EURAD-2 2nd wave Template #2

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<table>
<tr><td>Short Acronym and full Title</td><td colspan="3">R&DWP2
MOGARE (MOdelling of GAs behaviour and migration at the REpository scale storage/disposal)</td></tr>
<tr><td>Type of activity</td><td>☒R&D</td><td colspan="2">☐Strategic Study</td></tr>
<tr><td>Budget estimation (total budget in M€, i.e ~ 1.5 M€)</td><td>Total eligible budget of 3 M€, among which 1.5 M€ EC contribution</td><td>Duration of the WP
(in months)</td><td>36</td></tr>
<tr><td>Links with EURAD SRA / Roadmap Themes
(if multiple choices, indicate the primary link in bold – maximum 3)</td><td colspan="3">☐Programme Management (Theme 1)
☐Pre-disposal (Theme 2)
☒Engineered Barrier Systems (Theme 3)
☐Geoscience (Theme 4)
☒Disposal facility design and optimisation (Theme 5)
☐Siting and Licensing (Theme 6)
☒Safety Case (Theme 7)</td></tr>
<tr><td>Links with EURAD SRA topics
(if multiple choices, indicate the primary link in bold – maximum 3)</td><td colspan="3">3.4.1 EBS System
5.1 Design
7.3.1 Performance assessment and process models</td></tr>
<tr><td rowspan="2">SRA drivers (maximum 3)</td><td>☒Implementation Safety</td><td>☐Tailored Solutions</td><td>☒Scientific Insight</td></tr>
<tr><td>☐Innovation for Optimisation</td><td>☐Societal Engagement</td><td>☒Knowledge Management</td></tr>
<tr><td>Objective (What) – 1 sentence</td><td colspan="3">The main objective of this WP is to provide new advances (compared to the one provided in EURAD-GAS) for better consideration of gases in the long-term safety and in the optimization of the EBS, which could be used by WMOs to optimize repository concepts and could increase the confidence of the various stakeholders (TSO and public) regarding gas considerations.</td></tr>
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Justification: impact / innovation / added-value (Why) – bullet points or short paragraph **(maximum quarter of a page)**	Predicting the fate of gases is a crucial element in assessing the long-term safety of a repository. The main challenges are quantifying gas pressure, estimating changes in saturation levels and the possible release of radioactive gases. To do this, it is essential to simulate transport at the repository scale. Gas fate modelling at this scale requires specific strategies to consider the complete architecture of the repository including the properties of the different materials and all relevant gases. It must also consider computational aspects such as specific mesh, numerical methods, upscaling approach, etc. In the recent past, two European projects were devoted to the issue of gases in deep underground radioactive waste repositories: FORGE (2009-2013) and EURAD-GAS (2019-2024). However, in these projects, the tasks dedicated to performance assessment at the repository scale were designed to arrive downstream of the experimental results produced by the other tasks. These projects therefore did not allow the development of independent and self-supporting performance evaluation programs at the scale of a complete repository. This WP will be specifically designed around gas modelling at the repository scale in a clay host rock, based on the extensive data acquired in previous projects. Strategies and approaches for the representation of small-scale processes at the repository scale will be evaluated, assessing the latest developments (surrogate models, digital twins). General numerical approaches to optimize the mesh size will also be addressed. The aim will be to consolidate the choices and models used to represent gas transport at this scale, which can improve post-closure safety and optimise EBS. Training activities will be included to improve the ability of all partners to model gas migration at the repository scale. Benchmarking is essential to gain confidence in the numerical results relating to the long-term evolution of the repository.
List of planned tasks / subtasks with % of effort per task (5% increments) **(Maximum 10 bullets)**	To achieve the objective two tasks will be defined: • Task 1 (≈10% in terms of person/month): Coordination task including: - A sub-task dedicated to the definition of a generic repository on which task 2 teams will work - reflections on how to manage gas migration and maximum pressures at a repository scale with the aim of facilitating sharing of strategies between different WMOs. The outcomes of these reflections will be implemented in Tasks 2 and in the final SOTA document. • Task 2 (≈10% in terms of person/month): Knowledge Management: - Production of a SOTA document at the beginning and end of the WP, the latter integrating the progress made focusing the synthesis on the elements that can be evaluated for long-term safety and optimization of the repository EBS - Training material development: among which, joint modelling workshop (hackathon), where participants work together to solve specific programming tasks. This would build up on the experience obtained with such activity in the WP HERMES of the current EURAD2 phase. • Task 3 (≈90% in terms of person/month): Numerical modelling task of the gas behaviour in, and performance of a deep repository, focusing benchmarking/sensitivities on the discrimination of the dominant processes with respect to gas pressure (gas entry pressure, dissolution, diffusion of dissolved gases in unsaturated conditions,

	etc.) and migration of radionuclides (gaseous or dissolved, including C-14) and the efforts required for a good numerical representation (mesh refinement versus homogenization and computation time, surrogate models…).
List of expected outcomes linked to the identified SRA drivers **(Maximum 6 bullets)**	Implementation Safety: - Better understanding on gas processes and characteristic time used to define gas linked scenarios at repository scale in clay host rocks - Increase the confidence in gas linked scenarios in clay host rocks Scientific Insight: - Increase the knowledge on main processes driving the gas buildup in deep underground repositories in clay host rocks Knowledge Management: - Training activities - Determination of elements for a shared strategy on how to manage gas for a deep underground repository in clay host rock at WMO level
Deliverables **(Maximum 6 – including the prescribed deliverables)**	Initial SOTA - Description for each WMO of the way they treat, or intend to treat, gas in their performance assessment and safety analysis Milestone on month 9 for task 1: - Definition of the generic model on which the teams involved in task 2 will work - Definition of the reference case and first sensitivity analysis Milestone of month 18 for task 1 - Description of the first version of some elements for a strategy on how to manage gas at repository scale for a deep underground repository in clay host rock Milestone of month 18 for task 2 - Description of the model developed and main partial results by each involved team Final milestone at month 36 for task 2 - Synthesis of the main results achieved for each involved team End of WP SOTA - Synthesis of achievement during the WP, in delta mode compared to initial SOTA Outcomes to Member States and End-Users - Global strategy on how to manage gas at repository scale for a deep underground repository in a clay host rock
Critical input requirements & identified risks	There are two main risks: - One linked to the relatively short time of the WP (36 month) implying only a bit more than two years of real working time for teams involved in task 2 (9 month at beginning of WP to define the generic model, 3 months at the end for synthesis). - The second linked to the number of teams able (or willing) to simulate two-phase flow at repository scale; for a useful benchmark at least 4-5 teams should be involved. This risk seems quite limited as around 10 teams are willing to work on task 2.
(Optional - Explain what is out of the scope?)	The WP does not address gas source terms, which will be considered as an input data for the models, nor an explicit coupling with mechanics. Due to the WP's duration of 3 years, the number of possible sensitivities will necessarily be limited and only the main processes, defined at the start of the WP by the coordination task, will be addressed.

List of preliminary interested organisations as partners in the WP contributing effort; **% of effort (person months, by College)**	**Task 1 "coordination, strategy, synthesis" (16-18 person/month)** - WMOs (9 person/month): Andra: 3 person/month BGE: 2 person/month NAGRA: 1 person/month ONDRAF/NIRAS: 2 person/month POSIVA: 1 person/month - TSOs (4-6 person/month): ASNR: 2-3 person/month (provisionally) EIMV: 2-3 person/month (provisionally) - REs (3 person/month): PSI: 3 person/month **Task 2 "knowledge management" (16-18 person/month)** - WMOs (9 person/month): Andra: 3 person/month BGE: 2 person/month NAGRA: 1 person/month ONDRAF/NIRAS: 2 person/month POSIVA: 1 person/month - TSOs (4-6 person/month): ASNR: 2-3 person/month (provisionally) EIMV: 2-3 person/month (provisionally) - REs (3 person/month): PSI: 3 person/month **Task 3 "Numerical modeling" (171 person/month)** - WMOs (5 person/month): Andra: 5 person/month BGE: 10 person/month - TSOs (32 person/month): ASNR: 32 person/month - REs (134 person/month): BGR: 16 person/month EDF: 18 person/month PSI: 15 person/month UNI Luxembourg : 6 person/month (provisionally) UFZ: 18 person/month UPC/CINME: 55 person/month WSP Hungary: 6 person/month (provisionally) **WMOs interested by the results as End-Users:** - ARAO - ENRESA - NWS - PURAM

	- SKB
If applicable - links with previous projects / work packages	FORGE (Fate of repository gases) – EC project 2009-2012 EURAD WP GAS (mechanistic understanding of gas transport in clay materials) –2018-2023
WP Preparation Team (1 member per College) contact (**organisation + person**, email)	WMO: Andra, Jacques Wendling, jacques.wendling@andra.fr TSO: ASNR, Zakaria Saadi, zakaria.saadi@asnr.fr RE: PSI, Luca Urpi, luca.urpi@psi.ch