, significant work has been done on compiling and updating the status of SMR technology and its implementation worldwide, evaluating aspects such as licensing, siting, financing, supply chain, public participation, and fuel supply. The NEA SMR Dashboard reveals substantial progress towards the deployment and commercialization of SMR in both OECD and non-OECD countries, especially in the past two years.

According to the description provided by the OECD-NEA on its website, SMR are expected to play an essential role in supporting net-zero emissions goals, especially in hard-to-decarbonize industrial sectors. These new reactors offer potential benefits such as

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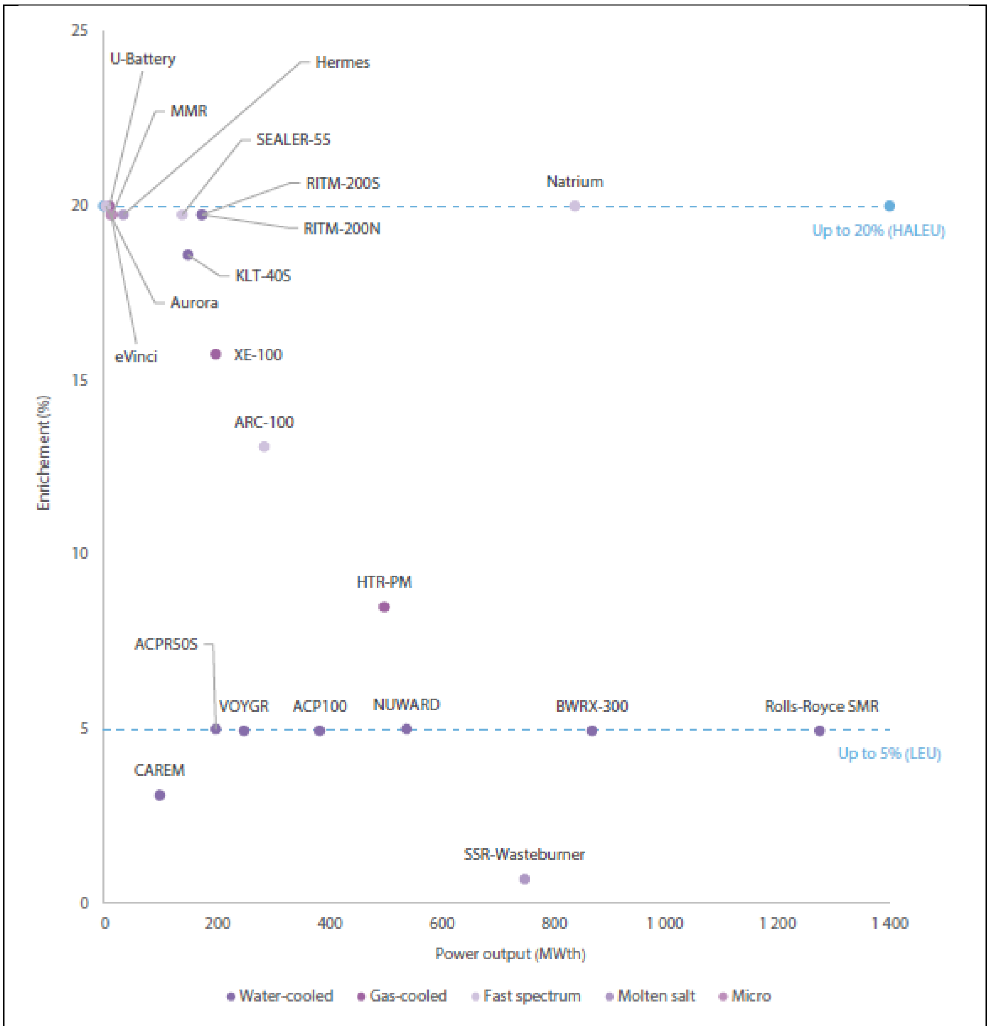
[4] For clarification of these terms, we keep the definitions used by the UK government, by which Generation IV reactors are considered AMR: https://www.gov.uk/government/publications/advanced-nuclear-technologies/advanced-nuclear-technologies

[5] The first two volumes of the first edition track the progress of 42 SMR worldwide. Volume I was launched in March 2023 during the NRC Regulatory Information Conference, and Volume II was published in July 2023 during the 14th Clean Energy Ministerial in Goa, India. The 2024 edition will evaluate 56 SMR globally. Source: https://www.oecd-nea.org/jcms/pl_73678/nea-small-modular-reactor-smr-dashboard

enhanced and passive safety systems, more attractive financing options due to shorter construction times, fewer components, and smaller plant footprints.

However, there are still many uncertainties regarding the type and quantity of radioactive waste/spent fuel they will generate, what challenges they will pose to existing regulatory frameworks, or if they are suitable for disposal in existing and planned waste repositories. This depends, of course, on the characteristics of the waste produced, for which there is no single answer. As a class of reactors, SMR are defined by their reduced size, but there is a wide variety in terms of power, temperature, technology, and fuel cycle, with sizes ranging from 1 MWe to over 300 MWe and temperatures from 285°C to over 850°C.



SMR concepts by type, thermal power and enrichment
NEA Small Modular Reactor Dashboard, N 20 EA No. 7650, © OECD 2023

To conduct this study, the conventional approach was followed: a task group of dedicated WG members was formed to help draft a questionnaire with what are considered the most relevant questions in this regard. Once the questionnaire was agreed upon, each member of the task group provided answers from the perspective of their country's situation. The task group included representation from the OECD-NEA, which was very useful in contextualizing the problem and providing us with additional information.

The countries that participated in this questionnaire were Argentina, Bangladesh, the USA, Slovakia, the United Kingdom, and France. Before starting to describe the results obtained,

I must express my gratitude to those who have greatly contributed to this study: Federico Winsens from Argentina, Stephen Tromans KC from the United Kingdom, Istiak Ahmed with responses from Bangladesh and the USA, Jerry Bonanno from the USA, Charles Bressant from France, and Katarína Duchoňová from Slovakia. I would also like to extend special thanks to Kaan Kuzeyli for his collaboration in comparing responses and always to our group's Secretary, Alexandra Van Kalleeven, for her enthusiasm and support throughout the entire process. Thanks also to Soufiane Mekki from the OECD-NEA for the valuable information provided.

B. QUESTIONNAIRE CONTENT

1. Plans and policies for the development of SMR. Consideration of the waste generated by them (questions 1a and 1b):

The first question of the questionnaire addresses the plans and policies for the development of SMR and to what extent the radioactive waste generated is considered in them.

In **Argentina**, with Decree 1107/2006, the construction of the CAREM-25 reactor has been promoted, and the state-owned National Commission for Atomic Energy (CNEA) has been tasked with the design and construction of its prototype. The response from this country mentions specific plans and a legal framework since 2006, highlighting some support measures for this project, such as tax benefits or a special customs control regime. The Argentine nuclear regulator, ARN, has already granted a construction license for the prototype, imposing a series of requirements. As for the waste that this reactor is expected to generate, it is anticipated to be LILW and initially stored temporarily within the site. The waste will be characterized in due course and treated according to the established general regulatory framework. It should be noted that CAREM-25 is currently achieving its approval as a prototype, but thereafter each individualized implementation project will need to obtain its respective authorization.

The response from **Bangladesh** indicates that a nuclear power plant with two reactors is under construction, although these will not be SMR. The development of SMR is under consideration, and the country is participating in international working groups to analyze the feasibility of developing this type of reactors within its territory. Regarding the new nuclear power plant under construction, which is being built in collaboration with ROSATOM, it is expected to conclude a take-back agreement with the Russian Federation for the removal of spent nuclear fuel from the plant.

Slovakia is one of the countries that has expressed interest in participating in the Phoenix project (9/2023) for the development of SMR[6]. Under the umbrella of this project, potential

[6] PROJECT PHOENIX was announced by U.S. Presidential Envoy for Climate John Kerry at the UN Climate Change Conference in Sharm El-Sheikh, Egypt (COP27). The project will be carried out under the U.S. Department of State's Foundational Infrastructure for the Responsible Use of Small Modular Reactor Technology (FIRST) Program in cooperation with the U.S. Department of Commerce's Small Modular Reactor Public-Private Program (SMR PPP), which aims to promote transatlantic cooperation to deploy SMR in Europe and Eurasia. Project Phoenix aims to accelerate the global clean energy transition by providing technical assistance to support decision making on pursuing the conversion of one or more coal-fired power plants to secure and safe zero-carbon small

sites are being studied in areas where nuclear power plants already exist, as well as cost analyses and predictable schedules; all within the framework of the country's industry decarbonization policy. The grant application to participate in this Project was submitted jointly by a consortium of partners who signed a Memorandum of Cooperation in June 2023. To present this grant application, State representatives, private companies, and research organizations have joined forces.

Furthermore, in this country, Memorandums of Understanding have also been signed in 2023 with EDF and Westinghouse to cooperate in the implementation of future SMR development projects.

At present, there is no schedule for the start of operation of this type of reactors, nor has a decision been made on their location. However, "considering that Jaslovske Bohunice V1 NPP is under decommissioning and the brownfield should be ready in 2029, it is highly probable that the first SMR/AMR will be located in this area."

Also in the **United Kingdom**, the government supports the development of SMR with a number of reactor types undergoing evaluation. Government funds have been allocated to support nuclear developments, including a specific fund for SMR developments and research related to AMR. In the near future, it is expected that 25% of the country's energy demand will be covered by new nuclear developments, but at the time the questionnaire was answered, it was not yet known what proportion of that figure would be occupied by SMR or AMR.

In 2023, the development of these new reactors was entrusted to the government-owned entity Great British Nuclear, equipped with a fund to select the best technologies. Great British Nuclear will be subsumed into the wider body, Great British Energy, announced by Sir Keir Starmer's Labour Government after the July 2024 general election. The Generic Design Assessment (GDA) process, a non-statutory and voluntary process initiated in 2008, will provide an important means by which new reactor designs can be assessed generically by the nuclear safety and environmental regulators. Currently, there are three SMR designs undergoing that process. The government will select which further designs will be able to enter the process. No licensing applications for SMR have been submitted yet and realistically are some way off. New types of reactors will also need to apply for regulatory justification approval.

Within these plans, decisions on the disposal routes for the radioactive waste/spent fuel have not yet been made. It is expected that the spent fuel and the most hazardous radioactive waste generated by these reactors will be disposed of in the future DGR facility, but for this to be possible, the waste management agency Nuclear Waste Services will need to conduct an assessment of their suitability for this type of disposal. The environmental studies required to license SMR must include information on the radioactive waste produced and a Best Available Technique (BAT) requirement for their optimization.

Among the spent fuel/radioactive waste expected to be generated by SMR and AMR, three categories are distinguished: those that will be similar to those generated in LWRs (Light Water Reactors); an intermediate category with many similarities to "traditional" waste, but which may present some differences in its characterization; and those for which there is

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modular reactor (SMR) nuclear energy generation. Source: https://www.smr-first-program.net/project-phoenix/

currently very little information and which may require decades of research to ensure their proper management.

France's energy strategy includes the development of 14 new nuclear reactors, both EPR and SMR, to increase the country's nuclear capacity and contribute to long-term climate goals. A notable example is the grant approved by the European Commission to support Nuward, a subsidiary of EDF, in its SMR research and development efforts. This project aims to design and construct small reactors (up to 300 MWe), intending to complete the research and development phases by 2027. Additionally, in 2021, President Macron announced a significant investment specifically for SMR.

Within the planned 14 new reactors, 6 should be EPR II, among which 4 should be settled in the North of France (two in Gravelines, with estimated commercial operation date by 2038, and two in Penly, by 2035) and 2 in the Centre of France (in Bugey, with commercial operation date by 2042). The overall cost for the 6 new EPR is estimated at 52 bn euros, and these projects should create 30,000 new jobs.

All this investment is accompanied by a legal framework that supports the development of these new facilities. A recent law from June 2023 establishes measures to accelerate the administrative licensing procedures for new nuclear installations, including SMR, if they are located on sites where nuclear installations already exist.

In June 2024, the first application for a construction license for an SMR was submitted in this country by a start-up called Jimmy[7].

Currently, there is no data available in this country regarding the generation of radioactive waste in these new types of reactors. In any case, following the general rule adopted for all Basic Nuclear Installations in France, any construction application must be accompanied by estimates of waste generation and cost calculations.

In the **United States**, several State policies support the development of SMR and AMR. The Department of Energy (DOE), through its Office of Nuclear Energy, promotes the advancement of nuclear technology and science to meet the country's energy and environmental needs. Among the DOE's programs and projects, the Advanced Reactor Demonstration Program (ARDP)[8] stands out with three pathways to support the demonstration of advanced reactors through public-private partnerships.

- Pathway 1: Advanced Reactor Demonstrations, with projects such as TerraPower's Natrium reactor and X-energy's Xe-100 reactor, aiming to operate within 5-7 years.
- Pathway 2: Risk Reduction for Future Demonstrations, supporting projects like Kairos Power's KP-FHR, Holtec's SMR-300, Westinghouse’s eVinci, BWX Technologies’ BANR, and Southern Company’s Molten Chloride Fast Reactor
- Pathway 3: Advanced Reactor Concepts 2020 (ARC 20), with projects such as General Atomics' Fast Modular Reactor, Advanced Reactor Concepts’ Advanced Sodium-Cooled Reactor Facility, and Mass. Institute of Technology’s Horizontal Compact High-Temperature Gas Reactor.

[7] https://www.francetvinfo.fr/societe/nucleaire/une-start-up-depose-la-premiere-demande-d-autorisation-pour-un-mini-reacteur-nucleaire-en-france_6515660.html
[8] https://www.energy.gov/ne/advanced-reactor-demonstration-program

Another program promoted by DOE is the Advanced SMR RD&D Program. Initiated in 2019, this program supports the research and deployment of SMR technologies. This program supported development of the NuScale VOYGR project[9]. The DOE has offered several additional funding opportunities, including funding assistance for multiple projects across the U.S. under the 2018 Funding Opportunity for Advanced Technology Development [10]; and loan guarantees offered by the DOE's Loan Program Office (LPO) which support advanced nuclear projects, including SMR[11].

The nuclear regulator (Nuclear Regulatory Commission, NRC) is also involved in the development process of these new reactors. The NRC has issued design approvals and certifications for the NuScale US600[12]. The NRC has also issued a construction permit for the Kairos Hermes low-power test reactor and is currently reviewing a construction permit application for the Kairos Hermes-2 project[13].

The response from the United States also provides abundant information about additional applications that are currently under review by NRC, pre-application activities and interactions between NRC and potential applicants, rulemaking and policy work underway at NRC, and siting decisions that have been announced by private entities. These efforts reflect a coordinated approach between the government and the private sector to advance SMR technology, contributing to energy independence and environmental sustainability in the United States.

Regarding the consideration of radioactive waste generated in all these new projects, in any case, the new SMR projects must comply with regulations that minimize waste generation and facilitate future decommissioning. The disposal of LILW is the responsibility of the states, while the disposal of SF and HLW is a federal responsibility according to the Nuclear Waste Policy Act.

2. Consideration of Specific Financial Mechanisms (question 1c)

Within the first set of questions, the questionnaire inquires whether national policies include specific provisions for financing the costs associated with radioactive waste generated by SMR:

In **Argentina**, the costs associated with the storage of radioactive waste must be included in the total cost estimate for the development of the SMR. This means that they must be considered in the financial analysis to decide if the prototype is economically viable. Regarding the costs of disposal, it has not yet been decided whether these will be covered by the waste management funds provided by the operators or if a special charge will be created for the SMR operator.

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[9] https://www.energy.gov/ne/advanced-small-modular-reactors-SMR , https://www.nuscalepower.com/en/news/press-releases/2023/uamps-and-nuscale-power-agree-to-terminate-the-carbon-free-power-project

[10] For more information on awards, https://www.energy.gov/ne/map-nuclear-energy-industry-foa-awardees-data-table

[11] https://www.energy.gov/sites/default/files/2022-05/DOE-LPO22-PPTv02_LPO-Overview-Slides.pdf, https://www.energy.gov/sites/default/files/2020/01/f70/DOE-LPO-Nuclear-Energy-Jan2020.pdf .

[12] https://www.nrc.gov/reactors/new-reactors/smr/licensing-activities/nuscale.html

[13] https://www.nrc.gov/reactors/non-power/new-facility-licensing/hermes-kairos/dashboard.html

In **Bangladesh**, there is no specific national policy for SMR, and therefore the costs associated with this type of waste have not been estimated. For the two new projected nuclear plants (which are not SMR), the national policy for the management of radioactive waste and spent nuclear fuel from 2019 requires producers to store the spent fuel for a minimum of 10 years. The financing system in place includes a radioactive waste management fund to cover long-term obligations, with contributions from the waste generators. These provisions are likely to be applicable to SMR waste management, if the country approves their development.

The response from **Slovakia** indicates that there is no special information or plan regarding the generation of SMR waste, nor have specific plans been developed for these costs.

In **France**, this type of information is not yet available either, with the general rule being the polluter pays principle. Operators of Basic Nuclear Installations are required to contribute financially to the management of the waste they generate, intended to finance the operations of the National Agency for Radioactive Waste Management (Andra). However, Andra has the right to refuse to manage this type of waste, which would be a major problem since this agency has a monopoly on radioactive waste management in the country.

A similar response is offered by the **United Kingdom**, where the current policy does not include specific cost estimates for SMR waste. Under the Energy Act 2008, a nuclear power plant operator needs to provide and grow a separated fund which will pay for the decommissioning costs, and the waste and spent fuel management costs of the plant. A plan for doing this must be approved by the UK Government before construction can start. To date, no Funded Decommissioning Programme has been put forward for an SMR or AMR, and so currently, the possible destination and associated costs of LILW generated during the operation of new SMR are being investigated by prospective reactor vendors and operators. The price that would have to be paid for transferring spent fuel to the future DGR, assuming there are no industry proposals for reprocessing, is also being studied.

In the **United States**, LILW generated during the operation of nuclear power plants is the responsibility of the license holder. Applicants for licenses who are not considered "electric utilities" must demonstrate their financial qualifications to cover estimated operating costs. Commercial power rector licensees must also provide NRC with reasonable assurance that funds will be available for decommissioning. All current commercial power reactor licensees have established Nuclear Decommissioning Trusts as the main source of funding for decommissioning. In the specific case of decommissioning financing for SMRs and AMRs, the NRC has indicated that it would manage such issues in the near-term on a case-by-case basis using design-specific decommissioning cost estimates with possible exemptions to the general requirements.The above refers to the management costs of LILW during operation and decommissioning of the nuclear facilities. Regarding the costs of disposal of SF and HLW, U.S. law authorizes the DOE to sign contracts with entities that generate or possess spent nuclear fuel for its transportation and final disposal. Historically, utility companies have paid fees to the Nuclear Waste Fund to cover the costs of disposing of SF and HLW. The financing for SMR and AMR would, in principle, not be different from that established for other nuclear power plant owners.

The DOE is working on two reports: one public report on strategies for the disposal of SF and waste from advanced reactors, and another for internal use, based on information received from vendors, with technical assessments of the feasibility of storage, transportation, and disposal of SF from advanced reactors and its economic implications[14].

In conclusion, no country has detailed specific provisions regarding the costs associated with radioactive waste generated by SMR. In some cases, it is indicated that, as a general rule, estimates should be provided with the initial budgets; however, there does not appear to be confidence in the accuracy of this information. Only the United States emphasizes in its response that the management of SMR/AMR waste is being addressed on a case-by-case basis.

3. Expected Inventory and Characteristics of Radioactive Waste from SMR (question 2, a, b, and c)

Information about inventories of existing waste and of estimates for the short and medium term is commonly made available in countries with nuclear power, and certainly in those participating in the questionnaire. An open and easy source for this are the national reports to the Joint Convention on the Safety of Spent Fuel Management and on the Safety of Radioactive Waste Management (hereinafter, Joint Convention)[15]. Finding estimates on SMR and AMR radioactive waste generation in those inventories is a different matter. The questionnaire included questions about SMR radioactive waste inventory estimates as well as the overall radioactive waste inventory. This approach aimed to use the general radioactive waste data to contextualize the proportion of waste derived from SMR in relation to the total.

In **Argentina**, the radioactive waste generated in CAREM-25, according to the available information, will consist of LILW and VLLW which is being considered under the existing regulatory frameworks. No information is currently available about the expected amounts of SF. The inventories of the operating plants are specified in the national report for the Joint Convention[16]. Quantitative estimates of waste generated in SMR are not yet mentioned, but this report indicates the temporary storage facilities at the CAREM site among its planned facilities. When asked if the physic-chemical and radiological characteristics of the waste expected to be generated are known, the respondent indicates that there will be no difference from other PWRs in the case of SMR based on this prototype.

In **Bangladesh**, there is no expected inventory for SMR.

The response from **Slovakia** refers to the facilities that currently exist for the two operating nuclear power plants, which consist of a surface disposal facility for LILW and a storage facility of SF. There are no specific provisions yet for SMR waste, and they will need to be included in the national program that covers all radioactive waste under the country's jurisdiction. The existing comprehensive storage and disposal infrastructure could include SMR waste. No inventory estimates are provided at this time.

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[14] For a summary of these projects see https://www.nwtrb.gov/docs/default-source/meetings/2023/august/ned-larson.pdf?sfvrsn=4

[15] Joint Convention on the Safety of Spent Fuel Management and on the Safety of Radioactive Waste Management, adopted in 1997, International Atomic Energy Agency (IAEA).

[16] This includes the two units of Atucha Nuclear Power Plant and one unit of Embalse Nuclear Power Plant, as specified on page 41 of the 2020 national report: *https://www.argentina.gob.ar/arn/informe-nacional-la-convencion-conjunta*

The inventories in the **United Kingdom** are made public on the website[17] (as in the case of France, spent fuel is not currently counted as radioactive waste). Current plans do not include estimates of radioactive waste from SMR or AMR.

In **France**, Andra is responsible for compiling and publishing the national inventory of radioactive materials and waste located on French territory every year. Every five years, Andra also publishes a report on the estimated management capacities and a proposal on the investments needed for efficient management. The last report (2023) does not include any information about SMR. However, since the pluriannual energy program requires the conduction of studies on that matter, Andra judges that the prospects of the use of SMR in France need to be defined more precisely in order to project an estimation of their waste disposal. The next prospective report, due in 2028, should then include provisions on SMR & AMR.

In the **United States**, there is abundant information on the waste inventories of reactors operational to date, based on the reports that nuclear facility operators submit annually to the NRC. The DOE has undertaken several projects to understand the quantity and characteristics of the SF that will be generated by SMR and AMR. For example, the ONWARDS Project (Optimizing Nuclear Waste and Advanced Reactor Disposal Systems) comprises eleven individual projects aimed at reducing waste volume in AMR. Another example of a project promoted by DOE is "Nuclear Waste Attributes of SMR Scheduled for Near-Term Deployment – Nuclear Fuel Cycle and Supply Chain" (DOE, ANL/INL): this study compared the waste from three small reactors scheduled for near-term deployment (VOYGR, Natrium, and XE-100) with that of a large reference Pressurized Water Reactor (PWR). It was found that SMR waste showed similarities to the large reference reactor and some potentially significant differences. Overall, this study concluded that “assuming appropriate waste management and system design and operational optimization, there appear to be no major challenges to the management of SMR wastes compared to the reference [reactor].”

The DOE and NRC have conducted investigations to better understand the issues associated with the storage and management of SF generated by advanced reactors. These investigations include different types of fuel, such as metallic fuel, tristructural isotropic (TRISO) fuel, and molten salt reactor (MSR) fuel.

4. Specific Provisions for Radioactive Waste from SMR, Different from Those Applicable to Other Radioactive Waste (questions 3, 4a, and 4b)

Question 3 of the questionnaire refers to specific binding provisions that have been developed in laws (question 3) or regulatory standards (question 4) related to SMR and different from those existing for other nuclear facilities.

Argentina does not specify unique provisions for SMR waste.

Bangladesh mentions the IAEA Country Nuclear Power Program but does not provide specific details.

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17 https://www.gov.uk/government/publications/uk-radioactive-waste-and-material-inventory-2022

Slovakia has not yet developed specific binding provisions that regulate the safety of SMR, but it is following the conclusions and recommendations of organizations such as the OECD-NEA with interest. Among the plans announced by the government to increase the country's electrical capacity, including the possible development of SMR, is the "improvement of administrative processes for connecting new sources to the electricity system", which may include the development of new regulatory standards.

The response from the **United Kingdom** indicates that there is currently no specific legislation distinct from the general regulations regarding SMR or AMR, neither at the level of laws or regulations nor regulatory standards.

France has an identical response, clarifying that "the French legal framework was designed for Basic Nuclear Installations and is not (yet) adapted to SMR. It is therefore possible that it will evolve to take into account specific characteristics of SMR."

The **United States** indicates, like other countries, that general provisions on the management of radioactive waste will also apply to SMR and AMR. Although exclusive standards for SMR and AMR have not been developed, the NRC uses the existing regulatory framework and can apply specific requirements through license conditions, orders, and exemptions from current regulations. The requirements for SMR and AMR waste management can be included in the current regulations through modifications and updates, ensuring that the challenges these reactors may present are adequately addressed[18]. If additional or more specific requirements are needed for the management of SMR and AMR waste, these will be achieved through specific licensing requirements or new regulations promulgated by the NRC.

5. Public Information and Participation Campaigns Regarding Radioactive Waste from SMR (questions 5a, b, c, and d)

The fifth set of questions in the questionnaire refers to public information and participation campaigns, both regarding the development of SMR and AMR and their waste. Again, the question focuses specifically on the waste from SMR and not on the generality of radioactive waste generated in existing or decommissioned facilities.

Argentina indicates that abundant information has been disseminated about the CAREM-25 project, although these campaigns have not specifically focused on the backend. It is noted that, according to existing legislation, neither the province nor the municipality has jurisdiction to decide on the location of radioactive waste storage and disposal facilities.

This is also the case in **Bangladesh**. The response from this country highlights the general support for the project to build a new nuclear power plant, although it is not an SMR, and describes the steps of public information and communication about this project.

In **Slovakia**, public participation is mandatory for new nuclear projects; however, no special plans for SMR/AMR are available. It is interesting to note that Slovakia is being consulted regarding the development of an SMR in Poland, within the framework of the transboundary environmental assessment. Additionally, the development plans for SMR in

[18] More information available in https://www.nrc.gov/reactors/new-reactors/smr/policy-development/resolved-policy.html

Slovakia have been widely discussed in news and press releases, and it is presumed that the existing site at Bohunice NPP will likely host the new facilities. The municipality is familiar with the operation of the plant and, in principle, accepts the new nuclear developments.

In the **United Kingdom**, although the energy policy and the location of the future DGR are being publicly debated, public information and participation campaigns are not yet explicitly addressing the issue of radioactive waste from SMR and AMR. CoRWM, a committee that provides independent scrutiny and transparent advice to the UK governments on the long-term management of HLW, has raised the issue in its 2024 Position Paper on Waste from SMR and AMR.

France has a solid infrastructure for public debate, with the *Commission Nationale du Débat Public* (created in 1997 to supervise consultations, transparency, and conciliation), which is expected to eventually promote and supervise a debate on the development, project per project, of SMR & AMR and the proposed management of the waste generated. As mentioned, very recently (June 2024), a start-up submitted the first application for the construction of an SMR, receiving wide media coverage.

In the **United States**, a consent-based approach strategy is being implemented to select a DGR site for civil SF and HLW. Since 2023, the DOE has allocated special funds to work with communities interested in hosting the site. The DGR would accommodate SF and HLW from reactors already in operation and eventually from future SMR and AMR.

The DOE has carried out communication campaigns directed both at the general public and potential host communities to explain the development of SMR and the management of the waste they generate. These campaigns aim to raise awareness about the specific nature of SMR and AMR waste. Notable among these is the initiative in which the DOE has awarded funding to the Energy Communities Alliance Inc. and the American Nuclear Society to disseminate knowledge about advanced reactors to the public.

6. Other Relevant Aspects (question 6)

A last question is introduced to allow the respondents express opinions not included in the previous parts. Here is a summary of their comments:

Argentina points out that there is no substantial difference of the CAREM project with other reactors. The same management principles and methods apply.

In **Bangladesh**, the demand for electricity is very high considering the country's growth and demographic characteristics. The nuclear power plant under construction will be the first experience in introducing nuclear power, and experts suggest waiting for the results of this new plant before making further decisions to develop SMR.

In **Slovakia**, according to the respondent, the main challenge will be to adapt the existing standards for operational plants to the specific characteristics of SMR. For now, it seems that the official bodies' position is strict considering that SMR should be treated like any other nuclear installation.

The representative from the **United Kingdom** indicates that the main problem is that the characteristics and amounts of radioactive waste and spent fuel from SMR and AMR are still unknown, which makes it very difficult to debate whether they can all be accommodated in the DGR, at least without special processing. CoRWM has published a Position Paper to flag the issue and promote debate.

In **France**, the primary issue for SMR & AMR would be whether their waste could actually be processed and managed with the infrastructures hosting “traditional” reactors’ waste, or whether Andra would accept responsibility over them.

In the **United States**, the respondents indicate that the legal and policy challenges are similar to those associated with the management of SF in general and focus on the need to find a suitable site for the DGR.

C. SOME CONCLUSIONS

We are satisfied with the picture reflected by the questionnaire. It would have been desirable to have a greater number of participating countries, particularly more from Eastern Europe, Scandinavian countries or Canada. Nevertheless, the data collected provides a good, though incomplete, picture of the countries planning to license SMR and AMR in the coming years.

Conceptually, we observe how legislators can favor the development of SMR and AMR through measures such as tax incentives (as cited by Argentina) or streamlining the licensing process in some cases (as in France). In the Argentine case, it appears that licensing a CAREM-25 prototype will pave the way for the more agile commissioning of commercial reactors. The chosen model (CAREM-25) seems to generate radioactive waste that is easier to manage as compared to other models available on the market, given the similarities to a PWR. Other countries, however (notably the USA), are expanding the range of reactors under consideration.

Not all responses reflect the same degree of certainty and confidence in the knowledge about SMR and AMR waste. The responses from France or the United Kingdom reflect these doubts and difficulties more intensely than, for example, those from the USA or Argentina. In the American case, there is confidence in being able to address challenges on a case-by-case basis, while the confidence shown by the Argentine respondent derives from the fact that only one model reactor is being evaluated, already with some knowledge about its similarities to a PWR.

In any case, the decision on the technology to be adopted should consider economic and supply factors, but also (in our opinion, very especially) factors related to the management of the expected waste. Therefore, it seems that designs generating waste and spent fuel for which there is greater knowledge today or that are suitable for existing disposal systems should be favored.

The questionnaire also reflects the necessary symbiosis between public support formulas for the development of SMR and AMR and mixed public-private cooperation formulas.

Regarding this, and particularly referring to the responses from France, an important issue is whether existing radioactive waste management agencies should take responsibility for the waste from SMR and AMR. This is especially relevant for agencies that have been funded by contributions from "traditional" nuclear power plants, and whose funds could now be diverted to managing waste from new producers. It is assumed that there should be an economic adjustment so that new producers compensate for using capacities that were not created for them. This adjustment should address questions such as who should bear the cost if an existing design for a DGR needs to be adapted to accommodate this new type of waste; or even who should bear the cost incurred by the authorities when new regulations are necessary.

Concerning the financing of SMR and AMR waste management, all respondents agree on applying the polluter-pays principle. However, there seem to be different approaches on whether an initial guarantee should be required from new SMR to cover future waste management and decommissioning costs, or if their financing can "join" existing systems by requiring new operators to make periodic contributions to the fund, without needing a substantial initial guarantee. Ultimately, this boils down to a matter of trust: will we treat new producers the same way we treat current NPP licensees, or will we demand high additional guarantees from them? Judging by the responses given, the dilemma is usually resolved in favor of trusting new producers, reflecting State support for these projects.

An added problem is how to calculate the costs to manage an inventory that is still unknown. Generally, all countries are deliberating the same issue. The only respondent who has provided some specificity is from the USA, stating that, initially, contributions should be imposed case-by-case for both operational waste management expenses and decommissioning.

As we have noted, inventory estimates are still lacking. Several countries have indicated that upcoming national policies (Slovakia) or the next edition of inventories (France) should already include this data.

To the question of whether there is legislation or regulation specifically aimed at SMRs and AMRs, the common response is negative. The respondent from the USA repeatedly explains that any specific requirements in addition to the existing, generally applicable regulations will initially be defined through the licensing terms, adopted case-by-case. This could make the USA a pioneer in regulating SMRs and AMRs when reactors with the same technical characteristics start to be built worldwide. In this regard, it is important to highlight the efforts of public agencies, particularly the NRC, to follow the technical developments occurring in the private sector. If those who know the technical characteristics of the new reactors best are their proponents (the industry), it is essential that the regulator does not lag too far behind in its capacity to evaluate these proposals from a nuclear safety perspective.

Finally, the public debate around SMR waste is generally underdeveloped. There are two necessary debates: the first, which is occurring to varying degrees in all countries, is about the advisability of developing SMR and AMR; the second is about the disposability of their radioactive waste.

Regarding the selection of sites for SMR and AMR, the responses from Slovakia and France are symptomatic, pointing out the preference for choosing locations with existing nuclear facilities where local populations already trust the activities being carried out. Additionally, it is interesting to note Slovakia's comment about its participation as a consulted country in the evaluation of its neighbor Poland.

Regarding the fate of waste from SMR and AMR, the responses from France and the United Kingdom reflect gaps in information about the nature and quantities of the radioactive waste and spent fuel that could be disposed of in a DGR. In the UK's case, the most urgent debate in the respondent's opinion is about determining whether radioactive waste/ spent fuel from SMR and AMR would be suitable for disposal in the planned DGR. Understanding what is included in the inventory for disposal will be important for communities in the UK Government's consent-based siting DGR process prior to deciding whether they wish to host a DGR in their area. . In the French case, this is complicated by the decision that needs to be made about whether Andra will take responsibility for these new types of waste.

The country that has already begun active information campaigns about the nature and possible management routes for SMR and AMR waste is the United States.

We can conclude that there are still many steps to take. First, sufficient knowledge must be acquired about the waste that can be generated in this new type of reactors; this knowledge should allow us to refine our inventory estimates and consequently the associated costs of their treatment and final disposal. Second, the regulatory framework specifically addressing SMR and AMR needs to be improved. In this sense, an approach like the US one suggests that it is preferable to go step by step and establish safety conditions for each case that arises, rather than trying to establish a one-size-fits-all regulatory framework a priori.

It has been a satisfaction to compose this study, and I believe all participants have learned from it. Surely, in the coming years, similar studies will be conducted that will reflect a greater maturation of all these issues.

***** The task group has determined that, given its level of detail and the interest of this information for other countries developing SMR/AMR, it is appropriate to include the responses given by the U.S. to the questionnaire as an annex to the report*****

ANNEX: USA responses

INLA WG 5, Task Group "SMR & AMR waste"

Draft July 26, 2023

Name, country and affiliation of the respondent:

Jerry Bonanno

United States of America

Nuclear Energy Institute

Date: 21 March 2024

1. **Plans and policy for the development of Small Modular Reactors (SMR) and Advanced Modular Reactors (AMR)**

1a) Please, describe the plans in your country to develop SMRs & AMR.

Please provide, if possible, the following information:

- ***The estimated time schedules and steps in those plans, such as generic design approval, justification, pre-licensing and licensing activities (estimate years of site selection, start of construction, start of operation, estimates for operation and closure & decommissioning)***

- ***Changes (if any) to timelines for projects which have been proposed***

- ***Origins of this information, i.e., are timelines set out in regulation or are they based on statements by industry/designers/the regulator?***

In the United States, private entities are the applicants for commercial SMR/AMR projects. The Nuclear Regulatory Commission (NRC) licenses and regulates the civilian use of radioactive materials to provide reasonable assurance of adequate protection of public health and safety, to promote the common defense and security, and to protect the environment. (https://www.nrc.gov/about-nrc.html) This includes the licensing and regulation of commercial reactors used to generate electric power, as well as reactors used for research, testing, and training. The Department of Energy's (DOE) Office of Nuclear Energy's mission is to advance nuclear energy science and technology to meet U.S. energy, environmental, and economic needs. (https://www.energy.gov/ne/about-us). Several states in the U.S. are also implementing or considering policies that will support the development of new nuclear deployment, including SMR/AMRs. (For more on state policies see https://www.nei.org/CorporateSite/media/filefolder/resources/reports-and-briefs/Compendium-January-2023.pdf).

The information below describes examples of several projects or initiatives underway by DOE, NRC, and private entities to support commercial deployment of SMR/AMRs in the United States. This list is not all encompassing but is meant to give the reader a sense of the scope and scale of projects and initiatives that are underway.

DOE

Advanced Reactor Demonstration Program: DOE's Advanced Reactor Demonstration Program (ARDP) supports the demonstration of advanced reactors through private-public cost-share partnerships (~50/50 cost shares). The ARDP provides support through three pathways:

- *Pathway 1 - Advanced Reactor Demonstrations*: The goal of this pathway is to test, license, and build operational reactors within 5-7 years. This pathway of the ARPD program is supporting the commercial deployment and demonstration of the TerraPower Natrium reactor and the X-energy Xe-100 reactor.

- *Pathway 2 - Risk Reduction for Future Demonstrations:* The goal of this pathway is to solve technical, operational, and regulatory challenges to support demonstration within 10-14 years. Projects under this pathway include Kairos Power's KP-FHR (fluoride salt-cooled high-temperature reactor), Westinghouse Nuclear's eVinci (heat pipe-cooled microreactor), BWXT's BANR (high-temperature gas-cooled microreactor), Holtec International's SMR-160 (advanced light-water small modular reactor), and Southern Company's Molten Chloride Fast Reactor.

- *Pathway 3 - Advanced Reactor Concepts 2020 (ARC 20)*: The goal of this pathway is to solidify concept to mature technology for potential demonstration by mid-2030s. ARC 20 projects include Advanced Reactor Concepts'[19] Advanced Sodium-Cooled Reactor Facility, General Atomics' Fast Modular Reactor, and Mass. Institute of Technology's Horizontal Compact High-Temperature Gas Reactor.

For more information on ARDP see https://www.energy.gov/ne/advanced-reactor-demonstration-program.

Advanced SMR RD&D Program: The DOE's Advanced SMR R&D program was initiated in FY2019 and supports research, development, and deployment activities to accelerate the availability of U.S.-based SMR technologies into domestic and international markets by the late 2020s or early 2030s. This program supported the commercial deployment and demonstration of the NuScale VOYGR (NuScale Power and Utah Associated Municipal Power Systems). For more information see https://www.energy.gov/ne/advanced-small-modular-reactors-smrs. Although the NuScale project with UAMPS Carbon Free Power Project was recently terminated, NuScale's announcement indicates that the lessons learned from the project will carry forward into the company's future development work. For more information see https://www.nuscalepower.com/en/news/press-releases/2023/uamps-and-nuscale-power-agree-to-terminate-the-carbon-free-power-project.

Funding Opportunity for Advanced Technology Development: In 2018, DOE issued a multi-year cost-shared funding opportunity to support innovative, domestic nuclear industry-driven concepts that have high potential to improve the overall economic outlook for nuclear in the U.S. Multiple projects across the U.S. have been awarded assistance under

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[19] Since issuance of the ARC 20 support Advanced Reactor Concepts has changed its name to "arc clean technology" (https://www.arc-cleantech.com/).

this broad funding opportunity. For more information on awards please see https://www.energy.gov/ne/map-nuclear-energy-industry-foa-awardees-data-table.

Loan Program Office: The DOE Loan Program Office (LPO) has $10.9 billion in loan guarantees available for advanced nuclear projects. The loan guarantees can be for advanced nuclear reactors including small modular reactors, uprates and upgrades at existing facilities and front-end of the fuel cycle projects (conversion, enrichment and fuel fabrication). LPO can offer 100% guarantee of U.S. Treasury's Federal Finance Bank (FFB) loans or partial guarantees of commercial loans. The following are links to a slide deck providing an overview of LPO and a fact sheet on the advanced nuclear energy loan guarantees.

- https://www.energy.gov/sites/default/files/2022-05/DOE-LPO22-PPTv02_LPO-Overview-Slides.pdf.
- https://www.energy.gov/sites/default/files/2020/01/f70/DOE-LPO-Nuclear-Energy-Jan2020.pdf.

NRC

Completed licensing/certification/approval activity

- Standard Design Approval issued for NuScale US600 small modular reactor issued (9/11/2020)
- Standard Design Certification issued for NuScale US600 small modular reactor issued by final rule (1/19/2023). Information on this review can be found here https://www.nrc.gov/reactors/new-reactors/smr/licensing-activities/nuscale.html.
- Kairos Power Construction Permit issued (12/14/23) for Hermes low-power test reactor to support development of Kairos Power's fluoride salt-cooled, high-temperature reactor technology in Oak Ridge, TN. Progress and timelines on this review can be found here https://www.nrc.gov/reactors/non-power/new-facility-licensing/hermes-kairos/dashboard.html.

Applications under review / approvals issued

- Abilene Christian University Construction Permit Application under review for Molten Salt Research Reactor in Abilene, TX. Progress and timelines on this review can be found here https://www.nrc.gov/reactors/non-power/new-facility-licensing/msrr-acu/dashboard.html.
- Kairos Power Construction Permit Application under review for Hermes 2 test reactor in Oak Ridge, TN. Progress and timelines on this review can be found here https://www.nrc.gov/reactors/non-power/new-facility-licensing/hermes2-kairos/dashboard.html.

- NuScale Standard Design Approval under review US 460 light water SMR. Progress and timelines on this review can be found here https://www.nrc.gov/reactors/new-reactors/smr/licensing-activities/current-licensing-reviews/nuscale-us460.html.

Pre-Application Activities/Interactions Between NRC and Potential Applicants

- General Atomics – Energy Multiplier Module (https://www.nrc.gov/reactors/new-reactors/advanced/licensing-activities/pre-application-activities/genatom.html)
- General Atomics – fast modular reactor (https://www.nrc.gov/reactors/new-reactors/advanced/licensing-activities/pre-application-activities/general-atomics)
- Kairos Power – fluoride salt-cooled high temperature reactor (https://www.nrc.gov/reactors/new-reactors/advanced/licensing-activities/pre-application-activities/kairos.html)
- Westinghouse – eVinci micro reactor (https://www.nrc.gov/reactors/new-reactors/advanced/licensing-activities/pre-application-activities/evinci.html)
- TerraPower/GE Hitachi – Natrium sodium fast reactor (https://www.nrc.gov/reactors/new-reactors/advanced/licensing-activities/pre-application-activities/natrium.html)
- TerraPower – molten chloride fast reactor (https://www.nrc.gov/reactors/new-reactors/advanced/licensing-activities/pre-application-activities/mcfr.html)
- Terrestrial Energy – Integral Molten Salt Reactor (https://www.nrc.gov/reactors/new-reactors/advanced/licensing-activities/pre-application-activities/imsr.html)
- X-energy – Xe-100 pebble-bed, high-temperature gas-cooled reactor (https://www.nrc.gov/reactors/new-reactors/advanced/licensing-activities/pre-application-activities/xe-100.html)
- ARC Clean Technology – ARC-100 Sodium-Cooled Fast Reactor (https://www.nrc.gov/reactors/new-reactors/advanced/licensing-activities/pre-application-activities/arc-100.html)
- Oklo – Aurora Powerhouse reactor, liquid metal-cooled, metal-fuel fast reactor (https://www.nrc.gov/reactors/new-reactors/advanced/licensing-activities/pre-application-activities/okla-aurora-powerhouse.html)
- University of Illinois Urbana-Champaign – Ultra Safe Nuclear Corporation's Micro Modular Reactor (MMR), high-temperature gas-cooled research reactor (https://www.nrc.gov/reactors/new-reactors/advanced/licensing-activities/pre-application-activities/university-of-illinois-at-urbana-champaign.html)

Rulemaking/Policy Development

- Risk Informed, Technology-Inclusive Regulatory Framework for Advanced Reactors ("Part 53 Rulemaking"): The NRC staff provided a proposed rule on March 1, 2023

(SECY-23-0021 (https://www.nrc.gov/docs/ML2116/ML21162A093.html) for Commission approval that offers a voluntary, performance-based alternative regulatory framework for licensing future commercial nuclear plants, including non-light-water reactors (non-LWRs) and LWRs. The Commission recently directed the NRC staff to modify and publish the proposed rule for comment. SRM-SECY-23-0021 (https://adamswebsearch2.nrc.gov/webSearch2/main.jsp?AccessionNumber=ML24064A047). Once finalized, the Part 53 Rulemaking would be available in addition to the existing licensing frameworks provided in 10 CFR Parts 50 and 52.

- Alignment of Licensing Processes and Lessons Learned from New Reactor Licensing Rulemaking: This rulemaking would amend the NRC's regulations for the licensing of new reactors. The rule would align requirements between the two licensing processes provided in the NRC's regulations to ensure that all new reactor applications conform to the NRC's policies and requirements, regardless of the selected licensing approach. The rule would address lessons learned from NRC reviews conducted for combined licenses, design certifications, early site permits, and operating licenses. (https://www.nrc.gov/reading-rm/doc-collections/rulemaking-ruleforum/active/ruledetails.html?id=27).

- Physical Security Rulemaking: The NRC staff has developed preliminary proposed rule language to amend its physical security requirements for small modular reactors and other advanced reactor technologies. The goal of the rulemaking is to provide regulatory stability, predictability, and clarity in the licensing process and minimize or eliminate uncertainty for applicants who might otherwise request exemptions from the regulations. (https://www.nrc.gov/reading-rm/doc-collections/rulemaking-ruleforum/active/ruledetails.html?id=76)

- Emergency Preparedness Rulemaking: The Commission recently approved publication of a final rule that would amend the agency's existing regulations to include new alternative emergency preparedness requirements for small modular and advanced reactors. (https://www.nrc.gov/docs/ML2120/ML21200A055.html).

- Advanced Nuclear Reactor Generic Environmental Impact Statement: The NRC staff has provided a proposed rule (SECY-21-0098) for Commission approval that would codify the findings of the draft Advanced Nuclear Reactor Generic Environmental Impact Statement. (https://www.nrc.gov/docs/ML2122/ML21222A044.html)

- Fuel Qualification for Advanced Reactors: In 2022, the NRC issued NUREG-2246 "Fuel Qualification for Advanced Reactors." The purpose of this report is to identify criteria that will be useful for advanced reactor designers through an assessment framework that would support regulatory findings associated with nuclear fuel qualification. (https://www.nrc.gov/reactors/new-reactors/advanced/rulemaking-and-guidance/fuel-qualification.html)

- Industry-Led Licensing Modernization Project: In 2020, the NRC issued Regulatory Guide 1.233 "Guidance for a Technology-Inclusive, Risk-Informed, and Performance-Based Methodology to Inform the Licensing Basis and Content of Applications for Licenses, Certifications, and Approvals for Non-Light-Water Reactors." This regulatory guide endorsed the methodology described in NEI 18-04, Revision 1, "Risk-Informed Performance-Based Guidance for Non-Light Water Reactor Licensing Basis Development," as an acceptable approach for informing the licensing basis and determining the appropriate scope and level of detail for parts of applications for licenses, certifications, and approvals for non-LWRs. (https://www.nrc.gov/reactors/new-reactors/advanced/rulemaking-and-guidance/industry-led-licensing-modernization-project.html)

- Non-Light Water Reactor Design Criteria: In 2018, the NRC issued Regulatory Guide 1.232 "Guidance for Developing Principal Design Criteria for Non-Light-Water Reactors." The guidance provided in this Regulatory Guide was the result of a joint initiative between the NRC and DOE. (https://www.nrc.gov/reactors/new-reactors/advanced/rulemaking-and-guidance/nrc-doe-joint-initiative-non-lwr-design-criteria.html).

- American Society of Mechanical Engineers Section III Division 5: In 2023, the NRC issued Revision 2 of Regulatory Guide 1.87 "Acceptability of ASME Section III, Division 5, High Temperature Reactors." This regulatory guide endorses, with exceptions and limitations, the American Society of Mechanical Engineers (ASME) Boiler and Pressure Vessel (BPV) Code (ASME Code) Section III, "Rules for Construction of Nuclear Facility Components," Division 5, "High Temperature Reactors," and Code Cases N-861, N-862, N-872, and N-898. The document describes an approach that is acceptable to the NRC staff to assure the mechanical/structural integrity of components that operate in elevated temperature environments and that are subject to time-dependent material properties and failure modes. (https://www.nrc.gov/reactors/new-reactors/advanced/rulemaking-and-guidance/asme-bpv-code-section3-div5.html).

- American Society of Mechanical Engineers / American Nuclear Society RA-S-1.4 Probabilistic Risk Assessment Standard for Advanced Non-Light Water Reactor Nuclear Power Plants: In 2021, ASME/ANS issued the advanced non-light water reactor PRA standard, ASME/ANS RA-S-1.4-2021, "Probabilistic Risk Assessment

Standard for Advanced Non-Light Water Reactor Nuclear Power Plants." In 2022, the NRC endorsed the standard as Trial Regulatory Guide (RG) 1.247 "Acceptability of Probabilistic Risk Assessment Results for Advanced Non-Light Water Reactor Risk-Informed Activities." This new guidance describes one acceptable approach for determining whether the acceptability of the probabilistic risk assessment (PRA) used to support a PRA application is sufficient to provide confidence in the results for non-light water reactors (non-LWRs) and risk-informed activities.

- International Cooperation: Information on NRC's collaborative projects with Canada can be found here: https://www.nrc.gov/reactors/new-reactors/advanced/who-were-working-with/international-cooperation.html.

Private Entities

Siting Decisions

- In May 2023, Dow and X-Energy Reactor Company announced that Dow has selected its Seadrift Operations manufacturing site in Texas for a proposed small modular reactor nuclear project. The project is focused on providing the site with power and steam, as existing assets near their end-of-life. (https://corporate.dow.com/en-us/news/press-releases/dow-s-seadrift--texas-location-selected-for-x-energy-advanced-sm.html).
- In May 2021, Kairos Power and the Tennessee Valley Authority (TVA) jointly announced the deployment of its Hermes low-power demonstration reactor in the East Tennessee Technology Park (ETTP) in Oak Ridge, Tennessee.
- In November 2021, TerraPower formally selected Kemmerer, Wyoming as the site of its Natrium demonstration reactor.

1b) Please, describe the consideration of waste and waste estimates in those plans.

E.g.: Is a requirement set to optimize waste? Are management and disposal routes for waste contemplated in those plans?

Waste Disposal

Low-Level Radioactive Wastes (LLRW)

In the United States, the disposal scheme for LLRW is set out in the Low-Level Radioactive Waste Policy Amendments Act of 1985 (LLRWPAA). The LLRWPAA defines LLRW as radioactive material that –

- is not high-level radioactive waste, spent nuclear fuel, or byproduct material (as defined in section 11e.(2) of the Atomic Energy Act of 1954); and

- the Nuclear Regulatory Commission, consistent with existing law and in accordance with paragraph (A), classifies as low-level radioactive waste.

The NRC describes LLRW as:

[A] general term for a wide range of items that have become contaminated with radioactive material or have become radioactive through exposure to neutron radiation. Radioactive materials are present at nuclear power plants undergoing decommissioning as the result of plant operations prior to permanent shutdown and as the result of decommissioning activities. Examples include radioactively contaminated equipment, piping, tanks, hardware, and tools; concrete debris and soil; liquid radioactive waste (radwaste) treatment residues; and radioactively contaminated protective shoe covers and clothing; cleaning rags, mops, and filters. The radioactivity in these wastes can range from just above natural background levels to much higher levels, such as seen in components from inside the reactor vessel of a nuclear power plant. LLW from decommissioning activities is typically shipped to a disposal site specifically licensed for disposal of LLW.

(NUREG-1307, Rev. 19, https://www.nrc.gov/reading-rm/doc-collections/nuregs/staff/sr1307/r19/index.html)

The LLRWPAA makes states responsible for disposal of LLRW generated within their borders and establishes a framework for states to form “compacts” to establish regional LLRW disposal facilities. There are currently four commercial LLRW disposal facilities operating in the United States located in Barnwell, South Carolina; Richland, Washington; Clive, Utah; and Andrews, Texas. The Barnwell and Richland sites accept waste from states within their respective compacts, the Clive site accepts waste from all regions of the United States, and the Andrews site accepts waste from generators within the Texas Compact and from other generators with the permission of the Compact. (see https://www.nrc.gov/waste/llw-disposal/licensing/locations.html)

Each year, commercial power reactor licensees submit Radioactive Effluent Monitoring Reports to the NRC. These reports contain information on waste form, waste volume, isotopic content, and shipping of dry active wastes and irradiated components (see https://www.nrc.gov/reactors/operating/ops-experience/tritium/plant-info.html).

Spent Nuclear Fuel and High-Level Wastes

In the United States, the Nuclear Waste Policy Act (NWPA) makes spent fuel (SNF) and high-level waste (HLW) disposal a federal responsibility. Specifically, the NWPA assigns responsibility for SNF and HLW disposal to three Federal agencies:

- *Department of Energy (DOE)* – has responsibility for developing permanent disposal capability for SNF and HLW.
- *Environmental Protection Agency (EPA)* – has responsibility for developing environmental protection standards for disposal of SNF and HLW.
- *Nuclear Regulatory Commission (NRC)* – has responsibility for developing regulations to implement the regulations developed by EPA; licensing the construction, operation, decommissioning, and closure of SNF/HLW repositories; and certifying packages used to transport SNF and HLW to licensed repositories. (see 10 CFR Part 60 “Disposal of High-Level Radioactive Wastes in Geologic

Repositories" and Part 63 "Disposal of High-Level Radioactive Wastes in a Geologic Repository at Yucca Mountain, Nevada"

The NWPA also:

- Authorizes DOE to enter contracts (i.e., "Standard Contract") with any person who generates or holds title to HLW or SNF of domestic origin for the acceptance of title, subsequent transportation, and disposal of such waste or spent fuel.
- Prohibits NRC from issuing or renewing a license to any person to use a utilization or production facility unless such person has entered such a contract or DOE affirms in writing that such person is actively and in good faith negotiating with DOE for such a contract.
- Prohibits spent fuel and HLW disposal in a DOE repository unless the generator or owner has entered a contract with DOE by the later of June 30, 1983, or the date on which the generator or owner commences generation of or takes title to such fuel or waste.

For information regarding DOE's management of the "Standard Contract for Disposal of Spent Nuclear Fuel and/or High-Level Radioactive Waste" see https://www.energy.gov/gc/office-standard-contract-management.

For a background and history of the Yucca Mountain program and license application see the Fourth, Fifth, and Sixth U.S. National Reports for the IAEA Review Meetings of the Joint Convention on the Safety of Spent Fuel Management and on the Safety of Radioactive Waste Management. (https://www.iaea.org/topics/nuclear-safety-conventions/joint-convention-safety-spent-fuel-management-and-safety-radioactive-waste/documents)

Waste Optimization and Management

Optimization

The NRC's Standards for Protection Against Radiation (10 CFR Part 20) require applicants for licenses to construct and operate new reactors under 10 CFR Parts 50 and 52 to describe how the design and procedures for operation of the facility will minimize contamination, facilitate eventual decommissioning, and minimize the generation of radioactive wastes. (*see* 10 CFR 20.1406, https://www.nrc.gov/reading-rm/doc-collections/cfr/part020/part020-1406.html). NRC provides guidance on waste minimization in Regulatory Guide 4.21 "Minimization of Contamination and Radioactive Waste Generation: Life-Cycle Planning." (https://www.nrc.gov/docs/ML0805/ML080500187.pdf).

NRC has also issued a Policy Statement entitled "Low-Level Waste Management and Volume Reduction," recognizing the "substantial progress made by licenses in reducing volumes of LLRW shipped for disposal" and highlighting a continuing emphasis on waste minimization, short-term decay and storage, long-term storage, as well as use of waste processing technologies and alternate disposal methods. (https://www.nrc.gov/docs/ML1502/ML15023A098.pdf). The NRC has pointed out that the cost of LLRW disposal at licensed commercial burial sites has prompted licensees to use process controls and volume reduction to reduce the amount and volume of waste generated. (https://www.energy.gov/em/articles/seventh-national-report-joint-convention-safety-spent-fuel-management-and-safety).

Apart from the general requirement in 10 CFR Part 20 described above, there are more specific requirements governing applications for various types of approvals for new commercial nuclear power plants that require the applicant to provide a description of the design objectives, performance requirements, and procedures governing radioactive waste handling systems. (see 10 CFR 50.34(b), 50.34a.(b)-(e), 52.47(a), 52.79(a), 52.137(a), 52.157(c)).

For example, the NRC's January 19, 2023, final rule certifying the NuScale small modular reactor design incorporated Chapter 11 "Radioactive Waste Management" of the NuScale design certification application by reference. In turn, Chapter 11 provides detailed information on radioactive source terms; liquid, gaseous, and solid waste management systems; the process and effluent radiation monitoring instrumentation and sampling system; and the instrumentation and control design features for process and effluent radiological monitoring, and area radiation and airborne radioactivity monitoring.

Management

The existing regulatory framework for managing low-level radioactive wastes in the U.S. is provided in the NRC's regulations at Subpart K to 10 CFR Part 20 and associated guidance, as well as in state requirements.

Management of spent fuel generated at operating reactors is addressed in the NRC's regulations 10 CFR Part 72. The regulations in this part establish requirements, procedures, and criteria for the issuance of licenses to receive, transfer, and possess power reactor spent fuel, power reactor-related Greater than Class C (GTCC) waste, and other radioactive materials associated with spent fuel storage in an independent spent fuel storage installation (ISFSI) and the terms and conditions under which the Commission will issue these licenses. The regulations in this part also establish requirements, procedures, and criteria for the issuance of licenses to the Department of Energy (DOE) to receive, transfer, package, and possess power reactor spent fuel, high-level radioactive waste, power reactor-related GTCC waste, and other radioactive materials associated with the storage of these materials in a monitored retrievable storage installation (MRS). The term Monitored Retrievable Storage Installation or MRS, as defined in § 72.3, is derived from the Nuclear Waste Policy Act (NWPA) and includes any installation that meets this definition. The regulations in this part also establish requirements, procedures, and criteria for the issuance of Certificates of Compliance approving spent fuel storage cask designs.

1c) Please, explain whether the national policy includes an estimated cost of management for this type of waste and the financing mechanism foreseen to cover this cost.

Low-Level Radioactive Waste Generated During Operation

Management and disposal of LLRW generated during plant operation is generally the responsibility of the NRC licensee and financed by the licensee through operating funds. The NRC requires applicants for licenses to operate commercial power reactors that are not "electric utilities" to demonstrate their financial qualifications to cover estimated operating costs of the facility. *See* 10 CFR 50.33(f)(https://www.nrc.gov/reading-rm/doc-collections/cfr/part050/part050-0033.html).[20] The NRC's regulations also require a demonstration of financial assurance when licensees will cease to be an "electric utility" (*see* 10 CFR 50.76), and in the event of a license transfer to a different entity (*see* 10 CFR 50.80).

LLRW burial fees associated with decommissioning of commercial power reactors are examined and periodically updated by the NRC in a guidance document entitled "Report on Waste Burial Charges: Changes in Decommissioning Waste Disposal Costs at Low-Level Waste Burial Facilities," NUREG-1307, Rev. 19 (Feb. 2023)(www.nrc.gov/docs/ML2304/ML23044A207.pdf). Estimated costs of disposing of LLRW via land burial are factored into the NRC's requirements for decommissioning funding assurance described below.

Decommissioning of Commercial Power Reactors

The NRC defines the term "decommission" as follows:

[T]o remove a facility or site safely from service and reduce residual radioactivity to a level that permits—

(1) Release of the property for unrestricted use and termination of the license; or

(2) Release of the property under restricted conditions and termination of the license.

10 CFR 50.2. Commercial power reactor licensees must provide the NRC with reasonable assurance that funds will be available to decommission the facility at the time of licensing and throughout the life of the facility. This funding assurance is provided through a series of regulatory requirements provided in 10 CFR 50.75. Funding for the decommissioning of power reactors may also be subject to the regulation of Federal or State Government agencies (*e.g.*, Federal Energy Regulatory Commission (FERC) and State Public Utility Commissions) that have jurisdiction over electricity rate regulation. The NRC's requirements are in addition to, and not substitution for, other requirements. As a facility approaches the end of its licensed life (i.e., at or about 5 years prior to projected end of operations), the NRC's regulations require the licensee to submit a site-specific decommissioning cost estimate. This cost estimate should include an "up-to-date assessment of the major factors that could affect the cost to decommission" the facility. 10 CFR 50.75(f)(3).

The acceptable methods of providing decommissioning funding assurance are provided in 10 CFR 50.75(e) and include:

- Prepayment
- External sinking fund
- Surety methods, insurance, or other guarantee method

[20] Historically, entities that meet the definition of "electric utilities" (i.e., "any entity that generates or distributes electricity and which recovers the cost of this electricity, either directly or indirectly, through rates established by the entity itself or by a separate regulatory authority" see 10 CFR 50.2), have relied upon rates set by the States to recover costs of reactor construction and operation.

- Contractual obligations
- Other methods approved by the NRC

Although the NRC regulations provide flexibility with respect to the methods available to provide decommissioning funding, all current commercial power reactor licensees have established Nuclear Decommissioning Trusts (NDTs) as the primary source of decommissioning funding. These NDTs are used to implement either the prepayment or external sinking fund methods of decommissioning funding assurance, depending on whether the licensee has access to rate recovery or a non-bypassable charge to fund decommissioning. The NRC's regulations generally restrict the use of funds set aside for decommissioning until after permanent shutdown and defueling of the reactor. *See* 10 CFR 0.82(a)(8)(ii). The NRC requires licensees to file biennial Decommissioning Funding Status Reports, which are due in March of odd-numbered years (see https://www.nrc.gov/docs/ML1934/ML19346E375.html and https://www.nrc.gov/waste/decommissioning/finan-assur/bi-decom-reports.html).

Where necessary to account for the unique design features of SMRs and AMRs that may affect decommissioning funding assurance, the NRC has indicated that it would manage such issues in the near-term on a case-by-case basis using design-specific decommissioning cost estimates and exemptions to the requirements of 10 CFR 50.75. (see SECY-11-0181 https://www.nrc.gov/docs/ML1126/ML112620358.pdf).

Spent Nuclear Fuel Disposal

As described above in response to Question 1.b, United States law:

- Authorizes DOE to enter contracts (i.e., "Standard Contract") with any person who generates or holds title to HLW or SNF of domestic origin for the acceptance of title, subsequent transportation, and disposal of such waste or spent fuel.
- Prohibits NRC from issuing or renewing a license to any person to use a utilization or production facility unless such person has entered such a contract or DOE affirms in writing that such person is actively and in good faith negotiating with DOE for such a contract.
- Prohibits spent fuel and HLW disposal in a DOE repository unless the generator or owner has entered a contract with DOE by the later of June 30, 1983, or the date on which the generator or owner commences generation of or takes title to such fuel or waste.

All entities that are currently licensed by the NRC use utilization or production facilities in the U.S. have entered contracts with DOE for the disposal of SNF. Historically, utilities that have DOE contracts were also required to pay fees into the Nuclear Waste Fund to cover costs associated with SNF and HLW disposal. This statutory fee was set at $0.001 per kilowatt-hour of electricity generated using nuclear power and was required to be evaluated annually. The fee remained in place until 2014, when it was adjusted to zero pursuant to a court ruling. The court determined that the fee could be reinstated when DOE either resumes compliance with the NWPA and develops the Yucca Mountain repository, or Congress enacts an alternative program. The current balance of the NWF is approximately $46 billion. (https://www.energy.gov/sites/default/files/2022-12/FY22%20-

%20NWF%20Annual%20Financial%20Report%20Summary.pdf). The fund continues to earn interest at a rate of approximately $1.6 billion annually.

DOE is currently working on one public and one proprietary report, which will address different aspects of the management of spent fuel from advanced reactors. The first report, which will be made public once completed is titled "Advanced Reactors Fuel and Waste Streams Disposition Strategies: Spent Fuel and Waste Disposition." This report will leverage DOE's experience with SNF from prior similar reactors to gain insights into issue like: degradation rate behavior constraints, potential for criticality over repository time scales, thermal output per waste package, secondary waste streams (from operations and treatment), potential impacts of alternative fuel cycles. The second set of reports will be proprietary and involve collecting advanced reactor data by engaging the advanced reactor vendors that are voluntarily working with DOE. The objectives of this report are to: (1) make a technical assessment of feasibility of storage, transportation, and disposal advanced reactor SNF; and (2) develop order-of-magnitude cost estimates for storage, transportation, and disposal. These proprietary reports will be used by the DOE General Counsel to inform them of necessary changes to Standard Contract for SMR/AR. For a summary of these projects see https://www.nwtrb.gov/docs/default-source/meetings/2023/august/ned-larson.pdf?sfvrsn=4

2. Expected inventory and characteristics of SMR & AMR waste in your country

2a) Briefly describe the current inventory and characteristics of nuclear waste inventory in your country.

This question refers to radioactive waste not generated at SMR & AMR. Reference can be made to the waste inventory as set out in your national program or in public documents such as the Joint Convention national reports[21]. If so, please facilitate the link and page, or a screenshot of those pages.

Each year, commercial power reactor licensees submit Radioactive Effluent Monitoring Reports to the NRC. These reports contain information on waste form, waste volume, isotopic content, and shipping of low-level dry active wastes and irradiated components (see https://www.nrc.gov/reactors/operating/ops-experience/tritium/plant-info.html).

The U.S. nuclear power industry has generated approximately 84,000 metric tons (MT) heavy metal (MTHM) of spent fuel as of the end of 2019. Of this, 39,000 MTHM is in dry storage at NPP sites. Most of the U.S. commercial spent fuel will remain stored at NPPs until a disposition path is identified. Some spent fuel is also being stored away from NPPs. DOE's inventory of spent fuel is approximately 2500 MTHM. https://www.energy.gov/sites/default/files/2020/10/f80/7th-JC-RM-United-States-NR-Final-Oct-2020.pdf.

2b) Do you know the forecasts for SMR & AMR waste generation in your country?

[21] National reports to the Joint Convention on the Safety of Spent Fuel Management and on the Safety on Radioactive Waste Management. https://www.iaea.org/topics/nuclear-safety-conventions/joint-convention-safety-spent-fuel-management-and-safety-radioactive-waste

If yes, please make a short description, adding, if possible, the estimated time schedule linked to this estimated inventory. Please indicate the source of this information.

2c) Characteristics of the inventory. Do you have information regarding the physic-chemical and radiological characteristics of the waste expected to be generated in SMRs & AMRs?

Please, make a short description (it does not need to be technically detailed), explaining as far as you can the differences between this type of waste and radioactive waste generated at conventional reactors[22]. Please indicate the source of this information.

DOE has undertaken several projects to understand both the amount and attributes of spent fuel that will likely be generated by SMR/AMRs, for example:

- **ARPA-e Optimizing Nuclear Waste and Advanced Reactor Disposal Systems (ONWARDS) Project:** Consists of 11 individual projects "To enable the growth of advanced nuclear energy, ONWARDS seeks to develop and demonstrate breakthrough technologies that will facilitate a 10x reduction in AR waste volume generation or repository footprint. In addition, ONWARDS aims to advance development of high-performance AR waste forms while maintaining exemplary safeguards standards and global back-end costs in the accepted range of $1/megawatt-hour." https://arpa-e.energy.gov/technologies/programs/onwards. Specific ONWARDS projects include:
    - Brigham Young University (BYU) - Two-Step Chloride Volatility Process for Reprocessing Used Nuclear Fuel from Advanced Reactors
    - Citrine Informatics - Novel Phosphate Waste Forms to Enable Efficient Dehalogenation and Immobilization of Salt Waste
    - Deep Isolation - UPWARDS: Universal Performance Criteria and Canister for Advanced Reactor Waste Form Acceptance in Borehole and Mined Repositories Considering Design Safety
    - General Electric (GE) Global Research - Resonance Absorption Densitometry for Materials Assay Security Safeguards (RADMASS)
    - Idaho National Laboratory (INL) - Traveling Molten Zone Refining Process Development for Innovative Fuel Cycle Solutions
    - Oklo - Enabling the Near Term Commercialization of an Electrorefining Facility to Close the Metal Fuel Cycle
    - Orano Federal Services - Off-Gas Treatment Process for Conditioning and Recycling Facilities

[22] By "conventional reactors", we understand reactors belonging up to Generation III. The scope of this questionnaire extends to SMR and AMR waste; for a clarification of these terms, we keep the definitions used by the UK government, by which Generation IV reactors are considered AMRs.

- Rensselaer Polytechnic Institute (RPI) - Metal-Halide Perovskites as Innovative and Cost-Effective Fluoride Salt Waste Forms
- Rutgers University - Pioneering a Cermet Waste Form for Disposal of Waste Streams from Advanced Reactors (PACE-FORWARD)
- Stony Brook University - MATRICY: Matrix Engineered TRISO Compacts Enabling Advanced Reactor Fuel Cycles
- TerraPower - Chloride-Based Volatility for Waste Reduction and/or Reuse of Metallic-, Oxide- and Salt-Based Reactor Fuels

- **Nuclear Waste Attributes of SMRs Scheduled for Near-Term Deployment – Nuclear Fuel Cycle and Supply Chain (DOE, ANL/INL):** This study focused on nuclear waste attributes of three small reactors (SMR) scheduled for near-term-deployment, VOYGR™ (NuScale Power), Natrium™ (TerraPower), XE-100 (X-energy). Compares those wastes to those of a reference large PWR, examining front-end wastes (e.g., fuel manufacture), back-end waste (e.g., spent fuel management), and end-of-life or decommissioning wastes. The study found that waste attributes of the SMRs showed both "similarities to the reference LWR and some potentially significant differences." Overall, the study concluded that "assuming appropriate waste management system design and operational optimization, there appear to be no major challenges to the management of SMR wastes compared to the reference LWR." https://fuelcycleoptions.inl.gov/SiteAssets/SitePages/Home/SMR_Waste_Attributes_Report_Final.pdf.
- **Several additional DOE studies on advanced reactor waste –** "Advanced Reactors Fuel and Waste Streams Disposition Strategies: Spent Fuel and Waste Disposition" (June 28, 2023); "Storage, Transportation, and Disposal of Advanced-Reactor Spent Nuclear Fuel and High-Level Waste: Spent Fuel and Waste Disposition" (https://www.nwtrb.gov/docs/default-source/meetings/2023/august/brady-hanson.pdf?sfvrsn=4.

3. Consideration of SMR & AMR waste in laws and regulations

Is there any provision in your national set of laws and regulations specifically addressed to waste from SMRs & AMR?

Please note that the focus of this question is on SMR & AMR wastes. Answers referencing general provisions for radioactive waste management should briefly explain how those provisions are relevant to managing SMR and AMR waste.

See existing framework described above in response to questions 1 and 2, which would generally apply to wastes generated by SMR/ANRs licensing in the U.S.

Regulatory requirements concerning SMR & AMR waste

4a) Has your nuclear regulatory authority developed specific standards for SMR & AMR waste management? If yes, please shortly quote and describe them.

The standards referred to may address aspects such as conditioning, treatment, packaging, storage, transport and disposal of SMR & AMR waste. Please note that the focus of this question is on SMR & AMR wastes. Answers referencing general regulations for radioactive waste management should briefly explain how those provisions are relevant to managing SMR and AMR waste.

4b) Has your nuclear regulatory authority announced plans for developing specific standards for SMR & AMR waste?

Please, quote and describe shortly these plans.

See existing framework described above in response to questions 1 and 2, which would be applicable to wastes generated by SMR/ANRs licensed in the U.S. For a complete list of policy issues relevant to SMRs and non-light water reactors that have been considered and resolved by NRC see https://www.nrc.gov/reactors/new-reactors/smr/policy-development/resolved-policy.html. Any additional or more specific requirements necessary to address wastes generated by SMR/ANRs could be achieved through specific licensing requirements or new/amended regulations promulgated by the NRC (in addition to license conditions, orders, and exemptions from existing requirements).

5. SMR & AMR waste and the rights of public information and participation

5a) Please, explain to what extent decision-making in rule-making and policy setting in your country has been subjected to the principles of transparency and public participation: a) as regards the development of SMR & AMR; and b) as regards the management of waste generated by SMR & AMR.

This question focuses on specific measures for transparency and public participation, beyond the general rules for public participation in rule-making and policy setting. Examples may include a public referendum about the development of SMR & AMR, specific consultation campaigns being conducted (nation-wide or in the potential hosting communities for SMR & AMR), etc.

5b) Please, provide examples or describe the communication campaigns addressed in your country to the general public: a) as regards the development of SMR & AMR, and b) as regards the management of waste generated by SMR & AMR.

This question refers to communication campaigns rather than public participation in decision-making.

5c) Please, provide examples or describe the communication campaigns addressed in your country specifically to the potential host communities of SMR & AMR: a) as regards the development of SMR & AMR, and b) as regards the management of waste generated by SMR & AMR.

This question refers to communication campaigns rather than public participation in decision-making. A specific question in this regard is: Are potential host communities generally aware of the specific nature of SMR & AMR waste?

5d) Is any negotiation being carried out with local communities who are proposed as hosts for a disposal site for conventional waste in your country? If this is the case, has the issue of SMR & AMR waste arisen in the dialogue? For example, related to a possible extension of the inventory to be emplaced in the site.

[*I am interpreting this question to focus primarily on national policy (i.e., actions by the Federal government), rather than activities that may be undertaken by private entities interested in pursuing licenses to manufacture, construct, and operate commercial reactors and waste facilities, or current licensees that are operating such facilities.*]

DOE is committed to a consent-based approach to finding sites to store and dispose of spent nuclear fuel. DOE's approach centers on broad public participation, equity, and environmental justice. DOE's efforts to develop a consent-based siting process by working collaboratively with members of the public, communities, stakeholders, and governments at the Tribal, state, and local levels began in 2015. DOE requested public comment on the process in both 2017 www.energy.gov/sites/prod/files/2017/01/f34/Draft%20Consent-Based%20Siting%20Process%20and%20Siting%20Considerations.pdf) and in late 2021 (https://www.federalregister.gov/documents/2021/12/01/2021-25724/notice-of-request-for-information-rfi-on-using-a-consent-based-siting-process-to-identify-federal).

In 2023, DOE awarded $26,000,000 in funding to 13 geographically an institutionally diverse awardees consisting of university, nonprofit, and private-sector entities to work with communities interested in consent-based siting of spent fuel storage and disposal facilities. The awardees – representing 12 states and the District of Columbia – will constitute a consent-based siting consortium and collectively help DOE facilitate engagement activities and dialogue. DOE and the consent-based siting consortia will collaborate to build equity and environmental justice principles into the community engagement processes. The preliminary project teams receiving awards are:

- American Nuclear Society (IL) as the lead, with South Carolina Universities Research and Education Foundation (SC), Northern Arizona University (AZ), University of New Mexico (NM), South Carolina State University (SC), and City College of New York (NY) as partners.
- Arizona State University (AZ)
- Boise State University (ID) as the lead, with the National Tribal Energy Association, Arizona State (AZ), Colorado State (CO), Idaho State (ID), Montana State (MT), University of Idaho (ID), University of Wyoming (WY), and University of Michigan (MI) as partners.
- Clemson University (SC) as the lead, with South Carolina Universities Research and Education Foundation (SC) as a partner.
- Energy Communities Alliance (DC)
- Good Energy Collective (CA) as the lead, with the University of Notre Dame (IN) as a partner.
- Holtec International (NJ) as the lead, with University of Florida (FL), McMahon Communications (MA), Agenda Global (DC), American Nuclear Society (IL), and Nuclear Energy Institute (DC) as partners.

- Keystone Policy Center (CO) as the lead, with Social and Environmental Research Institute, GDFWatch (UK), and the National Association of Regional Councils (DC) as partners.

- Missouri University of Science & Technology (MO) as the lead, with University of Missouri - Columbia (MO), University of Illinois (IL), Taylor Geospatial Institute (MO), and St. Louis University (MO) as partners.

- North Carolina State University (NC) as the lead, with the yak titʸu titʸu yak tiłhini Northern Chumash Tribe of San Luis Obispo County and Region (CA), Mothers for Nuclear (CA), and the Tribal Consent Based Coalition - Diablo Canyon Nuclear Power Plant (CA) as partners.

- Rensselaer Polytechnic Institute (NY) as the lead, with Schenectady Foundation (NY) as a partner.

- Southwest Research Institute (TX) as the lead, with Deep Isolation (CA), Westra Consulting (NE), Community Transition Planning (MI), Prairie Island Indian Community Tribal Nation (MN), Xcel Energy (MN), and Decommissioning Plant Coalition (DC) as partners.

- Vanderbilt University (TN) as the lead, with Rutgers University (NJ) and Oregon State University (OR) as partners.

(See https://www.energy.gov/articles/doe-awards-26-million-support-consent-based-siting-spent-nuclear-fuel). For more information on DOE's consent-based siting process generally, see https://www.energy.gov/ne/consent-based-siting.

Apart from its consent-based siting efforts, in December 2022 DOE awarded $800,000 to the Energy Communities Alliance, Inc. and the American Nuclear Society to expand engagement with energy communities, educational institutions, and underserved communities. These efforts are aimed at establishing education and outreach opportunities, focusing on localities impacted by or interested in deploying advanced reactors. (See https://www.energy.gov/ne/articles/us-department-energy-selects-partners-engage-communities-nuclear-energy).

While it does not have promotional responsibilities, the NRC has a long-standing policy of "provid[ing] the public with substantial information on its activities, to conduct business in an open manner, and to balance openness and transparency with the need to exercise regulatory and safety responsibilities without undue administrative burden." *See* Commission Policy Statement on Enhancing Participation in NRC Public Meetings, 86 Fed. Reg. 14964; March 19, 2021 ("The NRC has had a formal policy regarding open (public) meetings since 1978."). The NRC's organizational values and Principles of Good Regulation also stress "openness" as a core value. The Principles of Good Regulation describe the principle of "Openness" as "Nuclear regulation is the public's business, and it must be transacted publicly and candidly. The public must be informed about and have the opportunity to participate in the regulatory processes as required by law. Open channels of communication must be maintained with Congress, other government agencies, licensees, and the public, as well as with the international nuclear community." (*See* https://www.nrc.gov/about-nrc/values.html).

The NRC has also recently undertaken efforts to update and further improve its Environmental Justice ("EJ") policies. The NRC describes its EJ efforts as being aimed at "identifying and addressing, as appropriate, disproportionately high and adverse human health or environmental effects of an agency's programs, policies, and activities on minority and low-income populations." (See https://www.nrc.gov/about-nrc/regulatory/licensing/nepa/environmental-justice.html). The NRC has had an EJ strategy in place since 1995, and the agency's recent systematic assessment involved "extensive outreach effort to stakeholders, including environmental justice communities and Tribal nations, NRC staff, other federal agencies, industry groups, nuclear safety organizations and the public at large. Over the course of the assessment, the Team held several public meetings and received approximately 2,500 written comments." (See https://www.nrc.gov/about-nrc/regulatory/licensing/nepa/environmental-justice/assessment.html). The NRC staff's assessment and recommendations can be accessed here https://www.nrc.gov/docs/ML2203/ML22031A063.html.

6. Challenges related to SMR & AMR waste. Other considerations

6a) In summary and in your view, what new challenges do AMR & SMR waste pose to existing radioactive waste frameworks or disposal plans in your country?

The specific technical challenges associated with management and disposal of AMR & SMR are being addressed most directly through the multiple efforts underway at DOE (described above).

The legal and policy challenges associated with AMR & SMR waste in the U.S. are largely coextensive with the challenges associated with spent fuel management more broadly. As described above, the legal framework for used fuel management in the U.S. is provided in the NWPA, which created a structured program in which the federal government was required to begin removing used fuel from reactor sites in 1998. The federal government has failed to meet its obligations under the NWPA and effectively cancelled efforts to license at permanent repository at Yucca Mountain.

DOE's current efforts are focused on using a consent-based siting approach for a centralized interim storage facility. DOE has emphasized that it will take a stepwise, iterative, and adaptive approach process to determine whether and how potentially hosting a facility aligns with state and local community goals. According to DOE planning documents, this process would take roughly 10 years to complete for an interim storage facility but would likely take longer for siting a repository. (https://www.energy.gov/sites/default/files/2023-05/Consent-Based%20Siting%20Process%20Report-0424%203.pdf)

In the meantime, used fuel must be safely managed and stored by reactor owners until transported offsite for either interim storage or final disposal, with costs for fuel management and storage being borne by reactor owners. To address this issue, operating reactors have re-racked their used fuel pools to increase the pools' storage capacity and licensed and constructed onsite dry storage facilities. Although adopting those kinds of measures is costly, those costs are largely offset by operating reactors' ongoing recovery for DOE's failure to begin picking up the fuel.

There may be different business impacts associated with used fuel management and storage for new reactors because new reactor owners will have to enter an amended standard contract. The amended standard contract attempts to manage DOE's ongoing liability by, for example, extending the timeframe used fuel must be stored by new reactor owners and providing for limited damages if DOE fails to perform.

6b) Please, add any other consideration you might have in regard to the planning, regulation and public communication and participation in the management of this type of waste.