Developing a New National Programme and Implementation Plan for the Management and Disposal of Spent Fuel and Radioactive Wastes in Romania - 16391

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ABSTRACT

The European "Waste Directive" (2011/70/Euratom) required each Member State to report by August 2015 on their National Programme for management of spent fuel and radioactive wastes. In Romania, the Nuclear Agency (ANDR) was responsible for preparing the National Programme report, and this was done in a step-wise manner that involved the regulators and waste producers. The starting point for the process was an assessment of existing policy against the evolving situation in the nuclear sector in the country, most notably the decision to progress with the construction of two new CANDU reactors.

The final agreed National Programme report submitted to the European Commission describes the activities currently undertaken to manage spent fuel and radioactive wastes in Romania. The report also sets out, at a high-level, the additional activities that will need to be taken in the future (and an indicative timeline), including those steps that will be required to implement a new surface repository for short-lived wastes, and a geological repository for spent fuel and long-lived wastes.

Additional, on-going work is intended to lead to a revision of Government policy and the development of a more detailed implementation strategy, underpinned by a programme of R&D and robust financing plans.

INTRODUCTION

In 2011, the European Council (of the European Union) issued Directive 2011/70/Euratom establishing a Community framework for the responsible and safe management of spent fuel and radioactive waste (commonly known as the "Waste Directive") [1].

The Waste Directive imposed a number of obligations on Member States. One of these was for each Member State to report to the European Commission on the implementation of their "National Programme" for the management of all spent fuel and radioactive wastes under its jurisdiction. The Waste Directive specified the content of the National Programme to be reported (Article 12) and the deadline for reporting was set as not later than 23 August 2015 (Article 15).

The Romanian Nuclear Agency and for Radioactive Waste (Agentia Nucleara si Pentru Deseuri Radioactive, ANDR) was responsible for preparing the National

Programme report for Romania, and Amec Foster Wheeler was contracted to support ANDR in this activity.

Preparation of the National Programme report also provided an opportunity to review the existing Government policy and the national strategy for radioactive waste management (dated 2004), to reflect significant developments in the nuclear sector in the country.

THE NUCLEAR SECTOR IN ROMANIA

Romania has a large and established nuclear sector, and is active in most aspects of the nuclear fuel cycle, including mining, fuel manufacture and civil nuclear power generation. There is, therefore, a large and diverse range of radioactive wastes to be managed.

There are currently 2 civilian power reactors operating in Romania, both are CANDU designs located on a site near the town of Cernavoda. It is planned that 2 further CANDU reactors will be commissioned on the same site in the coming years.

Spent fuel is stored at the reactor site, first in cooling ponds and then transferred to a MACSTORE type interim dry fuel store. Romania adopts an open fuel cycle and consequently spent fuel from the power reactors is considered as a waste. Assuming 50 years operation of all 4 reactors, the total quantity of spent fuel that will need to be managed is around 20,000 tonnes U metal.

Both short and long-lived radioactive wastes (LILW-SL and LILW-LL) are produced during normal operations of the CANDU reactors, and these are also stored on site, after some segregation and packaging operations. The CANDU reactors are expected to undergo refurbishment half way through their design life (after around 25 years of operation) during which some reactor internal components will be replaced. Assuming 50 years operation of all 4 reactors, the total quantity of packaged and conditioned LILW-SL from routine operations, refurbishment and decommissioning that will need to be disposed is around 30,000 m^3.

There are no repositories in Romania suitable for the disposal of spent fuel or of any of the operational, refurbishment or decommissioning wastes currently in store, or will arise from the CANDU reactors in the future. A geological repository for the disposal of spent fuel and long-lived ILW is planned, but this is not likely to be operational for several decades. To dispose of LILW-SL, a new surface repository is planned to be constructed close to the Cernavoda reactor site, subject to regulatory approval. This repository will have a modular cell design which will allow it to be built in phases, and to adapt to future decommissioning and management decisions.

There are also two research reactors in Romania: a VVR-S type reactor at the National Institute for R&D in Physics and Nuclear Engineering at Horia Hulubei (IFIN-HH) and a TRIGA-type reactor at the Institute for Nuclear Research (ICN) at Pitesti. The VVR-S reactor has been defuelled and all spent highly enriched uranium

(HEU) fuel has been returned under agreement to the Russian Federation. The TRIGA reactor has been converted to operate with low enriched uranium (LEU) instead of HEU fuel, and all the HEU fuel has been returned under agreement to the USA.

Both the IFIN-HH and ICN research sites produce LILW-SL and LILW-LL from their own research activities and from facility decommissioning. They also collect radioactive wastes and spent sources from other research, industrial and medical institutions around Romania. Both research sites have their own on-site waste treatment plants that condition and package LILW-SL. These institutional wastes are disposed to an operating repository at Baita Bihor which is located within a redundant uranium mine and, following modernisation in 2010/11, is expected to continue operations until around 2040.

Specific laws have established the national framework for the responsible and safe management of spent fuel and radioactive wastes. The National Commission for Nuclear Activities Control (CNCAN) has the authority to license and regulate all nuclear activities, including waste disposal.

ANDR is the competent national authority responsible for preparing the National Programme, and for planning and implementing disposal of spent fuel and radioactive waste, and for coordinating the pre-disposal management of spent fuel and radioactive wastes arising from operations and decommissioning.

DEVELOPMENT OF THE ROMANIAN NATIONAL PROGRAMME

The existing Romanian national strategy for medium and long-term management of spent fuel and radioactive waste management is set out in Order 844/2004 [2]. This strategy predates the Waste Directive and so needs to be updated to meet European obligations and also to reflect recent developments in the nuclear sector in Romania, most notably the decision to progress with the construction of 2 new CANDU reactors.

The starting point for the development of the National Programme report was an assessment of existing policy against the evolving situation in the nuclear sector in the country. Two key objectives were:

1. to describe the activities currently undertaken to manage spent fuel and radioactive wastes in Romania; and
2. to set out, at a high-level, the additional waste management activities that will need to be taken in the future.

It was important that the National Programme was credible and underpinned with realistic milestones. It was also important that the programme was flexible to take account of potential future changes, such as policy or technical developments that may influence how spent fuels and radioactive wastes may be managed.

With this in mind, the project to develop the National Programme involved work in a number of complementary areas:

- *technical:* e.g. to establish realistic spent fuel and waste inventories, and identify future infrastructure needs, such as additional waste treatment and disposal facilities;
- *stakeholder engagement:* e.g. to involve key stakeholders such as waste producers and regulators, in the drafting and review of the National Programme;
- *programme planning:* e.g. to layout a realistic timescale for implementation and key milestones, with an emphasis on the short and medium-term;
- *economic:* e.g. to assess the total programme costs and to review the adequacy of existing funding mechanisms.

The National Programme was developed in a step-wise manner, with preliminary proposals prepared by ANDR and reviewed by stakeholders, and then appropriately revised.

The final agreed National Programme report submitted to the European Commission describes the activities currently undertaken to manage spent fuel and radioactive wastes in Romania [3]. The report also sets out, at a high-level, the additional activities that will need to be taken in the future (and an indicative timeline), including those steps that will be required to implement a new surface repository for short-lived wastes, and a geological repository for spent fuel and long-lived wastes. The outcomes from the National Programme are summarised below.

Management of Wastes Suitable for Surface or Near-Surface Disposal

The policy in Romania is for surface or near-surface disposal of LILW-SL, and the simplified management strategy for these wastes is shown in Figure 1. The main waste streams considered are:

- operational and decommissioning LILW-SL from the Cernavoda CANDU reactors and associated ancillary facilities;
- operational and decommissioning LILW-SL from the research reactor sites; and
- other institutional wastes from sites around the country, including from medical and industrial applications.

The total anticipated volume of LILW-SL that will require near-surface disposal is approximately 30,000 m^3 (packaged volume) of which around 90 % is derived from the Cernavoda reactor site.

Operating LILW-SL from the Cernavoda CANDU reactors are currently segregated, pre-treated (to minimise the volume of the wastes), then packaging for storage in the on-site Solid Radioactive Waste Interim Storage Facility (DIDR). Additional LILW-SL will be produced when the reactors undergo mid-life refurbishment and later decommissioning.

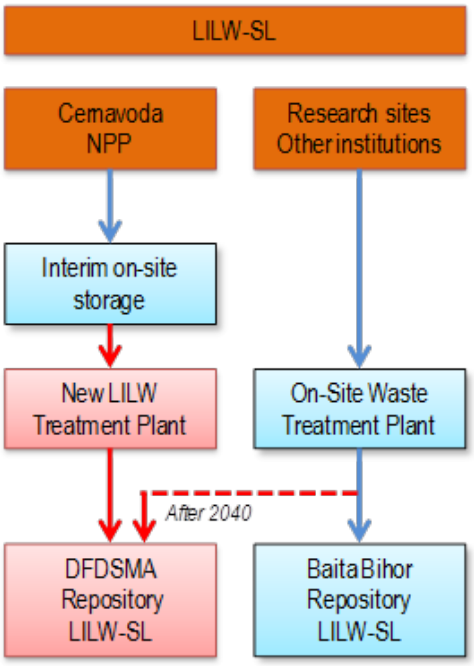

Fig. 1. The simplified management strategy for LILW-SL showing existing facilities (blue) and those that are planned for the future, subject to further approvals (red).

It is intended that all of these LILW-SL wastes will be disposed to a new engineered surface repository (the DFDSMA facility). This will be based on a modular design with concrete disposal cells, similar in concept to the Centre de l'Aube facility operating in France. Strict waste acceptance criteria will apply to disposals in the new repository, and all wastes will need to be conditioned to be in an inert solid form. To meet these criteria, new waste treatment facilities will need to be commissioned to enable the repository to operate.

It is planned that the first phase of the new repository will be built and licensed for waste disposals starting in around 2021. The main implementation milestones for the first phase of the repository are shown in Figure 2. The second and subsequent phases will be constructed on a schedule depending on the rate of future waste arisings.

Operational and decommissioning LILW-SL from the research reactor sites will continue to be treated in the existing on-site waste treatment plants (together with institutional wastes collected from other industrial and medical establishments) and disposed to the Baita Bihor repository. At the anticipated rate of waste arisings, the Baita Bihor repository is anticipated to be completed filled by around 2040, after which institutional wastes will be diverted for disposal to the new DFDSMA repository, as shown in Figure 1.

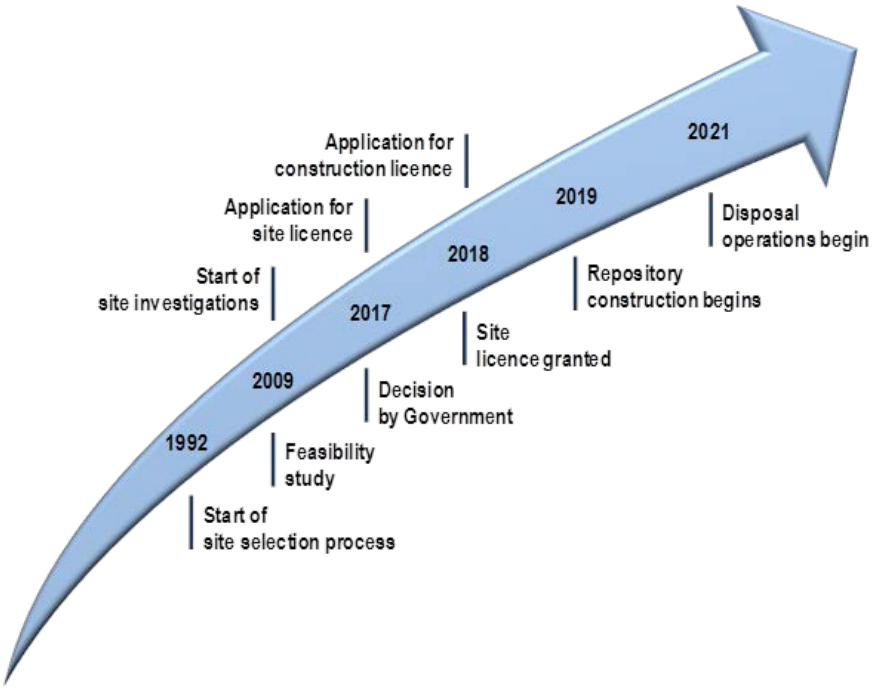

Fig. 2. The indicative timeline with key milestone dates for the implementation programme for Phase 1 of the new surface repository, subject to further approvals.

Management of Spent Fuel and LILW-LL

The policy in Romania is for geological disposal of both spent fuel and LILW-LL in a single repository, and the simplified management strategy for these wastes is shown in Figure 3. The main waste streams considered are:

- spent fuel and operational LILW-LL from the existing operating CANDU reactors at the Cernavoda site;
- spent fuel and operational LILW-LL from the planned new-build CANDU reactors at the Cernavoda site;
- operational and decommissioning LILW-LL from the research reactors, and associated ancillary facilities; and
- decommissioning LILW-LL from the Cernavoda reactor site and associated ancillary facilities.

The total anticipated volume of wastes that will require geological disposal is 42,500 m^3 (packaged volume) of which around 95 % is spent fuel from the Cernavoda reactors.

There is no geological repository currently available or operating in the country, so existing management arrangements focus on pre-disposal waste treatment and interim storage, and on preparatory works to implement geological disposal.

Spent fuel from the operating CANDU reactors is held in cooling ponds for a minimum of 6 years, after which it is transferred to an on-site Interim Dry Storage Facility (DICA). The DICA facility is based on MACSTOR 200/400 type modules which are passively air-cooled. Currently, 7 MACSTOR modules have been licensed at the DICA facility, each with a design life of 50 years. It is planned to expand the facility in stages to store all spent fuel from both the existing and planned new-build reactors.

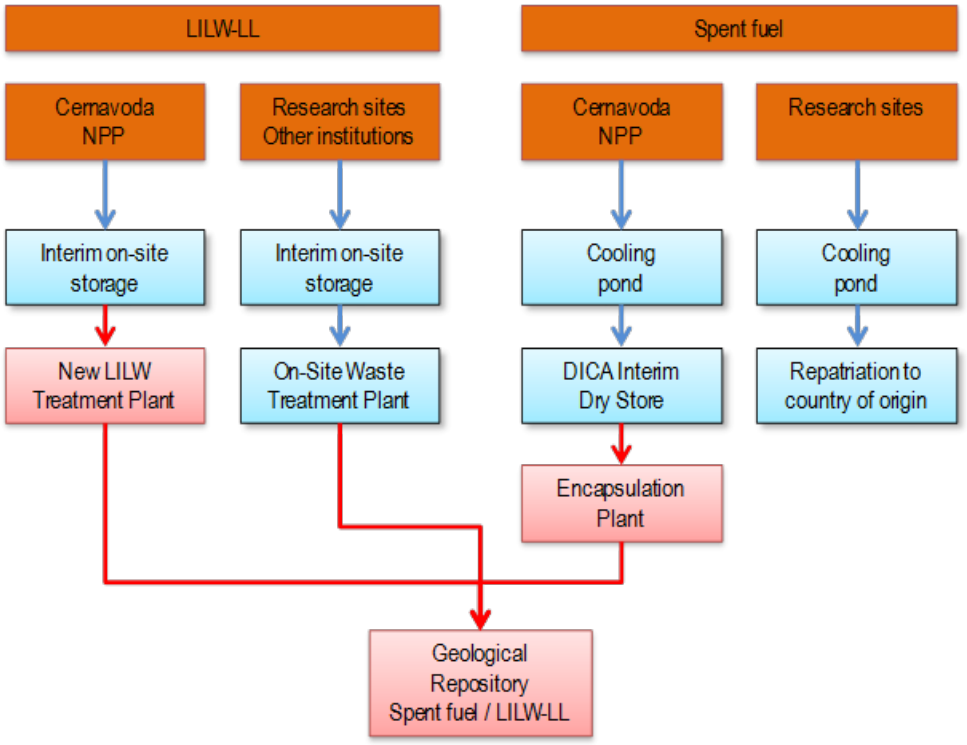

Fig. 3. The simplified management strategy for spent fuel and LILW-LL showing existing facilities and transfers (blue) and those that are planned for the future, subject to further approvals (red).

After storage and cooling, the spent fuel will need to be conditioned, packaged and transported for disposal to the planned geological repository when that becomes available. No site has yet been chosen for this geological repository. As a consequence, the repository layout, as well as the waste package design and the disposal technology have yet to be established. No repository design concept has yet been chosen but, purely for preliminary planning and costing purposes, the Canadian repository for spent CANDU fuel has been used as a reference.

For planning purposes, an indicative timeline with key milestone dates has been set out for the geological repository implementation programme, as shown in Figure 4. This anticipates an underground research laboratory (URL) will be constructed at the chosen site to confirm the suitability of the underground conditions. The repository will then become operational in around 2055 and there will be parallel phases of construction and operation until the repository is closed in around 2150.

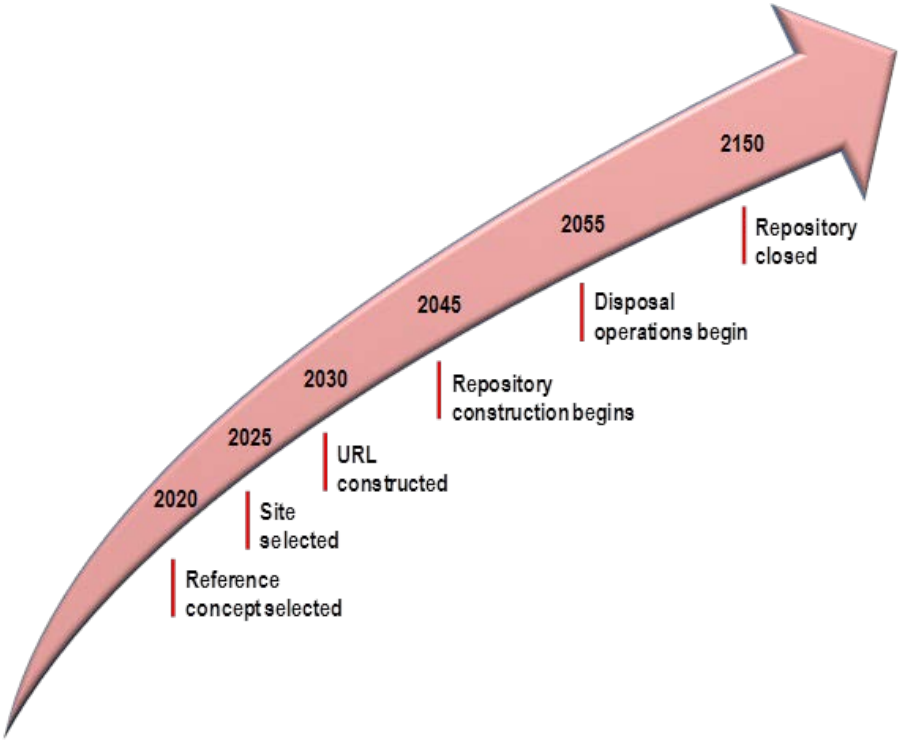

Fig. 4. The indicative timeline with key milestone dates for the Romanian geological repository implementation programme, subject to further approvals.

Supporting Research, Development and Demonstration

The geological disposal programme will need to be underpinned by supporting research, development and demonstration (RD&D), as will the near-surface disposal programme but to a lesser extent.

A new integrated national plan for RD&D to support spent fuel and radioactive waste management is under development. This plan will follow the recommendations from the European Commission's Implementing Geological Disposal of Radioactive Waste Technology Platform (IGD-TP) for establishing and prioritising RD&D objectives [4], and be based around a gap analysis.

The RD&D plan will align with a revision of the geological repository implementation programme, with emphasis on activities to support the key early stages, notably:

- establishing a detailed implementation plan for geological disposal, identifying the necessary infrastructure and skills base, plus a robust cost estimate;
- comparison of alternative disposal concepts, and adoption of a preferred design for further development and programme planning;
- site selection methodologies, including establishing the decision-making process and the involvement of stakeholders in it; and

- surface-based site characterisation plans and technical requirements.

In addition, preliminary planning is being done for RD&D needed to support activities in the medium to long-term, and those that may require long lead-times. This RD&D will be based on continued international cooperation and participation in European projects, and focussed research through Romanian organisations.

Economical and Financial Issues

The total cost for spent fuel and radioactive waste management in Romania was assessed to be US$ 3,920 million which is approximately equivalent to €3,500 million. These costs are dominated by the geological repository, with the cost for the planned new LILW-SL repository being only about 15% of the overall total.

These costs will be spread over more than 100 years due to the anticipated long operational life of the geological repository. The costs will not, however, be evenly distributed over time, as shown indicatively in Figure 5.

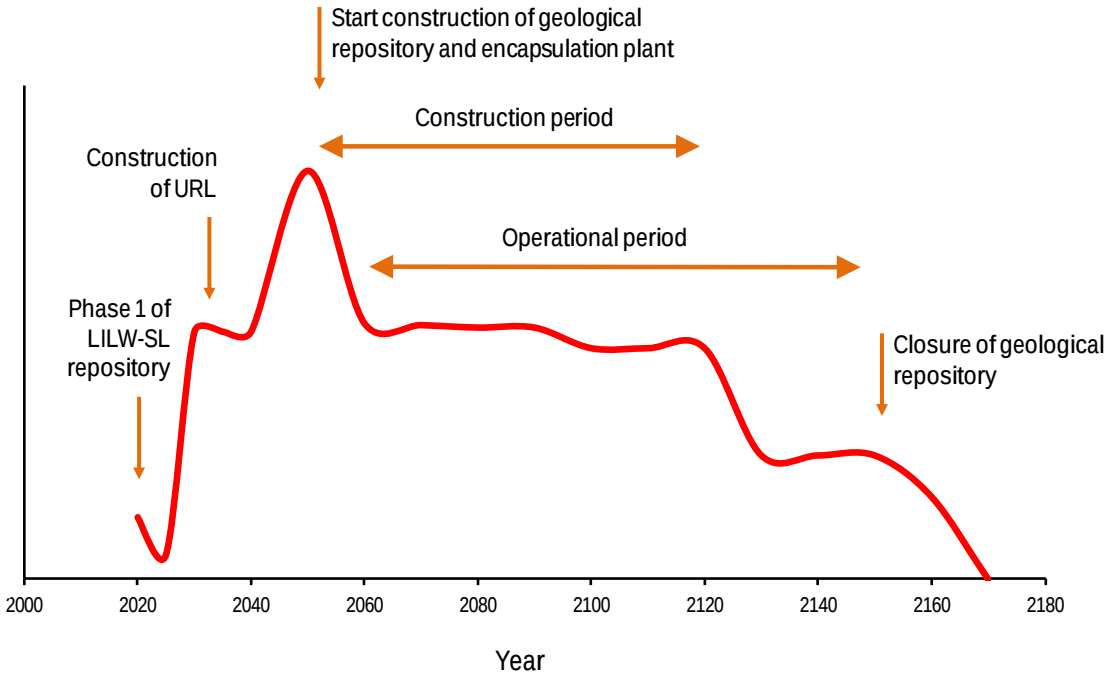

Fig. 5. An indicative profile of the management and disposal costs over time.

The earliest costs relate the construction of Phase 1 of the LILW-SL repository which is due to start operations in around 2021. After that, the costs for the geological repository begin to dominate, with construction of the URL planned for around 2030. The peak annual cost will occur around 2045–2050 with the beginning of construction of the repository in 2045 and construction of the encapsulation plant at around the same time. Costs then remain broadly constant

during the phased construction / operation period, until closure of the geological repository starts in around 2150.

A funding scheme to pay for the costs for waste management and disposal were established by the Romanian Government in 2007. This is based on the 'polluter pays' principle and requires the operators of the Cernavoda reactors to pay into segregated Decommissioning and Waste Disposal Funds.

An assessment of the predicted final value of the funds against the actual costs indicates a potential shortfall. To address this, a review of the funding arrangements is underway.

CONCLUSIONS

The European "Waste Directive" provided a timely impetus to review arrangements and programmes for spent fuel and radioactive waste management in all Member States. In Romania, a comprehensive review of existing arrangements was undertaken as part of the development of the National Programme report to the European Commission, required under the Directive.

The Romanian National Programme report identified where additional waste management activities will be needed in the future, particularly to implement a new surface repository for short-lived wastes, and a geological repository for spent fuel and long-lived wastes. A high-level implementation plan with key milestones was set-out, and this will be supported by a detailed revision of the national strategy together with an integrated RD&D programme and updated funding scheme.

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