PREDIS

PREDIS: Overall Achievements & Impactful Outcomes

PREDIS MANAGEMENT TEAM
PRESENTATION - WEBINAR

20 SEPTEMBER 2024, 13-14 CEST ONLINE

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

Agenda

- 13.00 Welcome & PREDIS overview. *Erika Holt (VTT, Finland), Co-Coordinator*
- 13.10 Strategic impacts *Anthony Banford (NNL, UK), WP2 leader*
- 13.15 Knowledge Management impacts, *Paul Carbol (JRC, Germany), WP3 leader*
- 13.20 Technical WP impacts (5 min each)
  - Metallic waste handling. *Abdesselam Abdelouas (IMT, France), WP4 leader*
  - Liquid organic waste handling *Rosa Lo Frano (Uni-Pisa, Italy), WP5 – Task leader*
  - Solid organics waste handling *Thierry Mennecart (SCK CEN, Belgium), WP6 leader*
  - concrete package handling & digital solutions *Ernst Niederleithinger (BAM, Germany), WP7 leader*
  - Value Assessments of PREDIS innovations, *Jenny Kent (GSL, UK) , Task leader*

- 13.45 Overall Project achievements & summary. *Erika Holt (VTT)*
- 13.50 Discussion/Comments – open to all
- 14.00 Close

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PREDIS

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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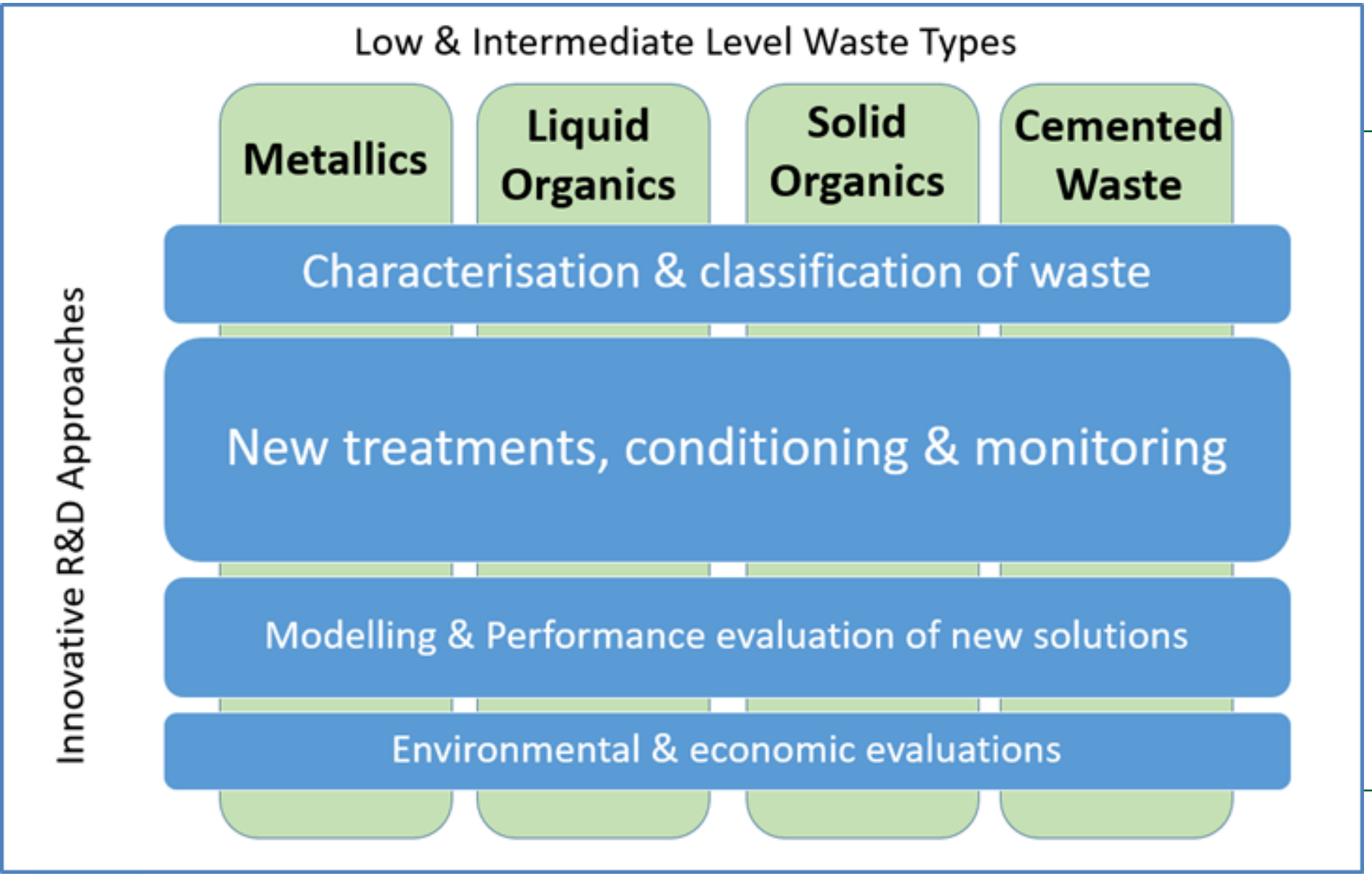
PREDIS TECHNICAL SCOPES

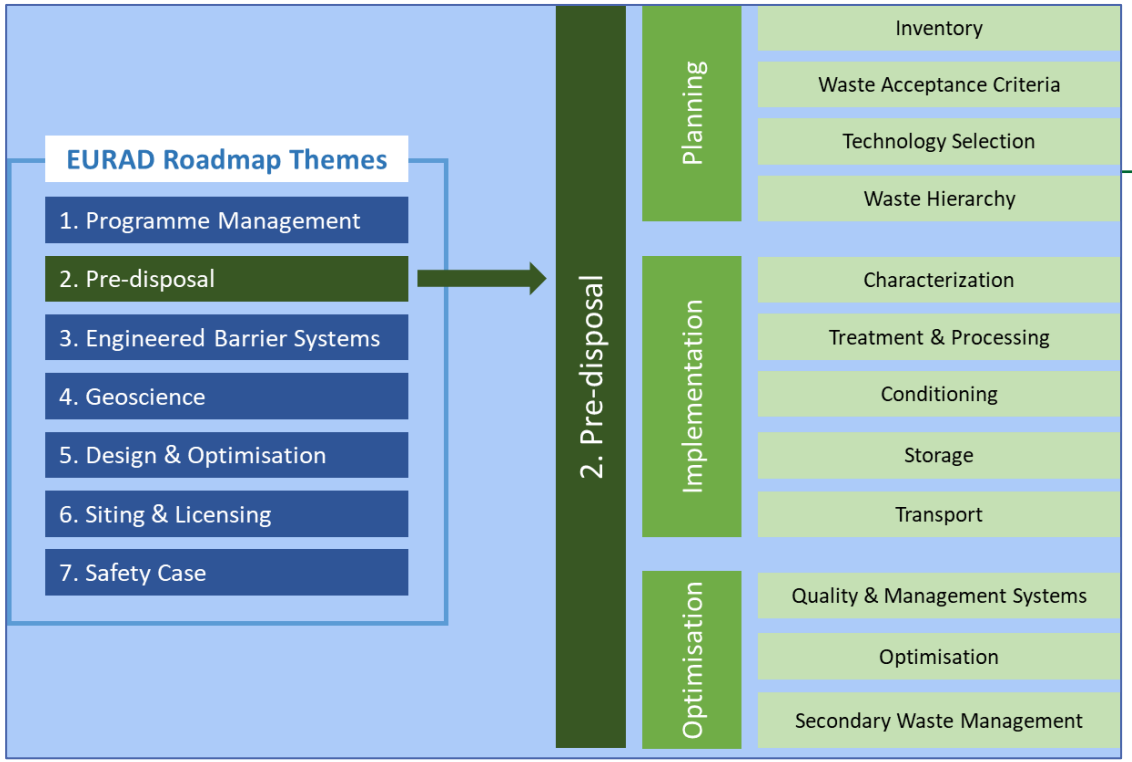


Scope was developed in spring 2019 based on iterative feedback from end user community, regarding priorities on R&D topics.

Selection of topics and tasks based on areas having highest potential for technical and innovation impact.

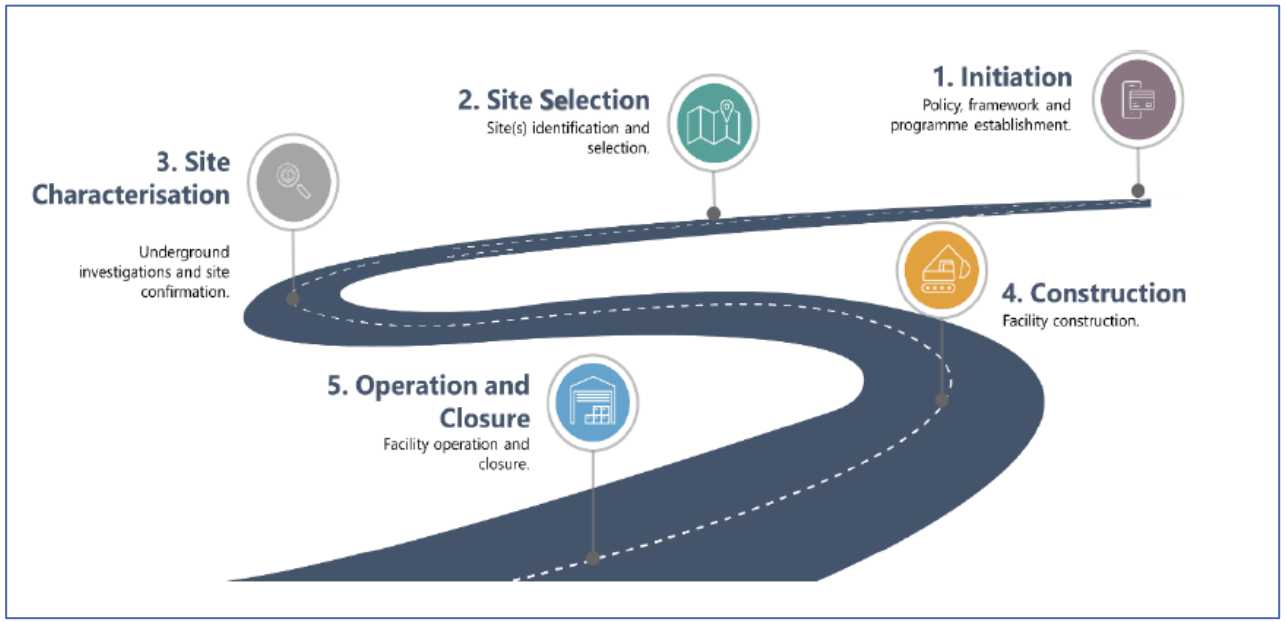
Description of Action (Project Plan) gives exact techniques and their current, project and future technology readiness level (TRL) targets

EURAD- Roadmap References



Pre-disposal Implementation (European SNETP network focus)

Repository / Disposal Implementation (IGD-TP focus)



See https://www.ejp-eurad.eu/publications/eurad-roadmap
Expected March 2023 updated EURAD SRA identifying topics and related drivers

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Work Package – Impacts & Highlights of Achievements, including Value Assessment

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WP 2 Strategic Implementation

Partners : NNL, VTT, CEA, SCK CEN, BAM, TUS, CVRez, SURO, Isotoptech, TS Enercon, SOGIN, FTMC, CIEMAT, ENRESA, GSL, UoM, SI IEG NASU

20 September 2024

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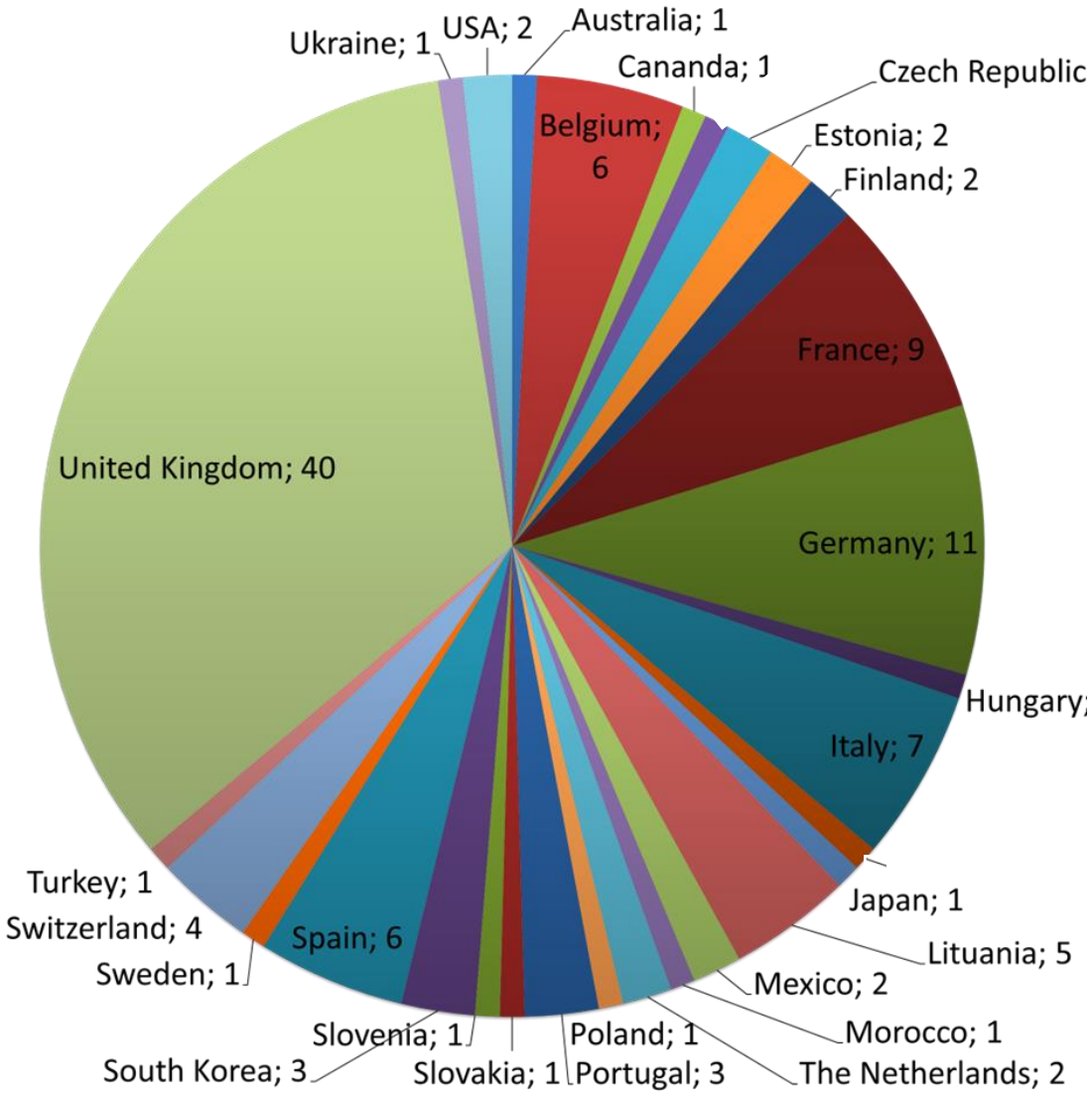
PREDIS

Established a pre-disposal stakeholder community

Registered stakeholders

- 119 individuals from **outside** project
- both end users and stakeholders
- 29 countries, 4 continents
- Many different actors

..and 100s of additional participants in PREDIS stakeholder engagement / webinars etc.



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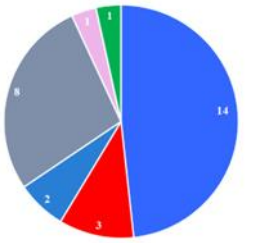
A Predisposal Strategic Research Agenda (SRA)

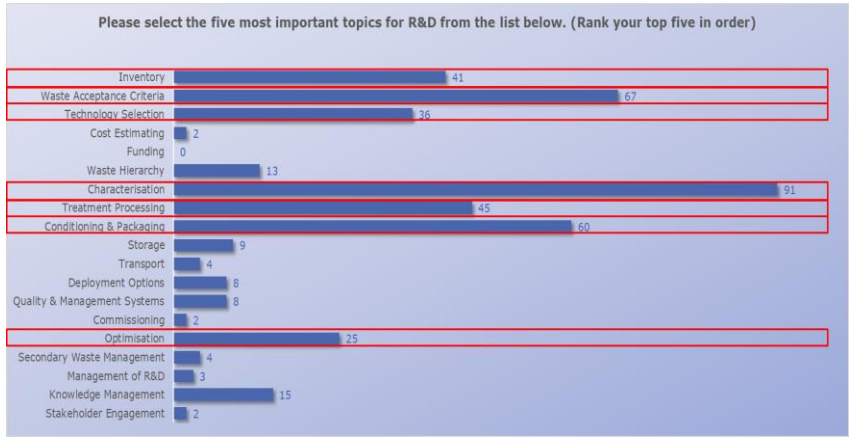
- PREDIS SRA developed, in collaboration and engagement with the wider PREDIS team, partner organisations and stakeholders.
- Represents a pan-European view of science, innovation and technological needs to be realised in the next decade.

Range of stakeholders



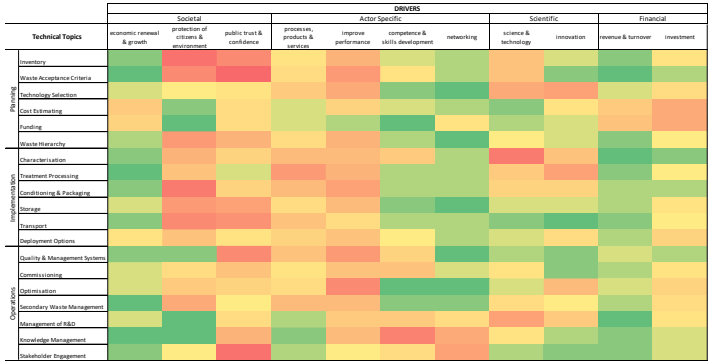
- Waste Management Operator
- Waste Generator
- Regulator
- Research
- TSO
- Government
- Other

	Waste Operator		DRIVER											
			Societal			Actor Specific				Scientific		Financial	
	Technical Topic	Priority Topics (1 - 5)	Economic renewal & growth	Protect citizens & environment	Public trust & confidence	Processes, products & services	Improved performance	Contributes to competences and skills	Improve networks	Science quality and TRL	Innovation	Revenue, turnover	Investment
Planning	Inventory	4		X		X						X	
	Waste Acceptance Criteria												
	Technology Selection												
	Cost Estimating												
	Funding												
	Waste Hierarchy												
Implementation	Characterisation	1		X			X	X					
	Treatment Processing	2		X		X						X	
	Conditioning & Packaging	3		X			X					X	
	Storage	5			X		X					X	
	Transport												
	Deployment Options												
Operations	Quality & Management Systems												
	Commissioning												
	Optimisation												
	Secondary Waste Management												
	Management of R&D												
	Knowledge Management												
	Stakeholder Engagement												



Stakeholders' key topics and drivers determined through a questionnaire

Heatmap of technical topic and driver priorities



7 priority topics identified

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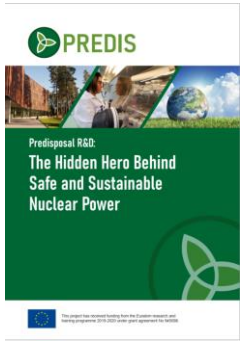
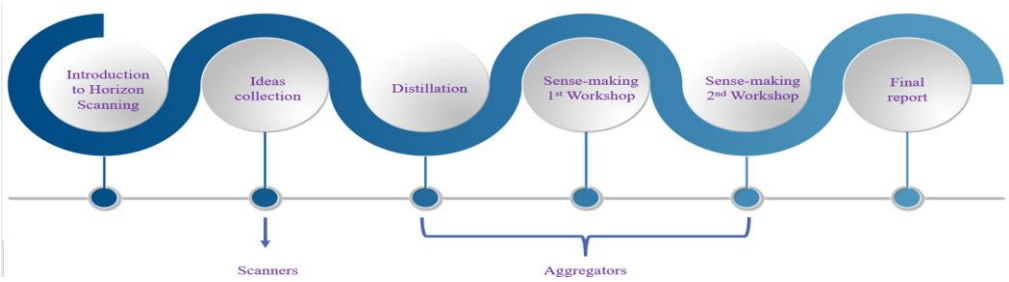
SRA and Horizon Scanning Findings

Summary of key cross cutting priorities from the SRA incorporated into a short summary document:

- Circular Economy
- Integrated Waste Management
- Digitalisation/Advanced Technologies
- Problematic and advanced reactor waste
- Knowledge Management





Horizon Scanning Process

Horizon Scanning Exercise

- **Gathered information** about emerging trends and developments that could have an impact on the policy or strategy area in the future.
- Explored how these **trends and developments** may combine and what impact they might have.
- Involved a range of people in **futures thinking** and increased their knowledge and insight about the changing policy environment

Horizon Scanning Stories

Sustainability of Nuclear

A New Nuclear Zeitgeist

Hearts and Minds

Knowledge and Skills

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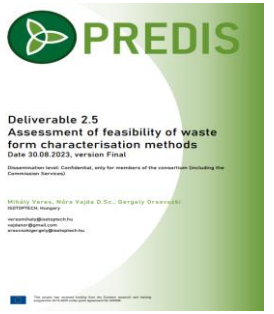
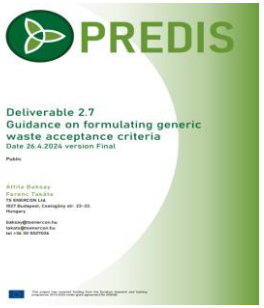
Providing Guidance on Waste Acceptance Systems/Criteria

Based on an overview of waste acceptance systems in 29 countries worldwide – PREDIS provided practical advice and guidance that will benefit stakeholders, especially the emerging programmes: including

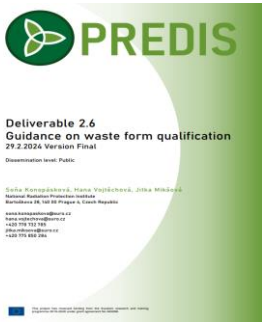
Physical/chemical/radiological parameters and methods for characterisation of radioactive waste





Guidance on Waste Form Qualification processes

Formulating generic waste acceptance criteria



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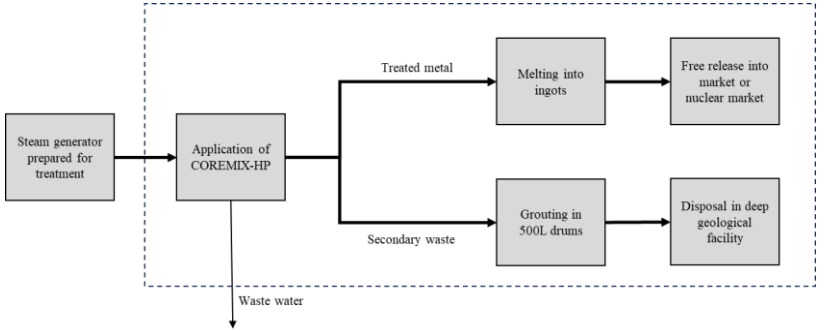
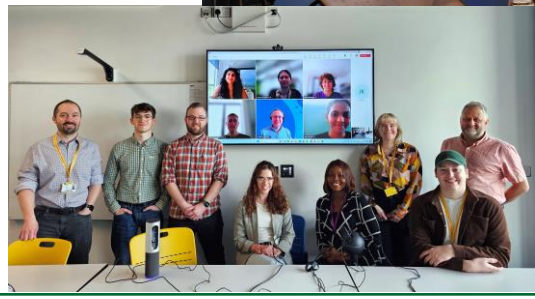
Life cycle assessment (LCA) and costing (LCC)

- PREDIS delivered the first back-end focused LCA/LCC modelling in the sector via >15 case study models across PREDIS: demonstrated to industry that geopolymer encapsulation can environmentally outperform cementation by >60%
- Showed that using LCA/LCC during process development reduces impacts: e.g. 439 t CO_2e saved per decontaminated steam generator; significant cost saved if diverting from GDF





- Broadened understanding and use of LCA/LCC in the sector through:
  - PREDIS webinar and workshop, 2 international conferences (IAEA and NEA)
  - 8 journal articles on predisposal sustainability (1 accepted thus far; 7 under review)
  - PREDIS LCA Training course
- 2 PREDIS PhD researchers, sustainability specialists, now employed full-time in the nuclear sector

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10 Deliverables
9 Milestones

Public reports available in PREDIS website

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PREDIS

Knowledge Management

PAUL CARBOL (EC, JRC), ALBA VALLS & MARIA ABADA (AMPHOS 21), JIRI FALTEJSEK (UJV), THIERRY MENNECART (SCK CEN), JENNY KENT (GALSON-SCIENCES.CO), ERIKA HOLT (VTT), ABDESSELAM ABDELOUAS (IMT/SUBATECH), ERNST NIEDERLEITHINGER (BAM), ROSA LO FRANO (UNIV. PISA), ISABELLE GIBOIRE & MARIA QUIROGA VALENCIA (CEA) AND FEDERICA PANCOTTI (SOGIN)

20 SEPTEMBER 2024

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Objectives

To develop and **transfer knowledge** and **competence** across EU Member States national programmes and to preserve knowledge for coming generations.

- Capturing knowledge (DI)
- Building competences (courses, webinars…)
- Acquiring tacit knowledge (mobilities)
- Dissemination and networking (conferences, students, ….)

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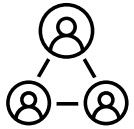
Achievements

Young Professionals & Networking

51 students



65 mobility´s

8 courses

2 case studies

19 webinars

End-users

identify KM needs

PREDIS KM programme

Interactions

best use of resources
(EURAD, IAEA, NEA)

Future generations

1 theme overview
12 domain insights

glossary (PREDIS/IAEA)

Dissemination

11 conferences
11 oral presentations
7 publications

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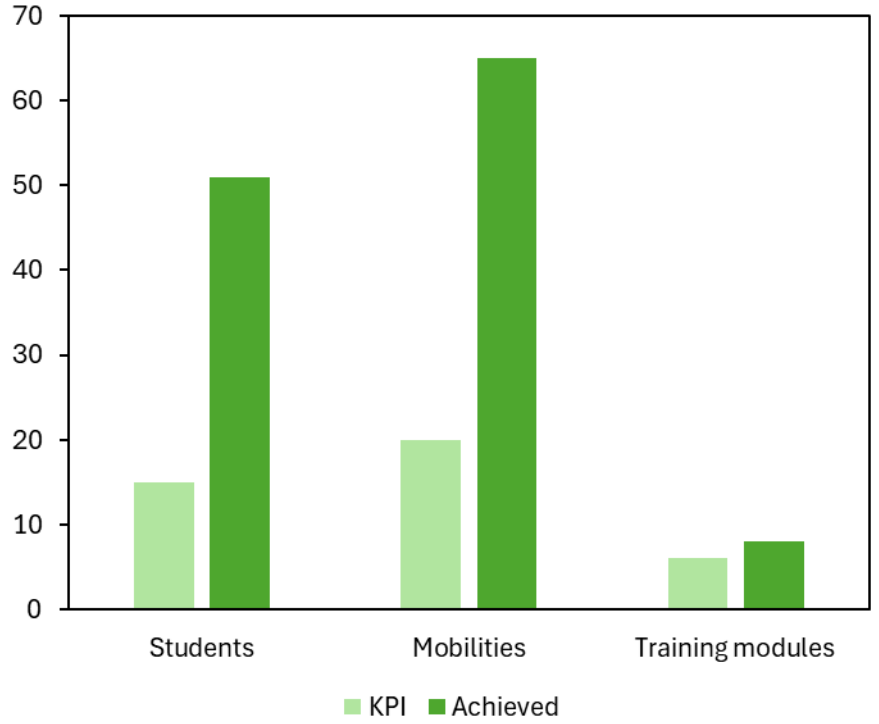
Assessment of KPIs

- Key performance indicators, set for training of new experts in the field of pre-disposal waste management technologies, has been achieved



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Assessment of KPIs

Positive feedback from at least 10 EU Member States

Test case to demonstrate **synergy** between **PREDIS and EURAD** concerning KM

Participants from a minimum of 10 organisations **showing interest** for each training

PREDIS training activities listed as a part of education portfolio at **EURAD School of Radioactive Waste Management**

Each training should attract at least 5 **mobility applications**

Each training should attract at least 3 specialists from different areas of implementation

5 deliverables from PREDIS in cooperation with EURAD

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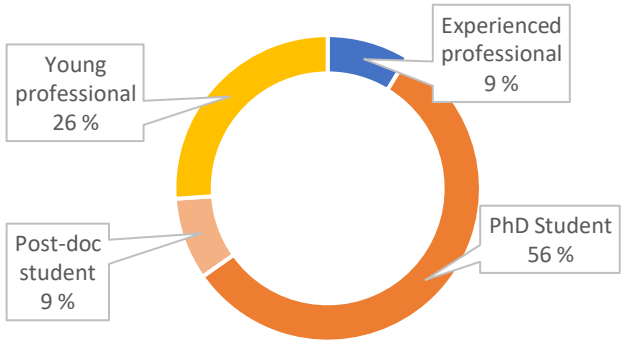
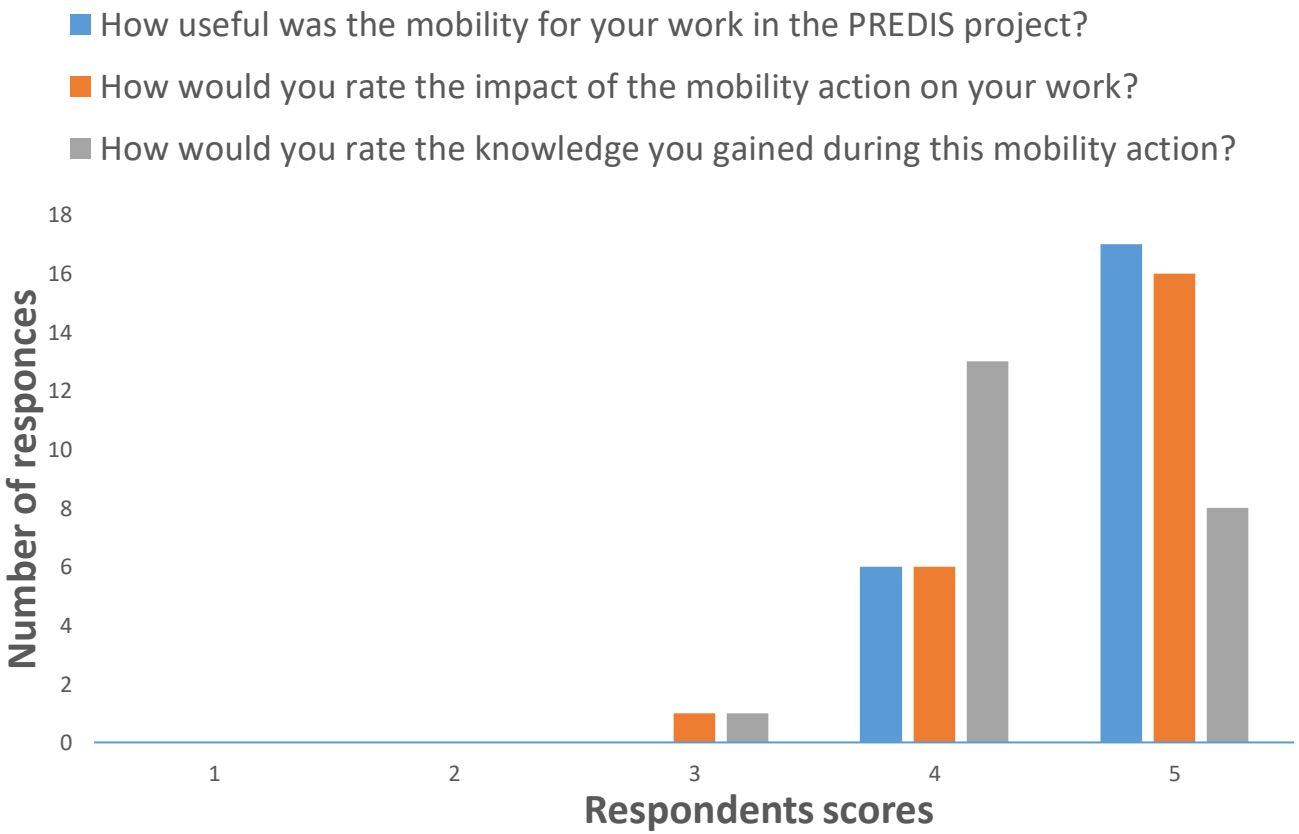
Feedback on achievements



- Mobility actions
- 23/61 responses
- All categories scored high: 4.3-4.7, where 1 is poor and 5 excellent
- “More mobility please, especially for the students because we provide most of the work, I won't be humble here, and we need to talk each other and create network with the professionals.”



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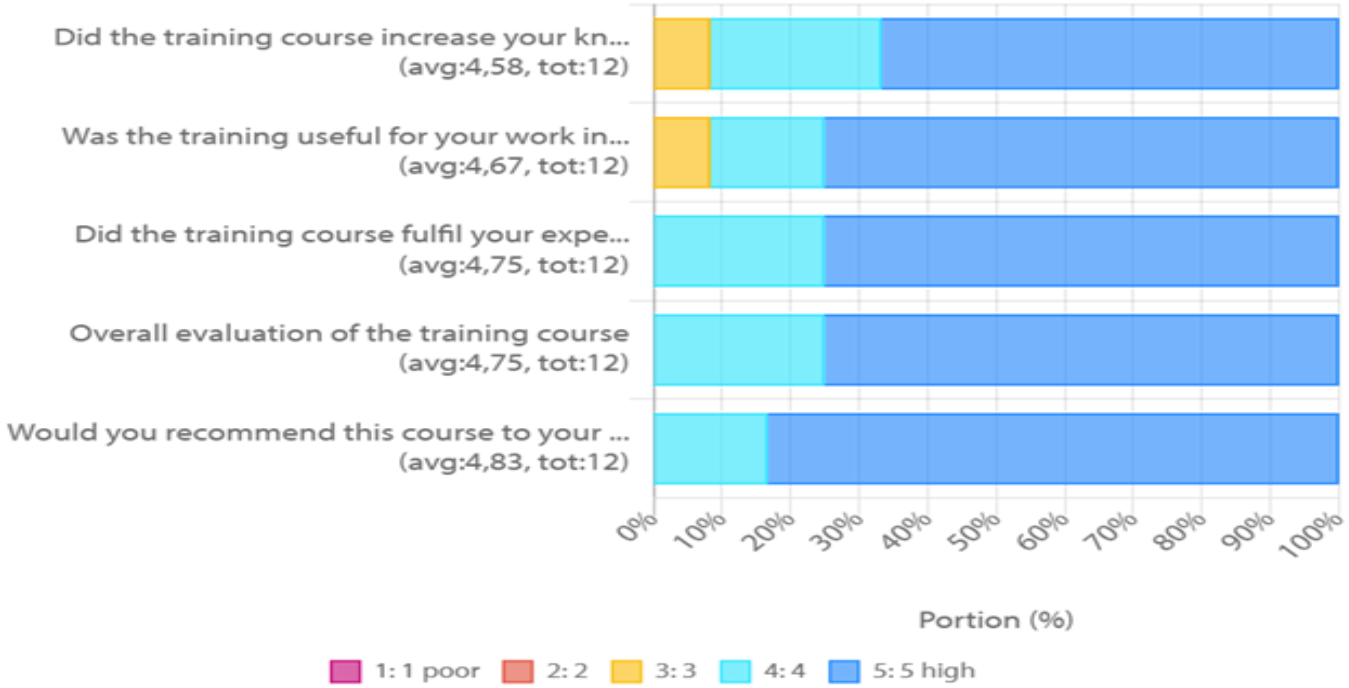
Feedback on achievements

- Training: Radioactive Waste Management Operations at ORANO, La Hague, France
- 16/18 responses
- All categories scored high: 4.5-4.8, where 1 is poor and 5 excellent



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Overall achievements

- **Integration** of KM in all PREDIS activities (MT, WP, students, partners, end-users) and beyond (EURAD, IAEA, NEA)
- Strong and vibrant **student group**!
- PREDIS and its KM activities were made **visible on a European scale**

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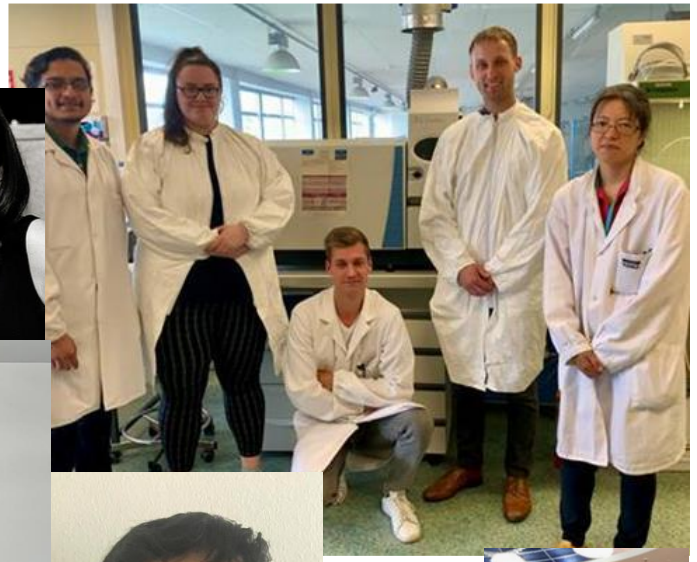

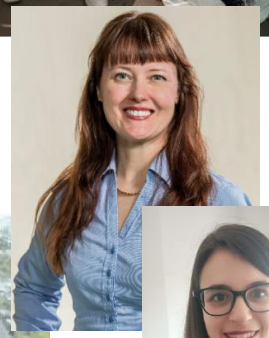

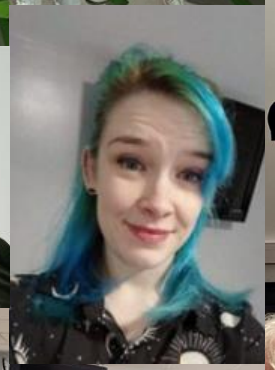




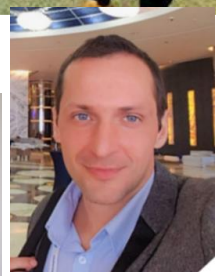

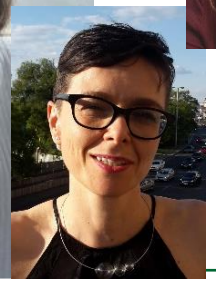

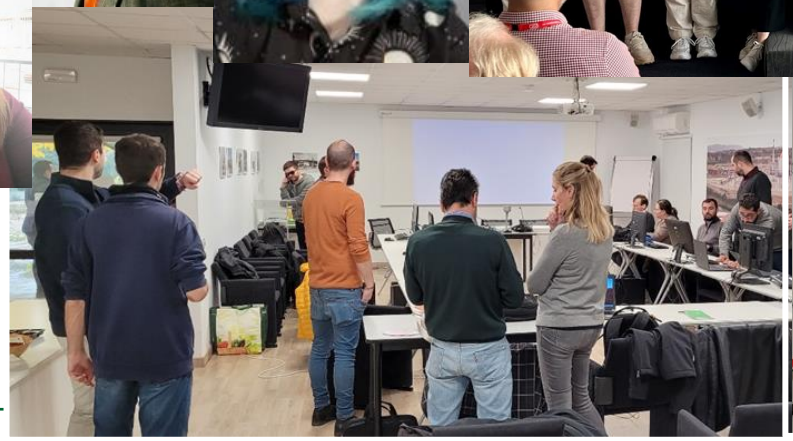


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7 Deliverables
4 Milestones

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WP 4 Innovations in metallic radioactive waste management

Partners : IMT, VTT, CNRS, UJV, POLIMI, Galson, UAM, NNL, SCK.CEN, CEA, ORANO, RATEN, CSIC, NUCLECO, DMT, CTU, ENRESA, NCSRD, KIPT, FZJ, FTMC, SORC

20 September 2024

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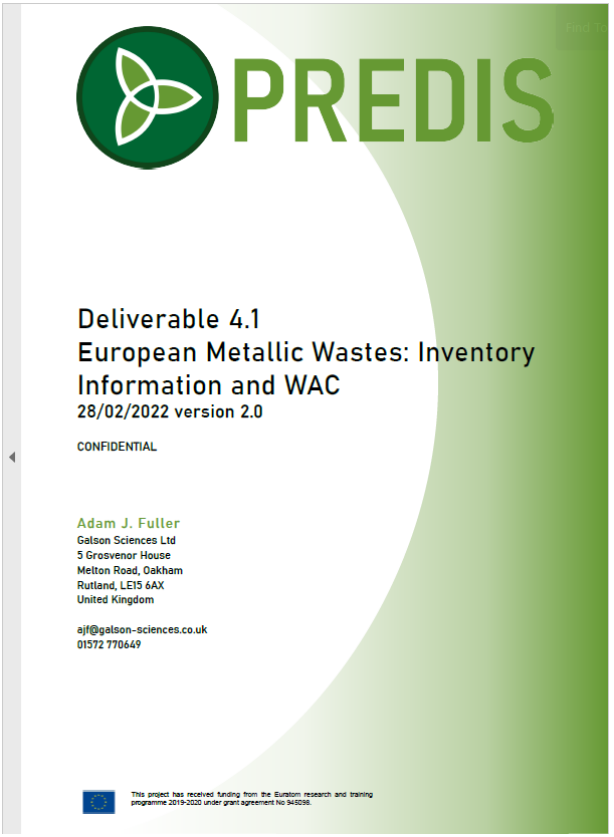
Metallic waste data collection & review

- **Description of Metallic wastes inventories at European level** in terms of chemical, physical and radiological properties, volumes, treatment options, etc. The main identified wastes are mixed operational waste, mixed metals, steels and other metallic waste. The survey used questionnaires completed by WP4 partners and EUG members.

- Inventories data were used to select metallic waste for experimental work (Steel, Ni-alloys).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Deliverable 4.1
European Metallic Wastes: Inventory Information and WAC
28/02/2022 version 2.0

CONFIDENTIAL

Adam J. Fuller
Galson Sciences Ltd
5 Grosvenor House
Melton Road, Oakham
Rutland, LE15 6AX
United Kingdom

ajf@galson-sciences.co.uk
01572 770649

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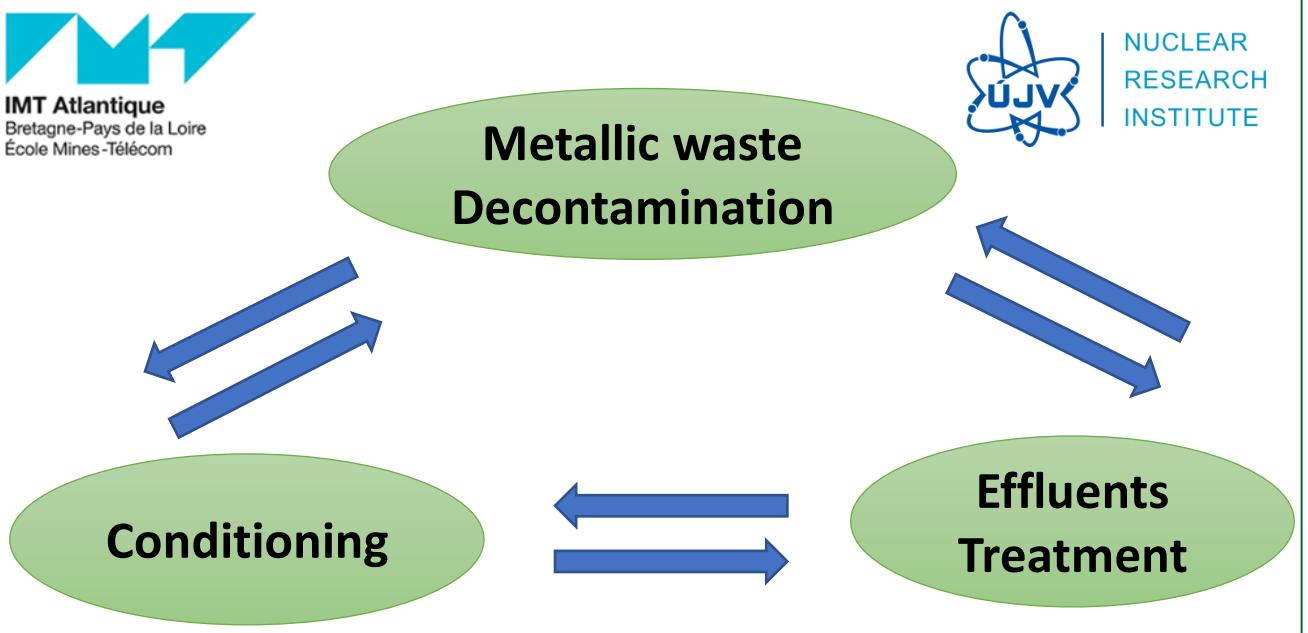
Task 4.4 optimization: COREMIX process

WP4 OUTCOMES



- Less complex process for industrial application: no UV light treatment for oxalic acid destruction. Safer, environmentally friendly & more economic !
  - Oxalic acid destruction by H_2O_2 & heating. LCA/LCC approach helped optimizing the process by reducing energy consumption & CO_2 production.
- Replacement of toxic and unstable permanganic acid ($HMnO_4$) by a mixture of $KMnO_4$ + HNO_3. $HMnO_4$ must be prepared onsite and requires expensive acid cation resins.
  - Safer, more environmentally friendly and more economic.
- Reduction of treatment time (less contact cycles) by 50%.
  - Safer, more environmentally friendly and more economic.
- The chemicals involved are compatible with the effluent treatment step as well as with the WAC for the conditioning/storage steps.
  - Use of chemical precipitation processes allowing the transformation of m^3 of waste effluents into a few 100g of residues compatible with cement/geopolymer matrices (WP4 & WP5)
- TRL moved to **TRL3-TRL4**

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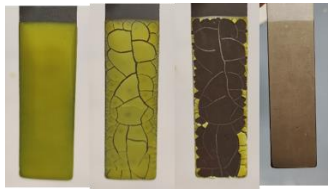
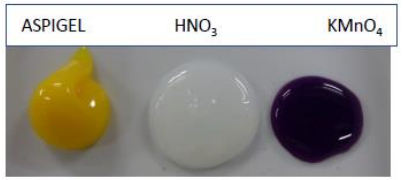
Task 4.4 innovation:
Magnetic gel decontamination

WP4 OUTCOMES

Metallic waste Gel Decontamination

Gel preparation & testing



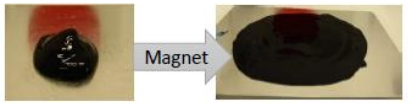


IMT Atlantique
Bretagne-Pays de la Loire
École Mines-Télécom

COREMIX process testing

NATIONAL NUCLEAR LABORATORY

Oxidized metal preparation
Gel preparation & testing



Social Organization for Radioecological Cleanliness

Oxidized metal preparation

- Development of gel formulations for “dry” decontamination
  - After drying the gel can be collected with the extracted contamination. No effluents: Safer, more environmentally friendly and more economic.
- Optimization of chemical parameters of the gel (e.g. COREMIX testing with gel).
  - Efficient for metals with small oxidized layer.
- Innovative formulation to decontaminate hardly accessible surfaces.
  - Gel application and removal using remotely a magnet.

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Task 4.5 Optimization: Radiological characterization

WP4 OUTCOMES

DMT

FIZINIŲ IR TECHNOLOGIJOS MOKSLŲ CENTRAS

VTT

NUCLECO

IMT Atlantique
Bretagne-Pays de la Loire
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MINISTERIO PARA LA TRANSICIÓN ECOLÓGICA Y EL RETO DEMOGRÁFICO

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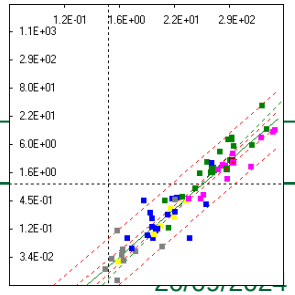
- Optimization of NDC using gamma spectrometry by reducing uncertainties.
  - Geometry of segment ; activity inhomogeneity ; measurement efficiency ; pipe direction
  - The method allows determination of activities of Cs-137 and Co-60 at the level of clearance in 1-2 min (amount of metallic waste about 100 kg)
  - Determination of activities in activated and / or contaminated metallic waste
- Optimization of sorting of metallic waste.
  - Scaling Factor.
- TRL moved to **TRL4-TRL5**
- Development of procedures for DTM measurement.
  - Ni-59, Ni63, Mo-93, Ca-41, Zr-93
  - Validation will be held by an intercomparison exercise in 2024

- Better determination of the waste management route
- Minimization of waste volume & increase of recycling



PREDIS

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Task 4.6 Optimization:

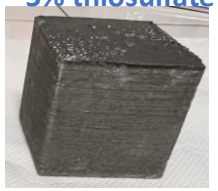
MPC formulations for reactive metallic waste encapsulation

WP4 OUTCOMES

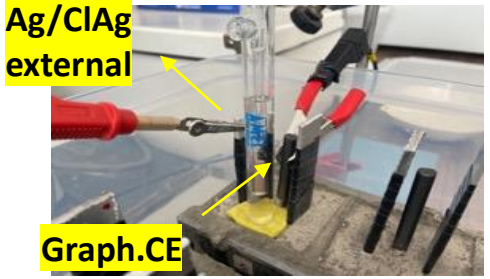
- Development of magnesium phosphate cement formulations based on WAC and economical considerations.

- Development of MPC formulations
  - Testing new alternative fillers to replace fly ash (volcanic ash, wollastonite)
- Optimization of cost production
  - Replacement of dead burned MgO by reactive MgO + retarder. MPC price reduction by 15%.
  - Lowering the volume of cement and increase the volume of aggregates
- Qualification of the developed MPC formulations
  - Corrosion, irradiation of MPC-Al, MPC-carbon steel, beryllium

B0T5
5% thiosulfate



B2T3
2% boric acid +
3% thiosulfate



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

13 Deliverables
17 peer reviewed papers
23 conference proceedings
4 webinars

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

PREDIS

WP 5 Innovations in liquid organic waste treatment and conditioning

Partners : CEA, SOGIN, RATEN, ECL, USFD, GSL, UNIPI, CIEMAT, CVREZ, ENEA, IMT, IRSN, KIPT, NNL, NUCLECO, POLIMI, SCK CEN, SIIEG, UJV

20 September 2024

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

A shared view of pre-disposal solutions for RLOW : RLOW data collection & review

- **Description of RLOW inventories at European level** (owners, radiological and chemical compositions, volumes, storage conditions…) using questionnaires completed by WP5 partners and EUG members.
- Used RLOW inventories to identify **reference wastes**, a combination of:

  Oils – Solvents – Scintillation cocktails

  (Cleaning and decontamination liquids – Organic effluents)

- A selection of raw materials and additives to formulate matrices:

  Locally-sourced **Metakaolin** and **Blast furnace slag**

  “Mixes (MK + Slag + Fly Ash)”

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

Availability of a treatment and conditioning process for RLOW up to TRL 6

WP5 OUTCOMES

- Identification of 3 reference formulations families
- Robustness to test
  - RLOW variability
  - Raw materials variability
  - Process variability
- Tests with Real RLOW
- Process scale-up

TRL 6

1) NNL formulation – MK based

- **Row material:**
  - Metamax® - RC: Al_2O_3 = 43.99%, SiO_2 = 51.48%
- **Activator:**
  - K silicate (K120): K_2O = 21.3wt%, SiO_2 = 30.38 wt%, H_2O = 48.32 wt%
- **Optimized formulation:**
  - SiO_2:K_2O = 1.2
  - K_2O:Al_2O_3 = 1.2
  - H_2O:K_2O = 13
- **RLOW**:
  - Nevastane Oil (20% vol.)

TRL 5

2) SCK CEN formulation – BFS based

- **Row materials:**
  - BFS = 46.5 wt% (Al_2O_3 = 11.10%, SiO_2 = 32.40%)
  - Sand = 28 wt%
- **Activator**:
  - $Na_2O.2SiO_2.xH_2O$ - 1.5 wt.%
  - NaOH (10M) - 5.5 wt.%
  - Additional water -18.4 wt.%
- **RLOW**:
  - Ionic liquid (Aliquat 336) - 9.9 wt. % (1)
  - TBP - 19.1 wt. %

(1) Tween 80 surfactant used : 0.5 % and 0.95 % relative to the waste volume

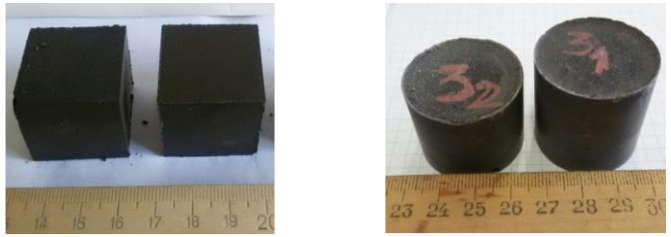
TRL 4

3) KIPT formulation – MIX based

- **Row materials:**
  - FA = 34 wt.% (Al_2O_3 = 18 %, SiO_2 = 46.12 %
  - BFS = 20 wt.% (Al_2O_3 = 6.02 %, SiO_2 = 40.6%)
  - MK = 14 wt.% (Al_2O_3 = 35.50 %, SiO_2 = 51 %)
- **Activator**:
  - K_2SiO_3 = 11 wt.%
  - KOH - 9 wt.%
  - Water -12 wt.%
- **RLOW**:
  - ShellSpirax: from 10% to 40% vol (2)

(2) Castament FW 10 (solid Polyethylene glycol-based additive) used to improve several propertie: 0.5 %

50 vol% loading of Nevastane EP 100 in MetaMax geopolymer (left) and Argicem geopolymer (right).



Geopolymer samples (curing 24h): comp. No.5 (left), and the same with pump oil content of 30 %wt (comp. No.8) of pump oil (right).

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Availability of a treatment and conditioning process for RLOW up to TRL 6

WP5 OUTCOMES

- Tests results with Real RLOW

	Oil ^{137}Cs + ^{60}Co	TODGA (solvent) ^{241}Am + ^{244}Cm + ^{152}Eu	Ionic solution ^{63}Ni + ^{14}C	Scintillation cocktail ^{63}Ni + ^{14}C
MK-Based	~30 % vol.	~30 % vol.	~15 % vol.	~15 % vol. ~30 % vol.
BFS-based	~20 % vol.	/	~20 % vol.	~20 % vol.
MIX-based	~30 % vol. No incorporation of real RLOW	/	/	/

- No significant differences
- Good leaching resistance
- Decrease in compressive strength with RLOW

- Process scale-up

	Nevastane oil 20 and 30 % vol.
MK-Based	50L – 100L Drum (20-30 % vol. pilot-scale) TRL = 6
BFS-based	50L Drum (20 % vol. pilot-scale) TRL = 5 Need formulation optimization

Figure 1 *Geopolymer composition during mixing (left), after curing (middle) and cut bottom of the drum after curing (right)*

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

Disposability assessment related to Waste Acceptance criteria (WAC)

WP5 OUTCOMES

- Leaching behavior of three formulation families
  - For the three formulations (MK-based, BFS-based and MIX-based) : **Storage conditions must be in endogenous and not in aerated conditions (cracks)**
  - For the three formulations (MK-based, BFS-based and MIX-based) : Leaching and waste release (surrogate or real radionuclides) in basic and neutral solutions remains low
- Stability to irradiation (60Co and 137Cs sources, up to 200kGy) : No significant impact on leaching.
- Evaluation of the RLOW geopolymer waste form characteristics and properties in terms of acceptability for disposal at near-surface and geological disposal facilities
  - Comparison of geopolymers with different RLOW with the typical current waste management approach, called the baseline scenario
  - Criteria studied: physical form, mechanical stability, homogeneity, void space, free liquids, chelating/complexing agents, leaching

Assessment area	Oil - MK	Oil - MK	Oil - Mix	Oil - BFS	Solvent - MK	Solvent - MK	Solvent - MK	CS - MK	CS - MK	CS - MK
	CIEMAT	NNL	KIPT	CVRez	NNL	POLIMI	UJV	POLIMI	UJV	CIEMAT
Physical form										
Mechanical stability										
Homogeneity										
Void space										
Free liquids										
Chelating agents										
Leaching										

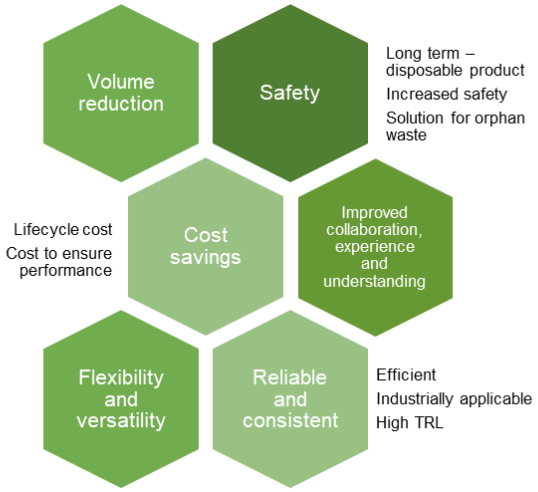
Rating	Risk to disposability
Green	No risk to disposability
Grey	No, limited or partially applicable experimental data
Amber	Limited risk to disposability
Red	Significant risk to disposability

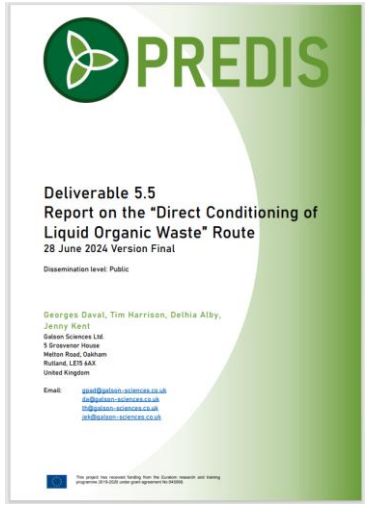
This project has received funding from the Euratom research and training programme 2019-2020 under grant agreement No 945098.

Preliminary technical, economic and environmental analysis (Value Assessment)

WP5 OUTCOMES

- Consistent methodology and approach was developed across all PREDIS WPs (4, 5, 6, 7)
- The Value Assessment Perform a strategic analysis of the performance of alternative waste management options for RLOW studied under WP5
- For WP5, we identified waste type and treatment / conditioning technology combinations (called variant scenarios) for comparison with the typical current waste management approach, called the baseline scenario
- The higher RLOW waste loading achievable with geopolymers in comparison with absorption/ cementation (oils and scintillation cocktails) leads to benefits in terms of safety, materials use and cost
  - Benefits not as significant for solvents owing to IRIS process (chosen as the baseline for solvents) leading to large volume reduction
  - Further R&D needed to bring the process towards a TRL 9 is acknowledged and is reflected in the EURAD-2 proposals.




PREDIS

Deliverable 5.5
Report on the "Direct Conditioning of Liquid Organic Waste" Route
28 June 2024 Version Final

Dissemination level: Public

Georges Duval, Tim Harrison, Delhia Alby, Jenny Kent
Galson Sciences Ltd.
5 Gravenor House
Melton Road, Oakham
Rutland, LE15 6AX
United Kingdom

Email:

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7 Deliverables
9 Milestones

Public reports available in PREDIS website

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PREDIS

Achievements in WP6

Innovation in solid organic waste treatment and conditioning

THIERRY MENNECART, SCK CEN

& WP6 PARTNERS (CEA, CIEMAT, CSIC, CVREZ, GLASON, KIPT, NNL, POLIMI, SCK CEN, SIIEG, UAM, VTT, USFD, VTT)

20 SEPTEMBER 2024

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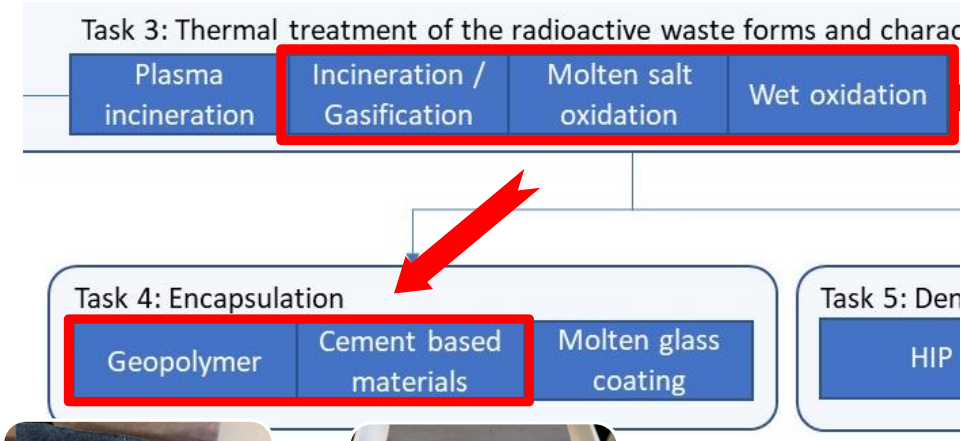
Geopolymer & Cement based materials immobilisation

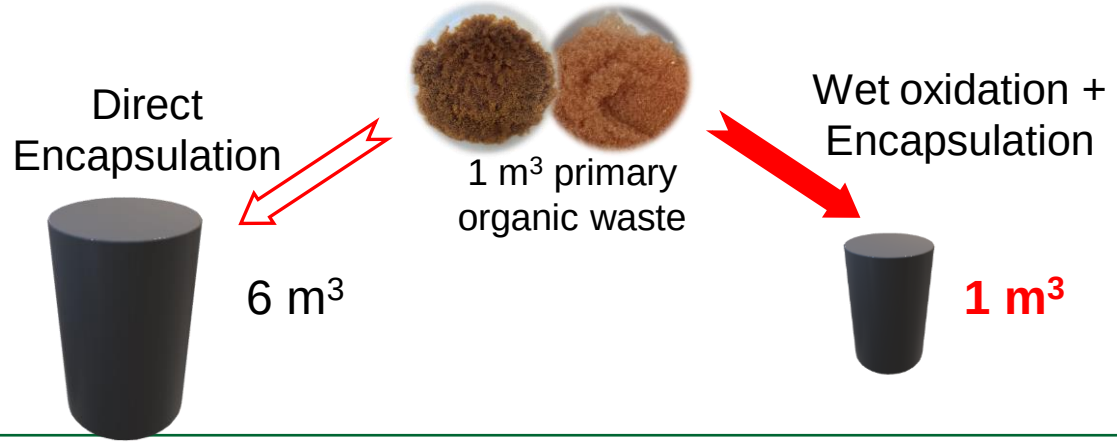


TRL

2 - 3 → **5** 3 → **5**

- Matrices design and optimization
  - 10% - 20% of thermally treated resins in the geopolymer
- Characterisation (calorimetry, µ-structure, mineralogy, porosity,…)
- Leaching experiments on reconditioned waste

Different treated wastes requires
different immobilisation matrices design



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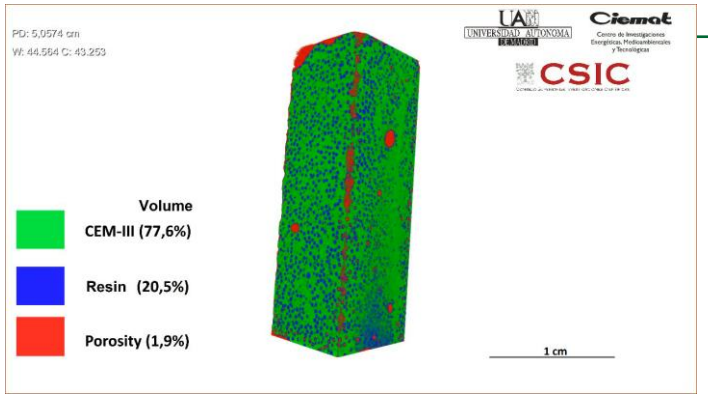
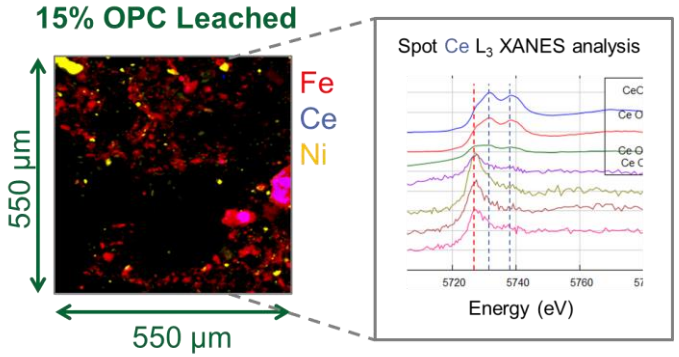
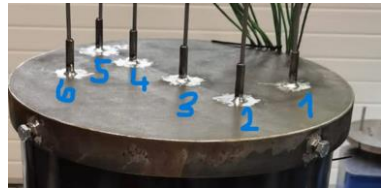
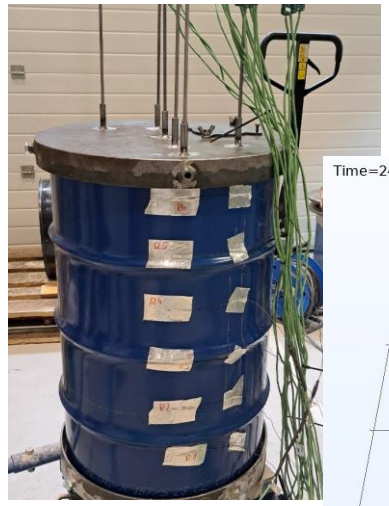
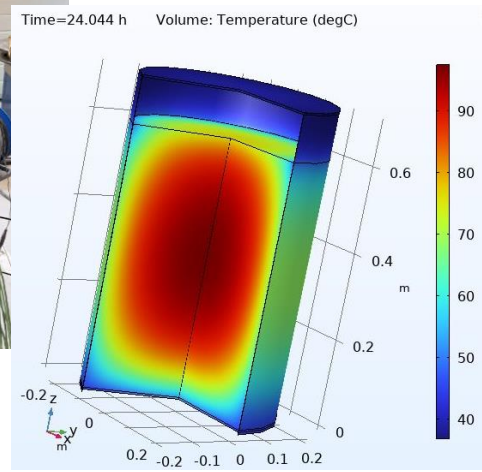
Physico-chemical characterization of reconditioned waste forms and stability testing



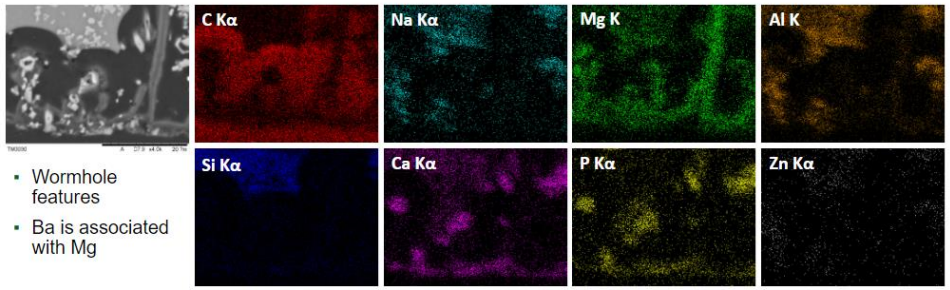




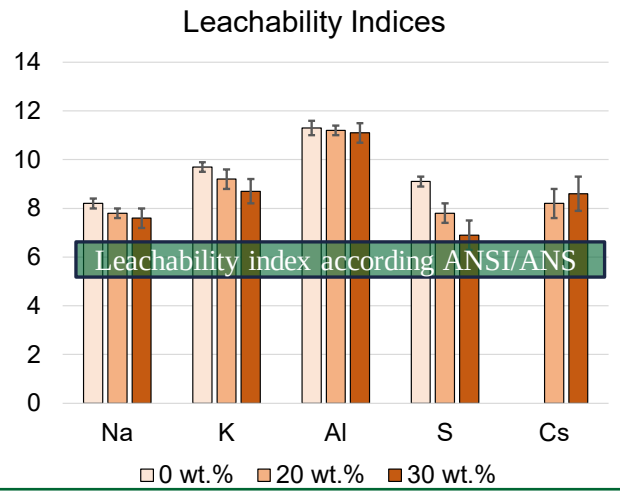




Month 3 - Ground Ash + $Na_2B_4O_7$



- Wormhole features
- Ba is associated with Mg



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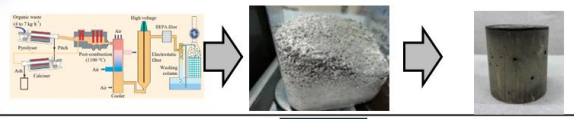
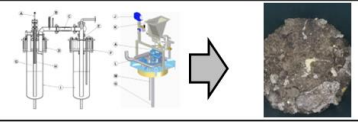
New treatment technologies generally offer benefits compared with current options

Scenario ID	Raw waste	Treatment baseline or novel technology	Treatment output
6.1	 Anionic IER Organic solids	 IRIS & HIP	200 L Drum 
6.2		 IRIS & Compaction	
6.3		 IRIS & Geopolymer	
6.4	Anionic IER 	 MSO & Geopolymer	

- Benefits in terms of material environmental impact, package disposability and the disposal and storage costs for the product drums.
- Further development would remove or reduce the identified disbenefits of the considered technologies, which could in future become more sustainable and less costly alternatives for the long-term management of RSOW.

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

PREDIS

Thank you for your attention !

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

PREDIS

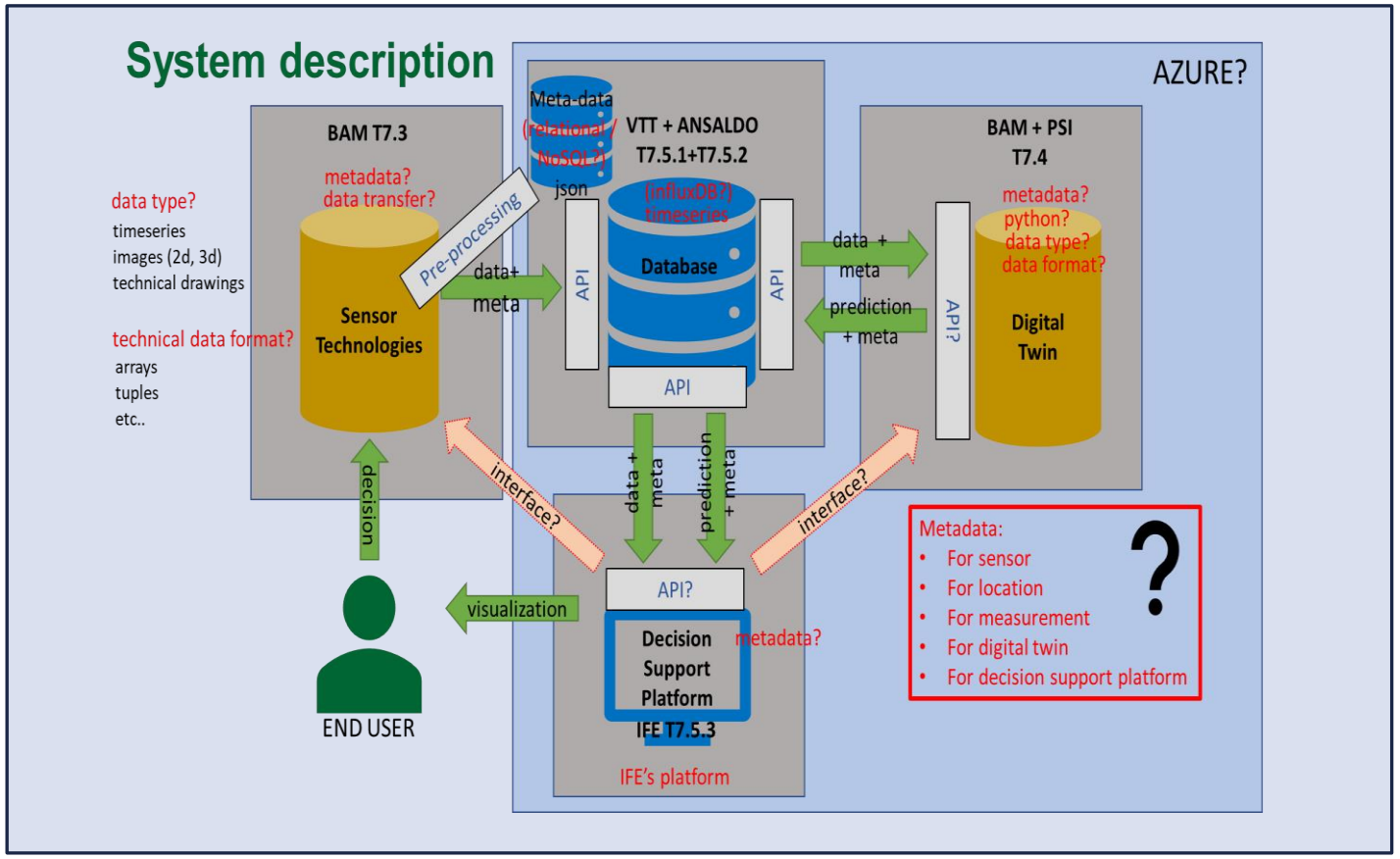
WP7 Innovations in cemented waste handling and pre-disposal storage

Partners : BAM (leader), A21, GLS, IFE, INFN, KIT, MAGICS, NNL, PSI, SCK_CEN, VTT, UNIPI, NRG, ORANO, SOGIN, UJV

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

WP Objectives

- Identify, **evaluate and demonstrate** store and package **quality assurance** (mainly NDE) and monitoring technologies
- Adapt and demonstrate **digital twin technology**
- Develop and demonstrate **methods for data handling**
- Develop and demonstrate a **digital decision framework**



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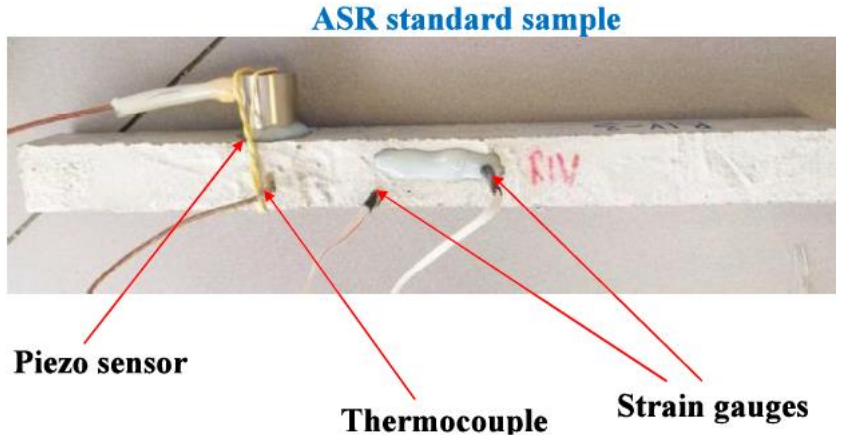
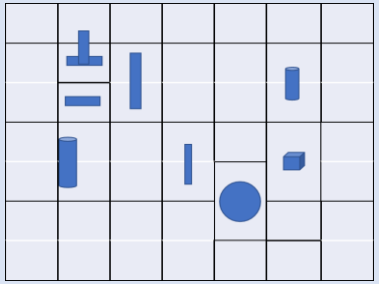
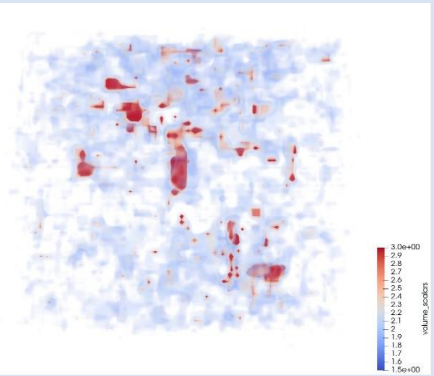
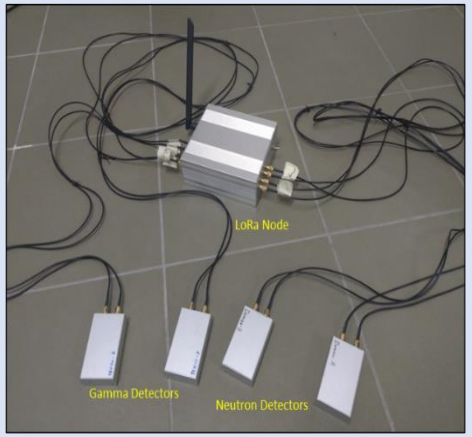
Task 7.3 Testing and Monitoring: New sensing options









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Task 7.4 Digital Twin

Development of DT straightforward:

- Collection of models predicting the evolution of cementitious wastes is available.
- Ability to run chemo-mechanical processes on different compositions – input: waste package properties – to asses for possible problems in chemo-mechanical evolution.
- Various models can be added, input/output can be developed
- Obtaining data for the training of the DT is complex.

Real cement drums created in 1994 at PSI

SCK-CEN: Drum-scale Alkali Silica Reaction (ASR) experiment

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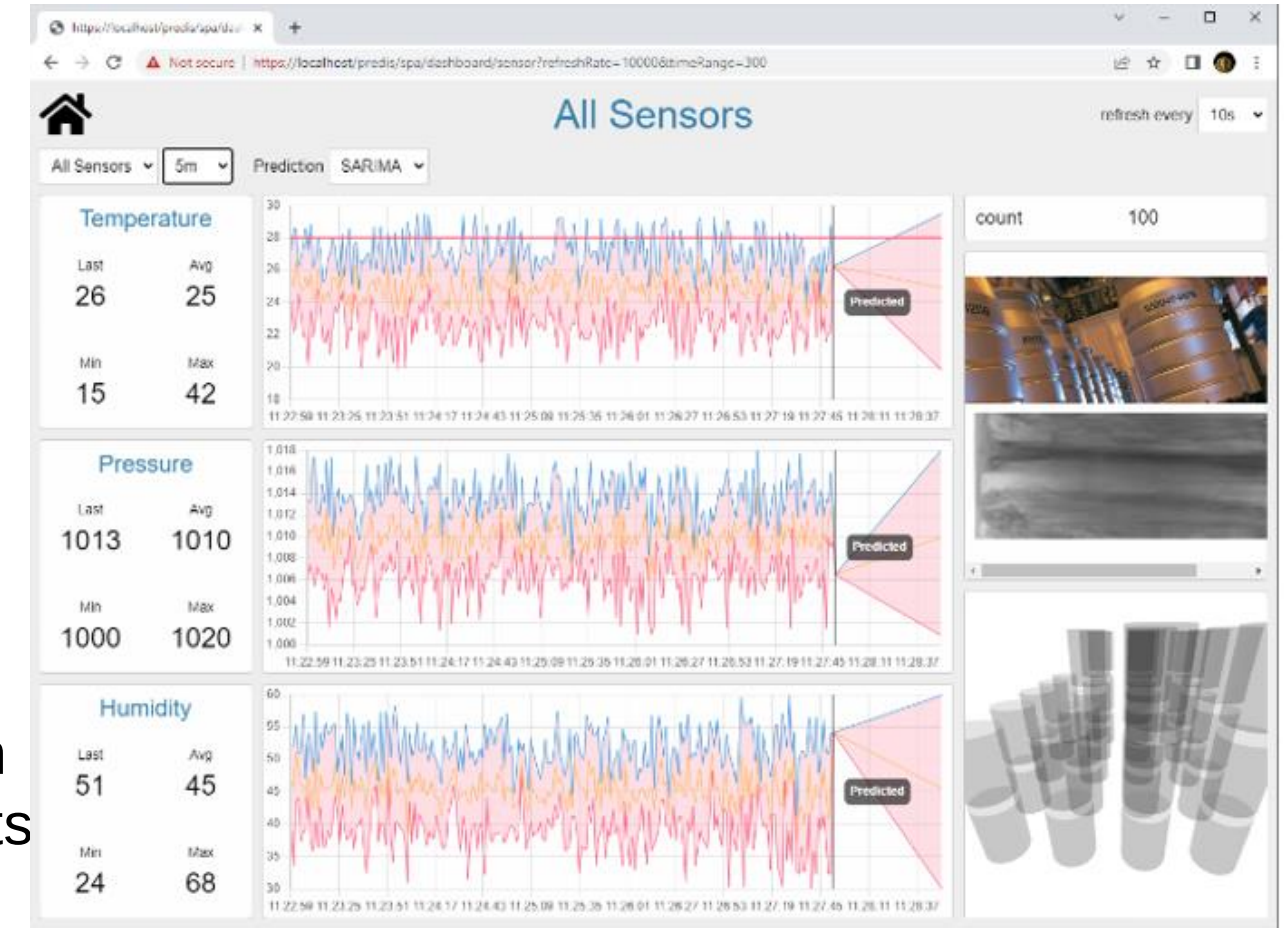
Task 7.5 – Data handling, processing and fusion

- Data management framework: seamless integration of data from sensing to decision framework
  → Support for informed decision-making
- Integration of sensor and monitoring data
  → Immediate insights, improved performance and safety
- Real-time monitoring capabilities
  → Instant detection of deviations from normal conditions and automated alerts
  → Timely interventions minimizing the likelihood of incidents/accidents or environmental impact.



Example dashboards of decision framework: dashboard for a single drum

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 945098.

Task 7.5 – Data handling, processing and fusion

- Data management framework: seamless integration of data from sensing to decision framework
  → Support for informed decision-making
- Integration of sensor and monitoring data
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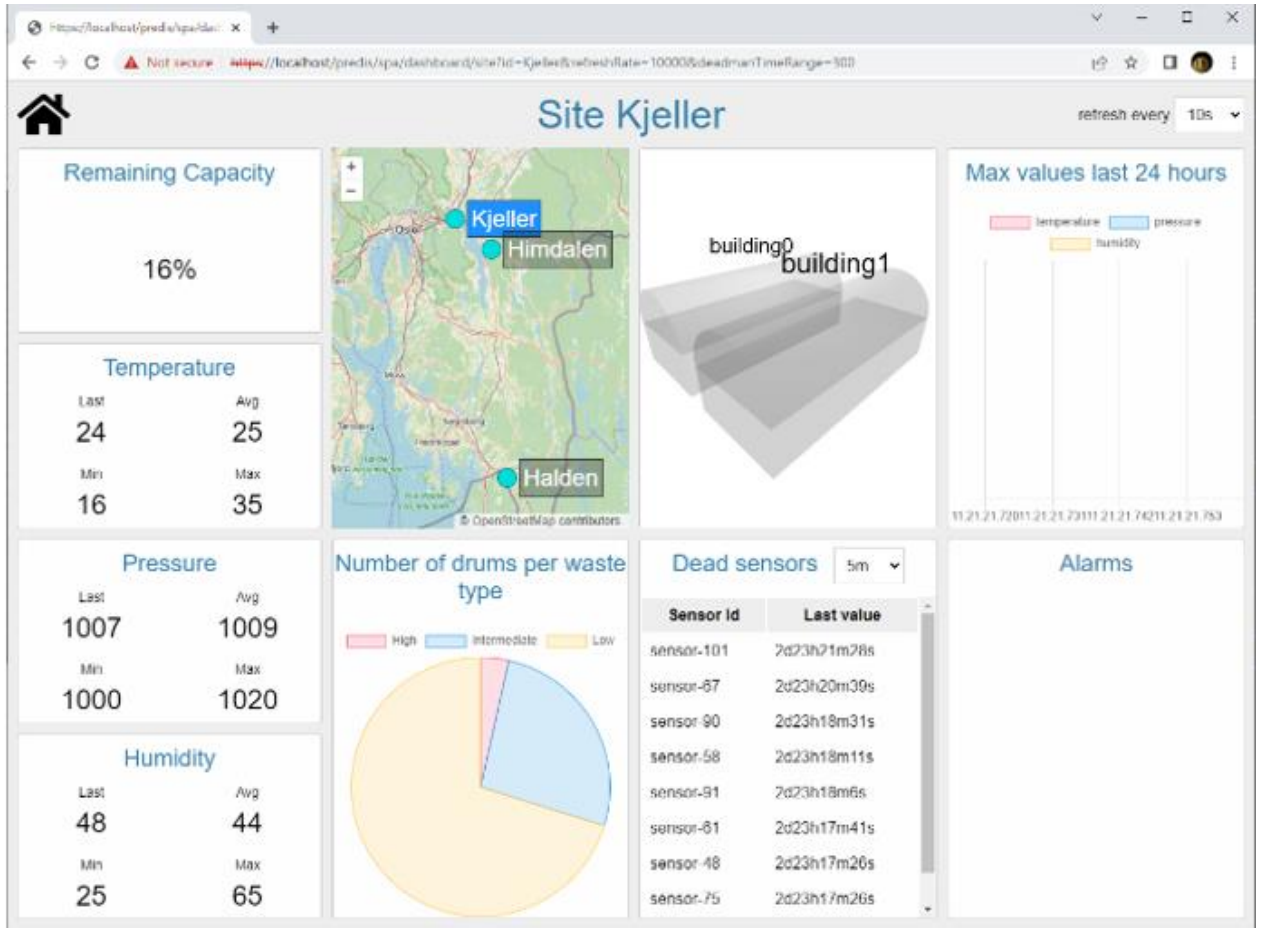

Example dashboards of decision framework: dashboard for entite facility

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 945098.

Task 7.6 : Demonstration tests

Demo test at UJV and NNL:

- **Objective** : Demonstrate that the technologies, methods, and models developed and identified in Task 2 to 5 can be used in a nuclear environment.

- Demonstration test at UJV :
  - 3 technologies tested (BAM/VTT, UniPi and INFN)
  - 2 mock-ups to replicate nuclear cimented packages
  - 3 months test
  - many parameters tested and monitored on a specific Dashboard

- Demonstration test at NNL :
  - 1 technology tested on real historial waste packages during many months
  - Many parameters measured and monitored

Configuration test at UJV

Configuration test at NNL

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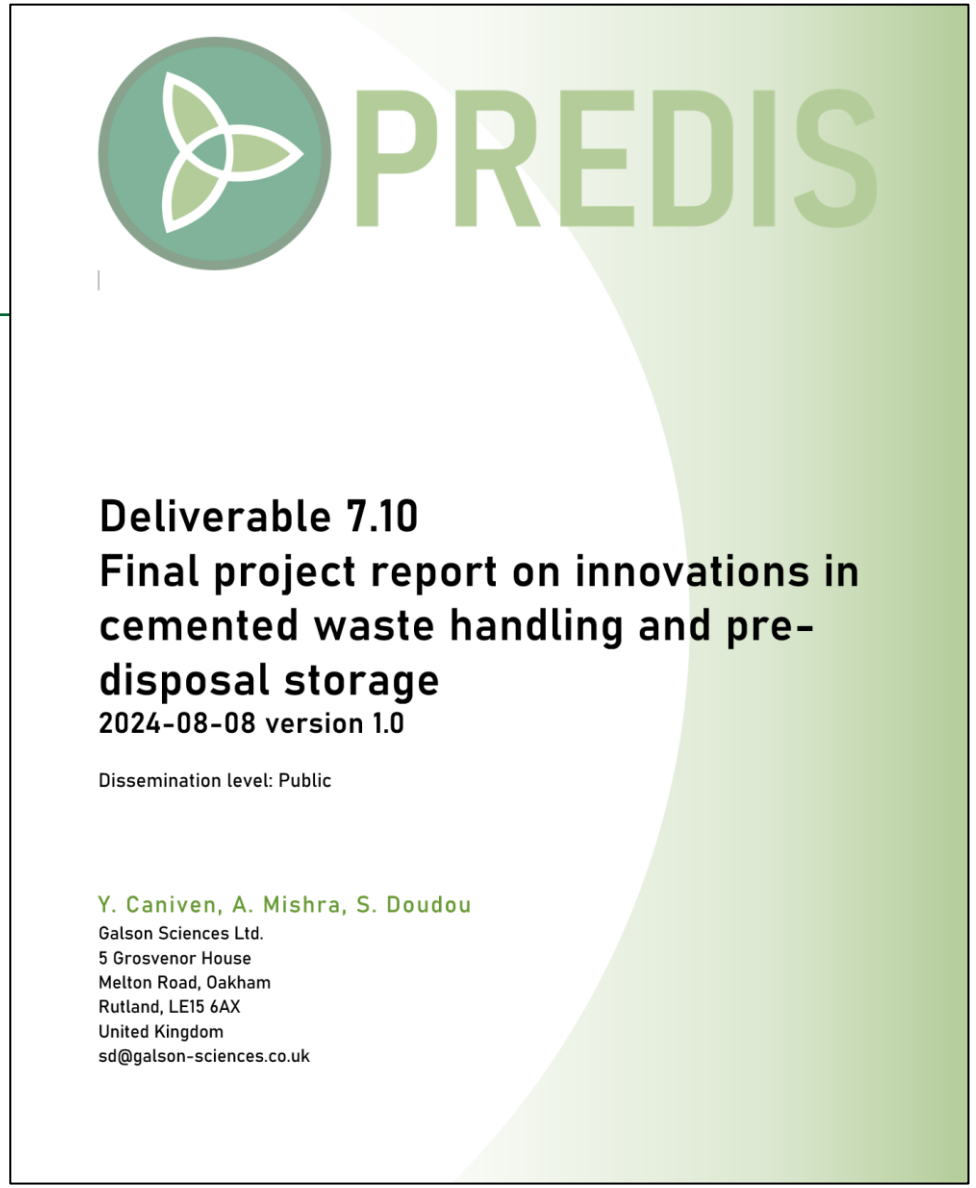
D7.10 Final Report

Available at:
predis-h2020.eu/publications-and-reports/



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PREDIS

Value Assessment of PREDIS Innovations

PARTNERS: **GALSON SCIENCES LTD (GSL)**, BAM, CEA, CVŘEŽ, IFE, IMTA, INFN, KIT, MAGICS, NNL, NRG, ORANO, PSI, ROMANIA INSTITUTE OF NUCLEAR RESEARCH, SCK CEN, SOGIN, UJV ŘEŽ, UNIVERSITY OF MANCHESTER, UNIPI, VTT

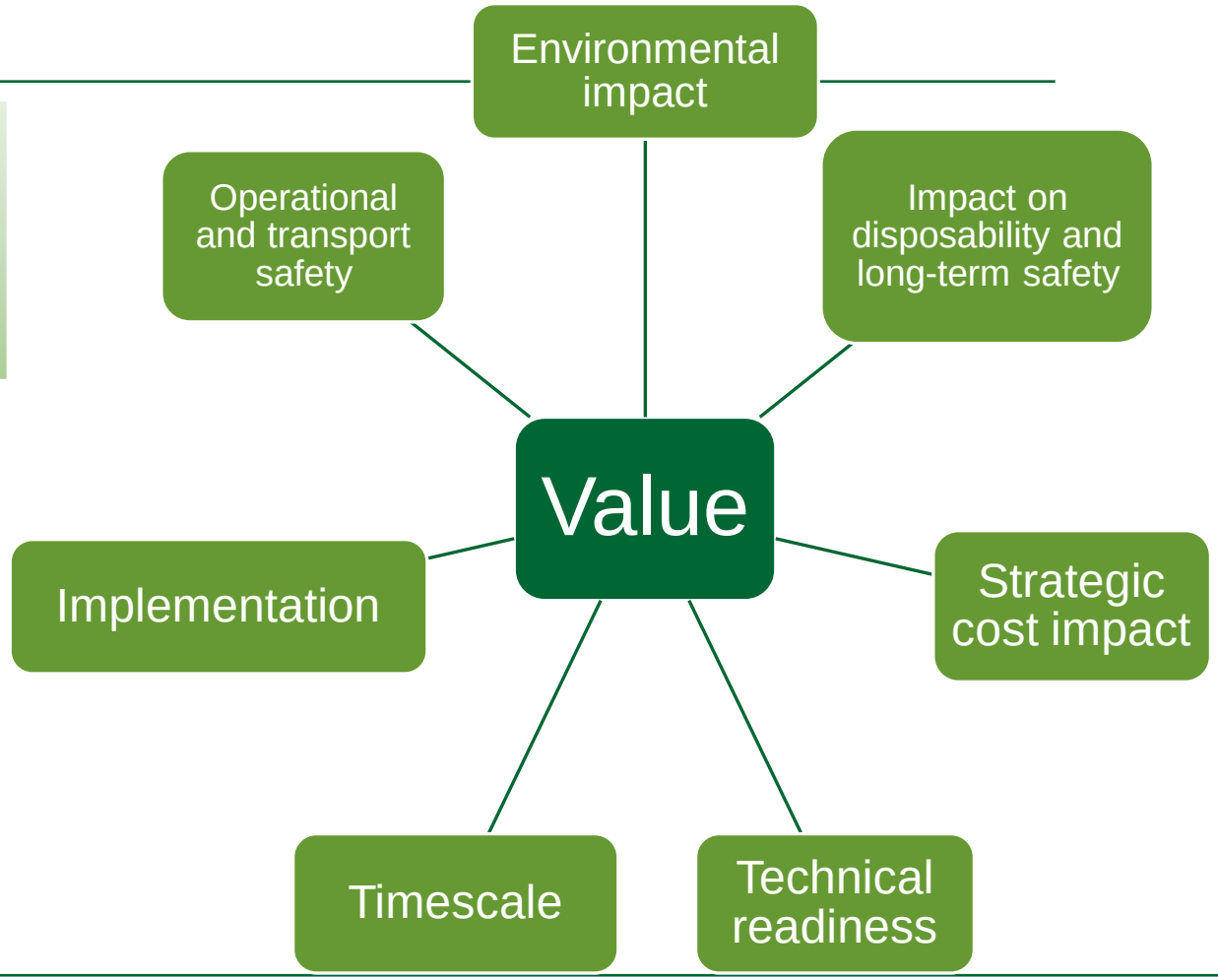
20 SEPTEMBER 2024

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

What is Value?

*"the realisable benefit in **safety, monetary and environmental** outcomes that will arise from implementing this technology at a specified time"*

- In PREDIS, value was assessed using **structured multi-criteria assessment**
- Value is considered across the full waste management lifecycle
- Supports engagement and collaborative decision making

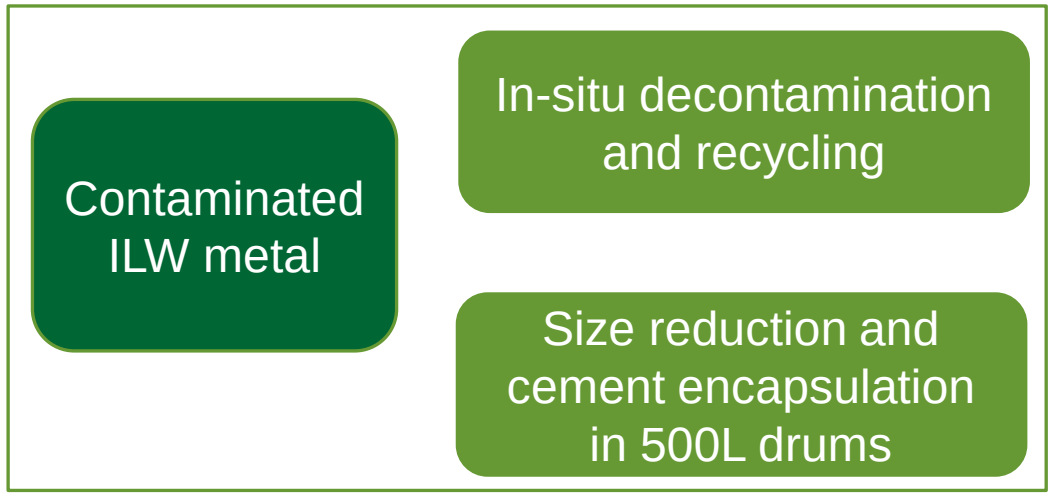


This project has received funding from the Euratom research and training programme 2019-2020 under grant agreement No 945098.

Scenario Definition

- Two types of scenarios:
  - **Variant scenarios:** Combination of waste types and treatment approaches / formulations developed in PREDIS
  - **Baseline scenario**: Current waste management practices for a given waste type
- Selection criteria:
  - Realism and relevance to PREDIS R&D Innovations
  - Alignment with Life Cycle Analysis and Life Cycle Costing (LCA/LCC) PREDIS case studies
  - Data availability

Example scenario from WP4: Metal decontamination



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

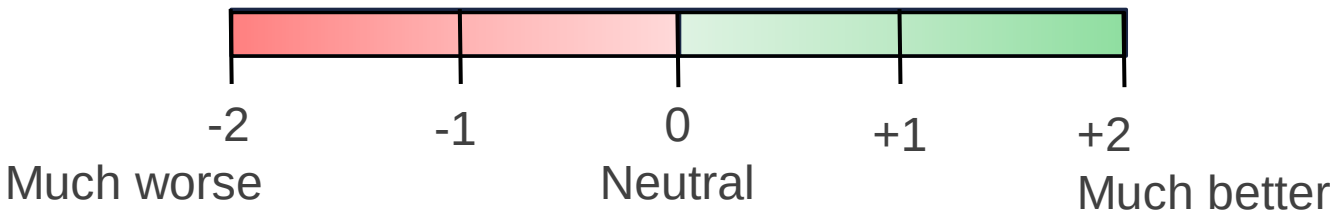
Value Assessment Structure

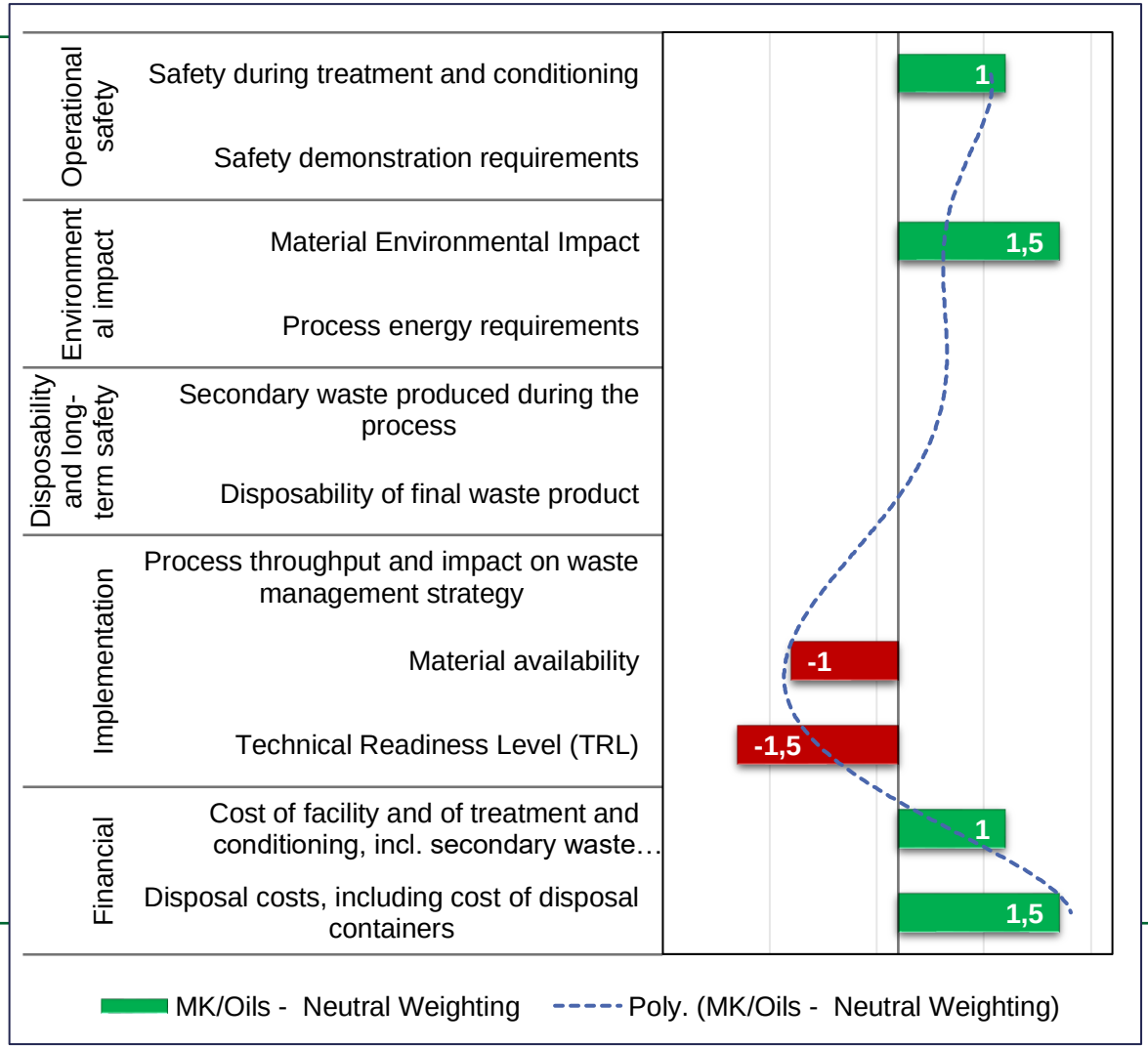
Attribute	Data Category	Assessment considerations					
		Planning	Pre-treatment	Treatment operations	Conditioning	Storage and Disposal	Decommissioning
Operational and Transport Safety	Facility construction and decommissioning						
	Waste pre-treatment requirements (conventional and radiological safety implications)						
	Waste post-treatment requirements (conventional and radiological safety implications)						
	Waste operational safety issues (e.g., ease of providing shielding during operation)						
	Transport safety issues						
Environmental Impact	Material requirements						
	Energy requirements						
	Secondary waste and gaseous/liquid discharges generated						
	Nuisance						
Impact on disposability / long-term safety	Ability to meet waste acceptance criteria						
	Disposability of secondary waste						
Implementation	Indicative lifetime feed						
	Ease of achieving required throughput for process (full-scale facility) (m^3/year)						
	Potential to treat a wide range of waste groups (flexibility) including problematic and orphan wastes						
	Impact on waste management strategy						
Timescale	Design, construction and active commissioning timescale						
	Lifetime operating timescale						
	Decommissioning timescale						
Technical Readiness	Maturity of technology						
Strategic Cost Impact	Costs of construction, operation and decommissioning						
	Impact on disposal costs (total packaged waste volume, disposal route, and required storage and disposal capacity)						

Common start and end points for each scenario – relevant life cycle stages

Value Assessment: Geopolymer encapsulation of oils

- Oils conditioned in Metakaolin-based geopolymers (similar results for BFS and MIX formulations)
- Compared to two-step cementation approach
- Focus on differentiators





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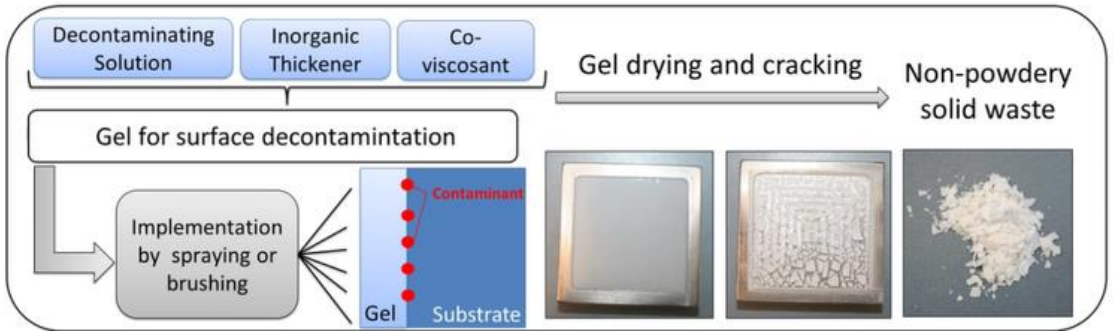
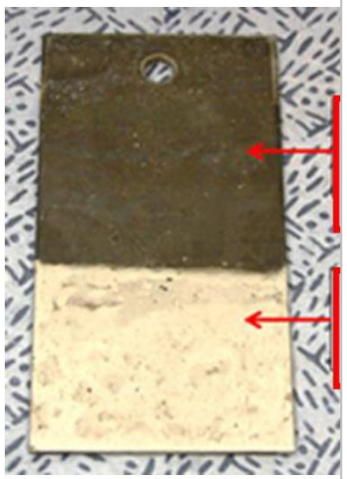
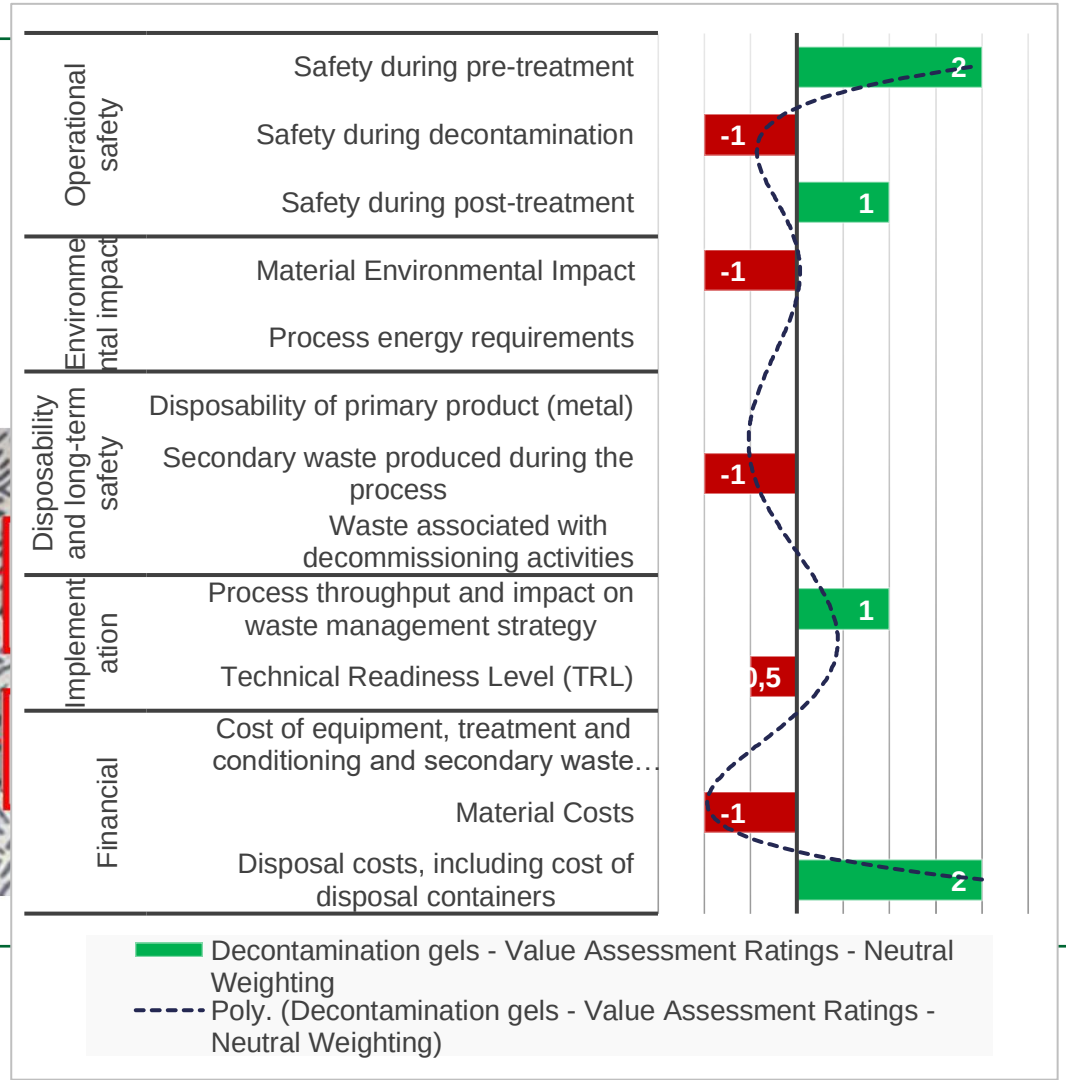
Value Assessment: Metal Decontamination

Gel decontamination of metal surfaces:

- Vacuumable gels
- Electrolytically assisted surface decontamination (EASD) gels







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Value Assessment – find out more?

WP	Waste Types	Deliverable or Milestone	Title
4	Contaminated metals	MS25 *D4.2*	Value Assessment Workshop *Included in Synthesis Report on Management of Metallic Waste Streams*
5	Organic liquids (oils and solvents)	D5.5	Included in Report on Direct conditioning of liquid organic waste route
6	Organic solids (mixed organics and ion exchange resins)	MS47 *D6.3*	Value Assessment Workshop *Included in Economic, environmental & disposability impacts of novel treatments report*
7	Cemented waste packages (in long-term storage)	MS54 *D7.9*	Value Assessment Workshop *Included in Economic, environmental, and safety impact report*

Underpinning data for PREDIS Case Studies

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

Overall Project Successes, Impacts & Conclusions

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 945098.

Project outcomes and impact as key performance indicators (KPIs)

Applying multidisciplinary and multiscale scientific approaches to demonstrate the new solutions

- Increase of TRL of innovations ≥ 10 solutions
- Technical/scientific journal publications ≥ 25 submissions
- Generate invention notifications ≥ 4 submitted

Addressing project drivers from the end users' point of view

- Participation of industry to EUG ≥30
- Demonstration or trial deployment of new technologies ≥3 EUG
- Adoption or refining of national WAC based on project guidelines ≥8

Fostering deeper cooperation between experts from many EU Member-states

- Engagement of other countries, beyond PREDIS membership ≥5
- Individual subscribers to project newsletter ≥200, from over 25 countries

Training new experts in the field of predisposal waste management technologies

- Number of PhD and Postdoc students ≥15
- Number of mobility between partners ≥20
- Number of training modules produced (WP3), in cooperation with EURAD ≥6

Updating and revising pre-disposal guiding documents

- Producing cooperative deliverables with EURAD ≥5
- Completed feedback from EUG for SRA ≥20
- Project feedback from EUG members at annual workshops ≥7/10

55 milestones
61 deliverables
Over 100 publications

19 webinars
> 450 individual participants
41 countries
4 open workshops

8 Courses
1 theme overview
12 domain insights
4 case studies

51 students in total
60+ mobilities

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PREDIS Actual Metrics in a Nutshell

Contributions

2500+ person months
450+ persons
(37 % **female**, 63 % male)
51 students

Outcomes

55 milestones
61 (+5) deliverables
3 large workshops (+3 online)
TRL increases, also LCA/LCC
Lab & field upscaling demos

Website

> 4500 users
> 10 000 sessions
> 30 000 pageviews

Publications

40+ Scientific articles
100+ Conference presentations
8 Newsletters
8 Blogs and Case Studies
1 Position paper **+ SRA**

Webinars

20 organised
> 600 individual participants
> 40 countries
Webinars recorded, serving as e-training lectures

Collaboration

4 MoUs signed
1 Joint statement
Over 100 companies on stakeholder list

PREDIS

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Administrative achievements

- **EC Review Spring 2024 Excellent work**
- **Targets (KPIs) achieved and with great metrics**
- >90% of Deliverables and Milestones (+100) delivered on-time
- Finances and schedule accurately followed the project plan
- 1st & 2nd Periodic reporting – positive feedback, no deviations
- Communication and dissemination actions strong
- Risk and data management good
- Ensuring excellence (QC) of results good
- Outreach to wider community

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End User Group

- 25 End User Group members

PREDIS

Overall Collaboration

- Great involvement of End User Group (industry) and Stakeholders
- Coordination and organised 20 webinars across WPs (2000+ reach), across other projects and with industry/guest speakers & discussion
- 3 on-line whole consortium workshops and 3 hybrid workshops with all partners – proceedings available
  - Finland, April 2022 – 100 persons present
  - Belgium, May 2023 – 150 persons present
  - France, June 2024 –180 persons present
- Dissemination activities (LinkedIn, blog texts, case studies)
- High visibility internationally – EURADWASTE, IAEA, WM2024 etc
- Active sharing and feedback with EURAD EJP
- Engagement with IAEA (especially in KM activities)

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Working Together for Sustainable Radioactive Waste Management

Philosophy
Fulfill individual mandates while optimizing synergies & leveraging outputs for maximum impact

Principles

Co-ordinate

Co-operate

Do not duplicate

Reference: R. Robbins, IAEA at PREDIS Annual Workshop, Belgium, May 2023

The IAEA's collaboration with the EC EURATOM projects provides the opportunity to extend their reach and impact beyond Europe for the benefit of all Member States with responsibility for the management of radioactive waste

Way Forward –

PREDIS “summary” video published next week (Linkedin etc)
PREDIS final conference proceedings & all deliverables on web page within a month
EURAD-2 launch, Belgium 23-24.10.2024 and annual workshop September 2025

Continue to use as a resource: https://predis-h2020.eu/

European Partnership
on Radioactive Waste Management

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VTT

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DE RADIOPROTECTION
ET DE SÛRETÉ NUCLÉAIRE
MEMBER OF
ETSON

orano

DMT

JÜLICH
Forschungszentrum

KIT
Karlsruhe Institute of Technology

DEMOKRITOS

Isotoptech Zrt.

Social Organization for
Radioecological Cleanliness

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Engineering and Consulting

ansaldo nucleare

ENEA

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Thank you

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