EASI SMR

D1.3 Main challenges and concerns of SMR-relevant waste management systems

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3. Summary

Deliverable D1.3 of the EASI-SMR project focuses on analyzing the main challenges and concerns related to radioactive waste management (RWM) systems for LW-SMRs. Even existing European RWM frameworks are technically basically applicable to LW-SMR deployment, targeted adaptations related to specific technical and operational features of LW SMRs to waste management chain reflected distinctive characteristics of LW-SMR spent fuel and waste streams.

It is expected that LW-SMRs typically would achieve lower discharge burnup compared to large LWRs, and the compact core geometry will cause significantly higher neutron leakage, resulting in greater activation of structural materials and altered radionuclide inventories. Some advanced designs would employ High-Assay Low-Enriched Uranium (HALEU), which impose enhanced criticality safety requirements, stricter safeguards, and the need to recertify or newly develop transport packaging. Waste volumes per unit of electricity generated may be higher than for optimized large LWRs.

Infrastructure and logistics present equally significant challenges. The modular and potentially distributed deployment of LW-SMRs will increase the number of waste-generating sites, complicate transport logistics, and raise demand for interim storage capacity and facilities capable of handling compact, high-intensity waste forms. The need to develop new robotic tools are also identified as potential challenges.

Existing concepts of DGR for final disposal of SF and ILW due to increasing volumes and different characteristics RW would require substantial adaptation of waste acceptance criteria for disposal and technical solutions for waste containers. DBD concepts for final disposal would be an option in specific cases (small RW inventory).

The need to update regulatory frameworks, need to update waste acceptance criteria (WAC) for different disposal concepts, unresolved mechanisms for long-term financing and liability allocation, and significant gaps in empirical data from actual LW-SMR operation can be described as a main cross-cutting concerns.

The report also recommends early integration of waste management into process of licensing, iterative development of WAC in collaboration between designers, waste organisations and regulators, and coordinated international R&D through initiatives such as EURAD-2 FORSAFF and IAEA working groups.

4. Keywords

LW-SMRs, WAC, DGR, RWM, R&D activities, cross-cutting, regulatory framework

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5. Abbreviations and acronyms

Acronym	Description
BWR	Boiled Water Reactor
C&D	Communication & Dissemination
DBD	Deep Borehole Disposal
DGR	Deep Geological Repository
EPR	European Pressurized Reactor
EPZ	Emergency Planning Zone
EURAD	European Partnership on Radioactive Waste Management
FORSAFF	EU project: Waste Management for SMRs and Future Fuels
HALEU	High-Assay Low-Enriched Uranium
HLW	High Level Waste
IAEA	International Atomic Energy Agency
ILW	Immediate level Waste
KBS 3V	Vertical Emplacement Variant of the KBS-3 DGR concept
LDR-50	Finish Nuclear District Heating SMR
LILW	Low and Intermediate Level Waste
LLW	Low Level Waste
LO	Loviisa NPP
LWR	Light Water Reactor
LW-SMR	Light water Small Modular Reactor
LW-SMR	Light water Small Modular Reactor
NPP	Nuclear Power Plant
OECD/NEA	Organisation for Economic Co-operation and Development/ Nuclear Energy Agency
OL	Olkiluoto NPP
ONKALO®	Posiva's proprietary integrated final disposal system at Olkiluoto
PWR	Pressurized Water Reactor
RR SMR	Rolls-Royce SMR
RW	Radioactive Waste
RWM	Radioactive Waste Management
RWM	Radioactive Waste Management
SF	Spent Fuel
SMR	Small Modular Reactor
VVER	Water-Water Energetic Reactor
WAC	Waste Acceptance Criteria
WP	Work Package

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6. Introduction

SMRs are considered a promising direction in the development of nuclear energy, offering increased flexibility, modularity, and potential safety advantages compared to conventional large-scale reactors. Due to their capability for serial production and flexible deployment, SMRs can play an important role in future low-carbon energy systems (IAEA, 2022).

At the same time, the deployment of SMRs is associated with several technical, regulatory, and infrastructure-related challenges. One of the key aspects is the need to ensure effective radioactive waste management systems throughout the entire lifecycle of the installations, including waste generation, treatment, storage, transport, and final disposal (COM, 2024; EC, 2011). One potential solution to the anticipated challenges associated with the deployment of SMRs could be the IAEA's approach "Decommissioning by Design" (IAEA, 2023b).

This report focuses on light water small modular reactors (LW-SMRs), which are based on established light water reactor technology. Although existing radioactive waste management systems are generally applicable, such reactors introduce specific challenges that require adaptation of current approaches, especially in terms of waste characteristics, waste acceptance criteria, compatibility with geological repositories, and handling procedures (Kim et al., 2022; EURAD-2, 2025).

An important issue is the limited availability of operational data for SMRs. Therefore, most assessments of radioactive waste characteristics and volumes are based on analytical models and assumptions, which lead to a higher level of uncertainty (Kim et al., 2022; EURAD-2, 2026). In addition, design features of LW-SMRs, such as compact cores and increased neutron leakage, may result in higher activation of structural materials and changes in waste composition (Krall et al., 2022).

The aim of this report (Deliverable D1.3 "Main challenges and concerns related to waste management systems relevant to SMR") is to identify and analyze the main challenges and concerns related to radioactive waste management systems for LW-SMRs.

The structure of the report includes the analysis of challenges related to geological repositories, the impact of waste characteristics, expected waste streams, and cross-cutting issues such as regulatory frameworks, infrastructure, and research needs.

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7. Geological repository challenges for LW SMRs

Light water small modular reactors (LW-SMRs) present specific waste management challenges that require adaptation of existing systems originally developed for large light water reactors. While the fundamental radioactive waste management frameworks in Europe are technically suitable for LW-SMR deployment, targeted adjustments or optimization may be necessary for example concerning the waste acceptance criteria (WAC), canister design and loading pattern, and thermal optimization of the repository layout. In addition, further adjustments may be needed for handling procedures to accommodate the distinctive characteristics of LW-SMR spent fuel and radioactive waste (EASI-SMR, 2025). Existing research confirms that the KBS-3V concept and similar European deep geological disposal (DGR) approaches remain fundamentally applicable, but that none of the required adaptations can be treated as routine or automatic and each requires dedicated licensing process, technical analysis, safety case calculations, regulatory engagement, and possibly also infrastructure investment (Keto et al., 2022; EURAD-2, 2025).

Besides DGR, deep borehole disposal (DBD) is increasingly recognised as a promising alternative or complement to mined repositories for HLW/SNF disposal. DBD is particularly attractive for countries with small quantities of higher-activity waste and no active DGR programme (EURAD-2, 2026), including countries such as Croatia, Denmark, Norway, and Slovenia (IAEA, 2023a). The concept has advanced from a theoretical alternative into an increasingly structured repository alternative, however, the concept has not yet reached the level associated with the most advanced mined-repository programmes. The most credible recent progress in DBD lies in formalised siting methodologies, improved performance assessment, source-term treatment, canister testing, and integrated waste-package strategies. (Waples et al. 2025; Prasad et al., 2026)

At the international level, the IAEA launched a new Coordinated Research Project (CRP T22003) aimed at expanding the scientific and technical groundwork for DBD and developing preliminary plans for a field-scale demonstrator (IAEA, 2023a). Nevertheless, the most significant barrier to broader acceptance of DBD concepts remains the absence of an end-to-end demonstration conducted under a regulator-relevant framework.

7.1. Waste characteristics and repository compatibility

Existing deep geological repositories, such as Finland's ONKALO® facility utilizing the KBS-3V disposal concept, were designed around standardized large LWR spent fuel assemblies. LW-SMRs introduce several compatibility considerations (Keto et al., 2022; EASI-SMR, 2025) discussed in more detail below.

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7.1.1. Fuel Assembly Geometry Differences

LW-SMR fuel assemblies are typically shorter than conventional LWR fuel. While many designs are based on 17×17 lattice configurations similar to those used in large PWRs, they employ a significantly reduced active fuel length.

Considering transport and storage solutions, the IAEA has explicitly identified that smaller LW-SMR fuel assemblies will require either recertification of existing systems or new developments (González, 2023; IAEA, 2024).

Another adaptation need concerns the encapsulation in final disposal canisters. For example, the NuScale Power Module uses an active fuel length of approximately 2.0 m (assembly length ~2.4 m), roughly half the height of the OL3 EPR assembly (~4.8 m), while the LDR-50 district heating reactor uses an active height of only 1.2 m, as summarized in Table 1 (Keto et al., 2022).

Table 1: Representative fuel assembly dimensions for LW-SMRs and LWRs (Keto et al., 2022).

Reactor / fuel type	Assembly lattice / shape	No. of fuel rods per assembly	Active fuel length (m)	Overall assembly length (m)	Assembly cross-section (mm)
OL1-2 BWR	8×8 / square	63-96	~3.7	4.1	139 × 139
LO1-2 VVER-440	Hexagonal	126	~2.5	3.2	144
OL3 EPR PWR	17×17 / square	265	~4.0-4.2	4.8	215 × 215
NuScale Power Module	17×17 / square	264	2.0	2.44	215 × 215
LDR-50	17×17 / square	264	1.2 (active core)	~1.2-1.3 (truncated design)	215 × 215

Similarly, the Czech disposal concept will need to be updated to include also the fuel and HLW/ILW from new units (APR-1000 and Rolls-Royce SMR, BWRX-300 SMRs are also being considered). Fuels different from the fuel currently used in the VVER-type NPPs will be used. The fuel will have different geometry (square cross-section 16x16 or shortened for the 17x17 Rolls-Royce SMR, respectively for the 10x10 BWRX-300 SMR vs. hexagonal cross-section of the VVER-type NPP), similar enrichment and similar or lower burnup. The Rolls-Royce SMR uses an active fuel length of approximately 2.8 m. In addition, existing transport and storage systems will need to be updated or a new system may need to be developed for the management of spent fuel from SMRs in Czechia.

7.1.2. Repository Layout Modifications

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The compact cores of LW-SMRs result in higher neutron leakage per unit volume compared to large reactors; a NuScale iPWR (160 MWth) may leak more than 7% of free neutrons, compared to less than 3% for a large 3,400 MWth PWR (Krall et al., 2022). This leads to spent fuel with altered decay heat profiles and activation product inventories, necessitating re-evaluation of disposal tunnel spacing, thermal modelling, and engineered barrier performance (Keto et al., 2022; Krall et al., 2022).

In the KBS-3V concept, the canister surface temperature limit of 95°C must be maintained to preserve the bentonite buffer's swelling and sealing properties; any change in decay heat per canister changes the required deposition hole spacing accordingly (Keto et al., 2022).

Re-evaluation of disposal tunnel spacing, thermal modelling, and engineered barrier performance is therefore required to ensure repository components can accommodate the altered thermal loads of LW-SMR fuel without compromising long-term safety (EASI-SMR, 2025; Keto et al., 2022).

7.1.3. Waste Package Design

Current transport casks and disposal packages were developed for specific and existing fuel dimensions and thermal characteristics. LW-SMR deployment requires either modification of existing systems or development of new certified packaging that can safely handle the altered geometry and potentially higher heat output per unit volume (Harvey, 2024; González, 2024).

The geometric differences of fuel assemblies for LW/SMR and LWR require either recertification of existing disposal canisters or development of new canister designs tailored to LW-SMR fuel dimensions (Keto et al., 2022; Koskinen et al., 2022). Preliminary analyses suggest that two NuScale assemblies might be stacked end-to-end in an existing OL3 EPR canister. However, compatibility with criticality safety and thermal constraints should be verified for this type of configuration (Keto et al., 2022; Keto et al., 2023b).

The PREDIS project has identified that waste acceptance criteria (WAC) govern the transfer of waste liabilities between organisations and must ensure compliance with safety requirements, assist with the selection of appropriate processing and packaging options, prevent technological problems during processing, standardise waste management operations, and assure waste tracking (Harvey, 2024).

Adapting or developing WAC for LW-SMR waste packages is therefore not a minor administrative step but a substantive technical and regulatory undertaking (Harvey, 2024; NEA, 2024).

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7.2. Thermal management and cooling requirements

Interim storage/cooling period is needed prior to encapsulation and final disposal. In addition, a cooling period may be also needed before transport of the waste to a centralized interim storage facility, if not located at the site.

The principal heat-producing nuclides at 50 years post-end-of-life are Y-90, Ba-137m, Am-241, and Cs-137, shifting towards Am-241-dominated output at 200 years as shorter-lived fission products decay (Keto et al., 2022).

According to Naumer et al. (2026), fuel burnup has a dominant influence on both the temperature-related behaviour and radioactivity of spent nuclear fuel. As burnup increases, a larger fraction of fissile material is converted into fission products and minor actinides, leading to a higher accumulation of radioactive nuclides. This results in increased decay heat generation, which directly affects the thermal output of the fuel after irradiation. Consequently, higher burnup fuel exhibits greater residual heat production and higher overall radioactivity compared to low-burnup fuel, influencing cooling requirements and thermal constraints in storage and disposal.

The required cooling time should be optimised by taking into account the characteristics of the spent nuclear fuel, particularly its nuclide composition and burnup, in order to ensure compliance with the specifications defined for both transport casks and final disposal concepts. For instance, in the KBS-3 disposal concept, the maximum surface temperature of the disposal canister is limited to 95 °C to prevent degradation processes such as illitisation or cementation of the bentonite buffer at elevated temperatures. Compliance with this limit is achieved through a combination of sufficient cooling time, optimisation of canister loading, and appropriate repository layout, including the spacing between canisters (Naumer et al., 2026).

Considering LWR-SMR fuels with similar fuel burnup (or lower), the cooling times are expected to be in the same order as for traditional LWR fuels from large NPPs.

7.2.1. Extended Interim Storage Requirements

Considering higher burnup fuels, extended interim storage periods may be required before emplacement in geological repositories to allow sufficient decay of short-lived radionuclides (Sustainability-Directory, 2025; Keto et al., 2022).

Lower discharge burnup in LW-SMRs generally means lower absolute decay heat per assembly at discharge, which may allow somewhat shorter storage periods compared to high-burnup large LWR fuel, but this benefit depends strongly on the specific burnup and design of the LW-SMR in question (Keto et al., 2022; Schatz, 2022).

Where multiple assemblies are packed together in a single disposal canister to improve repository utilisation, the aggregate canister heat load must be carefully evaluated against barrier temperature limit (Keto et al., 2022).

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7.2.2. Enhanced Cooling and Shielding at Interim Storage

Enhanced cooling and shielding at interim storage facilities must accommodate higher specific thermal loads of high-burnup LW-SMR spent fuel (EASI-SMR, 2025).

The NRC Regulatory Guide 3.54 (Revision 2) requires that dry cask storage systems accommodate decay heat without active cooling, and that minimum cooling times before dry storage placement be demonstrated for each fuel type; for LW-SMR fuel, the specific burnup, enrichment, and enrichment profile must be individually characterised to establish acceptable minimum cooling times, since existing regulatory guidance was validated against conventional LWR parameter ranges (NRC, 2018).

Natural circulation cooling systems typical of many LW-SMR designs, such as the NuScale Power Module, which is fully driven by natural circulation with the entire module submerged in a safety-related water pool, also influences spent fuel pool operations and dry storage transition timing, requiring integration into national waste management strategies (EASI-SMR, 2025).

7.2.3. Repository Ventilation and Thermal Buffering

Repository ventilation and thermal buffering systems require upgrading to maintain safe temperature limits within the engineered barrier system and host rock (EASI-SMR, 2025).

In the KBS-3V concept, deposition hole spacing is sized to prevent thermal accumulation above the 95°C canister surface limit; for LW-SMR fuel with potentially lower per-assembly decay heat, it may be possible to reduce spacing and decrease excavation costs, but only after detailed 3D thermal modelling confirms compliance (Keto et al., 2022).

If assemblies are stacked to increase canister packing efficiency, the aggregate canister decay heat may approach or exceed reference limits, and full thermal recalculation would be mandatory (Keto et al., 2022).

7.3. Capacity and infrastructure scaling

The deployment of LW-SMRs introduces additional considerations for capacity planning and infrastructure development, particularly in relation to a potential shift from centralized to more decentralized deployment models (EASI-SMR 2025; EURAD-2 2025). Unlike traditional nuclear programmes, which are based on a limited number of large units, SMRs may be deployed across multiple sites, including industrial or remote locations, with direct implications for the organization of RWM systems.

From a repository perspective, existing concepts remain applicable, however, capacity planning becomes more complex due to variability in waste volumes and timing of waste generation (NEA 2024). This suggests the need for more adaptive approaches to licensing and infrastructure development, including phased implementation and periodic revision of projections.

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7.3.1. Centralized versus Decentralized Approaches

The modular nature of LW-SMRs enables deployment at brownfield sites, remote locations, and existing industrial facilities, potentially increasing the number of locations generating nuclear waste (Kinghorn-Mills et al., 2023; Keto et al., 2022).

Three broad strategies have been identified for dispersed LW-SMR deployments: (1) centralised waste management, where all spent fuel and operational waste is transported to a central processing and disposal facility; (2) decentralised management, where each site manages its own waste; and (3) a hybrid approach, where spent fuel is managed centrally while low- and intermediate-level waste (LILW) is handled near the reactor site (Keto et al., 2022; Schatz, 2022). In Finland, the centralised strategy is considered most technically and economically feasible, though it substantially increases the need for cross-country transport of spent nuclear fuel given the potential for LW-SMRs to be deployed at multiple locations for district heating applications (Schatz, 2022; Koskinen et al., 2022).

For countries with relatively small nuclear programmes, the development of national disposal facilities may be associated with significant economic and institutional challenges. In such cases, multinational or shared repository concepts may represent a potential solution, allowing cooperation between countries in the back-end of the fuel cycle. However, this may lead to deferral of decisions rather than acceleration especially because of import bans in numerous Member States (COM, 2024).

Overall, large-scale SMR deployment may lead to a transition towards more flexible and distributed waste management models. This does not change the fundamental role of centralized facilities, including geological repositories, but increases the importance of system integration, logistics, and adaptive infrastructure planning.

Key differences between centralized and decentralized waste management approaches for SMRs are summarized in Table 2.

Table 2: Comparison of centralized and decentralized RWM approaches for SMRs

Aspect	Centralized approach	Decentralized approach
Reactor siting	Limited number of large or co-located SMR sites with one national backend system	Multiple geographically distributed SMR sites, each with more on-site backend functions
Transport frequency	Infrequent, large and well-planned transport operations from many sites to one facility	More frequent and operationally diverse shipments between many sites and facilities
Transport package	Highly standardized solutions for a single set of national facilities	Similar highly standardized solutions
Treatment, conditioning and disposal	More easily standardized	More site/specific adaptation of diverse waste forms
Interim storage	Centralized facilities	More flexible and potentially distributed solutions

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Repository planning	Relatively predictable waste streams	Higher uncertainty in volumes and timing by local deployment and policy
System management	Simpler coordination	Broader institutional coordination requirements

DBD concept has been identified as a promising option due to its potential for decentralized option. The EURAD programme evaluates various disposal pathways and emphasizes that predisposal routes—including storage, conditioning, and transport—strongly influence the feasibility of final disposal options (EURAD, 2024). In this context, DBD is attractive because it can potentially be implemented at smaller scales, therefore making it supporting to SMR deployment strategies in geographically widely broad range under ability for reducing transport distances for SF and RW. However, this option is conditional on several factors, including the alignment of reactor sitting with suitable geology, the suitability of waste packaging systems, and the maturity of DBD demonstration technology. While DBD offers a promising pathway for reducing transport distances and associated risks, both long-term and operational safety needs to be demonstrated for the concept, it should be able to pass all the same licensing and siting processes as current DGRs. In addition, it introduces new technical and logistical challenges that must be addressed through complex system design and accelerated further research.

7.3.2. Transport Logistics

More dispersed siting increases cross-country transport requirements for spent fuel and operational waste to centralized facilities (NEI, 2024; Kinghorn-Mills et al., 2023).

In this context, the role of transport infrastructure and interim storage becomes increasingly important. A more distributed generation of waste may require more frequent transport operations, as well as adaptation of transport solutions to new waste forms, including modular or integrated components (EURAD-2, 2025). At the same time, uncertainties related to deployment timelines and RW characteristics highlight the need for more flexible approaches to interim storage capacity development.

At the first World Nuclear Transport Conference held in London in November 2025, representatives from around the world agreed that without prepared transport systems, the rollout of LW-SMRs would be postponed (NEI Magazine, 2026).

For SMR concepts that rely on high-assay low-enriched uranium (HALEU), transport packaging remains a key challenge, because most existing certified packages were designed for conventional low-enriched fuel below 5% U-235. Industry analysis (NEI, 2024) notes that regulatory authorities will have to qualify new package designs and update associated regulations for HALEU fuels and, in some advanced designs, for the transport of fully fuelled turn-key modules. Although several HALEU transport concepts are now under development and licensing, these efforts are still at an early stage and will need to mature in parallel with deployment of HALEU-fuelled SMRs. (NEI, 2024).

7.3.3. Repository Capacity Planning

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While individual LW-SMR units produce smaller absolute volumes of spent fuel than large reactors, deployment of multiple modules at a single site or across distributed locations presents infrastructure challenges (Kinghorn-Mills et al., 2023; EASI-SMR, 2025).The peer-reviewed study (Krall et al., 2022) showed that, across a range of SMR concepts, energy-normalized waste volumes can increase by factors of 2 to 30 compared to a large PWR, with the upper end of this range driven mainly by non-LWR designs and certain decommissioning waste categories. For a NuScale-type LW-SMR, they estimate 9 to 17 fold higher volumes of long-lived decommissioning waste and about a twofold increase in short-lived decommissioning LILW per unit of electricity. Kim similarly finds that, while the total decommissioning LLW volume (Class A–C) for VOYGR™ is about 10% lower than for a large PWR, the higher-activity fraction (comparable to ILW/GTCC) is roughly six times larger per GWe-year (Kim et al., 2026). Quantitative estimates for operational low- and intermediate-level waste from LW-SMRs are not yet available in comparable detail, and current assessments therefore rely primarily on decommissioning and spent-fuel metrics.

The Czech Republic faces the same challenge, as it plans a relatively large-scale SMR project. The method of management of SMR SF in Czechia will be similar to SF from operating NPPs and an assessment of the quantities of SF was already included in the update of the Policy for RW and SF Management in the Czech Republic (Czech Policy, 2025). Storage capacity should be expanded to meet needs of currently operated and planned NPPs and SMRs. Existing storage facilities could be used for storage of SF or a central storage facility could be built. It will be also necessary to update the quantity of HLW/ILW to be disposed of in the DGR when the required information is available and based on that to ensure sufficient disposal capacity in the DGR.

8. Impact of Chemical Composition of LW-SMR Spent Fuel

8.1. Fuel Burnup and Enrichment Characteristics

In nuclear reactor physics, maximum fuel burnup (often expressed in MWd/kgU or GWd/tU) is the amount of thermal energy extracted per unit mass of heavy metal. It is fundamentally dependent on the initial enrichment of the fissile isotope (typically ^{235}U). Open literature describes this relationship as generally positive and approximately linear within the conventional operating range of commercial LWRs.

The primary basis for this relationship is neutron economy. A higher initial enrichment provides a larger inventory of fissile atoms that can undergo fission to produce energy. As burnup increases, fissile material is depleted, and neutron-absorbing fission products (neutron poisons) accumulate. Higher enrichment provides the necessary excess reactivity to overcome these parasitic absorption effects and sustain the chain reaction to a higher integrated energy extraction point. Research shows that at the same burnup, spent fuel with a higher initial enrichment will have a higher remaining fissile content.

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Open-source data from experimental reactor programs and fuel cycle simulations confirm a roughly linear correlation between enrichment and the achievable burnup for PWRs, BWRs, and other reactor types. For example, to achieve higher burnup levels (e.g., 50-60 GWd/tU), initial enrichments above 4.5-5.0 wt% ^{235}U are typically required. Conversely, lower burnup is achieved with lower initial enrichment. This clear cause-and-effect relationship is a fundamental input for fuel cycle and nuclear forensics analyses and is used to validate reactor operation scenarios.

The generally linear relationship between maximum burnup and enrichment is well-established in open literature and remains a defining principle in nuclear fuel design and core physics analysis.

LW-SMRs typically employ standard UO_2 fuel with enrichment levels similar to conventional PWRs (generally <5% U-235), though some advanced designs may utilize high-assay low-enriched uranium (HALEU) up to 19.75% (Kim et al., 2023; González, 2024; EURAD-2, 2025; EASI-SMR, 2025).

8.1.1. Lower Discharge Burnup

Many LW-SMR designs achieve burnup levels between 35-60 GWd/tU, which may be lower than optimized large PWRs achieving 50-60 GWd/tU (Keto et al., 2022; Krall et al., 2022; EASI-SMR, 2025).

For example, VTT Serpent 2 calculations confirm NuScale average burnups of approximately 36–40 GWd/tU for three-cycle assemblies, and LDR-50 burnups of approximately 18–20 GWd/tU for three-cycle assemblies (Keto et al., 2022).

Lower burnup results in:

- **Different radionuclide inventory profiles** affecting source term calculations for safety assessments; the PNAS study confirms that LW-SMRs do not reduce generation of I-129, Tc-99, and Se-79, which are important dose contributors for most repository designs (Krall et al., 2022).
- **Higher residual fissile material content**, raising criticality concerns during interim storage and disposal that require careful analysis and potentially separation across a greater number of waste packages (Kinghorn-Mills et al., 2023; Keto et al., 2022; EASI-SMR, 2025).
- **Potentially less demanding handling** with respect to lower short-term decay heat and ionizing radiation compared to high-burnup large LWR fuel (Keto et al., 2022).

8.2. Neutron leakage and activation effects

The compact core geometry inherent to LW-SMR designs results in higher neutron leakage relative to core volume compared to large reactors. This fundamental physical phenomenon has profound implications for waste classification, volumes, and long-term safety cases (Kang et al., 2026; Krall et al., 2022; EASI-SMR, 2025).

8.2.1. Increased Structural Material Activation

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Higher neutron leakage causes enhanced activation of reactor pressure vessels, core internals, reflectors, and structural components, resulting in higher volumes of intermediate-level waste (ILW) per unit of electricity generated compared to large LWRs (Krall et al., 2022; Kang, 2026).

The NuScale reactor core is surrounded by a stainless-steel heavy neutron reflector 6.4–31.0 cm wide; while this improves neutron economy, it simultaneously becomes a significant source of activation products, notably Co-60, Fe-55, Mn-54, Ni-63, and various chromium isotopes, that contribute to the ILW stream at end-of-life (Keto et al., 2022; Krall et al., 2022).

The Rolls-Royce confirms that the management strategy for all RR SMR waste streams through the plant lifetime must account for activated structural components, liquid effluent, and gaseous effluent, with ILW streams processed for disposal in a Geological Disposal Facility (GDF) and LLW processed for near-surface disposal (Rolls-Royce, 2024).

8.2.2.Altered Radionuclide Composition

The spent fuel and operational waste from LW-SMRs contain different concentrations of activation products and transuranic compared to conventional LWR waste. This affects (EURAD-2, 2025; Krall et al., 2022):

- Long-term radiological hazard assessments for disposal, including the 10,000-year radiotoxicity profile; VOYGR™LW-SMR fuels are projected to be approximately 6% more radiotoxic than conventional spent fuel after 10,000 years due to their altered transuranic inventory (Kim, 2022).
- Chemical reactivity and corrosion behaviour within disposal packages, which depend on the specific isotopic inventory and its evolution over thousands of years.
- Performance modelling for engineered barriers and host rock interactions over geological timescales, where the specific chemistry of LW-SMR waste must be characterised separately from large LWR baselines (EURAD-2, 2025).

8.2.3.Source Term Implications

Safety analyses for accident scenarios, emergency planning zones (EPZ), and repository post-closure performance must account for the specific isotopic composition of LW-SMR waste, which differs quantitatively from large LWR baselines even when using similar fuel types (EASI-SMR, 2025; Krall et al., 2022; Kim et al., 2024; Naumer et al., 2026).

EURAD-2 FORSAFF specifically identifies source term characterisation and long-term safety case development as key knowledge gaps requiring dedicated research programmes for LW-SMR waste streams (EURAD-2, 2025).

8.3. Criticality Safety Considerations

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Safety assessment in radioactive waste management can be divided into safety during long-term storage and safety under accident conditions. In addition, safety of the operation of the disposal facilities and their post-closure safety needs to be demonstrated. The main parameters that determine safety are the waste activity, isotopic composition, and chemical form of the RW. Based on the specific features of the SMR technology and a preliminary assessment of existing designs, it can be tentatively concluded that the enrichment and achievable burnup depth will be the most significant parameters affecting the RW characteristics that influence safety. The chemical form of the RW may vary depending on the composition of structural materials, process additives ensuring coolant quality, and the use of a liquid neutron absorber, but provided that water is used as the coolant, the formation of aggressive chemical substances is unlikely.

Currently, fuel with an enrichment of 4.95% and a maximum burn-up of up to 60 MW·d/kgU is used. For SMRs, the following combinations are possible: equal enrichment with lower burn-up, and higher enrichment with higher burn-up. Lower discharge burnup and potential use of HALEU in LW-SMRs create enhanced criticality concerns throughout the full waste management chain (Kinghorn-Mills et al., 2023; Krall et al., 2022; EURAD-2, 2025; EASI-SMR, 2025).

A preliminary assessment of the technological processes for RW management at LWR-NPPs indicates that the same radioactive waste types can be managed using currently existing methods, and no new types of RW are not expected in LWR-type SMRs. However, changes in the amount of RW per unit of installed capacity and in the relative proportions of different classes of RW are possible and many may require adjustments to long-term RW management plans. Moreover, the financial component of the long-term RW management strategy may be significantly affected, because different types of RW, with increasing potential hazard and time to be released from regulatory control, require the planning of financial costs that differ non-linearly.

For safety under accident conditions, an increase in RW activity could potentially lead to more severe consequences for typical initiating events, such as depressurisation of an RW container, which may require compensatory measures to be put in place. In the event of a decrease in activity – which could be achieved by increasing fuel robustness and quality or by reducing the activity of radionuclides through lower burnup – the safety level may increase.

The following conclusions can be drawn: the implementation of LWR-SMR technology will not lead to conceptual or fundamental challenges, nor to the need to develop completely new technologies. Adaptation of existing technologies is feasible but may require a revision and reassessment of the long-term RW management programme, which could affect the financial component in either direction. Under accident conditions, the RW characteristics of SMRs could potentially necessitate an upgrade of the management system or the introduction of compensatory measures.

8.3.1. Subcritical Margin Demonstration

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Higher fissile isotope concentrations in LW-SMR spent fuel require rigorous subcritical margin demonstration throughout interim storage, transport, and disposal phases.

The universally applied regulatory criterion is k_eff ≤ 0.95 in the most reactive configuration, including all sources of uncertainty. SKB shows that for the Rebus PWR canister insert design, at 5% enrichment a burnup of at least 25 MWd/kgU is required to comply with the criticality criterion, and for BWR fuel at 5% enrichment a burnup of at least 38 MWd/kgU is required (SKB, 2025).

LDR-50 assemblies at 18–20 GWd/tU fall below these thresholds, requiring either a reduction in the number of assemblies per canister, the inclusion of neutron absorber materials, or a detailed 3D demonstration that subcriticality is maintained under all credible scenarios (Keto et al., 2022)

8.3.2.Repository Evolution Scenarios

Disposal package design must ensure geometric arrangements prevent criticality under all credible repository evolution scenarios, including package degradation and water ingress (SKB, 2025).

These scenarios include: intact canister (fully controlled configuration); partial degradation of the copper overpack exposing the insert to groundwater; full canister breach (water-saturated conditions, representing the most reactive bounding configuration); and collapse of the iron insert leading to redistribution of fuel material into potentially more reactive geometric arrangements (SKB, 2025; IGD-TP, 2014).

Krall (2022) notes that SMR spent fuel will contain relatively high concentrations of fissile nuclides, demanding novel approaches to evaluating criticality during storage and disposal (Krall et al., 2022).

8.3.3.Limitations of Existing Safety Assessments

Criticality safety assessments developed for conventional LWR fuel may not directly transfer to LW-SMR fuel without detailed recalculation and validation (González, 2024). NRC investigates the effects of extended enrichment (5–8 wt% U-235) and high burnup (up to 80 GWd/tU) on burnup credit criticality safety analysis, confirming that existing validation databases require extension for LW-SMR fuel parameter ranges (NRC, 2025). IAEA is explicitly developing roadmaps for managing spent fuel from different SMR technologies, including criticality safety aspects (IAEA, 2025b).

9.Anticipated waste streams from LW-SMR

9.1. Operational waste characteristics

LW-SMRs may generate operational low- and intermediate-level waste (LILW), which in general is similar in type to the waste produced by conventional LWR. However, their characteristics may differ in terms of activity levels, and conditions of generation, as suggested by generic assessment (EASI-SMR, 2025) and by design-specific analysis for a NuScale-type LW-SMR (Krall et al., 2022).

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The main operational waste streams include spent filters, ion-exchange resins, contaminated tools, personal protective equipment, as well as other solid and liquid waste generated during reactor operation (Rolls-Royce, 2024; EASI-SMR, 2025).

For example, in the Rolls-Royce SMR design, operational waste streams remain broadly consistent with those of conventional LWRs, although design-specific features may influence handling and processing requirements.

One of the key differences is the higher specific activity of the waste. Due to the compact core design and increased neutron leakage typical for SMRs, more intensive activation of structural materials and reactor fluids can occur. As a result, even if the total waste volume per reactor module may be lower, the activity per unit of volume or mass can be higher compared to large reactors (Krall et al., 2022; Kim et al., 2022).

In addition, differences in chemical composition may occur due to plant-specific coolant chemistry and water-treatment regimes used, which can influence waste treatment and conditioning processes, as well as compliance with waste acceptance criteria for storage and disposal (Keto et al., 2023a; EURAD-2, 2025).

Another relevant aspect is the potential for different operational regimes and maintenance strategies. In some LW-SMR concepts, certain components (such as filters or ion-exchange materials) may be replaced more frequently, which can increase the number of individual waste streams without necessarily increasing the total waste volume (Koskinen et al., 2024).

Additional complexity is associated with the use of integrated or sealed reactor modules. Factory-fabricated components may limit access for inspection, maintenance, and waste segregation, which can complicate waste characterization and processing compared to conventional reactors with on-site serviceable systems (EURAD-2, 2025).

A summary of the main differences between operational waste from large LWRs and LW-SMRs is presented in Table 3.

Table 3: Comparison of operational waste characteristics for LWR and LW-SMR (based on EURAD-2, 2025; Koskinen et al., 2024)

Parameter	Large LWR	LW-SMR
Waste types	Standard LILW (filters, resins, solid waste)	Similar types of waste
Specific activity	Moderate	Potentially higher
Neutron leakage	Well established	May differ due to compact design
Material activation	Moderate	Potentially higher
Chemical composition	Well defined	Potentially more variable
Component replacement frequency	Standard	Potentially higher
System design	Conventional (serviceable)	Modular

The Rolls-Royce LW-SMR will not use boric acid in the coolant, which would simplify the RW management system. The generation of problematic RW from LW-SMRs is not foreseen; already available and applicable technologies can be used for RWM. An assessment of the quantities of RW is included in the update of the Policy for RW and SF

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Management in the Czech Republic (Czech Policy, 2025). The data will be further refined depending on the progress of the work in the area of preparation and implementation of the planned NPPs and SMRs. The future updated assessment will also include the expected radionuclide composition of the waste, which may differ from that typical of VVER plants with respect to the construction materials, fuel used and the chemical regime of the primary circuit. It is also advisable to deal with the processing of RW from SMRs in a centralised manner and possibly also using mobile technologies. A detailed assessment of the possible alternatives will have to be carried out.

9.2. Intermediate-Level Waste (ILW) Generation

The compact geometry of LW-SMRs may alters ILW generation profiles compared to conventional reactors (Krall, 2022; EASI-SMR, 2025; Kang, 2026).

ILW in LW-SMRs is mainly generated due to neutron activation of structural materials, similarly to conventional LWR. However, specific design features of SMRs, particularly compact core geometry and higher power density, fundamentally influence the intensity and distribution of this process (Krall et al. 2022; Kim et al. 2022).

A key factor is increased neutron leakage, which is generally higher in SMRs compared to large reactors. Together with relatively high neutron flux levels in the reactor vessel region (typically in the range of 10^{12}-10^{13} n/cm²·s), this leads to more intensive and more uniform activation of structural materials, including reactor internals, control rod drive mechanisms, reflectors, and core support structures (Krall et al. 2022; Kim et al., 2022).

As a result, a larger amount of activated materials may be generated and classified as ILW. The main radionuclides in such waste are activation products, including ^{60}Co, ^{63}Ni, ^{55}Fe, and ^{14}C (Krall et al., 2022; Kim et al., 2022). Among them, ^{63}Ni and ^{14}C are particularly important for long-term safety and disposal requirements.

The specific activity of ILW from SMRs may reach the upper range of values typical for conventional reactors, reflecting the higher activation of materials (Kim et al. 2022). In addition, due to design characteristics, the amount of activated materials generated per unit of electricity may be higher in some SMR designs compared to conventional LWRs.

Higher activation levels may also result in increased dose rates, requiring the use of remote handling technologies and enhanced radiation protection measures during waste handling and decommissioning. In addition, longer decay periods may be required before certain waste streams can be conditioned or disposed of. These factors also affect interim storage, where higher activity concentrations may require improved shielding and thermal management capabilities.

Table 4: Typical ILW-related characteristics for LWR and LW-SMR (based on Krall et al. 2022; Kim et al. 2022; NEA 2024)

Parameter	Large LWR	LW-SMR
Neutron leakage	Typically < 3%	Generally higher than in LWR

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Neutron flux (vessel region)	~10^{12} n/cm^2·s	Up to 10^{13} n/cm^2·s
Main radionuclides	^{60}co, ^{137}cs	^{60}co, ^{63}ni, ^{55}fe, ^{14}c
Long-lived radionuclides	Limited	Potentially higher share
Specific activity	10^4-10^7 Bq/g	May reach upper range of large LWR values
Material activation	More localized	More uniform and extensive

Another important feature of SMRs is the potential generation of compact but radiologically more intense waste forms. The use of integrated or sealed reactor modules may result in waste packages that are smaller in size but have higher activity concentration compared to conventional reactor components.

In some LW-SMR concepts, including factory-fabricated modular designs, activated components may be removed as integrated units, resulting in compact but highly active waste packages (EASI-SMR, 2025).

Although operational waste streams such as filters, ion-exchange resins, and contaminated materials remain similar in form to those from large reactors, their activity concentration may be higher. This may require adaptation of WAC and certification approaches, as existing frameworks were developed primarily for conventional LWR waste (EURAD-2, 2025).

These differences in waste characteristics have direct implications for RWM systems.

Table 5: Comparison of ILW generation and management for LWR and LW-SMR based on Kim et al., 2022; EURAD-2, 2025)

Waste category	Conventional LWR	LW-SMR	Management implications
ILW activated materials	Bulk components (vessel, shielding)	Higher activation per unit mass; more compact but more intense waste	Enhanced shielding, remote handling, longer storage
Operational waste	Filters, resins, contaminated surfaces	Similar forms, potentially higher activity	Adaptation of WAC and certification
Conditioning requirements	Established technologies	Additional requirements (shielding, heat management, packaging)	Need for advanced and modular conditioning solutions

Overall, ILW generation in LW-SMRs is characterized by more intensive and more uniform activation of materials, higher activity concentrations, and the occurrence of compact high-activity waste forms. These factors introduce additional challenges for waste conditioning, storage, and disposal, and require adaptation of existing radioactive waste management systems.

9.2.1. Activated Structural Materials

Reactor pressure vessel internals, control rod drive mechanisms, reflectors, and core support structures experience significantly higher neutron fluence per unit volume in LW-SMRs, resulting in (Krall et al., 2022; Kang, 2026):

- Greater mass of ILW classified waste per MWe-year of electricity production, higher volumes than conventional LWRs depending on specific design.
- Higher dose rates requiring remote handling and specialized shielding during decommissioning.
- Longer decay periods before waste can be downgraded or processed for disposal, due to the higher concentrations of long-lived activation products such as Ni-59 (half-life ~76,000 years), Co-60 (~5.3 years), and Ni-63 (~100 years).

For LW-SMRs specifically, the stainless-steel reflectors common to many compact designs are a primary driver of elevated ILW volumes (Keto et al., 2022).

9.2.2.Compact High-Intensity Waste Forms

Sealed reactor modules and integrated components create waste packages that are physically smaller but radiologically more intense than equivalent large reactor components. This requires (EASI-SMR, 2025):

- Novel conditioning and packaging approaches to ensure adequate heat dissipation and containment.
- Enhanced interim storage facilities capable of managing higher activity concentration per storage position.
- Potential revision of waste classification schemes to appropriately categorize compact high-activity items that may not fit existing near-surface or intermediate-depth disposal categories.

9.3. Decommissioning Waste Considerations

Decommissioning waste from LW-SMRs shows several important differences compared to conventional large reactors. Although SMRs are smaller in size, their design features lead to differences in waste composition, activity levels, and distribution of radioactive materials (Krall et al., 2022; NEA, 2024; EASI-SMR, 2025). The following subsections address the key aspects: modular replacement strategy, higher specific activity, material diversity, long-lived radionuclides, and cumulative deployment effects.

9.3.1. Modular Replacement Strategy

A specific feature of some SMR concepts is the possibility of modular replacement strategies, where reactor modules can be removed and replaced during the operational lifetime of a facility. LW-SMRs under consideration are designed with minimum operational lifetimes of approximately 60 years, with many designs targeting up to 80 years. This approach leads to a more distributed generation of decommissioning waste over time, rather than a single end-of-life dismantling phase. Waste management systems must therefore ensure:

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- Continuous availability of processing, storage, and transport capacities rather than campaign-based approaches.
- Flexibility to handle intermittent waste streams, including potentially high-activity sealed components throughout the facility's operational life.

Several SMR concepts analysed in European studies consider the removal of entire reactor modules as single units, differing from conventional segmentation approaches and significantly influencing waste handling, transport, and disposal strategies (Koskinen et al., 2024). IAEA has specifically identified the intermittent decommissioning of modular components as one of the novel aspects of LW-SMR waste management that requires dedicated roadmap development (IAEA, 2025b; González, 2025; EURAD-2, 2025).

9.3.2. Radiological Characteristics and Specific Activity

The main source of decommissioning waste is activated structural materials, including the reactor vessel, internal components, and biological shielding. Due to higher neutron leakage and more intensive activation in SMRs, the share of ILW may be higher compared to large reactors (Krall et al., 2022; Kim et al., 2022).

While the total physical volume of decommissioning waste from a single LW-SMR module is smaller than from a large reactor, the specific activity (Bq/kg or Bq/m^3) is substantially higher due to enhanced activation. This necessitates (Krall et al., 2022; EASI-SMR, 2025):

- Extended cooling or decay periods (potentially 30–50 years) before dismantling activities can safely commence at the required dose rates.
- Greater reliance on remote handling technologies and hot cell facilities for segmentation and conditioning.
- Specialized transport containers and disposal packages designed for compact, high-intensity waste that may not be covered by existing transport package certifications.

Furthermore, the more uniform distribution of activation in structural materials may result in a larger fraction of components being classified as radioactive waste, complicating segmentation, decontamination, and waste management processes (NEA, 2024).

9.3.3. Integrated and Sealed Reactor Modules

In some SMR designs, integrated or sealed reactor modules are used, which may be removed and transported as single units. While this can simplify dismantling operations, it may limit possibilities for on-site waste segregation, characterization, and treatment, and may create challenges related to transport, waste acceptance criteria (WAC), and compatibility with existing disposal concepts (Koskinen et al., 2024; EURAD-2, 2025). International assessments similarly indicate that modular deployment strategies are

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expected to shift waste generation from a single end-of-life phase to a more distributed pattern over time (NEA, 2024).

9.3.4. Long-Lived Radionuclides and Disposal Requirements

The presence of long-lived radionuclides such as ^{63}Ni and ^{14}C in activated materials may influence disposal requirements, potentially increasing the need for long-term management solutions, including geological disposal for certain waste streams. Recent assessments (EURAD-2, 2025) indicate that adjustments in waste acceptance criteria, conditioning approaches, and disposal concepts may be necessary, particularly in the case of integrated or sealed reactor modules. This suggests that SMR deployment will require not only technological solutions but also system-level adaptations in radioactive waste management frameworks.

9.3.5. Novel Materials and Characterization Challenges

The use of advanced manufacturing techniques and novel materials in some SMR designs may introduce additional complexity for waste characterization and the development of appropriate disposal pathways, as material compositions may differ from those traditionally encountered in large reactors (EASI-SMR, 2025). The use of novel materials could be challenging and may require the development of specific tools to be able to safely handle them. To optimize this phase (i.e. reducing decommissioning cost and workers dose rate), the need for specific accesses associated with specific tools has to be anticipated at the design phase. Advanced manufacturing, including additive manufacturing for heat exchangers and other components, may introduce novel material compositions requiring characterization and disposal pathway development before waste acceptance at processing or disposal facilities.

The PREDIS project's domain insight on waste acceptance criteria explicitly identifies the characterization of heterogeneous wastes as a critical challenge, noting that it is costly to implement, requires access to the waste, and demands representative data from heterogeneous waste forms (Harvey, 2024).

9.3.6. Cumulative Effects of Large-Scale SMR Deployment

Large-scale deployment of SMRs may result in a higher number of reactor units, leading to cumulative amounts of activated materials over time. This may require adaptation of waste management infrastructure and long-term planning for storage and disposal capacity (NEA, 2024; EURAD-2, 2025).

Table 6 summarises the key parameters comparing decommissioning waste characteristics between conventional large LWRs and LW-SMRs, based on available literature (Krall et al., 2022; Kim et al., 2022; EURAD-2, 2025).

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Table 6: Comparison of decommissioning waste characteristics for large LWR and LW-SMR

Parameter	Large LWR	LW-SMR
Total waste volume	High	Lower (per unit)
RW generation patterns	End-of-life dominated	Distributed over time (many designs)
Specific activity	Moderate	Substantially higher
Share of ILW	Moderate	Potentially higher
Material activation	More localized	More uniform
Cooling periods required	Standard	Potentially 30–50 years
Long-lived radionuclides	Limited	Potentially higher share
Segmentation	Standard	Potentially more complex
Design approach	Serviceable	Modular / integrated
Disposal requirements	Established approaches	May require adaptation
Remote handling needs	Standard provisions	Greater reliance required

Overall, decommissioning waste from LW-SMRs is characterized not only by differences in total volumes but also by changes in waste structure and radiological properties, including a higher share of activated materials and long-lived radionuclides. As highlighted in Deliverable D1.2, existing radioactive waste management systems are generally applicable to SMRs but require adaptation to account for these specific characteristics. Recent assessments (EURAD-2, 2025) further indicate that adjustments in waste acceptance criteria, conditioning approaches, and disposal concepts may be necessary — particularly for integrated or sealed reactor modules — pointing to the need for system-level adaptations across waste acceptance, transport, interim storage, and final disposal.

9.4. Waste Stream Volumes and Projections

The assessment of radioactive waste volumes from LW-SMRs remains subject to significant uncertainties, as most designs are not yet deployed at commercial scale. Available studies nevertheless indicate that waste generation patterns may differ substantially from early assumptions that smaller reactors would produce proportionally less waste per unit of electricity generated.

In particular, analyses consistently suggest that LW-SMRs may generate higher volumes of radioactive waste per unit of electricity produced compared to optimized large light water reactors, depending on reactor design, fuel characteristics, and operational conditions (Krall et al., 2022; Kang et al., 2025; Kim et al., 2026). Reported estimates vary significantly across SMR designs and assumptions, as waste characteristics are sensitive

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to reactor configuration, fuel cycle strategy, and operational parameters — which limits the applicability of generalized conclusions.

9.4.1. Specific Waste Streams

Spent nuclear fuel (SNF) volumes may be higher per GWe-year for LW-SMRs compared to conventional PWRs, primarily due to lower fuel burnup and higher neutron leakage reducing fuel utilisation efficiency (Krall et al., 2022). The SMRSiMa project confirms that LW-SMR spent nuclear fuel is quite similar to conventional nuclear power plant fuel when burnup and enrichment are similar, and that waste management could in principle be carried out with current methods. However, enrichment, burnup, assembly dimensions, and operational context must each be specifically evaluated for any given LW-SMR design deployed (VTT, 2025; 2026).

LILW volumes may increase depending on specific design, with the greatest increases in ILW categories driven by activated structural materials (Krall et al., 2022; Kim et al., 2026; Kang et al., 2026). This is linked to higher neutron activation and a larger fraction of materials being classified as radioactive waste due to the compact geometry and higher neutron leakage characteristic of SMR designs.

Decommissioning waste from SMRs may be lower in volume per unit than from large reactors, but its radiological characteristics may require more complex management due to higher activity concentrations and a greater share of activated materials. More rigorous and longer-duration management is therefore expected for this waste stream (EASI-SMR, 2025).

9.4.2. Summary of Indicative Waste Generation Projections

Table 7 summarises the key trends and uncertainties associated with waste generation from LW-SMRs compared to conventional large reactors (Krall et al., 2022; Kang et al., 2026; EURAD-2, 2025).

Table 7: Indicative trends in waste generation for large LWR and LW-SMR

Waste stream	Large LWR	LW-SMR	Key influencing factors
Spent nuclear fuel	Reference baseline	higher per GWe-year (design-dependent)	Burnup, neutron leakage, fuel utilisation
LILW (overall)	Established volumes	increase depending on design	Activation levels, material inventory
ILW (activated materials)	Moderate share	Potentially higher share	Neutron leakage, compact geometry

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Waste stream	Large LWR	LW-SMR	Key influencing factors
Decommissioning waste	Large volume, lower activity concentration	Lower volume per unit; higher activity concentration	Material activation, design configuration
Waste generation pattern	Concentrated at end-of-life	May be more distributed over time (modular replacement)	Deployment strategy, modularity

An important consideration is the scaling effect. In the case of large-scale deployment of SMRs, even relatively small waste volumes per module may result in significant cumulative amounts of radioactive waste due to the potentially large number of reactor units. This creates additional challenges for national waste management systems and requires careful long-term planning of infrastructure capacity (EURAD-2, 2025).

National radioactive waste programmes must therefore incorporate these increased specific waste intensities into capacity planning for interim storage facilities, processing plants, and disposal repositories (EURAD-2, 2025; EASI-SMR, 2025). The Czechia is a very representative and illustrative example of a country where the potential deployment of LW-SMRs could give rise to new requirements for innovation or updates to the national radioactive waste management program. The capacity of the currently available low-level waste (LLW) repository in Czechia is not sufficient for SMR radioactive waste, and a suitable solution will therefore need to be found. SMR radioactive waste must meet the acceptance criteria of existing or envisaged repositories, or these criteria must be modified in due time on the basis of appropriate safety analyses.

9.4.3. Implications for Waste Management Planning

A key implication of these findings is the need to incorporate potential variations in waste generation into national radioactive waste management strategies. This includes planning for sufficient capacity of interim storage facilities, waste processing infrastructure, and disposal systems, as well as ensuring flexibility to accommodate uncertainties in future waste streams (EURAD-2, 2025; NEA, 2024). Waste management systems should be developed with sufficient flexibility to accommodate a wide range of possible scenarios, given the diversity of SMR designs, the lack of operational experience, and the sensitivity of waste characteristics to design and operational parameters.

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10. Cross-Cutting Management System Concerns

10.1. Regulatory framework adaptation

Current regulatory frameworks and waste acceptance criteria were developed around well-characterized large LWR waste streams. LW-SMR deployment requires targeted adaptation at multiple levels (NEA, 2024; EURAD-2, 2025; EASI-SMR, 2025).

10.1.1. Updated Classification Schemes

Updated classification schemes may be required to ensure that compact, high-activity waste forms from LW-SMR are appropriately categorized and demonstrably disposable within existing regulatory frameworks (EASI-SMR, 2025). NEA RWMC explicitly identified waste classification as one of the principal technical challenges for LW-SMR deployment, recommending engagement between waste management organisations and reactor designers from the earliest stages of licensing (NEA, 2025a).

10.1.2. Waste Acceptance Criteria Revision

WAC revision for processing facilities, interim storage, and disposal sites to accommodate different geometries, thermal loads, and radionuclide profiles of LW-SMR waste (Harvey, 2024; EASI-SMR, 2025).
PREDIS defines WAC as consisting of three elements: a parameter, its permitted value, and the method of its determination. In practice, each LW-SMR fuel and waste type will require a facility-specific WAC parameter set, permitted values, and measurement methods validated against the specific waste form (Harvey, 2024).

10.1.3. Harmonised International Standards

IAEA SMR Platform (IAEA, 2025a) highlights that international cooperation between SMR technology vendors and Member State regulators, including the regulators of the countries wishing to deploy SMRs, and the evolution of the international legal framework, safety standards and security guidance may result in further harmonization of requirements among Member States, which may in turn facilitate the deployment of SMRs globally.

The OECD Nuclear Energy Agency (NEA) highlights the need for greater harmonisation of international standards, particularly in the context of SMR deployment, where cross-border transport of spent fuel and radioactive waste and the potential development of multinational repositories are anticipated (NEA, 2025a; NEA, 2025b). This need is also reflected in European research initiatives such as the LEI-coordinated HARMONISE project (HARMONISE, 2022), which aims to support the alignment of

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licensing approaches and regulatory frameworks for innovative nuclear technologies, including SMRs, across different countries.

Kinghorn-Mills et al. (2023) conclude that SMR-related back-end challenges are unlikely to present technical barriers significant enough to impede the development of multinational repositories. However, this conclusion is contingent on effective international cooperation, including early coordination of SMR design selection and deployment timelines among participating countries (Kinghorn-Mills et al., 2023).

10.2. Infrastructure and Technology Readiness

Existing waste management infrastructure requires targeted enhancements to accommodate LW-SMR waste streams (Kinghorn-Mills et al., 2023; EASI-SMR, 2025).

10.2.1. Processing Facilities

Processing facilities may need to be adapted or expanded to handle LW-SMR-specific waste forms, particularly compact sealed modules and highly activated components. (EASI-SMR, 2025).

IAEA explicitly notes that spent fuels coming from many SMR designs will have different characteristics and irradiation histories, so existing back-end technologies will need to be leveraged and, where necessary, adapted or supplemented with new developments across all stages of the back end of the fuel cycle (IAEA, 2024).

10.2.2. Interim Storage Capacity

Interim storage capacity must be planned to accommodate potentially longer cooling periods and higher heat loads per storage position than many current facilities were originally designed for (EASI-SMR, 2025).

IAEA provides the overarching framework, but specific guidance notes for LW-SMR fuel types with non-standard geometries, thermal characteristics, and enrichment levels are not yet developed. Such guidance will need to be developed or adapted as LW-SMR move forwards deployment (IAEA, 2012).

10.2.3. Transport Systems Recertification

Existing regulatory systems for RWM have been largely developed based on the experience of operating large light water reactors, where waste characteristics are well understood and relatively standardized.

The deployment of LW-SMRs doesn’t introduce fundamentally new types of waste; however, it changes their characteristics in ways that require adaptation of existing approaches (EURAD-2, 2025). Transport systems need recertification or development to handle different fuel assembly dimensions and waste package configurations (Nuclear Engineering International, 2024; NEA, 2024).

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Finland's KBS-3V repository and similar facilities represent mature technologies for LW-SMR spent fuel disposal but require iterative adaptation rather than fundamental redesign (Keto et al., 2022; EASI-SMR, 2025).

The main challenges and directions for adapting the regulatory framework can be summarized as follows:

1) Updating waste classification approaches

Existing classification systems remain broadly applicable but may require refinement. LW-SMRs are associated with compact but more intensively activated waste, as well as differences in geometry and activity distribution. This can complicate the straightforward assignment of waste to existing categories.

In this context, rather than introducing new waste classes, it is more appropriate to refine classification criteria and allow for more flexible interpretation of existing schemes (EURAD-2, 2025).

2) Revision of WAC

WAC, applied at different stages of waste management, have been developed based on waste streams from large reactors. In the case of SMRs, deviations from these typical characteristics may occur, particularly in terms of waste geometry, specific activity, heat generation, and radionuclide composition.

This suggests that existing WAC may need to be adapted or supplemented, especially for non-standard waste forms such as integrated components or compact high-activity items. At the same time, it is important to ensure that such adaptations remain consistent with overall safety principles and long-term disposal concepts (EURAD-2, 2025; PREDIS, 2024).

3) Regulatory implications of SMR modularity

The modular nature of SMRs introduces new challenges for regulatory systems. In some designs, entire reactor modules or large integrated components may be removed and transported, which differs from conventional segmentation practices.

This raises several regulatory questions, including how such items should be classified, what transport requirements should apply, and how compliance with WAC should be assessed. These aspects are only partially covered by existing regulatory frameworks and require further development (EURAD-2 2025; Koskinen et al. 2024).

4) Harmonization of regulatory approaches

With the potential large-scale and international deployment of SMRs, the importance of harmonizing regulatory requirements across countries is increasing. In particular, differences in waste classification, WAC, transport requirements, and disposal approaches may create barriers to cross-border cooperation, including the potential development of multinational disposal solutions.

In this context, EURAD-2 (WP FORSAFF) findings highlight the need for greater alignment of regulatory approaches and a common understanding of key safety parameters (EURAD-2, 2025).

Overall, the deployment of SMRs doesn't require the creation of entirely new regulatory systems but rather the adaptation of existing ones. The main focus should be on increasing flexibility, aiming for technology neutrality, addressing uncertainties, and gradually updating regulatory frameworks as more operational experience becomes available.

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Thus, regulatory adaptation for SMRs should be seen as an evolutionary process, combining established safety principles with the need to respond to emerging technological challenges.

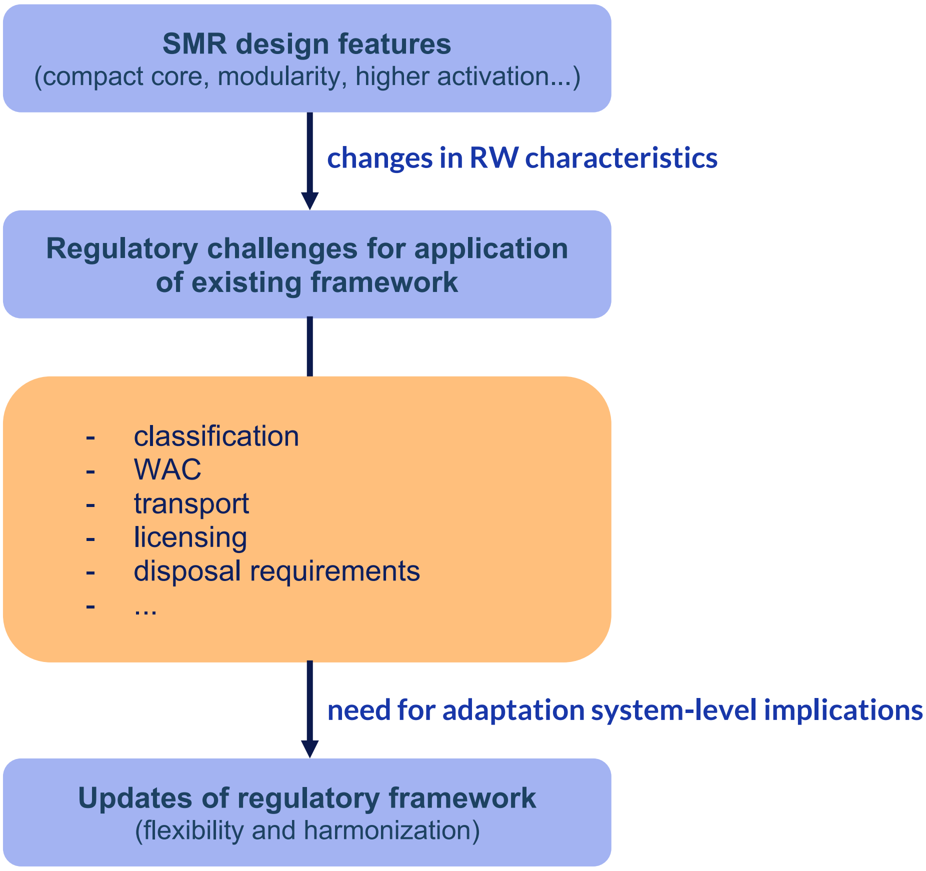

Figure 1: Regulatory adaptation framework for SMR RWM

Existing radioactive waste management infrastructure in most countries has been developed mainly based on experience from large light water reactors, where waste characteristics, volumes, and processing approaches are relatively well established. For LW-SMRs, it is generally not expected that completely new infrastructure will be required. However, some targeted adaptations of existing systems will be necessary to reflect differences in waste characteristics and generation patterns (EASI-SMR, 2025; EURAD-2, 2025).

One important aspect is the readiness of processing and conditioning facilities.

In general, existing technologies can still be applied, but in some cases their operating limits may be reached earlier. This is mainly related to the presence of more compact but more highly activated components, which may require increased shielding and a wider use of remote handling technologies.

In addition, in some SMR designs that use integrated or sealed modules, waste conditioning can be more complex due to limited possibilities for on-site segmentation or pre-treatment. This means that facilities may need to be adapted not only in terms of capacity, but also in terms of flexibility and ability to handle different waste forms (EASI-SMR, 2025).

Interim storage is another key element that needs to be considered. As discussed in previous sections, waste from SMRs may have higher specific activity and, in some cases, different thermal behavior. This does not necessarily lead to a significant increase in total storage volumes, but it can affect storage conditions.

For example, it may be necessary to reconsider loading density or heat removal conditions to ensure long-term safety. At the same time, the modular nature of SMRs can lead to a more uneven generation of waste over time, which requires more flexible approaches to storage capacity management.

Transport infrastructure is also an important aspect, although it is sometimes underestimated at early stages. In the case of SMRs, differences in fuel assembly design or waste package configurations may require adjustments to existing transport solutions.

For instance, the use of integrated modules or non-standard containers may require either the development of new packaging designs or re-certification of existing transport systems. This becomes especially relevant if centralized waste management or long-distance transport is considered (EURAD-2, 2025).

In addition to technical considerations, the transport of radioactive waste may also influence public acceptance, particularly in densely populated areas. This aspect should be taken into account in infrastructure planning and communication strategies.

Compatibility with existing disposal concepts is a key factor when evaluating overall infrastructure readiness. Studies from countries such as Finland shows that existing approaches, including the KBS-3V concept, can in principle be applied to LW-SMR waste as well. At the same time, this does not mean that no changes are needed.

Rather, some parameters, such as waste packaging, thermal limits, and acceptance criteria, may need to be adjusted. Finnish studies (Keto et al., 2023a) indicate that these adjustments can be implemented as stepwise refinement of existing concepts, rather than requiring completely new solutions and should be based on the specific characteristics of each SMR design.

Overall, existing radioactive waste management infrastructure can be considered as a sufficient basis for SMR deployment. However, its effectiveness will depend on the ability to adapt to new conditions. The key issue is not only the availability of technologies, but also their integration into a flexible system capable of operating under uncertainties related to waste characteristics and deployment scenarios.

In this context, infrastructure readiness for SMRs should be seen as a dynamic process, involving gradual adaptation of existing systems, development of new technological solutions where needed, and continuous refinement based on emerging experience.

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Table 8: Key differences between LWR-based infrastructure and SMR RWM needs

Existing infrastructure (LWR-based):	**SMR requirements:**
- standard RW forms; - known volumes; - stable operation cycles	- compact high-activity RW; - uncertain volumes; - modular deployment
adaptation needs:	
- flexible systems; - scalable capacity; - updated processing technologies	

10.3. Financing and long-term liability

Financing systems for radioactive waste management have traditionally been developed based on the operation of a limited number of large utility operators, which provide stable financial flows and clearly defined responsibilities over the entire lifecycle of nuclear installations. The deployment of LW-SMRs may significantly modify this model, as it can involve a larger number of operators, more diverse business models, and different project structures (EURAD-2, 2025; NEA, 2025e). This includes non-utility industrial or municipal owners such as district heating companies, and the integration of multiple smaller LW-SMR operators into existing waste management funding schemes presents institutional challenges that require proactive policy development (EASI-SMR, 2025).

One of the key challenges is the integration of new types of operators into existing financing mechanisms. Unlike traditional large utilities, potential SMR operators may include industrial companies, municipalities, or smaller consortia with limited experience in nuclear activities. This makes it more complex to apply existing approaches for the establishment and management of radioactive waste funds, and requires adaptation of contribution schemes, oversight mechanisms, and long-term financial assurance systems.

Another important aspect is the adequacy of financial contributions. As discussed in previous sections, SMR waste streams may differ in terms of activity levels and management requirements, which can influence overall lifecycle costs. Under-estimation of waste volumes — which has historically affected large reactor programmes — would be particularly consequential given the 2–30× multiplication factor for ILW volumes associated with LW-SMRs (Krall et al., 2022; Kim, 2026). This means that contribution models calibrated for conventional LWRs may not fully reflect the actual costs associated with SMR waste management. In this context, more flexible and differentiated approaches may be needed to ensure sufficient long-term funding (EURAD-2 2025).

In practical terms, this may involve:

- adjusting contribution methodologies to reflect design-specific waste characteristics;
- introducing mechanisms for periodic revision of financial assumptions;

- ensuring that uncertainty is explicitly considered in long-term cost estimates.

Long-term liability represents another critical dimension. The modular nature of SMRs and the possibility of phased replacement of reactor modules may lead to a more distributed generation of waste over time, including questions about who is responsible for spent modules removed mid-life and held in on-site or centralised interim storage (EASI-SMR, 2025). This complicates the definition of liability boundaries between operators, state authorities, and other stakeholders. In addition, the involvement of new types of owners or international project structures may require clearer allocation of responsibilities across all stages, from operation to final disposal (EURAD-2, 2025). The Kojo et al. (2023) study on the institutionalisation of the SMR promise in Finland confirms that financing and liability frameworks are among the most complex governance challenges, requiring multi-level regulatory reform involving political, economic, and social actors (Kojo et al., 2023).

A further challenge is the limited availability of data on long-term RWM costs for SMRs. This introduces uncertainties that may affect both the adequacy and efficiency of funding mechanisms. As a result, there is a need for adaptive financial frameworks that can be updated as more operational experience and cost data become available.

An important factor influencing the feasibility of SMR deployment is the existence of a well-established and credible radioactive waste management programme. In many countries, responsibility for spent fuel and high-level waste is assigned to national waste management organizations, often publicly owned. Where such systems are already in place, they provide clarity regarding the back-end of the fuel cycle and reduce uncertainty for new projects. In contrast, in countries with less developed frameworks, this may create additional challenges, particularly for new or smaller SMR operators.

Overall, the deployment of SMRs doesn’t change the fundamental principles of radioactive waste financing, including the “polluter pays” principle and the requirement to secure sufficient resources for long-term management and disposal. However, it does require adjustments to existing financial and institutional frameworks to account for a larger number of stakeholders, more diverse project configurations, and higher levels of uncertainty.

In addition, uncertainties related to long-term policy decisions, infrastructure development, and public acceptance may influence the timing and implementation of RWM solutions.

In this context, the key objective is to ensure that financing systems remain robust, flexible, addresses liabilities and support safe and sustainable RWM over the long term.

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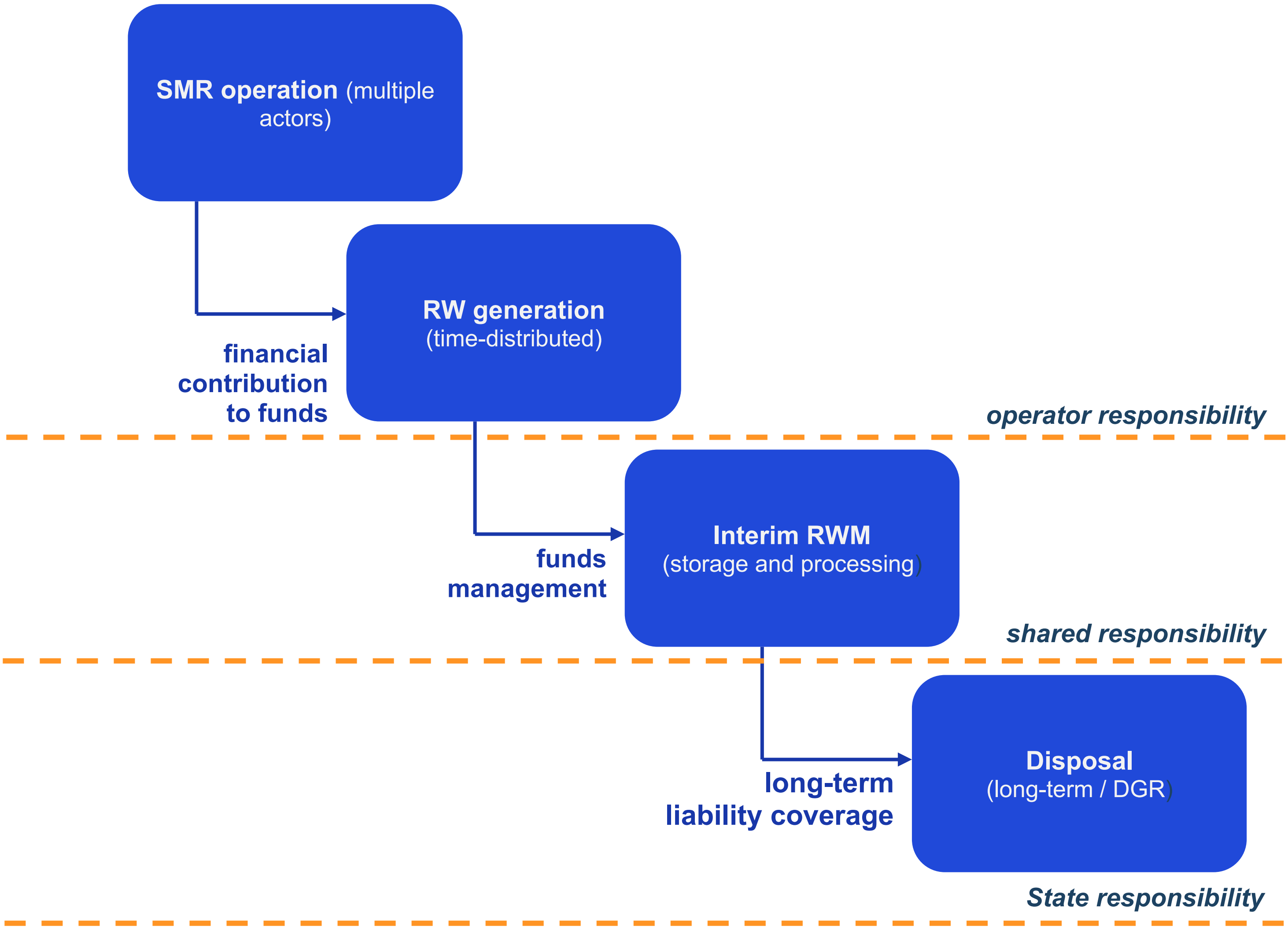

Figure 2: Example of integration of operational processes, financial flows and responsibility allocation in LW-SMR RWM

10.4. Knowledge management and R&D needs

Addressing LW-SMR waste management challenges requires sustained and internationally coordinated research and development (NEA, 2024; EURAD-2, 2025; Krall, 2022; EASI-SMR, 2025).

10.4.1. Priority R&D Areas

Priority R&D areas identified across EASI-SMR and international programmes include:

- Characterization of waste forms from operational LW-SMRs which is currently limited due to minimal operational experience from deployed commercial units (EURAD-2, 2025).

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- Long-term behavior modeling of LW-SMR spent fuel and activated materials in geological disposal environments, particularly for radionuclide release under far-field groundwater conditions (EURAD-2, 2025).
- Development and qualification of conditioning technologies for compact, high-intensity waste packages that cannot be treated with existing large-component conditioning equipment (EASI-SMR, 2025).
- Criticality safety analysis methodologies validated for lower-burnup and HALEU fuel configurations, extending existing burnup credit frameworks (NRC, 2025).
- Transport package certification programmes for non-standard geometries and thermal loads, including HALEU-fuelled systems and sealed reactor modules (NEI, 2024; NEI, 2026).
- Decay heat measurement data for new LW-SMR fuel types to support the validation of decay heat calculation codes against the extended parameter ranges relevant to LW-SMRs (NEA, 2025d).

10.4.2. International Collaboration

International collaboration through initiatives such as EURAD-2 FORSAFF, IAEA technical working groups, and the European Industrial Alliance on SMRs is essential to share operational experience, harmonize approaches, and avoid duplication of effort (EURAD-2, 2025; NEA, 2025b; IAEA, 2025b). Given the potential for parallel SMR deployment across different countries, such coordination is especially important (NEA, 2024; EURAD-2, 2025). García et al. (EURAD-2, 2025) provides the most comprehensive European synthesis currently available, drawing on input from waste management organisations, technical support organisations, and research entities. The SMRSiMa research programme reinforces this interconnection by linking directly to both EURAD-2 FORSAFF and the NEA WIZARD network, ensuring that national findings feed into and draw from international developments (Keto, 2025).

The development of RWM systems for LW-SMRs carries a significant level of uncertainty, driven by the scarcity of real-world operational data, lack of source term data concerning new materials (e.g. dissolution of accident tolerant fuel cladding materials in water) and the diversity of technological designs. In contrast to conventional LWRs, where extensive datasets have been accumulated over decades, many key parameters for SMRs remain unvalidated in practice (EASI-SMR, 2025).

In this context, knowledge management (KM) and targeted research activities become critically important. This is not only about generating new data, but also about ensuring that existing knowledge is consistent, accessible, and properly integrated into regulatory and engineering practices. As highlighted within the EURAD-2 (WP FORSAFF) framework, one of the main challenges is not the lack of individual studies, but rather the fragmentation of knowledge and the absence of a common approach to its use.

As outlined in previous section, the priority R&D areas span waste characterization, long-term behavior modelling, conditioning technologies, criticality analysis, and transport solutions. Across all these areas, available data currently rely heavily on modelling, expert judgement, or limited studies of specific concepts, covering both operational and decommissioning waste. Further empirical work is needed to:

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- better characterize RW streams from real or demonstration units;
- refine radionuclide inventories and physico-chemical properties;
- assess variability across different SMR designs.

Another important area is related to long-term waste management, especially in the context of geological disposal. Considering potential differences in waste composition and activity levels, it is necessary to ensure reliable modelling of RW behavior in repository conditions. This includes both SF and activated structural materials.

Special attention should also be given to conditioning technologies. Compact and potentially high-activity waste forms typical for SMRs may require new approaches to packaging, heat management, and long-term stability, necessitating the development and qualification of purpose-built solutions capable of handling such radioactive waste in compliance with safety requirements (EASI-SMR, 2025).

Table 9 : Key R&D needs and system implications (based on EURAD-2 WP FORSAFF)

R&D area	Key challenge	System impact
Waste characterization	limited operational data	uncertainty in WAC and classification
Long-term behavior	lack of validated models	disposal safety assessment
Conditioning technologies	new waste forms	infrastructure adaptation
Criticality analysis	new fuel types	licensing requirements
Transport solutions	non-standard packages	logistics and certification

At the same time, it is important to note that these areas aren’t entirely new, but rather represent an extension of existing research programmes in a new context. This confirms that the key challenge is not to develop a new one, but to adapt and expand the current knowledge base.

Overall, effective KM and R&D are key prerequisites for the safe deployment of SMRs. The focus should be not only on data generation, but also on its systematic integration into decision-making, regulatory frameworks, and engineering practice. This will help to reduce uncertainties and support the consistent development of RWM systems in the context of emerging nuclear technologies.

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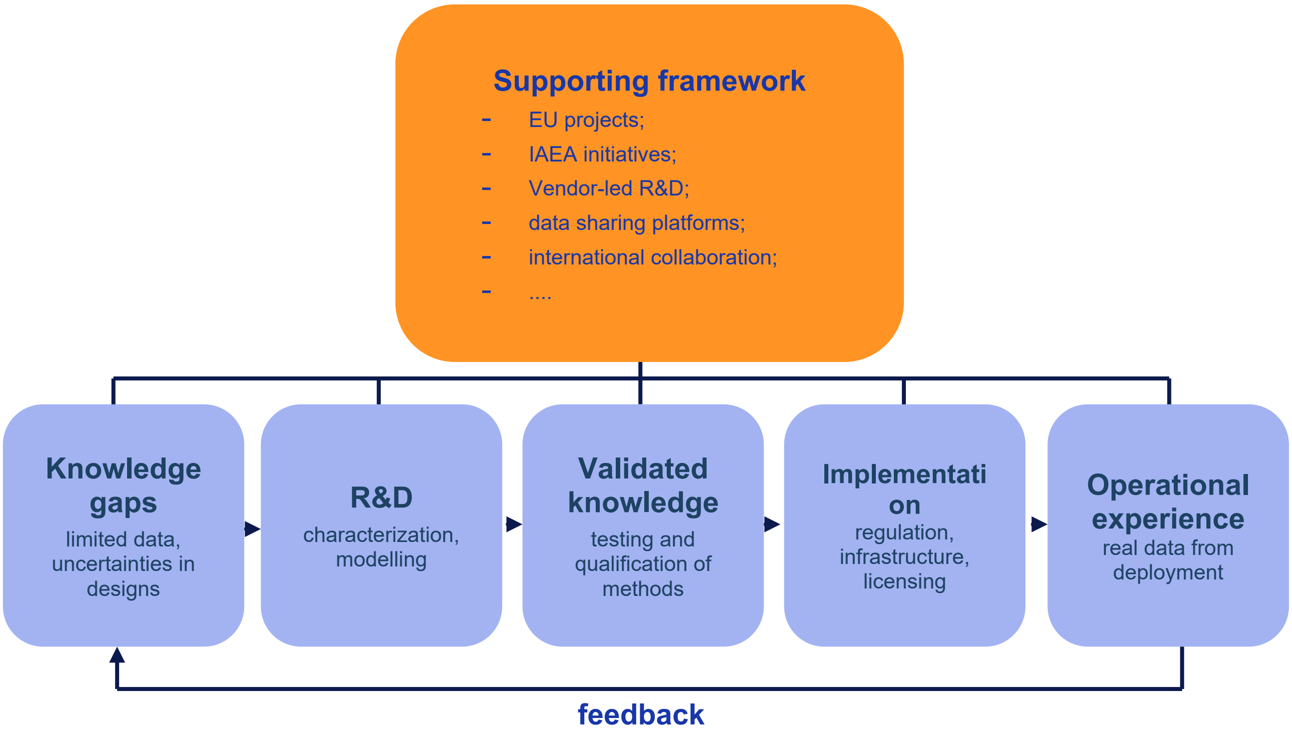

Figure 3: KM and R&D feedback loop for LW-SMR RWM

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11. Conclusions and recommendations

The deployment of LW-SMRs across Europe is technically feasible within existing radioactive waste management frameworks. However, it requires proactive, technology-specific adaptations rather than fundamental system redesign (EURAD-2, 2025; EASI-SMR, 2025; Keto et al., 2022).

Key findings specific to LW-SMR waste management:

1. Geological repositories based on concepts like KBS-3V remain applicable for LW-SMR spent fuel, but require updated thermal modelling, revised tunnel layouts, and adapted disposal canisters to accommodate shorter fuel assemblies and higher decay heat densities (Keto et al., 2022; EASI-SMR, 2025). Current waste management programmes have primarily been designed for waste from conventional NPPs, and some technical, organisational, and licensing aspects may require adaptation for the management of LW-SMR waste. ONKALO® can be give as an example of an advanced programme (Keto et al., 2024; Helsinki Times, 2025) while some other countries that are planning to deploy small modular reactors (SMRs) in parallel with their existing NPPs will face a similar challenge.

2. Differences in the waste characteristic, particularly lower discharge burnup and potential HALEU utilization, necessitate enhanced criticality safety analysis, revised source term calculations, and adapted safeguards approaches throughout the waste management chain (González, 2024; Kim et al., 2023; SKB, 2025; Keto et al., 2024; EASI-SMR, 2025).

3. Waste volumes per unit electricity will be higher for LW-SMRs compared to optimized large LWRs depending on waste category, requiring upward revision of repository capacity projections and interim storage infrastructure (Krall et al., 2022; Kim et al., 2026).

4. Compact, high-intensity waste forms from LW-SMRs demand novel packaging solutions, extended interim storage periods, and specialized remote handling capabilities not fully addressed by current infrastructure (Krall et al., 2022; EASI-SMR, 2025).

Strategic recommendations for EASI-SMR consortium and national programmes:

- Early integration: Waste management planning must be incorporated into LW-SMR licensing and site selection from the outset, not treated as a back-end afterthought (NEA, 2024; EASI-SMR, 2025).
- Iterative development: Waste acceptance criteria, repository designs, and operational procedures should be developed iteratively in collaboration between reactor designers, waste management organizations, and regulators (Harvey, 2024; EASI-SMR, 2025).
- Infrastructure prioritization: Member states planning LW-SMR deployment should prioritize enhancement of interim storage capacity, hot cell facilities for high-intensity ILW conditioning, and transport certification programmes (EASI-SMR, 2025).

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- Coordinated R&D: The EASI-SMR programme should maintain close liaison with EURAD-2 FORSAFF, IAEA and OECD/NEA programmes and other international initiatives to ensure waste management research addresses the most critical knowledge gaps for LW-SMR technology (EURAD-2, 2025; IAEA, 2022; NEA, 2025b).
- Regulatory harmonization: Support for harmonized European approaches to LW-SMR waste classification, acceptance criteria, and safety assessment methodologies will reduce barriers to deployment and enable economies of scale in waste management infrastructure (NEA, 2025a; NEA, 2025b).

The comprehensive technical evidence gathered across EASI-SMR Deliverable D1.2 and the referenced international literature demonstrates that while LW-SMRs introduce specific waste management challenges, none of them constitute fundamental showstoppers. Through coordinated technical adaptation, regulatory evolution, and sustained international collaboration, European waste management systems can safely and effectively accommodate LW-SMR deployment in support of decarbonization objectives (EASI-SMR, 2025; Kinghorn-Mills et al., 2023).

Underpinning all of the above is the need for clearly defined responsibilities and credible national waste management programmes. These are not merely regulatory formalities, they are the institutional foundation without which technical and financial planning for SMR deployment cannot proceed with confidence Overall, while LW-SMR deployment is not expected to introduce fundamentally new challenges in radioactive waste management, it will require careful optimization of existing approaches, continued research, and adaptive regulatory frameworks to ensure safe, efficient, and economically viable long-term waste management. In order to successfully deploy SMR in energy supply systems, it is also essential to gain the public’s support for these steps. It is crucial that SMR development includes robust, inclusive, and transparent engagement processes, with clear accountability on long-term waste management. Without this, trust in both the technology and its promoters is unlikely to improve.

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12. Bibliography

COM 197 (2024). Report from the Commission to the Council and the European Parliament on progress of implementation of Council Directive 2011/70/EURATOM. Brussels, 22.5.2024.

Czech Policy (2025). Draft of the Policy of Radioactive Waste and Spent Nuclear Fuel Management in the Czech Republic (Draft Update for the period 2025 to 2035 with a view beyond 2050), Ministry of Industry and Trade, 02/2025.

EASI-SMR (2025). EASI-SMR Deliverable D1.2: SMR-compatible waste management systems. EASI-SMR Consortium.

EC (2011). Directive 2011/70/Euratom.

EURAD-2 (2025). Deliverable 4.2: Guidance on SMR Implementation and Deployment Needs from the Back-End of the Fuel Cycle Perspective (Work Package: FORSAFF).

EURAD-2 (2026). Deliverable 4.3: Identification of knowledge gaps for future RD activities (Work Package: FORSAFF).

González Espartero, A. (2023). IAEA Ongoing Activities on Nuclear Fuel Cycle Options and Spent Fuel Management. EURAD Webinar, June 2023. https://euradschool.eu/wp-content/uploads/2023/06/IAEA-On-going-activities-on-NFCO-and-SFM_EURAD-Webinar_June-2023.pdf.

González Espartero, A. (2024). Fuel Cycle Options for SMRs. Presentation at 4th Joint ICTP-IAEA Workshop on Physics and Technology of Innovative Nuclear Energy Systems, Trieste, 11–15, November,2024.
https://indico.ictp.it/event/10524/session/3/contribution/13/material/slides/0.pdf.

González Espartero, A. (2025). Status and Trends of Spent Fuel Management from Power Reactors. IAEA TWG-NFCO 22nd Meeting.
https://conferences.iaea.org/event/399/attachments/18638/31452/04_A.
Gonzalez_Espartero_IAEA.pdf.

(HARMONISE, 2022). EU project Towards harmonisation in licensing of future nuclear power technologies in Europe, https://cordis.europa.eu/project/id/101061643/reporting

Harvey, L. (2024). Waste Acceptance Criteria (WAC): Domain Insight within EURAD Roadmap. Galson Sciences Ltd for PREDIS/EURAD, May 2024. https://predis-h2020.eu/wp-content/uploads/2024/08/DI-2.1.2-Waste-Acceptance-Criteria-–-Domain-Insight.pdf.

Helsinki Times (2025). Finland Leads Race to Build World's First Permanent Nuclear Waste Repository (April 2025).

IAEA (2012). Storage of Spent Nuclear Fuel. Safety Standards Series No. SSG-15. International Atomic Energy Agency, Vienna.

IAEA (2020). Advances in Small Modular Reactor Technology Developments. Supplement to ARIS 2020. International Atomic Energy Agency, Vienna.

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IAEA (2022). Small Modular Reactors: A New Nuclear Energy Paradigm. International Atomic Energy Agency, Vienna.

IAEA (2023a). New CRP: Enhancing Global Knowledge on Deep Borehole Disposal for Nuclear Waste (T22003). International Atomic Energy Agency. Available at: https://www.iaea.org/newscenter/news/new-crp-enhancing-global-knowledge-on-deep-borehole-disposal-for-nuclear-waste-t22003 [Accessed April 2026].

IAEA (2023b). IAEA Bulletin, Vol. 64-1 – "Decommissioning by Design: How Advanced Reactors are Designed with Disposal in Mind", April 2023

IAEA (2024). Considerations for the Back End of the Fuel Cycle of SMRs. IAEA-TECDOC-2040. International Atomic Energy Agency, Vienna.

IAEA (2025a). IAEA SMR Platform Annual Report 2025.pdf

IAEA (2025b). Status and Trends of Spent Fuel Management from Power Reactors. 22nd TWG-NFCO Meeting, 2024–2025.

IGD-TP (2014). Requirements on Spent Nuclear Fuel for Disposal in a KBS-3 Repository. Implementing Geological Disposal Technology Platform.

Kang, J.S., Chang, I.G. & Cheong, J.H. (2026). Comprehensive review of small modular reactor development focusing on challenges in the backend nuclear fuel cycle. Nuclear Engineering and Technology, 58(3). DOI: 10.1016/j.net.2025.103528.

Keto, P. (2025). Lessons Learned from SAFER2028 SMR Siting and Waste Management. Presentation at EASI-SMR/SAFER2028 workshop. https://bin.yhdistysavain.fi/1608821/3HTbMFKoINYCklv5kZal0czmkB/Paula_Keto_Lessons.

Keto, P. (ed.), Juutilainen, P., Naumer, S., Airola, M., Schatz, T., Haavisto, T., Gotcheva, N. and Häkkinen, S. (2023a). SMRSiMa: SMR Siting and Waste Management. Waste Management Considerations and Societal Acceptability. Research Report VTT-R-00040-23.

Keto, P. et al. (2023b). SMRSiMa: SMR Waste Management and Siting — Phase 2. VTT Research Report. VTT Technical Research Centre of Finland.

Keto, P., Juutilainen, P., Schatz, T., Naumer, S. & Häkkinen, S. (2022). Waste Management of Small Modular Nuclear Reactors in Finland. VTT Research Report VTT-R-00076-22. VTT Technical Research Centre of Finland, Espoo. https://cris.vtt.fi/en/publications/waste-management-of-small-modular-nuclear-reactors-in-finland.

Keto, P., Naumer, S., Juutilainen, P., Heino, V., Niskanen, M., Schatz, T. & Häkkinen, S. (2024). Adaptation of Current Final Disposal Strategy and methods in Finland for Spent Fuel From SMRs. International Conference on the Management of Spent Fuel from Power Reactors. Conference Proceedings. Paper No 71. 10-14 June 2024. Vienna, Austria. Available at: https://www.iaea.org/publications/15919/management-of-spent-fuel-from-nuclear-power-reactors.

Kim T. K., Boing L., Halsey W., Dixon B. (2022). Nuclear Waste Attributes of SMRs Scheduled for Near-Term Deployment. ANL/NSE-22/98.

Kim, P. & Macfarlane, A. (2026). Challenges of small modular reactors: A comprehensive exploration of economic and waste uncertainties associated with U.S. small modular reactor designs. Progress in Nuclear Energy, 190. DOI: 10.1016/j.pnucene.2025.105387. https://www.sciencedirect.com/science/article/abs/pii/S0149197025003877.

Kim, T.K. et al. (2023). Pros and Cons Analysis of HALEU Utilization in Example Fuel Cycles. Idaho National Laboratory/SAI, June 2023. https://sai.inl.gov/content/uploads/29/2024/12/182926.pdf.

Kim, T.K. et al. (2024). Nuclear waste attributes of near-term deployable small modular reactors, Nuclear Engineering and Technology, Volume 56, Issue 3,2024,Pages 1100-1107,ISSN 1738-5733, https://doi.org/10.1016/j.net.2024.01.046

Kinghorn-Mills, J., Chapman, N., Kegel, L., McCombie, C. & Tyson, S. (2023). How Will Backend Issues Affect The Global Deployment Of SMRs? Proceedings of the International Conference Nuclear Energy for New Europe (NENE), Portorož, Slovenia, 11–14 September 2023, Contribution No. 502. https://www.djs.si/upload/nene/2023/proceedings/Contribution_502_final.pdf.

Kojo, M., Lehtonen, M., Kari, M. & Litmanen, T. (2023). Institutionalizing a promise: The case of small modular reactor regulation in Finland. 2023 19th International Conference on the European Energy Market (EEM), Lappeenranta, Finland. DOI: 10.1109/EEM58374.2023.10161978.

Koskinen V., Schatz T., Keto P., Juutilainen P., Naumer S., Häkkinen S. (2024). Issues in SMR Spent Fuel and Waste Management from Finnish Perspectives.

Koskinen, V. (STUK), Schatz, T. (VTT), Keto, P. (VTT), Juutilainen, P. (VTT), Naumer, S. (VTT), Häkkinen, S. (VTT), Hashymov, A. (Energorisk) & Sevbo, O. (Energorisk) (2022). Issues in SMR Spent Fuel and Waste Management from (mainly) Finnish Perspectives. IAEA Technical Meeting on Back End of the Fuel Cycle Considerations for SMRs, 20–23 September 2022. https://conferences.iaea.org/event/321/attachments/13273/20591/D2_27_Finland_Finnish Perspectives on SMR BEFC_Koskinen.pdf.

Krall, L.M., Macfarlane, A.M. & Ewing, R.C. (2022). Nuclear waste from small modular reactors. Proceedings of the National Academy of Sciences (PNAS), 119(23), e2111833119. DOI: 10.1073/pnas.2111833119. https://www.pnas.org/doi/10.1073/pnas.2111833119.

Naumer, S., Keto, P., Kojo, M., Kiviluoma, N., Hietava, J., Gotcheva, N., Kähkönen, T., Reijonen, H., Aaltonen, I., Airola, M., Juutilainen, P., Tornberg, S. & Vainio, A., (2026), VTT Technical Research Centre of Finland. 46 p. (VTT Research Report; No. VTT-R-00071-26).

NEA/OECD (2024). Proceedings of the Workshop on the Management of Spent Fuel, Radioactive Waste, and Decommissioning in SMRs/Advanced Reactor Technologies, Ottawa, 7–10 November 2022. NEA/RWM/R(2024)1. Nuclear Energy Agency, Paris. https://one.oecd.org/document/NEA/RWM/R(2024)1/en/pdf.

NEA/OECD (2025a). Challenges in the Back-End Management of Small Modular Reactors and Generation IV Nuclear Technologies: Outcomes of the RWMC-57 Topical Session, March 2025. https://www.oecd-nea.org/upload/docs/application/pdf/2025-03/2025_rwmc-57_brochure.pdf.

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NEA/OECD (2025b). Strategising for the Back End of Small Modular and Generation IV Reactors: Outcomes of the 7th Joint Session of the CDLM and RWMC, July 2025. Nuclear Energy Agency, Paris.

NEA/OECD (2025c). Workshop on the Initial Estimation of Back-end Costs for Advanced Reactors and SMRs. EGCDL Workshop, November 2025. Nuclear Energy Agency, Paris.

NEA/OECD (2025d). Summary of the NEA Assessment on Spent Nuclear Fuel Decay Heat for Light Water Reactors. Nuclear Energy Agency, Paris.

NEA/OECD (2025e). NEA Small Modular Reactor Dashboard: Third Edition; https://www.oecd-nea.org/jcms/pl_116777/discussing-nuclear-liability-and-radioactive-waste-disposal-facilities

NEI (2024). Nuclear Engineering International (NEI Magazine) (2024). SMRs and the transport challenge (11 January 2024) https://www.neimagazine.com/advanced-reactorsfusion/smrs-and-the-transport-challenge-11427709/.

NEI (2026). Nuclear Engineering International (NEI Magazine) (2026). Navigating the Future of Transport (21 January 2026). https://www.neimagazine.com/analysis/navigating-the-future-of-transport/.

NRC (2018). Regulatory Guide 3.54, Revision 2: Spent Fuel Heat Generation in an Independent Spent Fuel Storage Installation. U.S. Nuclear Regulatory Commission, Washington DC. https://www.nrc.gov/docs/ML1822/ML18228A808.pdf.

NRC (2025). NUREG/CR-7309 (ORNL/TM-2023/3243): Validation Studies for High Burnup and Extended Enrichment Fuels in Burnup Credit Criticality Safety Analyses. Oak Ridge National Laboratory/NRC, April 2025.

Prasad S., Wickham S., Drouin J., Begg J. (2026). Towards a Generic Deep Borehole Disposal Concept. Final version as of 16.01.2026 of deliverable D3.2 of the European Partnership EURAD-2. EC Grant agreement n°:101177718.

PREDIS (2024). Waste Acceptance Criteria (WAC); Domain Insight. Liz Harvey, PREDIS Project.

Rolls-Royce SMR (2024). E3S Safety Case Chapter 11: Management of Radioactive Wastes, Issue 3. Generic Design Assessment documentation. https://gda.rolls-royce-smr.com/assets/documents/documents/rr-smr-e3s-case-chapter-11---management-of-radioactive-waste-issue-1-public.pdf.

Schatz, T. (2022). Unique Issues in SMR Spent Fuel and Waste Management. Presentation at SNETP Forum TS5: Waste Minimization and Fuel Cycle, 6 June 2022. https://snetp.eu/wp-content/uploads/2022/06/P7a_Schatz_SMR_SNETP_2022.pdf.

SKB (2025). Post-closure Safety Evaluation of a Carbon Steel KBS-3 Canister Insert. TR-25-05. Svensk Kärnbränslehantering AB, Stockholm.

Sustainability-Directory (2025). How Does SMR Waste Disposal Compare Conventionally? https://energy.sustainability-directory.com/question/how-does-smr-waste-disposal-compare-conventionally/ What Are Long-Term SMR Waste Storage Challenges? https://energy.sustainability-directory.com/question/what-are-long-term-smr-waste-storage-challenges/ What Challenges Do SMRs Face Currently? (24 April 2025).

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https://energy.sustainability-directory.com/question/what-challenges-do-smrs-face-currently/.

VTT (2025). SMRSiMa: SMR Waste Management and Siting — Waste Characteristics and Organisational Aspects. VTT-R-00243-25. VTT Technical Research Centre of Finland, Espoo.

VTT (2026). Spent Fuel from Small Reactors Demands Large-Scale Attention (15 March 2026). https://www.vttresearch.com/en/news-and-ideas/spent-fuel-small-reactors-demands-large-scale-attention

Waples Matt, Ethan Bates, Stan Gingrich, Andrew Griffith (2025), Accelerated High-Temperature and Pressure Demonstration of Deep Borehole Disposal Canister Technology, WM2025 Conference, March 9 - 13, 2025, Phoenix, Arizona, USA.