



# Applicability of multi-criteria decision analysis in the site selection procedure for high-level radioactive waste final disposal: robustness-oriented comparison of emplacement concepts

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**Abstract.** The verbal and argumentative approach predominantly practiced in previous repository projects is only comprehensible to the general public to a limited extent (FKT, 2021; Blattman et al., 2023). One option to improve the transparency and the comprehensibility of decision-making processes is to supplement verbal and argumentative approaches with multiple-criteria decision analysis (MCDA) (Geldermann and Lerche, 2014; Frieling et al., 2020; Blattman et al., 2023).

In nuclear waste management, MCDA has been used sporadically with respect to disposal strategies and site selection procedures (Achillas et al., 2013; Frieling et al., 2020). For the German site selection procedure, Frieling et al. (2020) identified the potential suitability as well as the development and testing needs of MCDA. Collaborators of the Chair of Repository Safety at RWTH Aachen University are investigating the applicability of MCDA for specific decision problems in the German site selection procedure. One decision problem is the emplacement of high-level radioactive waste (HLW) packages, which is being researched in the context of a doctoral thesis. For this decision problem, influencing factors and interdependencies between decision criteria, for example operational and long-term safety, and between other decision processes in the site selection procedure need to be considered.

In the research project presented here, the emplacement of radioactive waste packages is categorized into three concepts: (1) drift emplacement and (2) horizontal and (3) vertical borehole emplacement. All concepts are tracked internationally. In principle, the Bundesgesellschaft für Endlagerung (BGE) evaluates the three concepts as feasible. However, for the performance of the representative preliminary safety investigation (rvSU), the drift emplacement concept is preferred, which is verbally and argumentatively weighed in BGE (2022).

In this present research, the applicability of MCDA to the decision of the emplacement concept with respect to the German site selection process is explored in four main iterative steps based on Belton and Stewart (2003): (1) decision problem definition, (2) problem structuring, (3) decision model creation, and (4) verification. Currently the decision problem is being structured. Preliminarily, testing of the applicability of the sequential MCDA methods Preference Ranking Organization Method for Enrichment Evaluation (PROMETHEE) I and II is planned, although the method selection has not been finalized (Brans, 1982; Brans and de Smet, 2016). Furthermore, the combination of different MCDA methods will be elicited.

The expected outcome of the research project is a basic decision model for robustness-based comparisons of disposal concepts of HLW. The decision model has the potential to provide decision support and to identify areas for further research regarding safety investigations as well as an increase in transparency, understanding, and acceptance in the site selection procedure. When MCDA methods are adequately applied by the decision maker, benefits are possible in terms of problem structuring, information processing, integration of qualitative and quantitative factors, deeper insights into relevant factors, and identification of compromises (Geldermann and Lerche, 2014; Frieling et al., 2020). Furthermore, the research results are particularly significant for international

site selection procedures that are at the beginning of the selection procedure or at a comparable level in the German procedure.

## References

- Achillas, C., Moussiopoulos, N., Karagiannidis, A., Baniyas, G., and Perkoulidis, G.: The use of multi-criteria decision analysis to tackle waste management problems: a literature review, *Waste management & research the journal of the International Solid Wastes and Public Cleansing Association, ISWA*, 31, 115–129, <https://doi.org/10.1177/0734242X12470203>, 2013.
- Belton, V. and Stewart, T. J.: *Multiple criteria decision analysis: An integrated approach*, 2. print, Kluwer Acad. Publ., Boston, Mass., 1–12, ISBN 9780792375050, 2003.
- BGE – Bundesgesellschaft für Endlagerung mbH (Ed.): *Methodenbeschreibung zur Durchführung der repräsentativen vorläufigen Sicherheitsuntersuchungen gemäß Endlagersicherheitsuntersuchungsverordnung*, 124–126, 2022.
- Blattman, H., Clauser, C., Geckeis, H., Grathwohl, P., Grunwald, A., Kühn, M., Markl, G., Röhlig, K.-J., Scheck-Wendenroth, M., Scherbaum, F., Teutsch, G., and Wenzel, F.: *Sichere Entsorgung und Tiefenlagerung von hochradioaktivem Material – Forschungsperspektiven*, acatech DISKUSSION, Online-Ressource, Deutsche Akademie der Technikwissenschaften e.V. (acatech), München, ISBN 978-3-96834-021-0, 2023.
- Brans, J. P.: *L'ingénierie de la décision; Elaboration d'instruments d'aide à la décision. La méthode PROMETHEE, L'aide à la décision: Nature, Instruments et Perspectives d'Avenir*, Presses de l'Université Laval, Québec, Canada, 183–213, 1982.
- Brans, J.-P. and de Smet, Y.: PROMETHEE Methods, in: *Multiple Criteria Decision Analysis*, edited by: Greco, S., Ehrgott, M., and Figueira, J. R., Springer, New York, NY, 187–219, [https://doi.org/10.1007/978-1-4939-3094-4\\_6](https://doi.org/10.1007/978-1-4939-3094-4_6), 2016.
- FKT – Fachkonferenz Teilgebiete (Ed.): *Bericht Fachkonferenz Teilgebiete: Februar 2021 bis August 2021*, 107–109, 2021.
- Frieling, G., Fischer-Appelt, K., Beuth, T., and Bracke, G.: *Ressortforschungsberichte zur Sicherheit der nuklearen Entsorgung: Methoden für sicherheitsgerichtete Abwägungen und vergleichende Bewertungen im Standortauswahlverfahren (MABeSt) – Vorhaben 4718F13001*, GRS – Gesellschaft für Anlagen- und Reaktorsicherheit, Berlin, p. 117 and p. 186, 2020.
- Geldermann, J. and Lerche, N.: *Leitfaden zur Anwendung von Methoden der multikriteriellen Entscheidungsunterstützung: Methode: PROMETHEE*, Lehrstuhl für Produktion und Logistik, Georg-August-Universität Göttingen, Göttingen, 2–10, 2014.