# EURAD: a step change in european joint

# collaboration towards safe radioactive

# waste management

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**Abstract**

Within the domain of radioactive waste management (RWM) and deep geological disposal, the European Commission has been funding research and development (R&D) for over 40 years, fostering what is today a strong cooperation between European Waste Management Organisations (WMO), Regulatory Technical Support Organisations (TSO) and Research Entities (RE). The underpinning technical knowledgebase is now sufficient to allow Europe to be on the verge of operation of its first geological disposal facilities for spent fuel and/or high-level and intermediate long‐lived radioactive wastes. Despite this progress, continued R&D is necessary to develop, maintain and consolidate knowledge throughout the stepwise development, increase safety margins and disposal robustness, support optimization, and integrate scientific and technological progress over long time of disposal facilities operation to the closure.

The European Commission has promoted a step change from a previous model of individual projects to a more enduring and integrated programme of cooperation activities between EU Member State (MS) National Programmes. This change is realized by the establishment of a European Joint Programme (EJP) of collaborative research called EURAD.

Launched in 2019, EURAD is an initial 5-year EJP on RWM, built on the basis of activities of shared importance between WMOs, TSOs and nationally funded REs. Guided by a shared Vision, Roadmap and Strategic Research Agenda, EURAD supports MS at various stages of geological disposal implementation and is focused on scientific and technological R&D, aligned to implementation needs, scientific excellence and safety considerations and underpinned by an ambitious knowledge management programme.

EURAD’s concept is to generate new and manage existing knowledge to support MS in the implementation of the Directive 2011/70/EURATOM, and more specifically to support and complement the national programmes in their development and delivery of safe long-term management solutions of different types of radioactive wastes, taking into account different programme sizes and stages of advancement.

## a leap forward

Considerable scientific and technical knowledge has been acquired in Europe in the field of radioactive waste management (RWM) over the last 40 years. This has enabled countries to progress towards licensing of geological disposal facilities (e.g. Finland, Sweden and France) and contributed to the progress of numerous Member States’ disposal programmes) [1].

Recently, the EC has promoted a step-change in European research cooperation between EU Member State national programmes by replacing EU competitive calls for projects with the promotion of an inclusive joint R&D programmes in Europe that attracts and pools a critical mass of national resources on specific shared needs and challenges. The objective is to promote and co-fund an ambitious programme that brings together mandated entities from EU Member-States and associated countries able to direct national funding and/or with national responsibilities to manage RWM R&D.

Based on the positive achievements of the European JOPRAD project to study the feasibility of creating such an EJP in the field of RWM, a first 5-year European Joint Programme on Radioactive Waste Management (EURAD) was launched in 2019.

### The Vision

EURAD pushes for a step change in European collaboration towards safe RWM, including disposal, through the development of a robust and sustained science, technology and knowledge management programme that supports timely implementation of RWM activities and serves to foster mutual understanding and trust between Joint Programme participants [2].

The aim is to implement a research programme and knowledge management activities of common interest at the European level, bringing together and complementing EU Member State programmes to ensure cutting-edge knowledge creation and preservation in view of delivering safe, sustainable and publicly acceptable solutions for the management of radioactive waste across Europe now and in the future.

RD&D efforts in radioactive waste management, including disposal, are necessary to:

develop, maintain and consolidate scientific and technical knowledge throughout the progressive development, operation and closure of disposal facilities, which will be spread over many decades and make this knowledge available to all end users;

ensure the optimisation of waste management routes and of disposal solutions;

address evolving regulatory concerns;

reduce the risk of shortages of the skilled, multidisciplinary human resources needed to develop, assess, license and operate facilities for RWM;

reinforce knowledge transfer and collaboration between advanced and less advanced programmes of European member states;

contribute to gaining and maintaining public confidence.

EURAD supports the implementation of the [Waste Directive](https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=celex%3A32011L0070) in EU Member-States, taking into account the broad spectrum of stages of advancement of national programmes, particularly with respect to their plans and national policy towards implementing geological disposal. Programmes differ significantly depending on the national waste inventory, with some member states only responsible for relatively small volumes of medical and research reactor wastes, compared to others that have comparatively large and /or complex waste inventories from large nuclear power (and fuel reprocessing) and defence programmes [3]. Programmes also differ significantly in the way in which they are managed, regulated and funded, particularly with respect to the national policy and socio-political landscape in relation to longer-term storage and geological disposal.

EURAD therefore gathers Members-States:

with no nuclear power programme operating, but with research, training or demonstration reactors, and/or other sources of radioactive waste;

with a nuclear programme;

at different stages of advancement in the implementation of their national RWM programme; and

with plans for geological disposal for Spent Fuel, High-level Waste and long-lived intermediate level waste, with different host rocks and different disposal concepts and at different stages of implementation [3].

### A community

In EURAD, participation as a Beneficiary is limited to organisations that have received a mandate by their national programme owner(s) (ministry, national/regional authority or private organisation in charge of setting-up and managing a national programme) and that are willing to adopt and share in the EURAD Vision/Strategic Research Agenda and Roadmap for European collaborative R&D.

115 organisations, from 23 European countries (20 Member States and 3 associated countries) are working in EURAD: 51 are mandated organisations and 61 are Linked Third Parties to the mandated actors and 3 are international partners. All participating organisations are part of one of the 3 EURAD Colleges:

Waste Management Organisations (WMOs) having the ultimate responsibility for the implementation of geological disposal (which includes the management of a supporting RD&D programme [4]), and for some other topics of RWM (e.g. waste characterisation, treatment and packaging, interim storage, etc.). WMOs from across Europe form a core part of the Joint Programme and provide a driving force for what is needed for successful, safe and practical implementation from an industrial perspective. WMOs are conducting RTD programs on their own and have established a network and coordination framework for RD&D needs of the implementers of geological disposal at the European level via the Implementing Geological Disposal Technology Platform (IGD-TP) [4];

Technical Support Organisations (TSOs) carrying out activities aimed at providing the technical and scientific basis for supporting the work and decisions made by a national regulatory body [4]. This includes the safety cases for waste processing, storage and disposal develop, as well as the safety case reviews and independent scrutiny responsibility by regulatory organisations in the framework of the decision-making process. In contrast, regulators supervising EURAD members are not part of the EURAD. Several TSOs, together with other organisations fulfilling a regulatory expertise function and Civil Society Organisations have established the SITEX network to support independent technical expertise in the field of safety of geological disposal of radioactive waste [4];

Research Entities (REs) working to different degrees on the scientific challenges of RWM, including disposal (and sometime in direct support to implementers or WMOs or TSOs), under the responsibility of Member States [4]. This includes national research centres, as well as research organisations and universities. RE’s assure scientific excellence and leading-edge research relation to the management of radioactive waste, and therefore represent an important proportion of the contributions to the Joint Programme. The RE’s have established the EURADSCIENCE network, an inclusive network to ensure scientific excellence and credibility to radioactive waste management.

A group of representatives of the European Civil Society Organisations (CSOs) who are involved in RWM activities at EU or national level interact with JP participants are also participants of EURAD. This is done via participation of a Civil Society expert group that follow and participate in technical work packages leading to an improved understanding of RD&D performed in the perspective of safety. A process has been defined to select the members of this group to allow an equilibrium between representatives of all EU countries and a quite well-balanced gender representability

### The governance

EURAD cooperation is structured via a specific governance composed of a General Assembly, a Bureau, a Programme Management Office and a Coordinator.

The General Assembly is the ultimate decision-making body. Composed of a member of each Mandated Actor, it is responsible for agreeing the strategy in line with the content of the founding documents and Euratom Work Programme.

The Bureau is an accompanying body to the General Assembly. Composed of 3 representatives from each College, it assists the General Assembly in the definition of the second wave of R&D and Strategic Studies, work plan for knowledge management and update of EURAD Strategic Research Agenda and Roadmap. The Bureau acts in close interactions with the Programme Management Office.

The Programme Management Office (PMO) is in charge of scientific and technical coordination of the implementation of the programme, as well as the day-to-day management and communication activities. It is responsible to the GA for the overall top-level planning, coordination and implementation of the work plan.

The Coordinator is the legal entity acting as the intermediary between the Beneficiaries and the European Commission [5].

The actual execution of the work programme is supervised by 16 work package leaders that are in most cases supported by task leaders and sub-task leaders.

The EURAD governance is completed by an appointed Chief Scientific Officer whose role is to enforce the scientific leadership on aspects of science, technology and knowledge management and to act as a high-level spokesman able to contextualize EURAD´s progress.

In addition to the initially planned EURAD governance mechanisms, after a year of operation, an independent External Advisory Board (EAB) was created to operate at a more strategic level. Composed of four distinguished members, the EAB’s main focus is to ensure that:

The EURAD consortium is well informed and acts upon the expectations of 'the outside world'

The EURAD programme is visible by 'the outside world'

The members act to provide expertise, balanced perspective and strategic advice to support EURAD as it establishes and delivers a step change in European collaboration towards safe radioactive waste management.

## Deployment plan

The cooperative research over the coming decades will be guided by a common vision as described but also by a Roadmap, shared Strategic Research Agenda and an Implementation Plan. This strategic approach will foster scientific capability and enhance the knowledge needed to implement safe management solutions, including disposal, of radioactive waste, promoting European research and delivering beneficial societal and economic impact for EU citizens [4].

### Roadmap

The EURAD Roadmap is a roadmap for implementing radioactive waste management, leading to geological disposal. It is a representation of a generic radioactive waste management programme that shall enable users and national programmes to ‘click-in’, and access existing knowledge and active work or future plans in EURAD and elsewhere [6].

The content is focused on what knowledge, and competencies (including infrastructure) are considered most critical for implementation of RWM, aligned to the EURAD Vision.

For each phase of the disposal programme from programme initiation over site identification and site selection and characterization over facility construction, operation and closure, the roadmap describes typical programme goals, activities and capabilities needed against the 7 Themes: (1) project management, (2) predisposal, (3) engineered barrier system, (4) geoscience, (5) design and optimisation, (6) siting and licencing and (7) safety case.

These themes are each further broken down into Subthemes and Domain Insights, in what we call the Goals Breakdown Structure [7]. The Roadmap allows one to identify gaps in knowledge and competencies needed individually by each of the member states to take action accordingly.

The Roadmap provides a common set of rules for contextualising knowledge, a common structure or schema for categorising knowledge, and common language and glossary – aligning where possible with glossaries and schema from IAEA, NEA and advanced (RWM) programmes. Experts have also evaluated a high level view on the current status of knowledge across each of the 7 Themes, identifying in a rough sense where resources exist and where efforts should be focussed as a programme evolves through successive phases of a waste management programme.

### Strategic Research Agenda

The EURAD Strategic Research Agenda (SRA) provides a description of scientific and technical (S/T) Themes and Sub-Themes of common interest between the Colleges. It should not be considered as an exhaustive list of all R&D initiatives or active work within Europe and includes only the ones that were considered relevant for cooperative work between EURAD Colleges. The SRA is structured by the above mentioned seven Scientific Themes, as illustrated in Fig. 1 and should allow to capture all areas relevant for the implementation of waste management solutions. Although all technical in nature, Theme 1 is an overarching theme, Themes 2-5 are predominantly focussed on fundamental science, engineering, and technology, and Themes 6 and 7 include aspects more of an applied science and integration focus [8].



*FIG. 1. EURAD Strategic Research Agenda Theme [8]s.*

The S/T scope in the SRA covers cutting-edge S/T activities on RWM from cradle to grave, including predisposal, interim storage and disposal solutions - mainly geological disposal of spent fuel, high level waste and intermediate level waste. The EURAD SRA has been set up as a dynamic and living document that shall be updated periodically in order to integrate outcomes of RD&D activities as well as any emerging collaboration needs identified by the RWM community during the implementation phases of EURAD [8].

### Deployment

To deliver against EURAD objectives, different types of activities have been adopted. These are each briefly described below.

R&D activities - The main activities of EURAD consists of RD&D activities aiming at developing and consolidating S/T knowledge for themes as identified in the EURAD Strategic Research Agenda and Roadmap. There shall be a balance between operational RD&D in direct link with implementation of repository concepts as well as concerns to safety requirements and prospective RD&D such as short and long-term experiments and/or modelling work to demonstrate the robustness of the waste management concepts, to increase understanding and predictability of the impact of fundamental processes and their couplings together with their associated uncertainties and to maintain scientific excellence and competences throughout the stepwise long-term management of radioactive waste including disposal [4].

Strategic Studies - Complementary to RD&D activities and in support of the implementation of the Member States’ national programmes, Strategic Studies shall give the opportunity to participants and expert contributors to network on methodological and strategic challenging issues that are common to various national programmes, often in close link with scientific and technical issues.

Knowledge management - Beyond RD&D and Strategic Studies, a large effort of EURAD is to consolidate efforts across Member-States on Knowledge Management – this includes providing access to existing Knowledge (State-of-Knowledge), guiding the planning and implementation of a RD&D plan of national RWM programme, and developing/ delivering training and mobility opportunities in line with identified core competencies.

Civil Society engagement - Specific interactions with Civil Society are organised as cross-cutting tasks providing access to knowledge/results and corresponding feedback that can be directly embedded in specific technical and strategic WPs.

The coordinator of EURAD is supported for the day to day work by the Programme Management Office (PMO) which is responsible for the proper coordination and implementation of the overall EURAD work plan as approved by the General Assembly.

### Flexibility mechanisms

EURAD’s ambition to be as needs-driven as possible and inclusive (allowing the integration of new organisations) means that some flexibility had to be maintained in the definition of the programme. For R&D and Strategic Studies this flexibility was implemented with only 70 % of the budget being allocated at the start of the programme. The remaining 30 % have been allocated, a year after the launch through a second-wave.

This second wave consisted of proposals of new work packages that were of common interest to the 3 Colleges. A specific selection process, open to new partners, was developed by EURAD Bureau with different steps such as a long list of eligible proposals, a consolidated list, a short list and then finally a time for development of the selected work packages before their submission to the General Assembly and the European Commission. For the knowledge management, the principle of flexibility is ensured by a yearly allocation of the budget. This has allowed at the end of the second year to redefine and plan new activities in knowledge management and to allocate budget to finance those activities.

*FIG. 2. EURAD Overview of Work Packages (1st and 2nd wave)*

## AMbition

As stated above, the main goals of EURAD are to:

Support Member‐States in developing and implementing their national RD&D programmes for the safe long‐term management of all types of radioactive waste through participation in the RWM Joint Programme;

Develop and consolidate existing knowledge for the safe start of operation of the first geological disposal facilities for spent fuel, high‐level waste, and other long‐lived radioactive waste, and supporting optimization linked with the stepwise implementation of geological disposal;

Enhance scientific and technological knowledge management and transfer between organisations, Member States and generations, in a framework of implementation (design and safety) as contextualized area.

### Complement the national Programmes

EURAD complements national efforts and enables the effective use of resources and experts by sharing RD&D efforts and by making existing knowledge more easily available to end-users across national boundaries. Overall, the following impacts can be expected:

Support compliance with European regulations – by supporting Member States in implementing RD&D, developing skills and providing for transparency in order to develop solutions for their radioactive waste

Support safety of radioactive waste management solutions – by contributing to the responsible and safe management of radioactive waste in Europe, including the safe start of operation of the first geological disposal facilities for high-level and long-lived radioactive waste / spent nuclear fuel as well as improvement, innovation and development of science and technology for the management and disposal of other radioactive waste categories;

Help to gain or maintain public confidence and awareness in RWM – by fostering transparency, inclusiveness, credibility and scientific excellence [2];

Support RWM innovation and optimisation – by aiding the development of solutions for different waste streams and types and continuously improving and optimising waste management routes and disposal solutions, including identifying needs specific to small inventory programmes with their particular challenges with respect to access to critical mass of expertise and developing appropriate disposal options [1];

Contribute to addressing S/T challenges and evolving regulatory concerns – by prioritising activities of high common interest, and creating conditions for cross fertilization, interaction and mutual understanding between different Joint Programme contributors and participants;

Foster efficient use of the RD&D resources at the EU level – by sharing and advancing existing knowledge, facilities and infrastructure rather than repeating and duplicating efforts; and

Bring together Civil Society partners from different MSs to transpose EURAD RD&D outcomes to the public.

### Ensure the sustainability of the knowledge

The capitalization and transfer of scientific and technical knowledge generated in EURAD is essential. EURAD aims to establish a sustainable, inclusive, transparent, leading-edge scientific and goal-oriented approach on European collaboration towards safe RWM. The robust and sustained scientific and technological programme will guide cooperative research and investments in the RWM field over the coming decades in Europe. It is developing an approach to ensure preservation and accessibility of publicly financed knowledge generated over the past, ongoing and future RD&D activities, in close link with needs for implementation (design and safety). This is essential to make sure that Member States can take advantage of this knowledge and know-how.Ensuring the sustainability, in view of the long lead-times and operational time-spans for RWM also means to provide support to ensure that the necessary expertise and skills are maintained through generations of experts for ongoing and future projects. EURAD provides an opportunity for programmes to collect, share knowledge and experiences and organise (in a common way) a preservation and transfer between organisations/programmes and for future generations.

This requires acknowledgement of existing knowledge structures and networks as well as of tacit knowledge, as over 40 years of developed RWM knowledge is codified and accessible in the various documents, procedures and processes, organisations, and people of the RWM community.

The role of KM in EURAD is therefore to make better use of this existing knowledge and integrate newly created knowledge, giving weight to:

Importance: Improved orientation of knowledge - how knowledge contributes to specific implementation goals and safety constraints in radioactive waste management;

Proficiency: Improved definition of needed competences – what level of proficiency is needed and available to support national programmes;

Codification: Improving accessibility to knowledge by signposting to people, communities of practice and documents, use of a common structure, digitalisation, or other codification activities – how knowledge is documented, stored and easily re-used;

Diffusion: Improving socialisation, training, and networking as well as production of guidance documents – how knowledge is transferred and spread;

Reflection and feedback: a number of functions, e.g. chat forum and webinars, are utilised to get a swift response on produced deliverables/output/activities for continuous improvement.

### Act as a platform

EURAD for the first time, collects a large part of European expertise, covering WMO, TSO and RE aspects, in one collective RD&D, Strategic Studies and KM and Networking programme, thus creating a platform for discussion, networking and communication.

Bringing together organisations in Europe with key responsibility for directing RD&D on RWM irrespective of the stages of development of their national programmes, EURAD fosters mutual understanding and trust between participants and other stakeholders, including from the civil society.

To avoid duplication of effort and resources and to benefit from participation, exchange and cooperation with international organisations and expert networks, the Programme Management Office have regular exchanges with International Organisations such as the International Atomic Energy Association (IAEA) and the Organisation for Economic Co-operation and Development – Nuclear Energy Agency (OECD-NEA), other EU projects, especially the PREDIS project (Pre-disposal management of radioactive waste) and has now 3 International Partners collaborating in the framework of the work package on CONtainer CORrosion under Diposal conditions (CONCORD).

## Conclusions

In line with the European waste directive 2011/70/EURATOM, EURAD, the European joint programming in radioactive waste management intends to initiate a step change in European collaboration between advanced and early-stage programmes on radioactive waste management and disposal as well as between waste management organisations driving for a timely establishment of geological disposal solutions, technical support organisations assuring that safety always remains the priority and research organisations assuring scientific excellence all over the many decades of any disposal programme.

Two years after its launch EURAD has achieved most of its objectives and milestones planned for its mid-term.

The EURAD Colleges have each found their voice, through their Bureau representatives and formal position papers, providing important governance and oversight used to drive EURAD strategy [9].

Most work packages have now reached their third year of implementation and are delivering encouraging results and the launch of the second has been timely implemented and will be further developed by taking into account lessons learned from the first years of the programme.

It is clear that the ambitious goals of EURAD require a long term perspective over another ten or more years. The building of confidence, trust and common understanding among the various categories of actors is a cornerstone of future success.

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