



# EURADWASTE'22

30 May - 3 June 2022  
Lyon, France

## Predisposal conditioning, treatment, and performance assessment of radioactive waste streams

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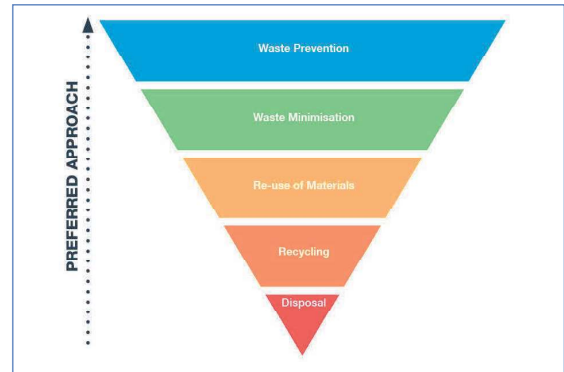
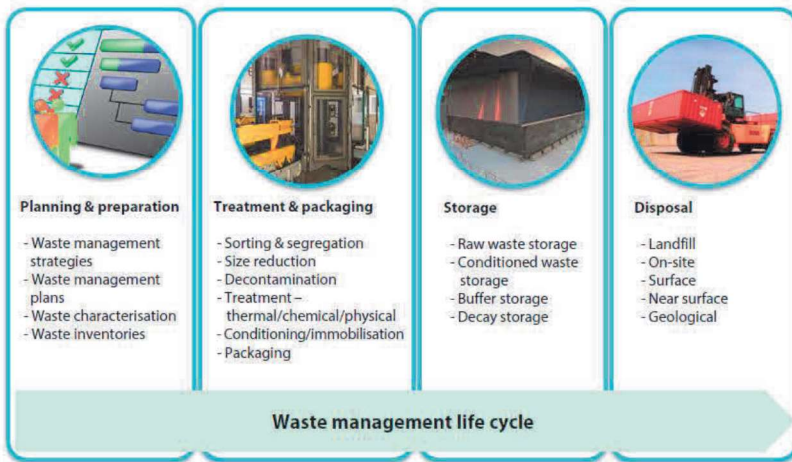
## Presentation Outline

- Objectives of Predisposal scope work
- THERAMIN project: overview and achievements
- PREDIS project: overview and achievements, to-date
- Ideas moving forward, future program



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# Objectives of Predisposal themed projects



NDA (UK). Radioactive Waste Strategy September 2019, [online](#).

OECD/NEA (2020), Optimising Management of Low-level Radioactive Materials and Waste from Decommissioning, NEA No. 7425.



# Predisposal projects in context of EURAD Roadmap

## EURAD Themes

1. Programme Management
2. Pre-disposal
3. Engineered Barrier Systems
4. Geoscience
5. Design & Optimization
6. Siting & Licensing
7. Safety Case

<https://www.ejp-eurad.eu/roadmap>

## PREDIS Theme



<https://predis-h2020.eu/roadmap-and-e-learning-material/>





# THERAMIN overview

Thermal treatment for radioactive waste minimization and hazard reduction

<http://www.theramin-h2020.eu/>



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## Overall Scope

- Objective: **Promotion of thermal treatment of low and intermediate level waste (LILW) prior disposal**
  - ✓ Strategic impact of thermal treatment
  - ✓ Demonstration of thermal treatment technologies
  - ✓ Disposability of thermally treated products
- Schedule: 1 June 2017 – 31 May 2020
- EC contribution: 3,9 M€
- 12 beneficiaries representing 7 European countries
- 12 End User Group members representing 7 European countries and USA



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# Overall Achievements

- Strategic review of
  - radioactive wastes that could potentially be thermally treated
  - available thermal treatment technologies
- Demonstration of thermal treatment technologies for selected waste stream/technology combinations
- Characterisation of thermally treated materials and assessment of disposability of treated products



## Strategic review of waste streams and thermal treatment technologies

- Estimation of volumes of LILW
  - Available data collected primarily from participating countries
  - Evaluation of LILW suitable for thermal treatment
- Value assessment of thermal treatment
- Guidelines for waste managers and decision makers on how to select the most appropriate waste and thermal treatment option for their particular need

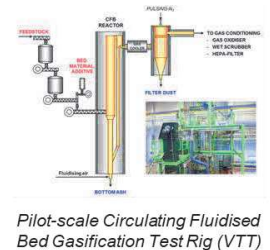
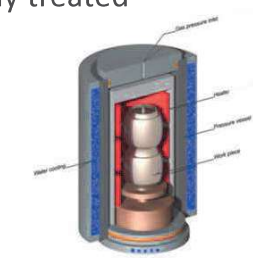
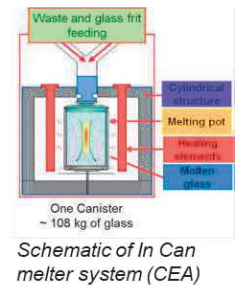


The GeoMelt® rig as installed in the NNL Central Lab.



# Demonstration of thermal treatment technologies

- Six thermal treatment technologies were demonstrated
  - Demonstrations with simulated and hot samples
  - The project partners provided all the treatment facilities for the project use (invested outside the project)
- Products from demonstration trials were characterised
- The impact in terms of disposability of thermally treated waste products was evaluated



# Disposability of thermally treated waste products

- The relevant criteria (Waste Acceptance Criteria, WAC) were identified and assessed
- Available data on current WACs were collected from partner countries
- Some generic disposability criteria were developed based on examination of the collected data
- Developed generic disposability criteria can be used to assist in evaluation of disposability of thermally treated products





# PREDIS overview

Pre-Disposal Management of Radioactive Waste

<https://predis-h2020.eu/>



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## PRE-DISPOSAL MANAGEMENT OF RADIOACTIVE WASTE



47 partners  
17 countries  
25 End User Group members



**Aim: Identify, develop and improve innovative technologies in pre-disposal radioactive waste management**



Endorsement and close interaction with SNETP-Nugenia, IGD-TP, IAEA, NEA, EURAD



Total budget 23.7 M€  
EC contribution of 14 M€



4 years  
Started Sept 2020

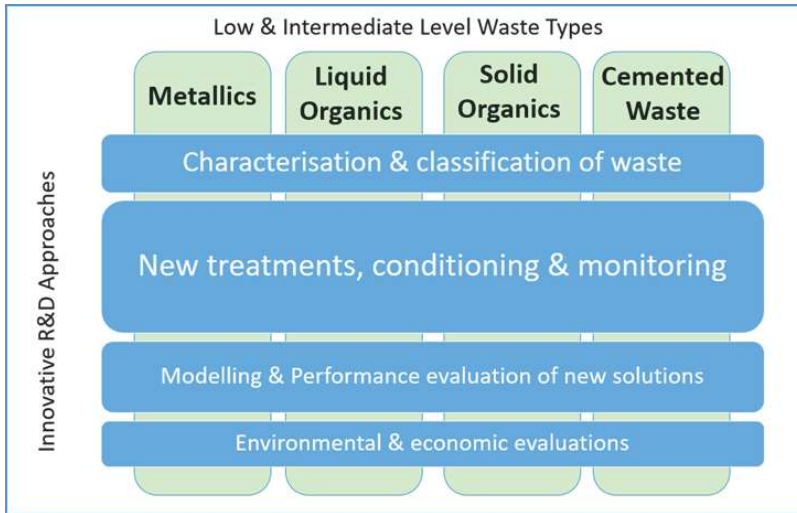


Detailed info:  
<https://predis-h2020.eu/>



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# PROJECT OBJECTIVES



- Develop solutions (methods, processes, technologies and demonstrators) for future treatment and conditioning of waste across a number of Member States, for which no industrially mature or inadequate solutions are currently available, improving safety during next waste management steps
- Improve existing solutions with safer, cheaper or more effective alternative processes where they bring measurable benefits to several Member States
- Analyse criteria, parameters and specifications for materials and packages with associated Waste Acceptance Criteria (WAC) for pre-disposal and disposal activities, supporting homogenisation of waste management processes across Europe



## Key Performance Indicators in DoA: Target to increase metrics each period

**Table 1.1. Key Performance Indicators (KPIs)**

Project's specific objective	KPI as measure of success	Targets, by project end
Applying multi-disciplinary and multi-scale scientific approaches to demonstrate the new solutions	Increase of TRL and innovations (see Table 1.5, Section 1.4.2 examples), WP4-7	At least +1 TRL level increase for 10 or more innovative solutions
	Technical/scientific journal publications (open access)	At least 25 submitted
	Generate invention notifications (pre-patent)	At least 4 submitted
Addressing project drivers from the end users' point of view	Participation of industry to EUG	At least 20 at start, 30 by project end
	Demonstration or trial deployment of new technologies (WP4-7)	At least 3 by EUG members, in different Member states
	Adoption or refining of national WAC based on project guidelines (WP2)	At least 8 EUG members implement
Fostering deeper cooperation between experts from many EU Member-states	Engagement of other countries, beyond PREDIS membership	Participants from at least 5 other countries to workshops
	Individual subscribers to project newsletter (WP1)	At least 200, from over 25 countries
Training new experts in the field of pre-disposal waste management technologies	Number of PhD and Postdoc students (see Table 3.4c)	At least 15
	Number of mobility between partners (WP3)	At least 20
	Number of training modules produced (WP3), in cooperation with EURAD	At least 6
Updating and revising pre-disposal guiding documents	Producing cooperative deliverables with EURAD	At least 5
	Completed feedback from EUG for SRA (WP2)	At least 20
	Project feedback from EUG members at annual workshops	Average score 7 out of 10 (survey questions)



# Overall Achievements to-date (Month 21, 30.5.2022)

- Web page and three newsletters, see <https://predis-h2020.eu/>
- 12 public deliverables and memos which are free to download from [Publications page](#), including key items:
  - International approaches to establishing waste acceptance systems (D2.4y, in WP2)
  - State-of-the-Art in packaging, storage and monitoring of cemented wastes (D7.1, in WP7)
  - Baseline SRA on predisposal waste management issues (Milestone 2.3) and Gap Analysis (D2.2)
  - PREDIS contribution to [EURAD Roadmap](#) as SoK guidance: “Theme 2 Overview: Predisposal issues ...”, September 2021
- 12 public webinars and discussion groups, with over 1500 participants, see [Events page](#)
- First public free online training course scheduled, June 9-10. [Registration](#) still open
- Activated 14 mobility grants so-far, including 3 supports to Ukraine partners
- Young Generation (student) group established, currently with 35 persons
- Excellent technical process – laboratory studies, modelling, baseline parameters established, etc.



## WP2 Strategic Studies Scope & Achievements to-date

- **Main Objectives:** To enhance the strategic implementation of the outputs of PREDIS and focus future predisposal collaborative programmes through extensive engagement of stakeholders across member states and international bodies.
- **Achievements to-date:**
  - End User and Stakeholder groups established.
  - PREDIS Gap Analysis performed and reported.
  - Baseline Strategic Research Agenda published.
  - Review of International approaches to establishing Waste Acceptance Systems.
  - Lifecycle assessment protocols defined.
- **Next steps:**
  - Further stakeholder engagement and development of the PREDIS SRA.
  - Guidance on wasteform characterization and qualification.
  - Lifecycle assessment case studies.



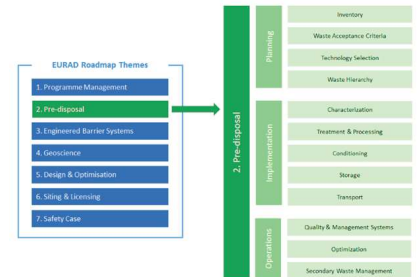
For more information, see also poster(s) at EURADWASTE '22





## WP3 Knowledge Management Scope & Achievements to-date

- Main Objectives:
  - To develop and transfer knowledge and competence across Member States national programs
  - To preserve knowledge transfer to coming generations.
- Achievements to-date:
  - Webpage focused on Knowledge Management launched
  - Learning by playing – 2 releases
  - Roadmap – 1 Theme Overview + 2 Domain insight docs under development
  - Training: 11 webinars + 3 courses scheduled in 2022
  - 36 students – KPI = 15; students group founded
  - 14 Mobilities accepted (4 finished) - KPI = 20
  - Join statement on KM with EURAD – High cooperation between projects
- Next steps:
  - To continue sharing knowledge, namely in a joint effort with EJP EURAD
- For more information, see also poster(s) at EURADWASTE '22



## WP4 Metallic Wastes Management: Scope & Achievements to-date

- Main Objectives:
  - Develop innovative characterisation techniques for metallic wastes.
  - Demonstrate innovative techniques to decontaminate metallic wastes.
  - Develop treatment techniques for secondary waste streams.
  - Develop innovative conditioning matrices for reactive metallic wastes.
- Achievements to-date:
  - Decontamination techniques based on chemical solutions and gel-based treatments are being optimized.
  - Parameters for gamma spectrometry measurement have been optimized for classification of waste streams.
  - Mg-phosphate cement (MPC) formulations and costs are being optimized.
- Next steps:
  - Select methods for waste streams treatments.
  - Apply life Cycle Analysis for decontamination techniques selection.
  - Qualification of optimized MPC formulations



Pristine and oxidized Stainless Steel (316-1.4571)



Decontamination of metallic waste using gel-like compounds



Corrosion tests in mortar under saturated conditions



## WP5 Liquid Organic Wastes: Scope & Achievements to-date

- Main Objectives:
  - Implementing geopolymers and related alkali-activated materials as mineral binders
  - Development of direct conditioning solutions for RLOW from TRL 3 to 6
  - Fulfilling technical and economic requirements related to RLOW
- Achievements to-date:
  - Description of RLOW inventories at European level and selection of reference wastes
  - Selection of 3 reference geopolymer formulations based on metakaolin, blast furnace slag and a mix of raw materials, showing high waste loadings
- Next steps:
  - Robustness and optimisation studies of the 3 reference formulations
  - Durability testing campaign under various conditions
  - Life Cycle Assessment (LCA) process



For more information, see also posters by Kahina HAMADACHE et al. and Federica PANCOTTI et al.



## WP6 Solid Organic Wastes: Scope & Achievements to date

- Main Objectives:
  - Propose innovative solutions for the management of problematic RSOW after thermal treatment
  - Demonstrate the reliability of alkaline binders (geopolymer, cementitious materials) for the conditioning of the treated wastes
- Achievements to-date:
  - Optimization of the treated waste loading in GP or PC, up to 25 %
  - Technology transfer from Liquid to Solid waste (Molten Salt Oxidation)
  - Promising immobilization of ashes whatever the process  
(e.g. possible CEA patent: Molten glass coating)
  - Upscaling the Wet Oxidation route (treatment of 2g of IER -> 1 kg)
- Next steps:
  - After immobilization, the stability and the durability of the reconditioned wastes are tested (leaching experiments, irradiation, ...).



# WP7 Cemented waste handling and pre-disposal storage: to-date

- Sensor prototypes
- Mockup designs
- Simulation software
- Monitoring concepts
- Radio Frequency Identification
- Digital Twin concepts
- Data Platform
- SRA contributions

SCK.CEN, MAGICS: Monitoring ASR development in samples using Acoustic Emission.

INFN: Scintillating Fibre Gamma Ray sensor, simulation for a cracked cask

Uni PISA: Micro gamma and neutron sensors, to be integrated into a Radio Frequency Identification (RFID) unit for identification and measurement

INFN: Muon tomography of metallic objects in a concrete block

BAM: RFID unit to be implemented inside the package: delivers temperature, humidity, pressure

PSI: Simulation/Digital Twin prototypes. Early-stage demo: [digitaltwin.geoml.eu](http://digitaltwin.geoml.eu)



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## PREDIS Cooperation Examples

- Memorandum of Understanding (MoU) signed with:
  - EURAD EJP
  - MICADO project
  - ERDO WG
  - PLEIADES and HARPERS under discussion
  - (SHARE project was not done, as project is ending now)
- Joint webinars (i.e. Digital Twins – February 2022)
- Common platforms and protocols for training, mobility
- EURAD – Joint presentations and posters for EURADWASTE2022 conference
- EURAD Joint statement on Knowledge Management – example of common “position papers”.

**JOINT STATEMENT ON KNOWLEDGE MANAGEMENT**

Knowledge management is critical to ensure safe and efficient radioactive waste management over the whole lifecycle. When all stakeholders actively contribute to knowledge management, the whole international programme will be more successful.

EURAD being approximately at the mid-term of its Programme while PREDIS is approaching the first year anniversary as a project, both decided to issue a joint statement on Knowledge Management (KM) progress. The goal of this document is to reinforce the common objective that drives the KM work in both projects and to offer to the community an overview of how KM-tasks are approached and share main achievements and plans for the future.

Knowledge management (including knowledge consolidation) is recognized as a key part of the Radioactive Waste (RW) implementation process and has gained increasing interest.

The European Commission is encouraging KM, through the 'Waste Directive', for more progress of EU Member States' implementation of their RW disposal programmes. The main reasons for the importance of KM are the RW disposal implementation times, disposal operation time spanning a number of decades and the complexity and variety of fields. Each individual phase of a RW management program from waste generation through processing, disposal and repository closure, will require continuous R&D development with improved process understanding (inventory, handling, treatment, geoscience, disposal-material development, chemical and physical interactions, long-term evolution of the environmental ...), that will form the knowledge base needed for waste processing, packaging, storage and then repository construction, operation and closure licenses. These long implementation time-spans (in the range of hundreds of years) require a robust KM programme, which includes the securing of gained knowledge, forecasting the needs to pass it over for several generations. Thus, there is a high motivation for logical and sustainable KM structures populated with publicly available, consistent, transparent and up-to-date evidence-based state of knowledge, which is necessary to evaluate the waste disposability, predict the behaviour of a disposal, with relatively small uncertainties, on time scales of 10<sup>3</sup> to 10<sup>6</sup> years.

KM is challenging but with EURAD and PREDIS we have great potential for success through access to experts with many decades of RWM experience and knowledge.

**Main achievements**

- Development of a Goals Breakdown Structure EURAD Roadmap, complemented by input from PREDIS on Pre-disposal activities.
- Publication of a wide range of KM-related documents such as Theme Overviews (top level documents of the EURAD Roadmap), State-of-the-Arts reports, glossary compiling most relevant pre-disposal terminology (to be released in autumn 2021) and initiation of experts authoring State-of-Knowledge documents.
- Creation of the School of Radioactive Waste Management, elaboration of training catalogue.
- Joint engagement and dissemination with stakeholders via webinar events, that also foster knowledge sharing and training (i.e. on waste acceptance criteria topics)
- Implementation of mobility programmes in both EURAD and PREDIS.

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<sup>1</sup> <https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=celext%3A32011L0070>

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# Moving Forward



## PREDIS SWOT Analysis – Month 18 (Feb 2022)

Strengths	Weaknesses
<ul style="list-style-type: none"> <li>- Excellent Consortium: positive/cooperative atmosphere, high commitment/engagement, students</li> <li>- Stakeholder/EUG/IAEA cooperation and outreach</li> <li>- Scientific excellence, multidisciplinary, experience</li> <li>- Streamlined organization issues</li> <li>- Communication (webinars, workshops, newsletters)                             <ul style="list-style-type: none"> <li>- Embracing online digital world with best practices</li> </ul> </li> <li>- Creating good impacts to wide international community</li> </ul>	<ul style="list-style-type: none"> <li>- <i>Large project organisation (communication needs)</i></li> <li>- <i>Limited inter-WP exchanges</i></li> <li>- Need more input from waste generators, WMOs</li> <li>- Lacking face-to-face (f2f) interactions</li> <li>- New concepts/needs of Strategy (WP2) and Knowledge Management (WP3) activities                             <ul style="list-style-type: none"> <li>- Commitment and value for all</li> </ul> </li> <li>- Diversity of partner roles</li> </ul>
Opportunities	Threats
<ul style="list-style-type: none"> <li>- Technical development achievements and impact for stakeholders/EUG</li> <li>- Exchange of best practices, real-world cases</li> <li>- Wide outreach with communication tools, f2f events</li> <li>- <i>Cooperation and future together with EURAD (SRA influence for future EC call), towards EURAD-2</i></li> </ul>	<ul style="list-style-type: none"> <li>- <i>Covid-19 pandemic continues</i></li> <li>- Are we doing the right thing?</li> <li>- Overload of activities</li> <li>- <i>Lack of end-users feedback/inputs</i></li> <li>- Expectations for PREDIS by external groups</li> </ul>

*Note – blue font items indicates similar to EURAD comments*



## Overall Summary

- Waste management community (industry, research, technical support organisations) recognize the importance of making advances in pre-disposal waste issues
- Focus on reduction of wastes, better treatment/processing of wastes with higher efficiency, lower costs, maintaining safety
- THERAMIN project completed successfully, wealth of information available as outcomes
- PREDIS project is on-track, making great impacts and wide engagement
  - Welcoming of additional End User Group and Stakeholder members
  - Already cooperating with EURAD in various ways, ready to merge within a EURAD-2 future joint program
  - Have reflected on strengths and lessons learned, acknowledging how to move forward together for Member State benefits



## Thank you! Merci!

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