JOURNAL OF ENERGY TECHNOLOGY
Vol. 18, No. 3, pp. 161–168, November 2025

Professional Article

RADIOACTIVE WASTE MANAGEMENT STRATEGY FOR A NEW NUCLEAR POWER PLANT

Submitted 24. 11. 2025
Accepted 26. 11. 2025
Published 28. 11. 2025

EVA BAHČIČ, KAJA NAGLIČ, TOMAŽ ŽAGAR
GEN energija d.o.o, Krško, Slovenia
eva.bahcic@gen-energija.si, kaja.naglic@gen-energija.si, tomaz.zagar@gen-energija.si

CORRESPONDING AUTHOR
eva.bahcic@gen-energija.si

Abstract An essential early phase of any new nuclear power plant (NPP) project is the drafting and preparation of a radioactive waste management strategy. The paper outlines the major steps in such a strategy, presented in a case study approach for the new NPP project in Krško (the JEK2 project). The paper includes analyses of the options and strategies for radioactive waste (RAW) and spent nuclear fuel (SNF) management. This article presents a proposed management plan for the RAW and SNF expected to be produced during the operation and decommissioning of JEK2, together with an assessment of the anticipated decommissioning and waste management costs. The document examines further the existing financing framework for radioactive waste management in Slovenia, which is regulated legally for the current nuclear facilities. A similar approach is planned for JEK2, including the expansion of the existing and planned facilities for waste handling and storage. Accordingly, additional financial resources will be required through contributions to the national decommissioning and disposal fund. An analysis was therefore conducted, to estimate the scale of the additional contributions needed to ensure adequate funding for the new NPP project in Krško.

Keywords
JEK2,
radioactive waste,
spent nuclear fuel,
storage,
fund

https://doi.org/10.18690/jet.18.3.161-168.2025

University of Maribor Press

1 Management of Radioactive Waste and Spent Nuclear Fuel and Assessment of the Fund Contributions

RAW is generated at any nuclear power plant (NPP) from the beginning of the trial operation, while SNF is first generated only after the completion of the plant's initial fuel cycle and the subsequent refuelling outage. The management of RAW and SNF from the new NPP project in Krško (JEK2) will be planned in accordance with the principles and guidelines of Resolution ReNPROIG23–32, or in accordance with the requirements of the resolution in force at the time the application is submitted [1], [2].

In Slovenia, waste management programmes will be prepared in accordance with the Regulation on Radiological and Nuclear Safety Factors, and will comply with the content requirements of the Regulation on the Management of Radioactive Waste and Spent Fuel [1], [2].

1.1 Storage and disposal of low- and intermediate-level radioactive waste

Based on their origin and characteristics, the following types of operational low- and intermediate-level radioactive waste (LILW) can be expected for an NPP: waste concentrates and sludges from the liquid systems, spent ion-exchange resins, used filter cartridges, compressible waste, and various solid and non-compressible waste. The waste concentrates, sludges and resins will be solidified prior to storage, either through drying, or by treatment with binding materials [1], [6], [7].

The LILW generated at JEK2 will, in accordance with the planned schedule, be transferred to the Agency for Radioactive Waste Management (ARAO) for disposal. The ARAO will operate the LILW Repository. The LILW Repository will be designed as a near-surface facility in the form of an underground silo, which will be filled from the surface. The standard storage packaging for LILW will consist of steel drums of various designs, made of either carbon or stainless steel. Prior to disposal, all the LILW will be placed into disposal containers, such as the N2d-type containers [1], [6], [7].

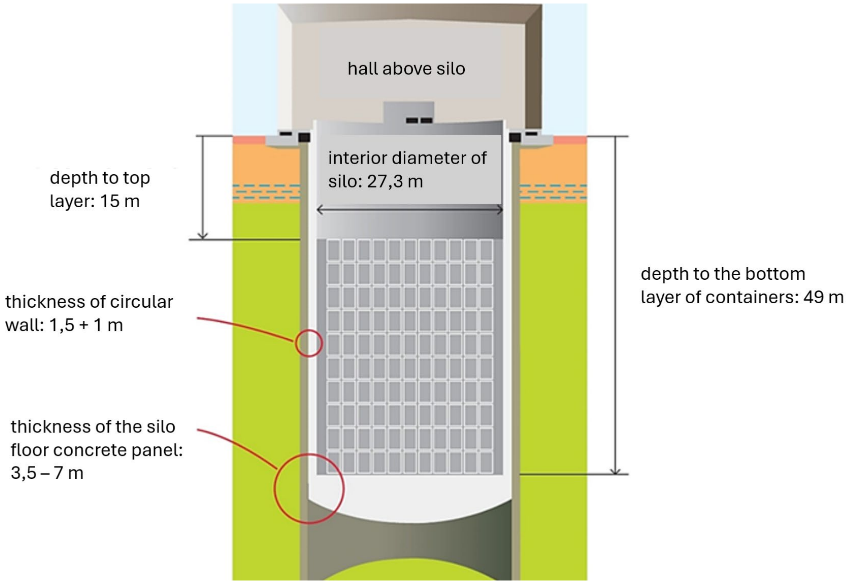

Figure 1: LILW disposal facilities in the form of a near-surface silo with an above-ground hall.

The first silo will have the capacity to accommodate 990 N2d-type containers, arranged in ten disposal layers. The interstitial spaces between the containers will be filled progressively with backfill material, and every second layer will be covered with a concrete levelling layer. The uppermost layer will have a thickness of one metre. Upon closure of the repository, the space above the silo will be filled almost to the surface with clay, which will serve to prevent water infiltration from above. During the operational phase, the silo will remain open at the top and protected by a surface enclosure. All above-ground structures will be dismantled following the closure of the repository [1], [7].

The management of LILW within the JEK2 project in Slovenia will, from a technological standpoint, represent an upgrade of the currently planned approach described in the Resolution on the National Programme for the Management of Radioactive Waste and Spent Fuel (ReNPROIG23-32) [2].

During its operational phase, the JEK2 project will necessitate an increase in disposal capacity, requiring the acquisition of appropriate construction permits for the existing disposal site. This will involve expanding the capacity of the current repository rather than constructing a new facility. Nevertheless, the remaining available capacity of the first silo will suffice for at least several years of operational LILW disposal from JEK2. In any case, with the addition of one extra silo for JEK2—already designated spatially —there will be sufficient capacity to cover 30 years of JEK2 operation [1], [7] .

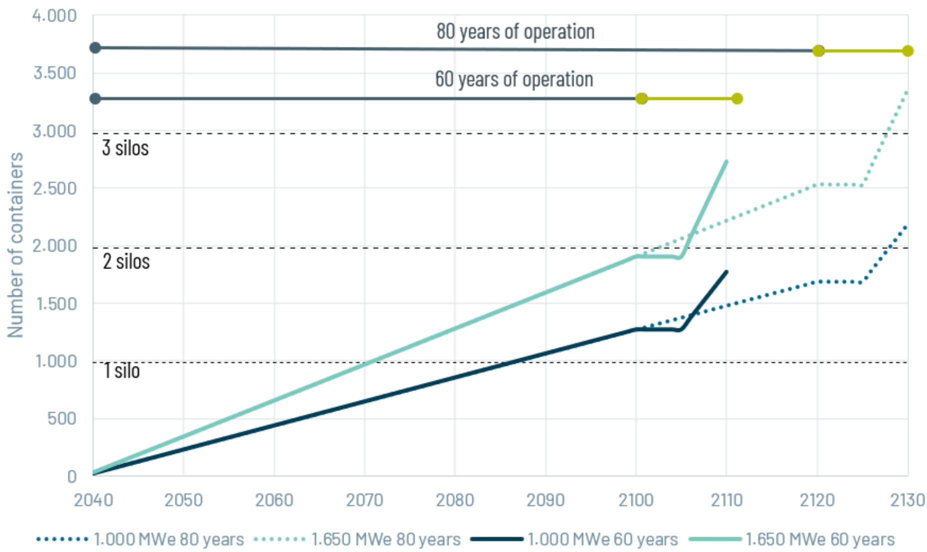

Figure 2: Display of the storage capacities for LILW.

The planned expansion will include the construction of additional silos, and will entail a corresponding increase in the repository's operational costs.

Assuming identical disposal conditions to those applied for the first LILW disposal silo, the management of the LILW generated by the new NPP project in Krško (JEK2), with a unit capacity of 1.000 Mwe, would necessitate the construction of two additional silos. For units with capacities of 1.250 MWe and 1.650 MWe, three additional silos would be required to accommodate the waste generated during a 60-year operational lifetime.

Table 1: LILW quantities and conservative estimate of silos [1], [7].

	JEK2 power 1.000 MWe	JEK2 power 1.250 MWe	JEK2 power 1.650 MWe
operational LILW (m^3)	3.000	3.577	4.500
LILW from decommissioning (tones)	5.000	6.250	8.250
Number of N2d containers for operational LILW	1.250	1.490	1.875
Number of N2d containers for LILW from decommissioning	500	625	825
Total number of N2d containers	1.750	2.115	2.700
Number of additional silos required (conservative estimate)	**1,77**	**2,14**	**2,73**

1.2 Dry storage and disposal of high-level radioactive waste

The SNF is first stored in a pool next to the reactor. The pool is designed to store sufficient capacity for at least 15 years of operation, considering an appropriate reserve, and space is always available in the pool for the insertion of the entire reactor core. The spent fuel will be stored in a water-cooled pool, and the heat will be dissipated into the environment by an active cooling system.

The JEK2 project, presented in this paper as an example of a new nuclear power plant construction project currently under discussion in Slovenia, also includes a facility for the dry storage of the SNF generated during the entire planned lifetime of the power plant. The SNF can be transferred to dry storage at least five years after removal from the reactor and cooling in the spent fuel pool. For the purposes of dry storage, the fuel elements will be removed from the pool and placed in multi-purpose containers in the building next to the reactor. The containers with SNF will be transferred to the dry storage building and placed in storage casks. These will provide passive cooling of the SNF with ambient air [1], [2].

The dry storage facility will be used to store the SNF until a deep geological repository is established, ensuring adequate temporal isolation of the waste from the environment.

Table 2: Number of fuel elements required for 60 years of operation.

	JEK2 power 1.000 MWe	JEK2 power 1.250 MWe	JEK2 power 1.650 MWe
Number of fuel elements – 60 years of operation	3.348	4.646	4.831

The fuel elements will be inserted into channels inside special containers. For fuel elements in PWR reactors, such as the planned JEK2, the design is such that each container has four separate channels, allowing four fuel elements to be placed in a single container. Based on the estimated number of fuel elements, we calculated the number of containers required for a power range from 1.000 MW to 1.650 MW.

Table 3: Number of required containers for 60 years of operation [1].

	JEK2 power 1.000 MWe	JEK2 power 1.250 MWe	JEK2 power 1.650 MWe
Number of required containers – 60-year operating life	837	1.161	1.208

1.3 Economic evaluation

The total cost of decommissioning for the JEK2 project, as an example of new nuclear power plant construction project in Slovenia, and additional funds for the LILW and HLW is currently estimated at an additional 1.386–2.250 million EUR for a 60-year operating period. Considering the 1.5% real target return on the existing fund (3.0% nominal with an expected inflation rate of 1.5%), an estimated 14.4 – 23.4 EUR million would need to be collected annually for this purpose, which means 1.62–1.83 EUR per MWh of electricity produced over a 60-year operating period. However, due to the high degree of uncertainty surrounding decommissioning and disposal, a significantly higher value was considered conservatively in the economic model, namely, a decommissioning compensation of 2.0 EUR/MWh, due to the uncertainties regarding profitability and the final costs of waste disposal and decommissioning [1], [4], [7].

Table 4: Estimated costs for radioactive waste management for 60 years of operation.

	Additional funds[1] 1.000 MWe [million EUR]	Additional funds 1.250 MWe [million EUR]	Additional funds 1.650 MWe [v million EUR]
LILW	236	305	318
HLW	330 (clay)	402 (clay)	474 (clay)
	402 (hard geological formations)	502 (hard geological formations)	578 (hard geological formations)
DECOMISSIONING	820	1.026	1.354
TOTAL	**1.386** (clay)	**1.733** (clay)	**2.146** (clay)
	1.458 (hard geological formations)	**1.833** (hard geological formations)	**2.250** (hard geological formations)

Table 5: Contribution to the fund for 60 years of operation [1].

	1.000 MWe	1.250 MWe	1.650 MWe
Contribution to the fund [EUR/MWh] (clay)	1,73	1,73	1,62
Contribution to the fund [EUR/MWh] (hard geological formations)	1,82	1,83	1,70
Estimated evaluation of the contribution to the fund [EUR/MWh]	**2,00**		

References

[1]IBE d.d. and Sava project Krško d.d., Proposal for a national spatial plan for JEK2, 2025

[2]Resolution on the National Program for Radioactive Waste and Spent Fuel Management for the Period 2023-2032 (ReNPROIG23-32), Resolucija o nacionalnem programu ravnanja z radioaktivnimi odpadki in izrabljenim gorivom za obdobje 2023–2032 (ReNPROIG23–32) (PISRS)

[3]ARAO, Third Revision of the Krško NPP Radioactive Waste and Spent Fuel Disposal Program, version 1.3, September 2019

[1] Additional funds needed for the new NPP

Rebekka Bärenbold et al. 2024, Renewable and Sustainable Energy Reviews, Decommissioning of commercial nuclear power plants: Insights from a multiple-case study

Regulations on the management of radioactive waste and spent fuel, No. 125/21 and 74/24, Pravilnik o ravnanju z radioaktivnimi odpadki in izrabljenim gorivom (PISRS)

ARAO, Safety report for the LILW Vrbina repository, 2021

Internal source, GEN energije d.o.o., https://jek2.si/ravnanje-z-radioaktivnimi-odpadki/

Povzetek v slovenskem jeziku

Predvideno ravnanje z radioaktivnimi odpadki in izrabljenim gorivom iz JEK2 ter s tem povezanimi stroški. Ključen del priprav projekta JEK2 predstavljajo analize, potrebne za dolgoročno, varno in učinkovito načrtovanje ravnanja z radioaktivnimi odpadki (RAO), izrabljenim gorivom (IG) in razgradnjo elektrarne po koncu obratovanja. Članek na primeru projekta JEK2 predstavi glavne elemente takšne strategije. Vključuje pregled možnosti in pristopov k ravnanju z RAO in IG, za katere se pričakuje, da bodo nastali med obratovanjem in razgradnjo JEK2, skupaj z oceno predvidenih stroškov. Dokument dodatno preučuje obstoječi finančni okvir za ravnanje z radioaktivnimi odpadki v Sloveniji, ki je zakonsko urejen za obstoječe jedrske objekte. Podoben pristop je predviden za JEK2, vključno s širitvijo obstoječih in načrtovanih objektov za ravnanje z odpadki, njihovo skladiščenje in odlaganje. Ekonomski vidik financiranja ravnanja z RAO temelji na uveljavljeni praksi zbiranja sredstev prek namenskega sklada, ki deluje kot mehanizem za upravljanje finančnih virov.