



Technical enhancement of wasteforms and their behaviour with the PREDIS project on pre-disposal waste management

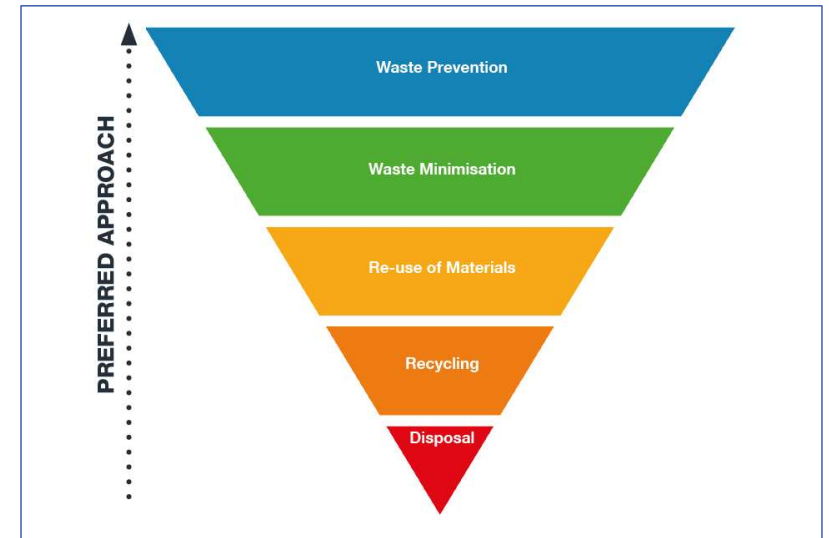
IGD-TP SYMPOSIUM, 21 SEPTEMBER 2022

ERIKA HOLT & MARIA OKSA, COORDINATORS



This project has received funding from the Euratom research and training programme 2019-2020 under grant agreement No 945098.

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.



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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/>



PRE-DISPOSAL MANAGEMENT OF RADIOACTIVE WASTE



47 partners
17 countries
25 End User Group members



Total budget 23.7 M€
EC contribution of 14 M€



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



4 years
Started Sept 2020



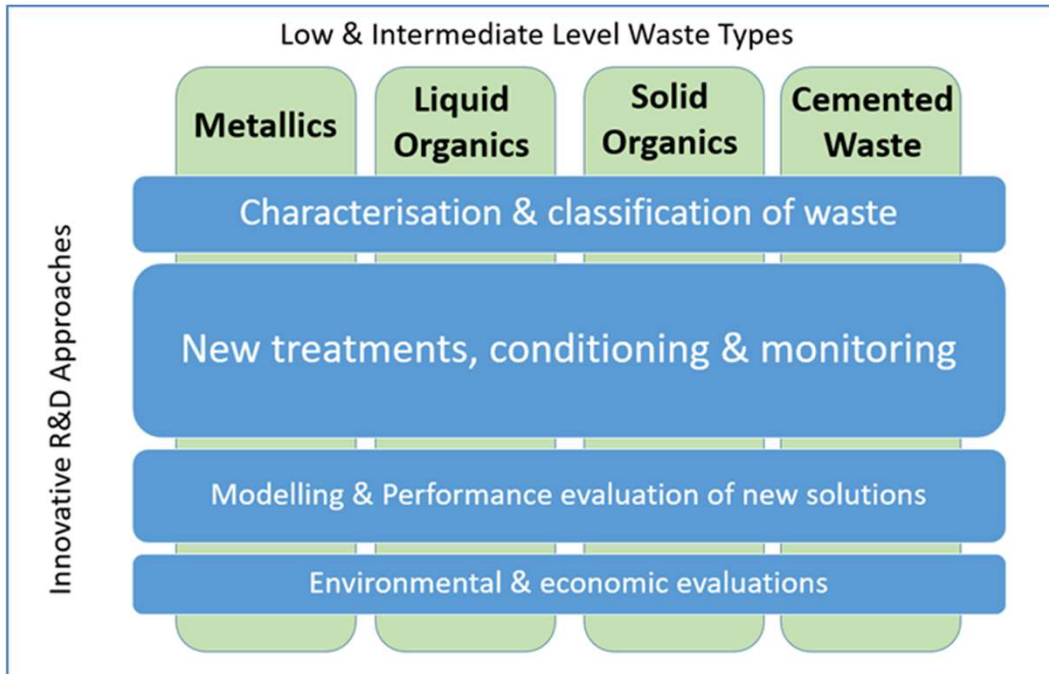
Endorsement and close interaction
with SNETP-Nugenia, IGD-TP,
IAEA, NEA, EURAD



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



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:

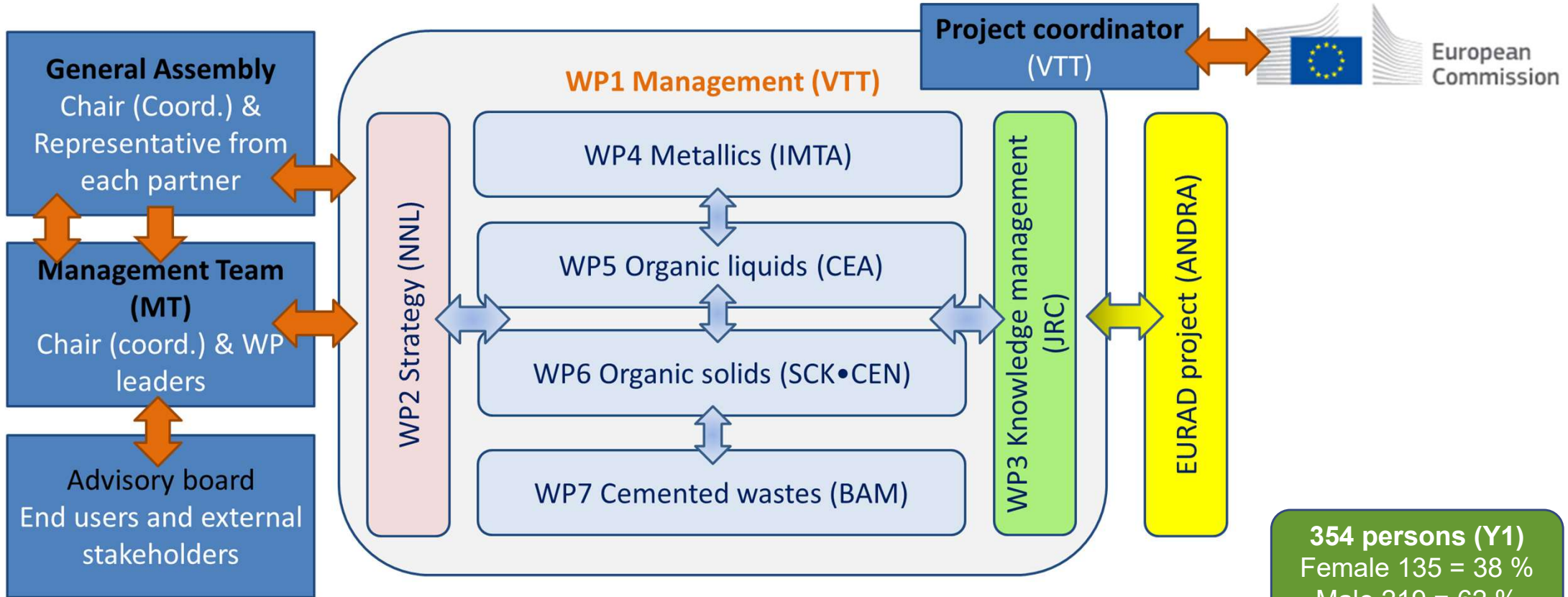
Target to increase metrics each period

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)



PROJECT STRUCTURE



354 persons (Y1)
 Female 135 = 38 %
 Male 219 = 62 %



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Achievements to-date (Month 24, 1.9.2022)

- Web page and three newsletters, see <https://predis-h2020.eu/>
- **17 public deliverables/memos**, 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
- 15 public webinars and discussion groups, with over **1500 participants**, see [Events page](#)
- First public **free online training** course held June 2022, student training session in CZ September 2022. [Registration](#) for 21-24 November training on waste characterisation (ENRESA, Spain).
- Activated **22 mobility grants** so-far, including 3 supports to Ukraine partners (6 months each)
- Young Generation (student) group established, currently with **35 persons**
- Excellent technical process – laboratory studies, modelling, baseline parameters established, etc.



PREDIS SWOT Analysis – Month 18 (Feb 2022) by MT

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

Note – blue font items indicates similar to EURAD comments (other presentation)



EUG Status

- Currently 25 members within End User Group (defined as **waste generators, waste management organisations**)
- Additional 15 of our 47 partners are ALSO End User Group qualified
- Additional interest parties (i.e. researcher, regulators, civil society) are part of the **Stakeholders** group
- Open to have more members - - please encourage your national key organisations to get in-touch (register via project webpage)



This project has received funding from the European Union's Horizon 2 research and innovation programme under grant agreement No 945091

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 was ending 2021)
- Joint webinars (i.e. Digital Twins – February 2022)
- Common platforms and protocols for training, mobility
- EURAD – Joint presentations and posters for conferences, like IAEA waste management & EURADWASTE'22
- 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 10^3 to 10^6 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 Predisposal 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 predisposal 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 catalogues
- 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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Version: 1.0, 11 October 2021

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

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17/09/2022

11

Technical Updates: Status to-date



PREDIS WP2 Strategic Studies

- **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:**
 - ‘Position paper on EURAD SRA’ to PMO, ready by 30 September 2022.
 - Further stakeholder engagement and development of the PREDIS SRA. Public Webinar scheduled for first week of November 2022
 - Publication of PREDIS SRA in March 2023 (final update by summer 2024).
 - Guidance document on wasteform characterization and qualification on-going.
 - Lifecycle assessment case studies ongoing (webinar targeted within 6 months).



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SRA (Deliverable D2.3) Development Timeline

Drafting

Wider Engagement



08/22

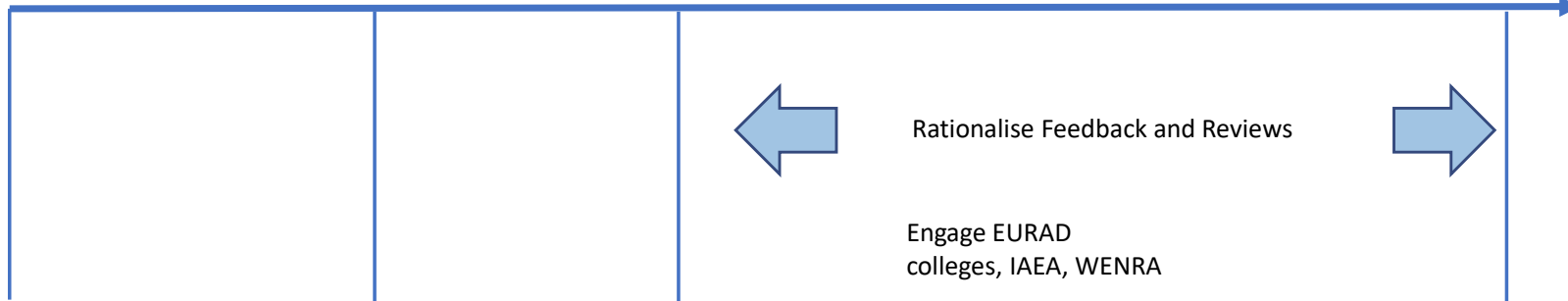
09/22

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01/23

03/23



Composing chapters of 1st draft of updated SRA

Draft EURAD position paper

1st Draft of updated SRA ready to socialise

Public Webinar

Final Draft of updated SRA Submitted

SRA updated after WP conclusions, summer 2024



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Development steps of the SRA

Story so far...

- Consolidated a baseline SRA (published Sept 21)
- Developed and delivered a survey to the PREDIS End Users group (April 22)
- Survey opened up to the wider PREDIS stakeholder group (May 22)
- Consolidated results (Spring 22)
- Delivered a series of Focus Sessions on the top topics with interested parties (Summer 22)

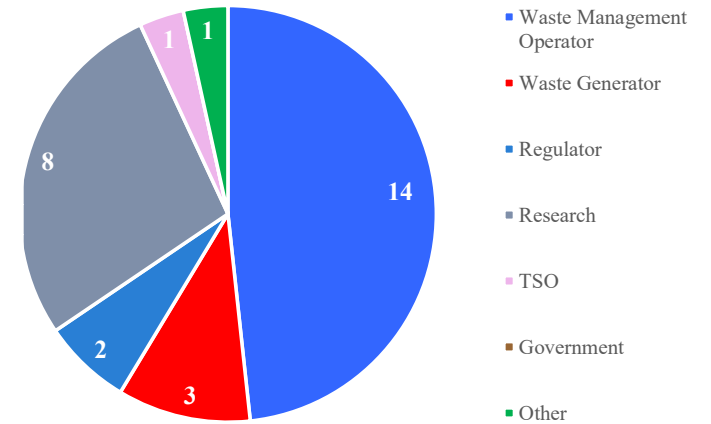
Next steps...

- Draft socialisation specific stakeholder groups, i.e. Engage EURAD colleges, IAEA, WENRA
- PREDIS SRA agenda item at targeted webinars and events (Oct 22-Mar 23)
- Feedback update (Oct-Dec 22)
- Revised final draft of updated SRA available (Mar 23)
- Final SRA update after conclusion of WPs (summer 24)



Drivers and respondee organisations

Technical Topics	DRIVERS										
	Societal			Actor Specific				Scientific		Financial	
	economic renewal & growth	protection of citizens & environment	public trust & confidence	processes, products & services	improve performance	competence & skills development	networking	science & technology	innovation	revenue & turnover	investment
Planning	Inventory	Green	Red	Red	Yellow	Yellow	Green	Orange	Yellow	Green	Yellow
	Waste Acceptance Criteria	Green	Red	Red	Yellow	Yellow	Green	Orange	Yellow	Green	Yellow
	Technology Selection	Green	Yellow	Yellow	Yellow	Yellow	Green	Orange	Yellow	Green	Yellow
	Cost Estimating	Orange	Green	Yellow	Yellow	Yellow	Yellow	Green	Yellow	Orange	Orange
	Funding	Green	Yellow	Yellow	Yellow	Yellow	Green	Yellow	Yellow	Green	Yellow
Implementation	Waste Hierarchy	Green	Orange	Orange	Orange	Orange	Green	Yellow	Yellow	Green	Yellow
	Characterisation	Green	Yellow	Yellow	Orange	Orange	Green	Red	Orange	Green	Yellow
	Treatment Processing	Green	Red	Yellow	Orange	Orange	Green	Orange	Yellow	Green	Yellow
	Conditioning & Packaging	Green	Red	Yellow	Orange	Orange	Green	Orange	Yellow	Green	Yellow
	Storage	Green	Red	Red	Orange	Orange	Green	Yellow	Yellow	Green	Yellow
	Transport	Green	Red	Red	Orange	Orange	Green	Yellow	Yellow	Green	Yellow
	Deployment Options	Yellow	Orange	Yellow	Yellow	Yellow	Green	Yellow	Yellow	Green	Yellow
	Quality & Management Systems	Green	Yellow	Yellow	Orange	Orange	Green	Yellow	Yellow	Green	Yellow
	Commissioning	Yellow	Yellow	Yellow	Yellow	Yellow	Green	Yellow	Yellow	Green	Yellow
	Optimisation	Yellow	Orange	Yellow	Orange	Orange	Green	Yellow	Orange	Green	Yellow
Operations	Secondary Waste Management	Green	Yellow	Yellow	Orange	Orange	Green	Yellow	Yellow	Green	Yellow
	Management of R&D	Yellow	Green	Yellow	Green	Orange	Yellow	Orange	Yellow	Green	Yellow
	Knowledge Management	Green	Green	Yellow	Green	Orange	Red	Orange	Yellow	Green	Yellow
	Stakeholder Engagement	Green	Yellow	Red	Green	Yellow	Orange	Yellow	Yellow	Green	Yellow



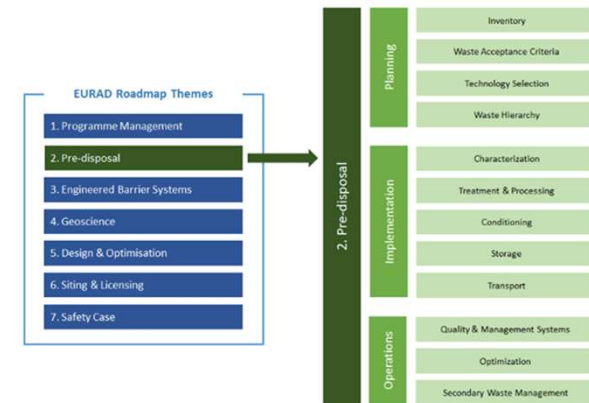
Top technical topic areas

Please select the five most important topics for R&D from the list below. (Rank your top five in order)



PREDIS WP3 Knowledge Management

- 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 at IGD-TP Symposium*



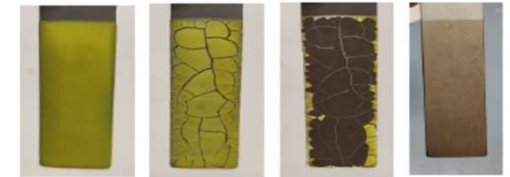
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PREDIS WP4 Metallic Wastes Management

- 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



PREDIS WP5 Liquid Organic Wastes

- 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 optimization experimentations on the 3 reference formulations
 - Selection of one most promising geopolymer matrix
 - Durability testing campaign under various conditions
 - Life Cycle Assessment (LCA) and LCC (Life Costing Analysis) process



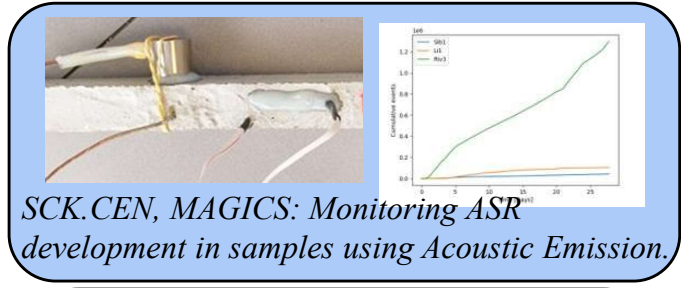
PREDIS WP6 Solid Organic Wastes

- Main Objectives:
 - Propose innovative solutions for the management of problematic RSOW after thermal treatment and demonstrate the reliability of alkaline binders (GP, PC) 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 with significant volume reduction factor (e.g. possible CEA patent: Molten glass coating)
 - Upscaling the Wet Oxidation route (treatment of 20 g of IER -> 1 kg)
 - Successful HIP immobilization of treated wastes at lab scale
- Current actions and next steps:
 - After immobilization, the stability and the durability of the reconditioned wastes are tested (leaching experiments, irradiation, ...)
 - Upscaling the HIP technology
 - LCA / LCC

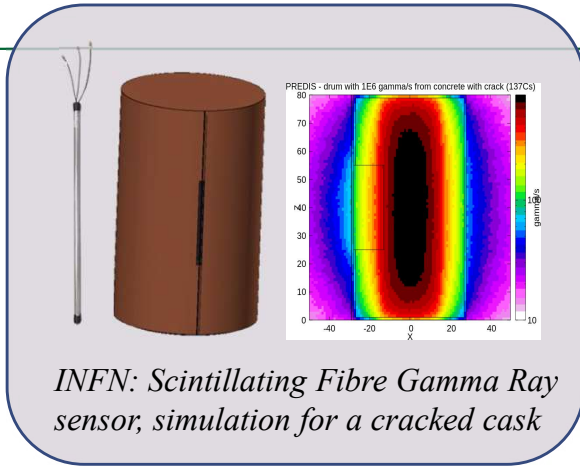


PREDIS WP7 Cemented waste handling & pre-disposal storage

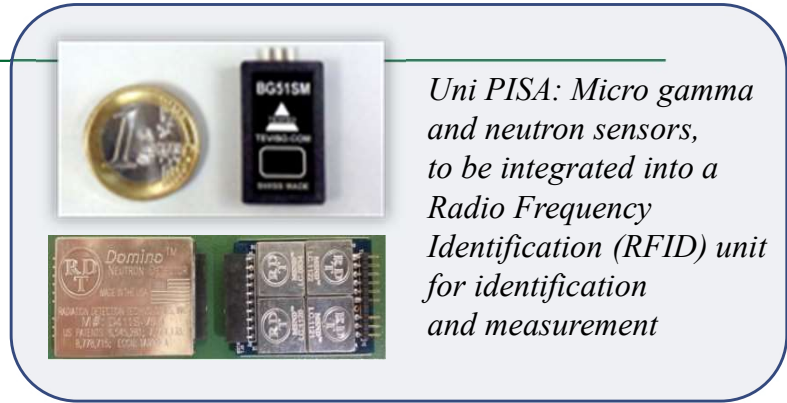
- Sensor prototypes
- Mockup designs
- Simulation software
- Monitoring concepts
- Radio Frequency Identification
- Digital Twin concepts
- Data Platform
- SRA contributions



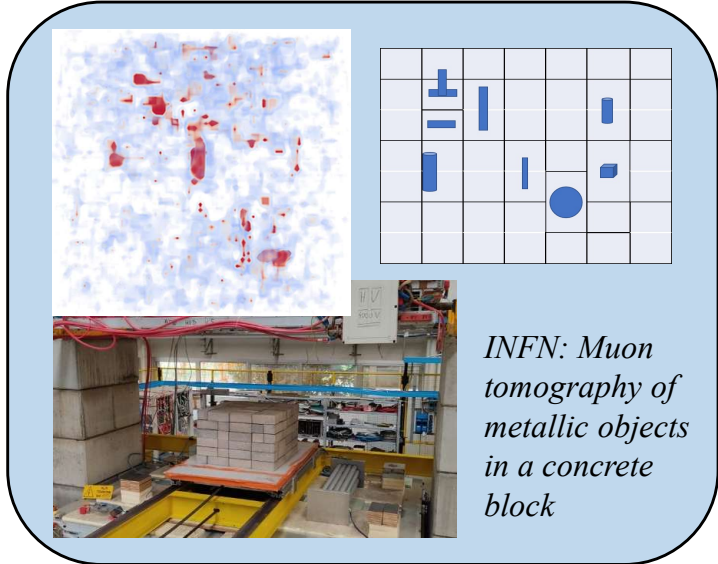
SCK.CEN, MAGICs: Monitoring ASRTM development in samples using Acoustic Emission.



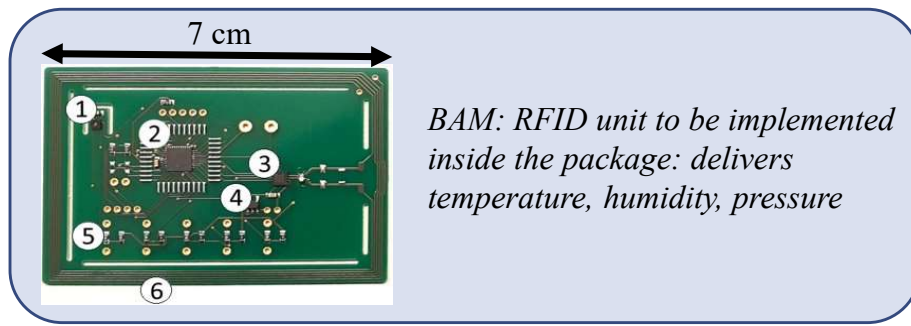
INFN: Scintillating Fibre Gamma Ray sensor, simulation for a cracked cask



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

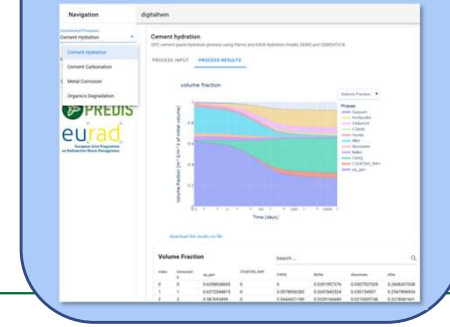


INFN: Muon tomography of metallic objects in a concrete block



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

PSI: Simulation/Digital Twin prototypes. Early-stage demo: digitaltwin.geoml.eu



Impacts toward Disposability, IGD-TP Vision 2040

- Addressing minimization of waste streams, applying waste hierarchy
- Improvement of knowledge on waste acceptance criteria, and impact of waste forms and their packaging to disposability
- Integrating holistic approach to consider economics (life cycle cost) and environmental impact (life cycle assessment) quantitative assessment to new solutions, to aid decision makers
- Gaining insights on digitalization tools for monitoring and performance assessment (digital twins)
- Competence development, training and knowledge capture for Member States and next generation of experts
- Studying innovative routes for specific wastes conditioning (e.g. RLOW) for storage and disposal



PREDIS Summary

- 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 partnership programme (Core Group representation)
- Have reflected on strengths and lessons learned, acknowledging how to move forward together for project great impacts and Member States' benefits

