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Nuclear disposal pathways under conditions of uncertainty

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Abstract. The ways to safely dispose of highly radioactive waste are manifold and remain a central sociopolitical challenge. Environmental compatibility, health protection and social peace are only some of the aspects that a future-oriented final disposal must meet. The corridor for action is thus still wide open in many countries, various disposal paths are under discussion, and a number of fundamental decisions still have to be made, even if geological disposal seems to be the reference pathway currently followed in Germany. Against this background, it is a central task to identify, analyze and evaluate target-adequate future paths for the disposal of highly radioactive waste – this is the focus of this paper in order to specify the approach of thinking of alternative options. On the one hand, the aim is a comparative analysis of the identified paths with regard to their prioritization and characteristics. On the other hand, superordinate strategies for dealing with uncertainties are derived from the pathways. One of the tasks of the research presented here was to clarify and classify this diversity. In an expert workshop, a total of seven different future paths of nuclear waste disposal were identified and classified in terms of their plausibility and probability of implementation. The expert workshop took place in spring 2021 with the project staff of the TRANSENS project, which is one of a handful of transdisciplinary research projects in the realm of nuclear waste management. The workshop gathered experts from various fields (e.g., radiation and nuclear science, risk analysis, law, social sciences, and engineering sciences) working at senior levels in science and dealing with nuclear disposal issues. The workshop discussed several pathway options, detailed their specific characteristics and assessed the relevance and impact for German nuclear disposal policies. The workshop was based on a qualitative discursive approach rather than a quantitative survey assessment. The following pathways were identified: (1) exotics: space, ocean, Arctic/Greenland Ice Sheet; (2) direct storage in interim storage tanks; (3) partitioning and transmutation; (4) deep well storage; (5) consolidated interim storage; (6) extended decentralized interim storage; and (7) post StandAG (Repository Site Selection Act). From a path comparison perspective, the strategies of uncertainty management can be derived. Three basic strategy approaches can be distinguished, and these were deduced on the basis of plausibility and drawing conclusions based on detailed pathway description and analysis.

First, a reduction of uncertainty occurs via a strategy of incremental status quo orientation. The main option envisages interim storage, followed by deep geological disposal in a mine with a multi-barrier system. However, this path has not been fully specified to date. With the revision of the repository process, this path focuses on the site search and the decision for the time being. The siting decision is to be made in incremental, procedural steps. Further planning, such as upgrading of the technical and geotechnical repository barriers or new construction of interim storage facilities, etc., is currently being pursued to any great extent at present. This is accompanied by a status-quo-oriented derivation of necessary actions, as discussed in the field of extended and consolidated interim storage.

Second, the strategy of strongly anchoring participation and involvement reduces uncertainty and insecurity. Past experiences with the Gorleben, Germany, aboveground interim storage facility and the Gorleben exploratory mine, as well as the Asse II mine in Germany, have clearly demonstrated the potential for social conflict in nuclear waste disposal – and ultimately played a decisive role in the new beginning of the site search. Social

and political feasibility is a decisive factor for successful disposal. With the help of a strong participation and involvement approach to the site selection process, social uncertainty factors should be minimized and robust decisions collectively made.

Third, the principle of flexibility and reversibility involves a strategy of maintaining the future capacity to act. This is to ensure that uncertainties arising in the future can be adequately dealt with via an adaptive learning procedure and that new bodies of knowledge can be integrated. Initial requirements have already been defined in terms of retrievability and salvageability, even if questions of technical and organizational feasibility have not yet been adequately answered. The procedural openness with respect to the future ability to act results in exciting aspects and challenges for the professional design of anticipatory governance structures in institutions and decision-making processes, especially from the perspective of political, administrative and planning science. Furthermore, the interface of science and politics is of great importance in the interplay between the analysis of unintended and unexpected side effects by science and the management of these side effects by administrators.

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