Supplement of

Pluralistic view of human-related uncertainties and their management – outcome of the European Joint Programme on Radioactive Waste Management (EURAD) strategic study UMAN (Uncertainty Management multi-Actor Network)

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PLURALISTIC VIEW OF HUMAN-RELATED UNCERTAINTIES AND THEIR MANAGEMENT – OUTCOME OF THE EURAD STRATEGIC STUDY UMAN


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UMAN: UNCERTAINTY MANAGEMENT MULTI–ACTOR NETWORK

• Develop common understanding on uncertainty management and how it relates to risk & safety among WMOs, TSOs, REs and Civil Society
  • If a common understanding is beyond reach → achieve mutual understanding on why the views are different

• Share knowledge/know–how and discuss common methodological/strategical challenging issues

• Identify contribution of past & ongoing R&D projects to the overall management of uncertainties

• Identify future joint activities and initiatives
METHODOLOGY

UNCERTAINTY IDENTIFICATION:
- UMAN Expert Groups
  - (Preliminary) lists of uncertainties

ANALYSIS:
- UMAN questionnaires
  - Overall picture of actors & their roles, types of uncertainties, generic management strategies
  - Significance for safety, characterisation, evolution

PREFERENCES:
- UMAN workshops
  - Preferred management strategies & options
  - Future programme activities
  - Actors: WMOs, TSOs, REs
  - Input: possible management strategies & options

PLURALISTIC DISCUSSION:
- UMAN seminars
  - CS views and opinions
  - Actors: WMOs, TSOs, REs, CS, Regulators, other uncertainty-specific invited actors

14 September 2023
SafeND 2023
**IDENTIFIED UNCERTAINTIES ON HUMAN ASPECTS POTENTIALLY RELEVANT FOR SAFETY**

- Process for the identification of a workable set of repository requirements
- Continuity of the waste management policy along political changes
- Robustness of the presently considered safety requirements with regard to the long term
- Public acceptance of the repository at potentially suitable or projected locations
- Schedule to be considered for implementing the different phases of the disposal programme
- Robustness of the safety case vis-à-vis sociotechnical factors
- Reliability of monitoring results and safety analysis
- Adequacy of safety-related activities (in siting, design, construction, operation and closure) for the implementation of safety provisions
- Robustness of safety performance vis-à-vis possible cyber-attacks or programming errors
- Availability of well-educated human resources and relevant experts in RWM along the repository lifetime until closure
ASSESSMENT OF UNCERTAINTIES SIGNIFICANCE FOR SAFETY

Uncertainties on:

A. Processes for identification of a workable set of repository requirements
B. Continuity of waste management policy along political changes
C. Robustness of presently considered safety requirements with regard to the long term
D. Public acceptance of the repository at potentially suitable or projected locations
E. Schedule to be considered for implementing the different phases of the disposal programme
F. Robustness of the safety case vis-à-vis sociotechnical factors
G. Reliability of monitoring results and safety analysis
H. Adequacy of safety-related activities for safety provisions implementation
I. Robustness of safety performance vis-à-vis possible cyber-attacks or programming errors
J. Availability of well-educated human resources and relevant experts along the repository lifetime until closure
ASSESSMENT OF UNCERTAINTIES SIGNIFICANCE FOR SAFETY

Uncertainties on:

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E. Schedule to be considered for implementing the different phases of the disposal programme
F. Robustness of the safety case vis-à-vis sociotechnical factors
G. Reliability of monitoring results and safety analysis “New” knowledge
H. Adequacy of safety-related activities during construction for safety provisions implementation
I. Robustness of safety performance vis-à-vis possible cyber-attacks or programming errors
J. Availability of well-educated human resources and relevant experts along the repository lifetime until closure
## UNCERTAINTIES CLASSIFICATION

<table>
<thead>
<tr>
<th>Programme uncertainties</th>
<th>Topical uncertainties</th>
<th>Known Unknowns</th>
<th>Unknown/Ignored Knowns</th>
<th>Unknown Unknowns</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Schedule</td>
<td>e.g. duration of licensing process</td>
<td>e.g. ignored lack of financial resources</td>
<td>e.g. unconceived political instabilities</td>
</tr>
<tr>
<td></td>
<td>Public acceptance</td>
<td>e.g. conditions set by a community for accepting the project on ist territory</td>
<td></td>
<td>e.g. unconceived negative decision of a community</td>
</tr>
<tr>
<td>Uncertainties associated with initial characteristics &amp; its environment</td>
<td>Implementation of safety provisions in construction → characteristics of built components</td>
<td>e.g. uncertainties in as-built repository components (due to construction errors)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Uncertainties in the evolution of the disposal system &amp; its environment</td>
<td>„New“ knowledge</td>
<td></td>
<td>e.g. ignored possible magnitudes of disturbing events (e.g. Fukushima)</td>
<td></td>
</tr>
<tr>
<td>Uncertainties associated with data, tools &amp; methods used in the safety case</td>
<td>Implementation of safety provisions in construction → tools &amp; methods</td>
<td></td>
<td>e.g. ignored mistakes in methods for implementing safety-related activities (e.g. 2nd WIPP incient)</td>
<td></td>
</tr>
</tbody>
</table>
ELEMENTS OF AN UNCERTAINTY MANAGEMENT STRATEGY

Prevailing circumstances

- State of Knowledge
- Waste inventory
- Available resources
- National Policies
- Regulatory framework
- Stakeholder conditions

Programmatic activities

- Uncertainty identification, characterization & analysis of safety relevance
- Uncertainty representation & evaluation in the Safety Assessment
- Identification of uncertainties that need to be reduced, mitigated or avoided

Specific actions to reduce, mitigate or avoid uncertainties

- R&D
- Data acquisition
- Siting
- Design & construction
- Definition of limits, controls & conditions
- Interactions with stakeholders

Return on experience
„NEW“ KNOWLEDGE: CONTEXT AND ASPECTS OF SAFETY RELEVANCE

**WMOs**
- New technologies/developments → well-proven vs new technologies
- Consolidates the existing knowledge and contributes to reduction of uncertainties
- Possible adaptations, modifications and optimisations (e.g. safety case/SA, facility design, regulatory framework)
- Basis for reversibility of decision-making process
- BUT: when to stop?

**TSOs**
- Unknown/ignored knowns vs unknown unknowns
- Appropriate uncertainty management strategy required → at the end of the decision-making process, no remaining uncertainty can potentially jeopardize disposal safety

**REs**
- New scientific findings
- Continuously generated → its management & systematic incorporation into safety case/SA necessary
- Knowledge relevant vs irrelevant to disposal safety
NEW KNOWLEDGE: EVOLUTION OVER PROGRAMME PHASES

Phase 0: Policy, Framework and Programme Establishment
Phase 1: Site Evaluation and Selection
Phase 2: Site Characterisation
Phase 3: Repository Facility Construction
Phase 4: Repository Facility Operation and Closure
Phase 5: Post Closure

WMOs: ! reversibility, waste retrievability, waste recoverability!

TSOs: unknown/ignored knowns (for “unknown unknowns” difficult to be assessed)

RES: safety significance cannot be known a priori

All actors: uncertainty reduction
<table>
<thead>
<tr>
<th>Elements of uncertainty management</th>
<th>WMOs</th>
<th>TSOs</th>
<th>REs</th>
</tr>
</thead>
<tbody>
<tr>
<td>Overall strategy</td>
<td>• Disposal should be promoted as new technologies/challenges</td>
<td>• Stepwise, flexible decision-making process</td>
<td>• Knowledge management</td>
</tr>
<tr>
<td>Representation in SA</td>
<td>• What–if scenarios • Robustness • Good analysis principle</td>
<td>• What–if scenarios • Systematic FEPs management</td>
<td>• Safety margins</td>
</tr>
<tr>
<td>Specific actions to reduce/mitigate/avoid</td>
<td>• R&amp;D programme (including trans–disciplinary research) • Robust disposal system • Periodic safety reviews • Experience feedback programme • Investigation of new components/materials • Strong regulator</td>
<td>• R&amp;D programme (including trans–disciplinary research) • Robust disposal system • Periodic safety reviews • Experience feedback programme • Defence in depth principle • Reversibility</td>
<td>• R&amp;D programme (including trans–disciplinary research) • Exchange with advanced programmes</td>
</tr>
</tbody>
</table>
"NEW" KNOWLEDGE: RESULTS OF UMAN SEMINAR

Pluralistic view:
• "New" knowledge is inherent to a safety analysis of a long-term process
• It is important to ensure resources for production of "new" knowledge and to develop a structure (linked to Rolling Stewardship) for generation of "new" knowledge and assessment of its relevance for DGR
• Transparency of monitoring results necessary
• Emergence of "new" knowledge may also cause a major trust issue regarding the whole assessment process.
• Consequences depend on the stage of the programme. If "new" knowledge emerges early in the programme, the consequences may be limited as there is a lot of time to adapt the design of the repository.

Management options:
• Margins in the safety case address known unknowns, thus cover partially the possibility of "new" knowledge. If "new" knowledge creates a safety issue, a dedicated research project should be launched to gather the information and address the consequences. The results should be communicated within the safety community.
• Involving CS early in the programme reduces the risk of large impact of "new" knowledge, as it may bring the focus on less investigated aspects. The role of an expert body, that may be consulted on what to do, is very important.
• If the consequences of the "new" knowledge are not specific to one national programme, discussions at international level are highly relevant.
<table>
<thead>
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<th>WMOs</th>
<th>TSOs</th>
<th>REs</th>
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<tr>
<td>• Volatile upon some factors: political, next generations</td>
<td>• With reversibility, site acceptance is never definitively achieved</td>
<td>• Consent–based process with some power attributed to key actors</td>
</tr>
<tr>
<td>• Relevant for interim storage, operational (e.g. waste retrievability) and long–term safety (e.g. post–closure monitoring, waste recoverability)</td>
<td>• Questioning competencies of actors involved in decision–making</td>
<td>• Public consent evolves and is influenced by many factors: cultural, societal, political factors, changes of individual/community preferences, world views and concerns for future generations, information, communication and unexpected nuclear events</td>
</tr>
<tr>
<td>• Can delay or abrupt national programme</td>
<td>• Can delay decision–making → impact on interim storage, transportation and disposal safety. Also: potential loss of resources resulting in poor execution of future activities, early closing or abandonment of facility</td>
<td>• Can delay or abrupt national programme → impact on interim storage safety, waste properties</td>
</tr>
<tr>
<td></td>
<td>• Additional requirements with positive/negative implications for safety</td>
<td>• Additional requirements with positive/negative implications for safety</td>
</tr>
</tbody>
</table>
PUBLIC ACCEPTANCE: EVOLUTION OVER PROGRAMME PHASES

<table>
<thead>
<tr>
<th>Phase 0</th>
<th>Phase 1</th>
<th>Phase 2</th>
<th>Phase 3</th>
<th>Phase 4</th>
<th>Phase 5</th>
</tr>
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<tbody>
<tr>
<td>Policy, Framework and Programme Establishment</td>
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</table>

WMOs: in general high in all programme phases with some minor differences

TSOs: evolution difficult to predict; uncertainty re-appears at each decision point in the programme

REs: public consent and the meaning of safety evolve as well

Uncertainty reduction (WMOs: through RD&D; TSOs: through participative and transparent decision-making process)
## PUBLIC ACCEPTANCE: MANAGEMENT PREFERENCES

<table>
<thead>
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<th>TSOs</th>
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</thead>
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<tr>
<td>Overall strategy</td>
<td></td>
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<tr>
<td>• Transparent, participative, science-based, safety-oriented and self-questioning site selection process</td>
<td></td>
<td>• Transparent and participative decision-making process</td>
<td>• Continuous, transparent and rule-based process of stakeholder engagement</td>
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<tr>
<td>• Continuous/intense dialogue with CS (suitable communication strategy, science and solid knowledge based)</td>
<td></td>
<td>• Continuous actions to build trust and participation willingness</td>
<td>• Building and maintaining trust</td>
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<tr>
<td>• Lessons learned!</td>
<td></td>
<td>• Flexibility (in terms of RWM options and schedule)</td>
<td></td>
</tr>
<tr>
<td>• Lessons learned!</td>
<td></td>
<td>• No decisions/preferences made in advance</td>
<td></td>
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<tr>
<td>Representation in SA</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>• Scenario of postponing/abruption of facility construction</td>
<td></td>
<td>• Assessment of risk associated with this uncertainty</td>
<td></td>
</tr>
<tr>
<td>Specific actions to reduce/mitigate/avoid</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>• What we try to avoid is the lack of public acceptance</td>
<td></td>
<td>• Uncertainty cannot be avoided</td>
<td>• Uncertainty cannot be avoided</td>
</tr>
<tr>
<td>• Reduction by R&amp;D (transdisciplinary research, ethical and societal studies, citizen science)</td>
<td></td>
<td>• Transparency, accessibility and understandability of research results</td>
<td>• Public acceptance cannot be increased by more R&amp;D and more communication on safety</td>
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<tr>
<td>• No real mitigation possible (unless unacceptance is only partial)</td>
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<tr>
<td>• Popularisation of science/educational measures (focus on new generations; change of paradigm <em>geology decides, not emotions</em>)</td>
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<tr>
<td>• Public acceptance assessment through dedicated surveys</td>
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<tr>
<td>• Development of local partnerships when regions are preselected</td>
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<tr>
<td>• Door-to-door discussions</td>
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### Note
- The table outlines various management preferences for public acceptance, focusing on elements of uncertainty and specific actions to reduce, mitigate, or avoid such uncertainty.
PUBLIC ACCEPTANCE: RESULTS OF UMAN SEMINAR

Pluralistic view:

• Should it be viewed as uncertainty or as uncertainty management strategy?
• Acceptance or non-acceptance: two ultimate manifestations of public views (not only motivated by safety), changing over time. Conditions for public acceptance: effective access to all relevant information, to participation in the RWM decision-making process, to justice and to sufficient resources (Aarhus Convention).
• Public acceptance vs acceptability → close notions but are not equivalent; acceptability cannot replace but complement acceptance. The project must be acceptable before being accepted, both are necessary.
• No legal definition available; different interpretation by different stakeholders
• Public acceptance has impact on the success of the siting and on the schedule of the project.

Management options:

• Necessity of a stepwise development. This requires fair communication and a transparent decision-making process.
• Continuous dialogue with CS (from the beginning) is necessary to maintain trust. Independent reviews contribute to building trust.
• The acceptance process should integrate ethical aspects of equity and fairness. Consensus cannot be achieved, but it must be assumed that people, who normally would be unwilling to accept a particular risk, would be inclined to submit to a decision-making process that is embedded in a fair and democratic structure, respecting the integrity of individual rights.
CONCLUSIONS

• Differences are relatively limited and are due to the different roles and responsibilities of the actors, due to national specificities (including regulations), current programme phase and lessons learned.

• Stepwise (flexible) programme and a public involvement seen as key management elements. But differences of views exist on how this could/should be done:
  • from regular stakeholder dialog to active involvement and taking some ownership
  • cannot be solved through more R&D/communication but through building trust

• Different actors may focus on different context of “new” knowledge.

• “New” knowledge is not necessarily negative for safety.

• Uncertainty related to public acceptance can be large and often considered as unavoidable.

• When to stop, when is it enough (w.r.t. uncertainties reduction, optimization)? Who defines the state-of-the-art?

• How to measure public acceptance? What is the sufficient public acceptance level?
THANK YOU FOR YOUR ATTENTION!