

EURAD-2 Focus Funnel (17 March 2023)

Overview

Theme 1 Programme management Session overview - Christophe Bruggeman (moderator, SCK.CEN), Nadja Zeleznik (rapporteur, EIMV)

The Theme 1 session on Programme management included six work package (WP) topics, of which three WPs were pitched by more than one College (WP1.1 by WMO and TSO, and WP 1.5 and 1.6 by all three Colleges) and three WPs were pitched by one College each. Overall, there were four pitches by WMOs, four pitches by REs and three pitches by TSO institutes. The session was attended by approximately 30 to 40 (for one WP) different persons (including experts from a diversity of programme sizes and maturity, with LIMS and SIMS countries). The proposals built upon work done in recent and past projects such as EURAD-ROUTES, EURAD-UMAN, EURAD-SFC, PREDIS, HARPERS, but also included completely new topics on sustainability and recycling and rapidly emerging issues such as SMR waste management. Each presentation was followed by constructive discussions involving representatives from different Colleges and programme sizes.

The following WPs topics were pitched, and main outcomes described:

- 1.1 Alternative RWM Strategies - ASTRA (StSt): Analysis of readiness, feasibility and challenges of alternative RWM solutions needed by many countries, in particular SIMS, to safely store and dispose their waste and to address the waste types without proper solution and identification of R&D needs. The discussion highlighted the need for shared facilities (focus on predisposal) and sharing of experiences between countries having small inventories of specific waste streams.
- 1.2 Deep Borehole Disposal / Sealing - Increasing the TRL – DEEPBORE (R&D): Understanding safety and demonstrating technologies for deep borehole disposal (DBD) (> 1 km), primarily for waste disposal, but also for site investigation (sealing issues). The discussion highlighted a broad support to start with a strategic study, culminating into a position paper supported by the whole EURAD community on DBD. The topic could be integrated with WP1.1.
- 1.3 Sustainability aspects in radioactive waste management: Strategies for environmental, economical und social challenges (StSt): Development of an understanding of sustainability in relation to nuclear waste management, to identify specific challenges on environmental, economic and social dimensions for the realisation and operation of a radioactive waste repository.
- 1.4 Recycling of Radioactive Matters (StSt): Systematic analysis of inventory data of radioactive matter for potential recycling, to identify the radioactive matters that could potentially be recycled, collect all the technological innovations for recycling, identify the potential applications, and propose them for validation via experimental work. There were clear synergies between WPs 1.3 and WP1.4, but many participants also recommended to exclude spent fuel and focus on other materials instead.
- 1.5 Waste Management for Small Modular Reactors (SMRs) (StSt): Provide outcome guidance for stakeholders to make informed decisions on SMR deployment and supplier options, with respect to nuclear waste management. Broad consensus to not only include light-water based concepts, but also advanced reactor types, albeit with a different level of detail and/or priority (given their longer time frame for implementation).
- 1.6 Advanced and innovative spent fuel characterization (R&D): Optimization, safety and risk assessment of spent fuel management up until final disposal by characterizing their thermo-mechanical-chemical behaviour following state-of-the-art techniques (e.g., Machine Learning, AI).

Focus is on new upcoming designs e.g., ATF, SMR's, but also older designs that are poorly characterized (VVER), General broad support for this topic.

The outcome conclusion by the audience was that some pitched WPs have synergies and overlapping. Therefore the merging of four topics have been suggested: 1.1 and 1.2 in a new strategic study, and 1.3 and 1.4 in a new strategic study. It was also seen that there are two SF proposals (one in Theme 1 and other in Theme 3). There was no decision on merging, but it is expected that the community will likely need to decide on a prioritization of the proposals (1.6 and 3.1).

Theme 2 Pre-disposal Session overview - Erika Holt (moderator, VTT), Kahina Hamadache (rapporteur, CEA)

The Theme 2 session on Pre-disposal issues included six work package (WP) topics, of which three WPs were pitched by two Colleges each and three additional WPs were pitched by one College each. Overall, there were two pitches by WMOs, four pitches by REs and three pitches by TSO institutes. The session was attended by approximately 45 different persons and the maximum number of persons in the room was about 35 people (including experts from diversity of programme sizes and maturity, including countries of Belgium, Czech Republic, Denmark, Finland, France, Germany, Greece, Italy, Poland, Romania, Spain, The Netherlands, United Kingdom and others). Each presentation had complimentary views by the other Colleges and a good atmosphere of discussion on collaboration and added-value. The proposals built upon work done in recent and past projects such as EURAD-ROUTES, PREDIS, THERAMIN, CARBOWASTE, CAST, GRAPA, INSIDER, CHANCE, MICADO, etc.. The main impression was that the six topics were of need and had support, also potentially from the waste generators who have been end users in PREDIS project. The outcome conclusion by the audience was that the pitched WPs had high synergy and overlap, which would benefit from re-alignment going forward. The topical groupings as outcomes included:

- 1) waste characterisation issues: focused on non-destructive and destructive assessments of fresh waste coming from decommissioning, prior to packaging/storage, and beyond what has been done for in-situ drum characterisation in other projects. High impact expected for improved efficiency (time and costs) and supporting the waste hierarchy for reduction of waste to repositories. *(resulting from pitches WP2.2 and WP2.5)*
- 2) waste treatment/conditioning/immobilization issues: focused on initial state new material matrices that are more environmentally-friendly and sustainable, such as geopolymers and other binders replacing traditional cements. Comparison to traditional binder matrices will still be needed as reference benchmarking of the conditioning effectiveness, as well as upscaling demonstration, TRL advancement beyond current levels, and assessing impact to waste acceptance criteria (WAC). May also include issues of thermal treatment if sufficient interest. *(resulting from pitches WP2.1, WP2.3, WP2.4 and some issues of 2.6)*
- 3) waste matrices long-term safety issues: focused on durability of treated waste matrices (resulting from above item #2), with respect to issues such as radionuclide retention, leachate, ageing, compatibility in repository conditions, impact to safety assessment and licensing/stakeholder acceptance. Focus on modelling but needing data from accelerated experimental testing to gain necessary THMC parameters. *(resulting from pitches WP2.3 and some issues of 2.6)*
- 4) handling of graphite: focused on treatment/conditioning, WAC and preparation for disposability. *(resulting from pitches WP2.1, WP2.2 and some issues of 2.6)*

It was acknowledged that some of the WPs in the Theme 2 session have high overlap with proposals from other sessions (specifically WPs 1.3 and 5.1), which can be considered for integration together by the Colleges during the refinement process. The community of practice associated with SIMS supported

the topics and the relevant WP2.6 pitched (addressing robust WAC for challenging waste streams) was taken for integration as tasks to the other newly proposed structure.

Theme 3 EBS Session overview - Lara Duro (moderator, Amphos21), Ursula Alonso (rapporteur, Ciemat)

The Theme 3 session on EBS issues included ten work package (WP) topics, of which three WPs were pitched by two Colleges each and seven additional WPs were pitched by one College each. Overall, there were three pitches by WMOs, six pitches by REs and four pitches by TSO institutes. The session was attended by approximately 60 different persons and the maximum number of persons in the room was about 40 people (including experts from diversity of programme sizes and maturity, including countries of Sweden, Belgium, Czech Republic, Denmark, Finland, France, Germany, Greece, Italy, Poland, Romania, Spain, the Netherlands, United Kingdom and others). Each presentation had complimentary views by the other Colleges and a good atmosphere of discussion on collaboration and added-value. The proposals built upon work done in recent and past projects within EURAD and also previous projects. The support to the ten topics was diverse and comments from the audience helped the suggestions for improvement and realignment of the different subjects.

The topics presented and main discussions were:

1) WP 3.1. Behaviour of **Spent Nuclear Fuel (SNF)** under disposal conditions

The subject was pitched by two different colleges: WMOs and REs. The proposal also received the support from the third college (TSOs). The main messages were the need of decreasing uncertainty in SA through the study of radionuclide releases, the convenience of taking advantage of running long-term experiments and existing infrastructures of SNF studies and to grant that knowledge is kept and new knowledge generated through new techniques and procedures not existing during the previous projects. The WP was developed by a very knowledgeable community across most member states and organizations.

2) WP3.2 Dissolution of **waste forms** under near-field conditions

This WP was pitched by the RE College. The pitch was the result of merging initial idea on vitrified waste studies with that of other type of wastes (geopolymer, cement, bitumen...). There was limited interest and much dispersion, focus was advised to further prioritize focusing ideas over inclusivity of many waste types. It was recognised that since the end of NF-PRO (FP6) no joint research on glass had been pursued. A way to focus and obtain value for this idea is to develop a strategic study focused on glass to analyse newly generated data and put it in context with previous data.

3) WP3.3. Behaviour of **bituminous** radioactive waste under thermal, radiological and leaching conditions.

This WP was pitched by the TSO college. There was a limited interest from the audience, mainly attributed to the fact that most countries do not have to deal with bituminous waste.

4) WP3.4. **Containers corrosion**

There were two pitches on this subject: one from the TSO College named SURFACE and one from the WMO College Development of innovative solutions for HLW container in geological disposal facilities.

WP focused on new materials and corrosion of containers under realistic conditions. Focus on different degradation processes that manufacturing methods and different materials can suffer. High interest from all the Colleges, especially in the WMO pitch, and no conflict with previous WPs and studies were identified.

There were three WPs on **buffer and backfill characterization** and **THMC modelling**, as follows:

5) WP3.5. Optimised buffer and backfill characterization.

This was pitched by the RE College

6) WP3.6. Characterization and THMC modelling of new composites and forms of buffer/backfill material.

This WP was pitched by the RE College.

7) WP3.9. Performance of Engineering barriers. Long-term evaluation

This WP was pitched by the TSO College.

Important commonalities were identified among the former 3 pitches and discussions on merging and integration of several of the tasks proposed were held. The discussions interested to a large community of the audience, from the three colleges, especially in those subjects of interest for THMC development in bentonites, that may make use of tailored experiments at different scales.

8) WP3.7. Effect of **microbial** and chemical factors in the long-term evolution of DGR material interfaces

There was no consensus on the interest of microbial effects by the general audience of the different colleges. One possibility would be to include the study of some microbial effects on a larger EBS WP.

9) WP3.8. **High T** concept of DGR over 100C.

As in the previous case, limited interest from the audience on T over 100C was gathered unless data is used for THMC model testing.

10) WP3.10. **Closure**

2 different pitches were given on closure. A large WP incorporating Civil Society, pitched by TSO College and a Strategic Study focused on how to optimize backfill for closure pitched by WMO College. It was not clear from the audience if there is an interest and the way forward of incorporating civil society in closure. A strategic study can focus the subject on the optimization and include some part of the best way to incorporate civil society for a future deeper investigation.

Theme 4 Geosciences Session overview - Astrid Göbel (moderator, BGE), Milena Schönhofen-Romer (rapporteur, BGE)

The Theme 4 session on Geosciences included three work package (WP) topics, of which two WPs were pitched by two Colleges each and one WP was pitched by the three Colleges. Overall, there were two pitches by WMOs, three pitches by REs and two pitches by TSOs institutes. The session was attended by about 20-30 different persons (including experts from a diversity of programme sizes and maturity, with LIMS and SIMS countries). Institutes from all the three Colleges (WMO, RE, TSO) were sufficiently represented at all pitches, so feedback from all was possible or guaranteed. The proposals built upon work done in recent and past projects such as BIOCLIM, BIOMOSA, CORI, FUTURE, CATCLAY, CEBAMA, BEACON, EURAD-MODATS, etc.

The discussions were very lively, goal-oriented and constructive in a positive and friendly atmosphere. The feedback of the participants on the chosen pitching format was overall positive. Keeping the strict schedule

was well accepted and the chance to switch between the parallel sessions was used by a considerable number of participants.

The main impression of the session on Geosciences was that the three topics received broad and good support. Aspects of potential synergies, foci and overlaps were discussed for the next phase of thematic grouping of WPs.

The following WPs topics were pitched, and main outcomes described:

- 4.1 Impact of Climate Change (StSt): Improve a common understanding of the impact of climate change (both temporally and spatially) for all types of facilities during construction, operation and post-closure (predisposal and disposal). A generic approach to define climate evolution scenarios and evaluation and development of methods and tools are sought. Within the discussion the idea of a joint vision and better predictability were highlighted. Using existing codes for modelling and including researchers with expertise in the field of climate research was suggested. Potential for future R&D to develop further tools and models was raised. The topic is also of high interest for CSOs.
- 4.2 Radionuclide mobility / migration (R&D or StSt): In recognition of extensive investigations in the last decades focussed on residual key issues important to long-term safety and develop a joint methodology (e.g. for selection of values). Potential for a study and experimental work to investigate processes under different perturbed conditions. Needs to more focus the proposal by considering the priorities of the WMOs and potential of the proposed substantiated Sorption/Transport Parameters (RTP) database were discussed. For this a link to the KM programme was suggested.
- 4.3 THMCG challenges (R&D): Improve the capability to represent the complex THMCG behaviour of clay-based host rocks and bentonite and improve the understanding of dispersion and coupling across THMC properties in host rock formations. The work shall focus on a system scale. The topic found much support in the discussion. Overlap and potential to merge it with a Theme 3 WP were identified.

Theme 5 Optimisation Session overview - Ingo Blechschmidt (moderator, Nagra), Alexandros Papafotiou (rapporteur, Nagra)

The Theme 5 session on Optimisation included seven work package (WP) topics, of which three WPs were pitched by two Colleges each and four additional WPs were pitched by one College each. Overall, there were five pitches by WMOs, three pitches by REs and two pitches by TSOs institutes. The session was attended by approximately 45 to 50 different persons and the maximum number of persons in the room was about 40 people (including experts from diversity of programme sizes and maturity, including countries such as Belgium, Czech Republic, Denmark, Finland, France, Germany, Greece, Romania, Spain, Sweden, Switzerland, United Kingdom and others). The 3 Colleges (WMO, RE, TSO) were sufficiently represented at all pitches, so feedback from all was possible or guaranteed.

There was generally a very good atmosphere throughout the session. All comments and questions about the presentations were factual and constructive. The feedback of the participants on the chosen pitching format was very positive, which is also supported by the very lively participation of the participants in the discussions. Only the fact that the pitching sessions for the various WPs were held in parallel was considered disadvantageous, as this made it difficult or impossible to participate in other pitching sessions too.

Many of the participants have already participated in previous EURAD projects, which was also helpful in the evaluation or classification of the presented WP proposals. It was noticeable that some of the WP proposals

presented covered a relatively wide range of topics and that there were synergies and overlaps (e.g., cement issues, Digital Twin) with other WP proposals. Duplications between the WPs or strong relationships to recent and past projects were also identified in some cases (e.g., monitoring, data management and concrete issues).

The main impression of the Session on Optimisation was that the seven themes received relatively broad and good support and the identified synergies and overlaps, will assist in the next phase of thematic grouping of WPs. A first proposal for the next phase of topical grouping is shown below:

- 1) Repository Optimisation:** *(resulting mainly from pitches WP 5.1, WP 5.2 and WP 5.7)*
 - a. Groups specific issues related to repository construction and on cement related topics of sub-surface and surface repositories
 - b. R&D WP, but consideration was also given to combining repository optimization WPs into a separate strategic study first due to the need to identify and investigate available methods and technologies and to involve new parties outside of EURAD 1; the results obtained could then form the basis R&D WPs of the second EURAD 2 wave
- 2) Digital Twins issues** *(resulting mainly from pitches WP 5.3 and some issues of 5.2, 5.4 and 5.5)*
 - a. Focuses on integration platforms with engineering models (not PA digital Twins)
 - b. Strategic study: while scope needs definition with new parties outside of EURAD 1
- 3) High fidelity numerical simulations** *(resulting mainly from pitches WP 5.4 and some issues of 5.3)*
 - a. Integration of PA digital Twins
 - b. R&D WP

It was acknowledged that some of the WPs in the Theme 5 session have clear overlap with proposals from other session (specifically Themes 2, 3 and 7), which can be considered for integration together by the Colleges during the refinement process.

Theme 7 Safety Case Session overview - Astrid Göbel (moderator, BGE), Milena Schönhofen-Romer (rapporteur, BGE)

The Theme 7 session on Safety Case included three work package (WP) topics, of which two WPs were pitched by one College each and one WP was pitched by two Colleges. Overall, there were two pitches by WMOs, two pitches by REs and no pitch by TSOs institutes. The session was attended by about 20-30 different persons (including experts from a diversity of programme sizes and maturity, with LIMS and SIMS countries). Institutes from all the three Colleges (WMO, RE, TSO) were sufficiently represented at all pitches, so feedback from all was possible or guaranteed. The proposals built upon work done in recent and past projects such as EURAD-SFC, CORI, FUTURE, CEBAMA, ReCoSy, MICADO, etc.

The discussions were lively, goal-oriented and constructive in a good atmosphere. The feedback of the participants on the chosen pitching format was overall positive. One critical comment was made by a TSO that the colleges that had not submitted a proposal were not requested to prepare also a pitch on this topic in advance. Keeping the strict schedule was well accepted and the chance to switch between the parallel sessions was used by a considerable number of participants.

The main impression of the Session on Safety Case was that the three topics received broad and good support. Aspects of potential foci and common interests were discussed for the next phase of thematic grouping of WPs.

The following WPs topics were pitched, and main outcomes described:

- 7.1 Criticality Safety (R&D): Attain an improved shared understanding regarding the methodological validation and possible experimental verification of key aspects in the criticality safety

argumentation for final disposal as well as consolidating its technical basis. Within the discussion the topic was broadly supported by organisations from all three colleges. A development of a common European method was highly welcomed including competence building. The proposal was considered as valuable beyond existing projects.

- 7.2 Thermodynamic (R&D): Improvement and consolidation of the knowledge to predict processes over long timescales in key fields for geological disposal of radioactive waste. Beyond the need to close existing data gaps and maintaining the know-how in the area of thermodynamics, this WP supports present and future capabilities to perform reliable use of thermodynamic model calculations. The topic was much supported by organisations from RE and TSO colleges. Organisations from WMO college were more critical about the needs but potential to cut out specific aspects were identified.
- 4.3 Natural Analogues (R&D): Support performance assessment and safety analyses and build confidence in the safety case through using anthropogenic and natural analogues (ANAs) to upscale and verify laboratory-based and URL-derived data (in space and time) and to test future scenarios of long-term evolution. The proposal received positive feedback and support but a focussed selection of the presented promising analogues was recommended.

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