

**PREDIS: EXAMPLE OF HOW STAKEHOLDERS CAN
IMPACT AN R&D PROJECT AND MAXIMIZE
THEIR BENEFITS – LEADING TO INCREASED
SAFETY AND IMPROVED SUSTAINABILITY IN
RADIOACTIVE WASTE MANAGEMENT**

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Abstract

The “PREDIS: Pre-disposal of Radioactive Waste” project targets the development and implementation of activities for pre-disposal treatment of radioactive waste streams other than nuclear fuel and high-level radioactive waste. In order to focus on the needs of stakeholders and end users, interaction with them has been established at different levels, on different topics and at different moments in time. Even during the preparation phase of the project, the needs of industry and stakeholders were evaluated for R&D and demonstration in predisposal waste management technologies, which initially defined the scope of the PREDIS project. During the first months of the project, a Gap Analysis was performed, where information from stakeholders and end users was gathered. A variety of methods, such as quantitative and qualitative surveys, live polling, interviews with end-users or webinar presentations, etc. was used. The outcome of the Gap Analysis led to an update of the work plan of some of the technical work packages. Another example of the impact of stakeholder engagement is the interactive process of writing the Strategic Research Agenda (SRA). The baseline PREDIS SRA focused on the consolidation of the existing published SRAs, while the revised 2nd edition SRA document has been developed based on the needs of PREDIS and the End User Group. The SRA will guide R&D in the coming years, to ensure maximal benefit for the end users. Throughout the project, technical interactions with stakeholders and end users were maintained. During each annual meeting, a dedicated session for end users was planned where they are allowed to join the technical meetings of the work packages and discuss recent results. These interactions directed the project to ensure maximum impact and utilization of the results. PREDIS has now reached 119 registered stakeholders from 29 countries, covering 4 continents. Stakeholders and end users have been invited to more than 20 public events such as webinars and the projects annual meetings, where they could interact directly with the technical WPs. This interaction, which is still on-going, directs the project to ensure maximum impact and utilization of the results, which will improve safety of radioactive waste management and enable sustainability.

1. INTRODUCTION

The “PREDIS: Pre-disposal of Radioactive Waste” project aims at developing and increasing the Technological Readiness Level (TRL) of treatment and conditioning methodologies for radioactive wastes (excluding high-level waste and spent nuclear fuel) for which no adequate or industrially mature solutions are currently available, including metallic materials, liquid organic waste and solid organic waste [1]. The implementation of these solutions will improve safety during the following waste management steps. The project also aims at developing innovations in cemented waste handling and pre-disposal storage. As an example, digitalization solutions such as “digital twins” are studied, which can improve safety and efficiency in handling and assessing cemented-waste packages in extended interim surface storage [2, 3].

Besides developing new methodologies, existing solutions are improved, which can lead to safer, cheaper or more effective and sustainable alternative processes, bringing benefits to several EU Member States. Better understanding and improving Waste Acceptance Criteria (WAC) are seen as key parameters for optimizing a safe and efficient handling and minimisation of wastes over the whole life cycle, from cradle to grave [1].

The project consists of 7 work packages (WP's), WP1 on Management and Dissemination, WP2 on Strategic implementation, WP3 on Knowledge management, WP4 on Innovations in metallic material treatment and conditioning, WP5 on Innovations in liquid organic waste treatment and conditioning, WP6 on Innovations in solid organic waste treatment and conditioning and WP7 on Innovations in cemented waste handling and pre-disposal storage (<https://predis-h2020.eu/>).

2. END USER AND STAKEHOLDER ENGAGEMENT WITHIN PREDIS

2.1. Objective of End User Group (EUG) and stakeholder engagement within the project

2.1.1. General description of the stakeholder and end user community

As described above, engagement with stakeholders and end users is a key priority in the PREDIS project. Within the Strategic Studies work package (WP2), a separate task aimed at establishing and coordinating a pre-disposal user community, from the start of the project. The user community is split into 2 groups, a first group with specific end users and second group with general stakeholders. The end user group (EUG) consists of radioactive waste generators (nuclear power plant operators, research reactor owners, fuel cycle companies), waste management organisations, and companies operating waste treatment, conditioning and storage sites. Only organisations which are involved in the activities mentioned above can become member of the EUG. The EUG is considered to be the driving force in the project as it is steering the research and innovation, based on the industrial needs and challenges. The second group consists of general stakeholders, and encompasses a very broad community with as main actors: research organisations, universities, supply industry, service providers, regulators, technical support organisations, civil society organisations and international organisations such as IAEA and NEA. The general stakeholder community is open to all interested organisations and persons. They are kept informed on the progress of the project, for instance through distribution of the newsletters and invites to attend webinars and annual events.

2.1.2. Role of the stakeholder and end user community

Active engagement with stakeholders and end users ensures interaction, which sets a clear focus and directs the project to ensure maximum impact, benefit and utilization of the results. As the end users are considered to be the “hands-on” users of the products that the project delivers, they have been directly solicited to provide feedback to the project team, to help ensure that the products are used by the people who need them. They are regarded as the “customers” of the project’s end results. Moreover, since the project relies on co-funding, the end users were also called upon directly to sponsor specific project tasks. About half of the project’s 47 partners had internal co-financing from their own institutes for the R&D work performed in the project, while the other 50% of the co-financing requirement came from sources such as industrial co-financing (15%), national level governmental support (approximately 25%), or other research grants including student activity funding [4].

The interactions that the project has established therefore serve to lead to a better understanding of end user needs, to a direct assessment of the applicability of proposed solutions and to offer a straightforward route for implementation of proposed technologies. An overview of the engagement of the EUG and stakeholder community is shown in TABLE 1. The different aspects of stakeholder and EUG engagement will be discussed in more detail in Chapter 3.

TABLE 1: overview of the engagement of the EUG and stakeholder community

End User Group	Stakeholder community
Drafting the GAP Analysis	Invited to public events to “follow” the project
Setting priorities for knowledge management	Invited to contribute to the SRA
Drafting and reviewing the strategic research agenda (SRA)	The target audience for dissemination activities
Participating to annual workshops and giving feedback on project progress	
Direct involvement in R&D by donating materials or host demonstrations of new technologies developed in the scope of the project.	
Acting as an interface, connecting scientists and industry	

2.2. The process of building the stakeholder and end user community

Building the stakeholder and end user community was one of the first priorities for PREDIS. In the first stage of the stakeholder engagement, an overview was created for 1/ (inter)national organisations (networks, associations, etc. including also communities of practice from ongoing or past projects) and 2/ individual organisations who might have an interest in pre-disposal. A list was compiled based on the network of PREDIS’ partners and their involvement in past projects. For each organisation, some characteristics like actor type (research entity, waste management organisation, waste owner, waste producer, utility, etc.), short descriptions of the organisation, field of interest, country, and contact details were listed based on available public information. In the second stage, organisations were actively encouraged to sign up as a stakeholder through a web link on the PREDIS homepage (<https://predis-h2020.eu/>). Organisations with available contact details were contacted by email to introduce the PREDIS project and were encouraged to sign up as stakeholders. The PREDIS project was presented at different events and conferences (IAEA Radioactive Waste Management Conference 2021 [5], IGD-TP symposium 2022 [6], EURADWASTE 2022 [7], Waste Management conference 2023 [8], SNETP conference 2023 [9], ICEM 2023 [10]), and a QR code which links to the stakeholder registration page was shown. Participants in the PREDIS webinars received a personal invitation to sign up as stakeholder. Potential end users (matching the end-user criteria) were contacted individually as end users needed to fill in the EUG Application form and had to sign the EUG Member Commitment to ensure confidentiality. All end users were approved by the PREDIS’ General Assembly. From the start of the project, the community of registered stakeholders and End Users has been regularly informed on the progress of the project through newsletters, webinars and annual meetings.

2.3. Presentation of the PREDIS stakeholder and end user community

At the start of the project (first stage as described in Chapter 2.2), PREDIS identified a total of 43 (inter)national organisations and 216 individual organisations (covering 5 different continents) as potential stakeholders and end users. As described above, these organisations were actively contacted. This allowed the establishment of a quite extensive EUG and stakeholder community from the start of the project. Other organisations joined later, based on their application after following a public communication from PREDIS (be it in the form of webinars, annual meetings, etc.).

When looking at the current stakeholders group, a total of 119 organisations/companies have registered. They represent 29 countries and 4 continents (FIG. 1). The EUG covers 25 external organisations and 16 consortium partners who are qualified as end user, together representing 17 countries from the EU and USA.

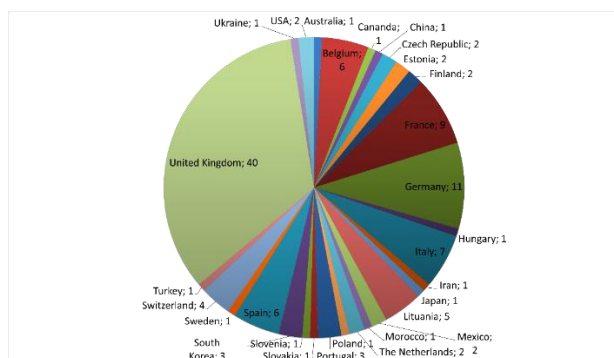


Figure 1: overview per country for the registered stakeholders

3. RELEVANT FIELDS OF STAKEHOLDER AND END-USER ENGAGEMENT IN THE PROJECT

3.1. Gap Analysis

The pre-disposal Gap Analysis was conducted in two separate phases. The first phase was performed during the 6-month preparation phase of the project proposal and aimed to evaluate the needs of industry and stakeholders for research, development and demonstration (RD&D) in predisposal waste management technologies and initially define the scope of the PREDIS project. Thus, end users were steering PREDIS already from the preparation phase of the project as inputs on priority predisposal R&D topics were gathered from industry via IGD-TP and SNETP communities where many end users are represented. The focus was on topics with the highest added value for return on investment of research funding to address a large number of Member State needs. A key aim was the increase of Technology Readiness Level (TRL) for techniques or methods that could be improved and implemented within the 5-10 year timeframe.

The second phase [11] was performed during the first eight months of the project (starting from September 2020) and aimed to further review, refine and prioritise project plans against identified needs and discern additional needs. Information was gathered by a variety of methods, including quantitative and qualitative surveys, live polling, interviews with end-users, webinar presentations, discussion groups and literature reviews. The outcomes of the phase 2 Gap Analysis was used to refine the scope of work for the various technical work packages. Some examples of refinement of the scope are given in the following paragraphs.

Within WP4 it was planned to optimise known chemical/gel decontamination processes with emphasis on the management of the treatment effluents. Based on the feedback from end users, it was decided to complement the planned research, on optimisation of chemical decontamination and management of secondary wastes from chemical decontamination, with life cycle analysis (LCA/LCC) [12] and to pay special attention to waste acceptance criteria (WAC) via interactions with waste management organisations. Within WP7, end users emphasised the need to study the monitoring of internal waste package pressure, which was taken up in the work plan. Further details about the Gap Analysis process and stakeholder engagements through the process can be found in [1] and [11].

3.2. Role of End Users and stakeholders in knowledge management

The PREDIS knowledge management programme [13] is complementary to the technical work packages by putting the pre-disposal topics in context. This is done by:

- Developing and populating the PREDIS roadmap, which is one theme of seven of the generalised EURAD roadmap (describing implementation of any type of radioactive disposal)
- Training and mobility actions
- Student group engagement.

The input and steering of the knowledge management (KM) work package work is made through surveying of the pre-disposal community (including all PREDIS partners), online polls during targeted KM webinars, panel discussions and PREDIS annual meetings (end-user and stakeholder's sessions). A large part

of this work is made in collaboration and agreement with large knowledge providers, such as IAEA and to some extent OECD/NEA, but also with EURAD (European Joint Programming on Radioactive waste management) [13] and national radioactive waste actors [14].

3.3. Drafting the SRA

A prominent example of the impact of stakeholder engagement is the interactive process of writing the Strategic Research Agenda (SRA). The first version of the SRA focused on the consolidation of the existing published SRAs [15], while the following version has been developed taking on board the specific needs of the End User Group [16]. The engagement included a survey/questionnaire to collate the needs and priorities from the stakeholder and end user community and the drivers behind these priorities. The questionnaire was completed by 29 respondents, representing waste management organisations, waste generators or owners, regulators, research entities, technical support organisations and governments. The stakeholder and end user engagement process led to the selection of seven SRA priority topics or themes, which were discussed in more detail at a series of public webinars/focus groups. The SRA guides R&D in the coming years, to ensure maximal benefit for the end users and Member States. As an example, one key theme that emerged from the development of the SRA and engagement with stakeholders and end users was the need for an integrated waste management approach, to enable optimisation of the whole waste lifecycle and to facilitate waste minimisation and the drive to a circular economy. This is consistent with the United Nations sustainable development goals [17] and European strategy [18], which strengthens the importance of this topic for future research.

3.4. Driving the R&D

End users are driving PREDIS already from the preparation phase of the project, as described in chapter 3.1. Their input led to the selection of four specific waste streams to be studied in the project, all having the highest urgency and importance for many Member States. The second phase of the Gap Analysis (see chapter 3.1) was performed early in the project and aimed to further review, refine and prioritise the project plans. Information was gathered by a variety of methods, including strong interactions with stakeholders and end users and provided further insights to the industry and other end-users needs, challenges and priorities. The Gap Analysis confirmed the initial focus of the project and suggested minor re-tailoring or adjustments of the technical scope inside the existing work packages and tasks [11]. Hence, from the preparation phase until the end of the first year of the project, several interactions with stakeholders and end users helped in shaping the project to meet as much as possible the needs of end users.

During the project, interactions with stakeholders and end users were maintained. During each annual meeting, a dedicated session for end users has been held where they were allowed to join the technical meetings of the work packages and discuss on the obtained results. These interactions directed the project to ensure maximum impact and utilization of the results. Some examples of the impact of end users in the R&D work packages are given in the following section.

The management of radioactive liquid organic waste is a subject of major interest for the European nuclear community. WP5 of the PREDIS project focuses in particular on the direct conditioning of such waste in geopolymer or related matrices. It is a large consortium of 18 partners from 8 countries that prepared the work program of the WP to meet the needs of the community. The broad outline is to develop the most robust conditioning matrices, to characterize their properties and durability [19]. Stakeholders and end users are regularly invited to discover and discuss the work progress in order to check its alignment with the needs of the waste producers and the organizations responsible for their management. This interaction between PREDIS partners and the Stakeholders resulted in an initial inventory of the waste of interest in order to select the project reference waste.

WP7 focuses on digital solutions for cemented waste package and facility monitoring, modelling and decision making. The work program was defined mainly by the ideas and the competencies of the research institutions involved. However, right from the start of the project, there was an intensive interaction with stakeholders and end users, some of them being partners in PREDIS (e.g. UJV, SOGIN, ORANO, NNL), others from outside the project. Main products of this interaction have been a Gap Analysis (see chapter 3.1) [11] and a state-of-the-art report (WP specific, using a questionnaire developed in WP7) [2]. Some techniques were discarded in this phase as it now could be foreseen that they wouldn't be sensitive enough to fulfil the demand in monitoring

LLW and ILW packages. Reference packages and mock-ups have been defined and built based on the end user's demands to guide the technical developments and to validate results. They will now be used in the demonstration phase of WP7, where various sensors and other developments will be tested in a realistic environment at nuclear facilities. The design of the mock-ups was continuously updated based on ongoing discussions between developers and stakeholders. Based on the results, exhibits will be developed to explain the outcome of WP7 to stakeholders at the final workshop and other events.”

3.5. End user point of view

So far, stakeholders and end users have been invited to participate in more than 20 public events such as webinars and the public parts of the project's annual meetings. In addition, end users were invited to the technical part of the annual meeting, where they could interact directly within the technical WP teams. This allowed end users to give feedback on the work plans, suggest materials for testing, provide case studies, but also offered the potential to review draft results, reports and other dissemination products. End-users were actively involved in surveys, which allowed them to express their technical challenges, needs, gaps and drivers, etc., As an example, WP7 performed a survey in 2021 on the state of the art and the end user needs in respect to monitoring waste packages and facilities. The results were compiled into a state-of-the-art report [2], which was used to guide the further work in WP7 (see Chapters 3.1 and 3.4).

During each annual meeting, a plenary session with direct involvement of end users was held [20, 21]. In 2022, a panel discussion was held in Finland, involving both of Finland's Nuclear Power Plant operators of TVO and Fortum who are responsible for waste pre-disposal issues, STUK as the national nuclear regulator, The Ministry of Economic Affairs and Employment who is responsible for nuclear energy issues, a representative from academics, and the IAEA. An interactive discussion session was held, to gain the end user feedback on relevant SRA topics such as characterization, waste acceptance criteria, conditioning & packaging and treatment processing. Aspects such as key research issues, importance, potential impact and urgency were discussed. End users were strongly involved in these discussions and provided valuable input to SRA priorities and drivers, which was incorporated in the SRA update of 2023 [16].

In 2023, a panel discussion was held in Belgium, involving Belgian waste generators (Belgoprocess and ENGIE), radioactive waste managers (ONDRAF/NIRAS), supply industry (Magics Technology) and the regulator (FANC). This discussion focused on the needs of end users with respect to future R&D. Belgoprocess formulated industrial needs for non-destructive analysis for radiological and chemical characterisation of waste packages, sampling and segregation techniques for large, highly heterogeneous, super-compacted waste and analytical methods for the determination of around 30 radionuclides in various waste types. The availability of reference materials and proficiency testing would be helpful and could be provided through future R&D programmes. FANC confirmed the need for characterisation techniques for historical, legacy waste, but also stressed the importance to anticipate now future waste streams, thus learning from the current situation. A nice example of best practices for transferring industrial needs into useful R&D was provided by Belgoprocess. Together with Magics Technology, a sensor platform was developed which allows remote monitoring of waste vessels in an interim storage facility. Similar R&D is currently performed in PREDIS WP7, in collaboration with SCK CEN and the Catholic University of Leuven. Magics Technology mentioned the fruitful collaboration with SCK CEN, Belgoprocess and ESV EURIDICE. The collaboration team is currently creating methods and experiments that will be used for the validation of the non-destructive sensor technology and a digital twin developed by SCK CEN. ENGIE stated the need for operators, who decommission/dismantle, to connect with research centres that have experience in decommissioning and waste. This allows experts to properly understand what the challenges are and to make proposals and provide support.

The Belgian nuclear waste processing and interim storage company Belgoprocess is one of the actively involved end users in PREDIS. From their experience, it could be helpful to increase the level of harmonisation and standardisation for WAC and the characterisation procedures, while some WAC are site- and waste type-specific, other waste acceptance criteria are not. Many countries – and sometimes there are already different approaches within one country – use their own methods to determine and interpret the different criteria. For Belgoprocess, the introduction of additional international standards on sampling and characterisation of radioactive waste could be beneficial. The creation of a structure to share analytical methods and validation procedures to determine the physical, chemical and radiological properties of different types of radioactive waste

could save a lot of time and money spent by operators worldwide. The publication of measurement results for specific waste types (e.g. scaling factors) could also be of interest to countries who will need to manage similar waste types. Accreditation of the radiochemical methods for radioactive waste can be challenging due to the absence of reference materials and proficiency tests. The availability of reference “radioactive waste” material and the organisation of proficiency tests (both destructive and non-destructive testing) would give operators the chance to validate and demonstrate the proper functioning of their characterization process to their WMO and regulator.

4. GENERAL CONCLUSION

In this paper, the importance of engagement of PREDIS partners with stakeholders and industrial end users has been discussed. To focus on the needs of stakeholders and end users, interaction with them was foreseen at different levels, on different topics and at different moments in time. Even during the preparation phase of the project, the needs of industry and stakeholders were evaluated for defining the priorities for R&D scope, as well as for demonstration in predisposal waste management technologies and knowledge management activities. During the first months of the project, a Gap Analysis was performed, where information from stakeholders and end users was gathered by a variety of methods, such as quantitative and qualitative surveys, live polling, interviews with end-users, webinar presentations, workshops and PREDIS annual meetings. The outcome of the Gap Analysis led to an update of the work plan of some of the technical work packages. Another example of the impact of stakeholder engagement is the interactive process of writing the strategic research agenda (SRA). The baseline SRA focused on the consolidation of the existing published SRAs, while the revised 2nd edition SRA document has been developed based on the needs of PREDIS and the End User Group. The SRA will guide R&D in the coming years, to ensure maximal benefit for end users. Throughout the project, also technical interactions with stakeholders and end users were maintained. During each annual meeting, a dedicated session for end users interaction was held where they are allowed to join the technical meetings of the work packages and discuss the obtained results. These interactions govern the project to ensure maximum impact and utilization of the results. A nice example of best practices for transferring industrial needs into useful R&D was provided by the Belgian end user Belgoprocess. Together with Magics Technology, a PREDIS partner, a sensor platform was developed which allows remote monitoring of waste vessels in an interim storage facility. Interaction with end users and stakeholders leads to innovation and to the development of applications aligned with industrial needs. The interaction with stakeholders and end users will continue throughout the last year of the project and even beyond and will guide the project to ensure maximum impact and utilization of the results, which will improve safety of radioactive waste management and enable sustainability.

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