Note:
This is a translation of the ESK Discussion Paper entitled
"Umgang mit wissenschaftlichem Dissens im Kontext der Endlagerung radioaktiver Abfälle"
In case of discrepancies between the English translation and the German original, the original shall prevail.

DISCUSSION PAPER of the Nuclear Waste Management Commission

Dealing with scientific dissent in the context of radioactive waste disposal

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1 Introduction

According to the German Site Selection Act [StandAG, 1], the site selection procedure for a repository for high-level radioactive waste shall be science-based [1, §1 (2)]. It is therefore characterised, among other aspects, by the state of scientific knowledge and activity [2]. Science, in turn, thrives on dissent; it does not necessarily or even timely fulfil society's desire for clear answers and consensus. Even beyond or outside the scientific community, science-related - possibly contradictory - arguments are used to support the respective position in situations of controversy and conflict. This applies in particular to the site selection procedure, too - also with regard to the attributes "self-questioning" and "learning" also mentioned for the procedure in [1, §1 (2)]. The fruitful effect of dissent within the scientific system on the one hand and the potentially unsettling effect of scientific dissent on other stakeholders in the site selection procedure on the other [3] must be understood and taken into account accordingly. The procedure requires approaches and practices that allow science-based decisions to be made even in the face of dissent.

At the 66th meeting of the ESK Committee on FINAL DISPOSAL (EL) on 18 October 2018 for example, the dissent in the Swedish licensing procedure for a repository for spent fuel was discussed, in particular with regard to the corrosion of copper [4]. In this context, it was specified i.a. that the Committee should provide fundamental advice on how to proceed in the event of contradictory statements on scientific and technical facts in order to achieve procedural and legal certainty. At its 79th meeting on 20 January 2021, the Committee accordingly established an ad-hoc working group on the "Procedure in the event of contradictory scientific statements".

The subject of the discussion paper in hand is the handling of contradictory procedural statements not only on scientific and technical issues, but also on their safety-related assessment. To this end, case studies from the context of the final disposal of radioactive waste were analysed. Similarities and differences were identified and typical phenomena and ways of dealing with scientific dissent were worked out. Conclusions are drawn with special consideration of the site selection procedure.

The discussion paper was prepared between February 2021 and March 2024. One working group meeting was used to exchange ideas with external experts. On 21 March 2024, the ESK adopted the discussion paper in its present form at its 114th meeting.

2 Methodology

Systematic analyses of case studies from the context of radioactive waste disposal are an important basis for this discussion paper. The so-called Case Study Methods, which have their origins in the social sciences, are widely used today, for example in the contexts of final disposal (cf. [2]) and mining (cf. [5]). The methodology unfolds its strength when the research questions focus in particular on the ‘How?’ and ‘Why?’ and refer to a manageable number of individual case studies characterised in particular by qualitative data. The aim is to identify overarching correlations, benchmarks and trends or even specific patterns and sequences as well as the corresponding derivation of strategies and solutions.

Firstly, individual cases were selected from the context of radioactive waste disposal (including the above-mentioned copper corrosion) in which dissent was observed with different actors, to varying degrees of

intensity, and with varying relevance in different discussion areas (Figure 1). In the case of Example 5 (temperature criterion), the ESK does not consider this to be a scientific disagreement. The ESK regards the definition of a limit temperature as ‘scientifically unjustifiable’ and ‘not justified by the precautionary principle’ [6]. The aim of this discussion paper is to shed light on phenomena such as the instrumentalisation of science and effects such as the tying-up of resources.

1. Copper corrosion The question of the corrosion of copper in oxygen-free water is answered differently due to different interpretations of an experimental investigation.	2. Salt percolation Results have been published on the increased hydraulic permeability of undisturbed rock salt. Such an increase would be highly relevant to safety, but it is disputed whether the results are valid and whether they are relevant under repository conditions.
3. Overburden Flow- and erosion-inhibiting layers above salt domes contribute to safety, but it is disputed how significant this contribution is to overall safety.	4. Corrosion at boundary surfaces The safety relevance of self-accelerated corrosion at the glass-container boundary surface is assessed differently.
5. Temperature criterion It is disputed whether the politically negotiated specification of a uniform, design-relevant maximum temperature on the outer surface of the cask is appropriate for all repository systems and fulfils the precautionary principle.	6 Cryogenic cracks The genesis of cracks found in salt domes is assessed differently by geoscientists, which leads to different prognoses regarding potential future damage scenarios.

Figure 1: Brief overview of the six selected individual case studies (Case Studies 1 to 6)

The information collected on these case studies was presented and discussed in various forms. The actual analysis then focussed on aspects that were selected with a view to the comparability of the case studies. The data from the individual case studies was systematically recorded using a matrix (‘Level 1’) and reduced into meaningful segments. The naming and gradual reduction (grouping) of these segments is referred to as ‘coding’. The grouping of the identified aspects leads to further, higher-level codes (Figure 2).

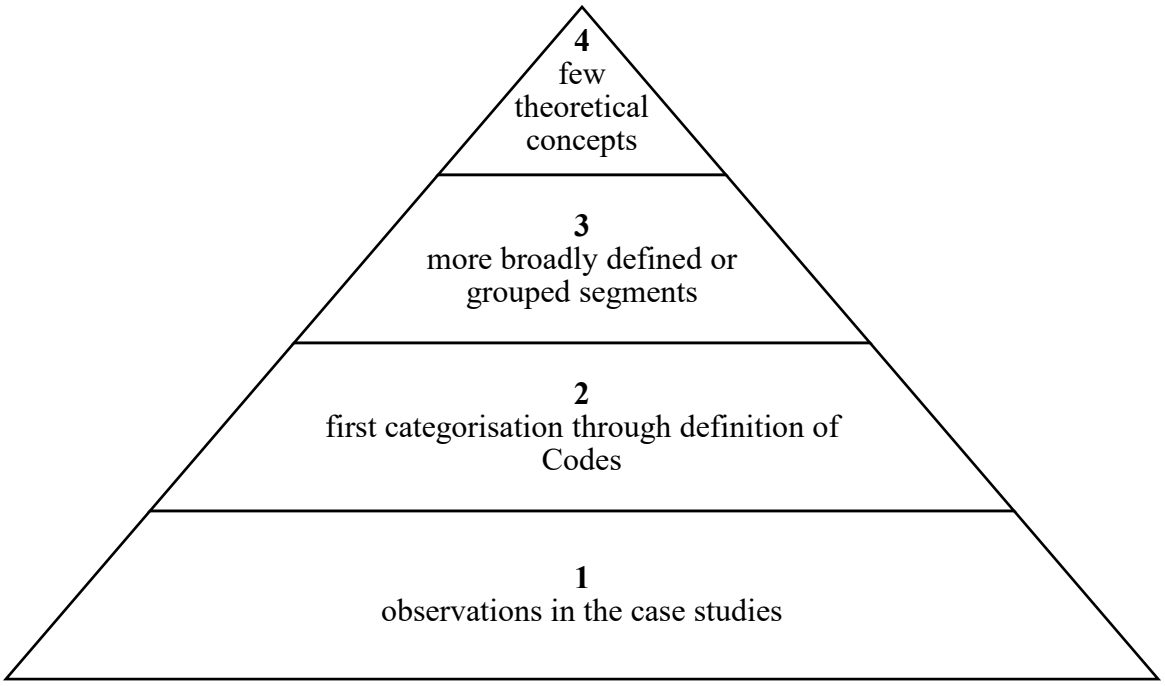

Figure 2: Levels 1 to 4 in the Coding process, modified according to [5]

All individual case studies were analysed again using these Codes. In this way, the applicability of the Codes was checked and verified for each individual case study. This formed the starting point for the cross-case-study analysis. By highlighting typical characteristics of certain Codes in the matrix, it was also possible to identify recurring patterns. These patterns can allow conclusions to be drawn about recurring phenomena, different types of dissent, and correspondingly applicable solutions.

As a result of this synthesis, phenomena and approaches for dealing with and possibly resolving dissent were identified (detailed Codes, Level 2). They could be reduced to a few characteristics (Level-4 Codes) via more broadly defined segments (Level 3 Codes) (see Figures 3 and Figure 4).

Irrespective of the individual case studies used as a basis at the beginning, validated and possibly applicable findings could be derived, e.g. for typical processes of dissent or the possible handling of any future dissent. The results of the case study analysis were supplemented and in turn verified by further research and a workshop with experts, in particular on dealing with dissent and scientific theory.

3 Typologies of scientific dissent

Scientific dissent in the true sense of the word arises when statements on scientific and technical facts and/or methods contradict each other (e.g. the examples of ‘copper corrosion’ or ‘cryogenic cracks’ mentioned above, see Figure 1). However, disagreements can also arise if the safety relevance of phenomena (e.g. ‘overburden’ or ‘corrosion at boundary surfaces’) or their relevance in the context of final disposal (e.g. ‘salt percolation’) or the adequate application of the precautionary principle are assessed differently. Conflicts between the legal assessment (‘legal’) of an issue on the one hand and its acceptability (‘legitimate’) on the other are also conceivable.

In addition to the nature of a dissent, its effects are an important criterion for categorisation (Figure 3). For example, dissent can reveal conflicts of objectives (e.g. occupational safety vs. long-term safety). Furthermore, dissent can have an impact on the content of statutory or sub-statutory regulations through to interpretations of existing regulations that are enforceable in court or the assessment of the state of the art in science and technology. Dissent can also lead to the creation of new regulations or influence them. While the achievement of scientific progress is generally a positive effect of scientific dissent, conflicts of interest can also arise when formulating new regulations. Scientific presentations or reviews can confirm the state of the art in science and technology or of corresponding regulations and ensure that conflicts are resolved.

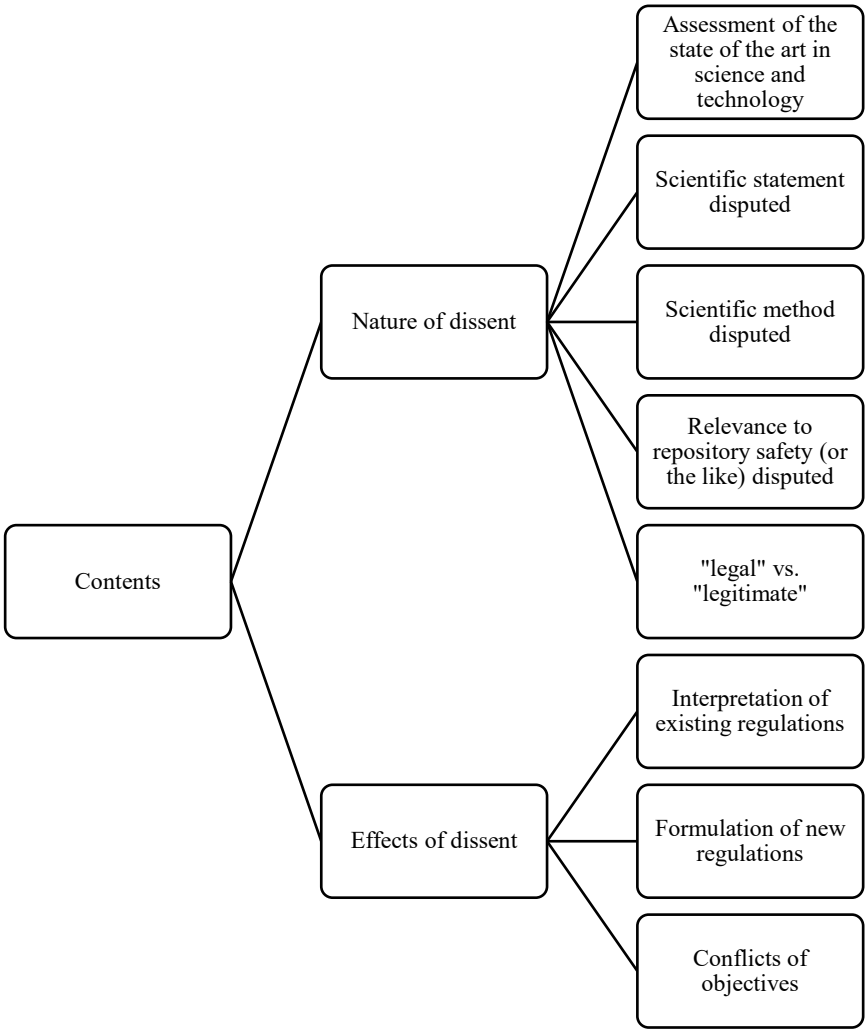

Figure 2: Identification and classification of scientific dissent

It is not always possible to clearly assign typical phenomena to certain types of dissent - in many cases, several of the characteristics mentioned apply to a dissent to varying degrees. Attributions are made by the actors involved themselves and can differ depending on their interests and the types of knowledge brought into the discourse.

Other recurring phenomena in connection with scientific dissent can be summarised under the keyword ‘stakeholders’ (Figure 4). The phenomena under consideration show that the course of a discourse depends on the actors involved and that actors exert a corresponding influence. The actors themselves have different levels of knowledge. They also operate in different discourse spaces with individually valid rules and mechanisms. Furthermore, dissent can exist within one scientific discipline or between different scientific disciplines. The discourse becomes even more complex when actors are involved who follow a ‘hidden agenda’ or ‘different internal logics and rationalities’ [3] and/or when it is conducted in public.

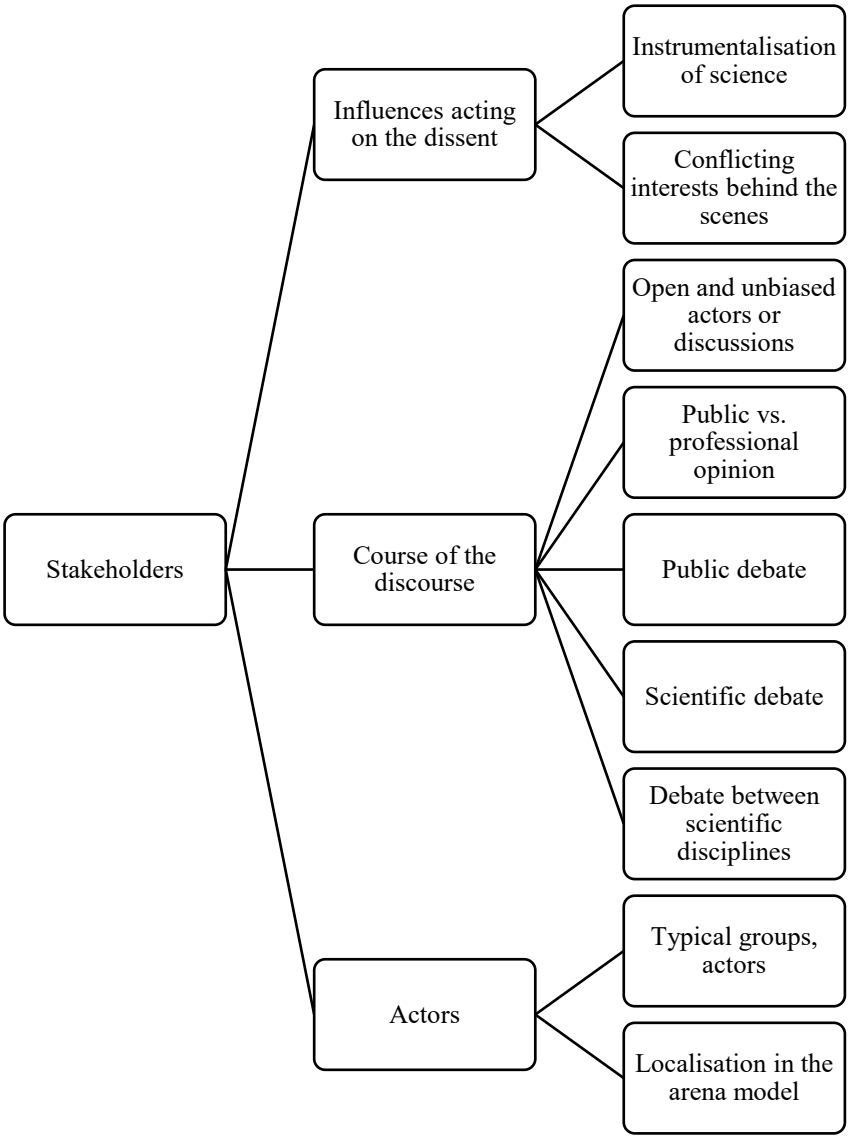

Figure 3: Involvement of various actors in the development of a dissent who can influence the course of the discourse to varying degrees.

The arena model[1] developed by [3] in the field of radioactive waste disposal (Figure 5) is suitable for a corresponding classification of the actors and their possible behaviour. For this purpose, it is important to

[1] arena = formal, cultural and social space for the interaction of actors on specific topics (cf. [3])

clarify who the actual actors in a dissent are (scientists, applicants, authorities, courts, government, NGOs, ...), and who is more likely to contribute to clarifying or even intensifying the debate. A dissent can also be carried out in several arenas or a deliberate change of arena can be initiated (e.g. by involving the public).

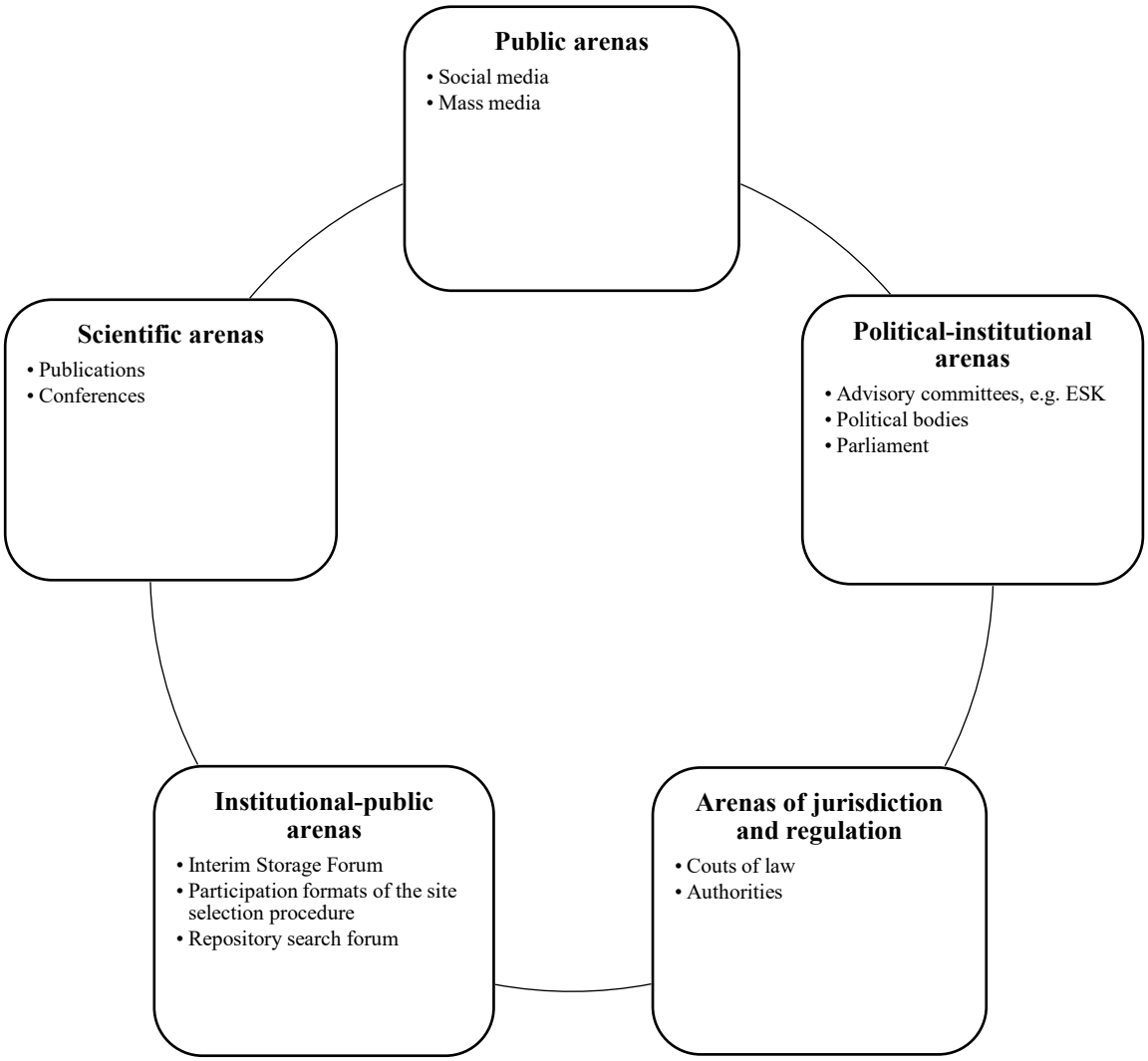

Figure 4: Arena model for dissents in the context of the site selection procedure with typical actors (further developed, including addition of scientific arenas, according to [3])

Both the course of a dissent and the influences on it can vary significantly, depending on the respective arena. For example, it is part of scientific culture to uncover uncertainties in knowledge, thereby enabling new research and ultimately achieving progress. When moving from scientific arenas to other arenas, it is possible that scientific arguments are only used but no longer scientifically scrutinised. In public and political arenas in particular, there is the possibility that science will be instrumentalised. Furthermore, dissent can be generated or kept alive in order to carry out other conflicts in the background (phenomenon: 'conflicting interests' (see Figure 4) or 'interest-led dissent' [2]).

The behaviour of the actors can differ from arena to arena. For example, well-founded, written statements can be made in professional discourse, while less constructive forms of conversation can also be observed in internet forums. The actual or perceived ability of individual players to exert influence also varies between the arenas.

External factors influencing dissent can change over time or even give rise to it in the first place. Political framework conditions can change and dissent can lose its social or procedural relevance[2]. This can also influence the provision of further research funding or the interest in scientific work in the respective field.

Ideally, the discourse in scientific arenas takes the form of purely scientific debate (both disciplinary, but also interdisciplinary, especially in the context of final disposal of radioactive waste). The questioning of methods or interpretations should be seen as a typical and productive process of science [2]. Discussions about disagreements with actors with an open mind would be desirable in all arenas. In the public, political-institutional and institutional-public arenas, aspects of dissent can be categorised or interpreted very differently than in the scientific arenas, which may lead to different conclusions.

4 Dealing with dissent

How dissent is dealt with depends on the type of dissent and the arenas in which it takes place. Dissent in general refers to disagreements between individuals or groups who have different points of view on a particular issue and is based on personal beliefs, experiences, values or knowledge. Dissent can also be emotionally charged.

Dealing with dissent generally means clarifying or ideally resolving a difference of opinion or disagreement between individuals or groups. This can be achieved through the exchange of information and arguments, the search for common goals or values, the use of mediation techniques, or the involvement of third parties (conciliation procedures, conflict moderation or mediation). The analysis of the case studies has shown that the number of players is not decisive for the potential success of mediation, but rather the willingness of the players to reach an agreement or a result. The aim of resolving a disagreement is to eliminate misunderstandings or conflicts and to achieve a co-operative solution. This can take the form of a consensus or a compromise.

[2] For example, the issue of 'salt percolation' would become less important if, in the course of the site selection procedure, the host rock type salt were to be eliminated. Conversely, public interest in such potential scientific dissent could increase if the site selection focused on this host rock type.

Scientific dissent in the true sense of the word is allocated in a scientific arena and is an integral part of scientific progress. Open discussion and critical questioning of scientific findings are necessary in order to consolidate, broaden and improve knowledge. Dealing with scientific dissent should therefore be characterised by respect, openness and transparency. However, this does not exclude the fact that emotions, interests and values also play a role in scientific arenas.

Irrespective of the possibility and obligation to present scientific findings for discussion and ultimately make them transparent through publications, science also repeatedly utilises the opportunity to withdraw into 'protected spaces'. The discourse there is primarily professional and is ideally not influenced by external stakeholders.

In a scientific context, dissent is traditionally dealt with through the use of publications, peer reviews and conferences for the professional discussion, confirmation or refutation of statements or facts. Discourse and scientific opinion-forming should be based on scientific evidence and not on political ideology or interests. Compromise is unsuitable for resolving scientific dissent. Dissent will be maintained in scientific arenas until a common interpretation or doctrine has prevailed (consensus building).

If the dissent in the scientific arena is not resolved or not resolved in time for an ongoing procedure, the remaining uncertainties must be addressed. This also applies to a drifting-apart of public and expert opinion. In such cases, participation formats and the objective weighing-up of opportunities and risks, such as different technologies or approaches that are the subject of dissent, are suitable approaches. Technical and substantive approaches for dealing with such uncertainties can be [see 8]

- avoidance of the impact of uncertainties by choosing safety-related solutions on which there is consensus (dissent loses its relevance for the chosen solution),
- mitigation of potential (safety-related) impacts, for example through a robust repository design, or
- research assignments to clarify the dissent or reduce the uncertainties caused by the dissent.

Site selection for a repository for high-level radioactive waste shall be science-based and is therefore characterised i.a. by scientific knowledge and activity (cf. Section 1). Dissent in public procedures such as site selection can arise with regard to the determination of the actual state of the art in science and technology to be applied or with regard to the different interpretation of the scientific facts to be considered in a concrete case.

In order to fulfil the high standards of prevention according to the state of the art in science and technology, the individual parameters of a dissent can and must be identified, discussed and explained. Further solution-finding and communication can be simplified by precisely narrowing down the aspects of the issue that are actually being discussed.

Various methods can be used to address dissent (in the sense of this discussion paper) in public procedures (cf. institutional-public arenas as per Figure 5). Some of these are expert hearings and workshops, peer reviews and stakeholder hearings.

It is important that dissent in public procedures is addressed transparently, fairly, comprehensibly and impartially so that dealing with dissent in participation procedures can be seen as an opportunity. In particular,

when dissent is dealt with in arenas other than science, there is also a risk that science will be politically instrumentalised or at least perceived as such by the public. On the positive side, however, this can also be seen as the inclusion of specialist expertise in the formation of political or public opinion [3] and decision-making.

While scientific dissent is maintained until a consensus is reached, a process with inherent time constraints requires a guided approach to contradictory statements. This is achieved through a predefined process structure whose individual process steps must be communicated openly, transparently and at an early stage since the subjective perception of sufficiently large time windows for forming an opinion and taking part in the process are fundamental for trust in the process.

The potentially unsettling effect of scientific dissent on those involved in the site selection procedure who are not based in science can ideally be limited by

- clear definition of the dissent by those involved,
- presentation of the respective backgrounds of the different actors and disclosure of the interests and motivation behind communicated positions in order to categorise different internal logics and to avoid the effects of hidden agendas,
- open, systematic and respectful behaviour when dealing with dissent[3],
- traceability of findings and decisions (knowledge management),
- explanation, delimitation and assessment of the relevance of a dissent, for example for repository safety and potential conflicts of objectives,
- weighing up the relevance of existing uncertainties against the effort (including e.g. time) required for and the expected benefits of further research,
- comprehensible presentation of well-prepared content,
- opinions of neutral bodies, committees and forums,
- the possibility of special votes, and
- clear communication about the consideration of the dissent by the decision-makers.

These approaches are applicable to different types of dissent and in different arenas. They can be used in supervisory or licensing procedures as well as in connection with public participation when mediating between different groups or arenas. By setting up exchange formats, dissent can be communicated, moderated and accompanied, thus promoting a transparent exchange.

Equally important for the process is the communication of consensus. Often, there is consensus on many aspects of an issue, but this is then communicated to the general public (including e.g. the media) with less commitment than the specific points on which there may be dissent.

Transparency and participation can be more conducive to a constructive approach to scientific dissent than delegating the decision to the courts. Such decisions do not lead to a resolution or pacification of dissent. Experts consulted are heard in court, but there is no longer a scientific exchange in the narrower sense. The court reaches a decision on the basis of the facts presented and the legal situation but does not serve to reach

[3] Three common theories and approaches should be mentioned here: argumentative confrontation, stakeholder process and co-operative discourse.

a scientific consensus. However, court hearings may become necessary if a disagreement is already being discussed in public arenas and a resolution of the conflict appears unlikely. The same applies to political opinion-forming and parliamentary decisions. Here too, the focus is not on resolving the dissent, but on reaching a decision.

5 Conclusions

The analysis of the case studies leads to the conclusion that the cases analysed represent different types of dissent: All cases concern scientific-technical statements, but not all relate to dissent among scientists. Since all cases concern issues relating to the safety of deep geological disposal, statements on the safety relevance of scientific and technical issues also play a special role. Furthermore, disagreements may concern the assessment of the relevant state of the art in science and technology, the adequate application of the precautionary principle, or other normative issues. This complexity is reflected in the ESK's definition of the subject matter - it is not about scientific dissent per se, but about „contradictory statements on a scientific-technical issue and/or its safety-related assessment".

As part of the science-based site selection procedure [1], the project implementer, authority and political decision-makers must arrive at proposals and decisions that take account of any existing dissent. With the wording 'science-based' (and not: 'science-led' or 'science-dominated'), the legislator allows for flexibility: The stakeholders should not act against existing scientific knowledge but are also not forced to resolve all dissent. The fruitful effect of dissent within the scientific community on the one hand and the potentially unsettling effect of scientific dissent on other stakeholders [3] must be understood and taken into account.

Within different arenas, different types or levels of knowledge come into play when dealing with dissent. Even within scientific arenas, for example, the assessment of safety relevance requires knowledge or assumptions about the repository system under consideration and its safety concept - changes in this regard may also lead to changes in the safety relevance of individual phenomena. An assessment requires knowledge of the overall repository system, which is not necessarily available even among many specialists in all the disciplines relevant to repositories. Different types and levels of knowledge make it difficult to reach a consensus.

Within the scientific arenas, scientific dissent - e.g. on a scientific issue - is the driving force of research that strives for a resolution. In this arena, it is particularly about the issue under discussion as such; dealing with dissent is an integral part of scientific progress. Publications, peer reviews and conferences for the professional discussion, and the verification or falsification of statements or facts are established tools and methods for dealing with dissent. Dissent will be maintained in scientific arenas until a common interpretation or doctrine has prevailed (consensus building). However, even if great efforts are made, it is not guaranteed that such an intra-scientific resolution will succeed within the time frame set by the procedure.

The debate is made even more complex by heterogeneous or multi-layered stakeholder constellations or conflicting objectives in other arenas in which different interests also come into play. Actors may be involved who follow a hidden agenda or different internal logics (see Section 3). However, even discourses in scientific arenas are not necessarily free of conscious or unconscious perceptions of interests. Especially when dissent is argued out in arenas other than science, attempts at resolution are complex. There is also a risk that science

will be politically instrumentalised, or at least perceived as such by the public. However, a well-communicated scientific debate can also legitimise and underpin existing regulations or political decisions [8] and be helpful for the discourse in other arenas.

Arenas in which discourse takes place and disagreements are aired are not static entities. They can overlap in terms of personnel, and participation processes have the potential to carry dissent from one arena to another. However, models for a possible resolution are different. In scientific arenas, resolution can only be achieved through consensus. In the case studies analysed, recurring patterns for the individual cases made it clear that the discourse is less complex in discourses conducted exclusively in scientific arenas than in cases in which the scientific arenas are left behind (cf. [2]).

On the other hand, other arenas open up possible solutions that cannot be realised within the scientific arenas. It is no longer about dissent per se, but about how to deal with it against the background of a specific objective (e.g. a site selection or a licensing decision). Compromise is also possible in political arenas - e.g. when weighing up safety relevance or conflicting objectives. This should then be clearly labelled as such and not concealed by seemingly scientific arguments. An open and proactive approach can also fulfil the requirement to proceed in a science-based and transparent manner [2].

It is also conceivable that certain dissents may become less important in the course of the site selection procedure, for example because they are specific to a certain host rock type and the host rock in question is then eliminated from the procedure.

The path to the final decision - like the entire procedure - requires a clear perception and communication of the roles of the stakeholders. In addition to the BMUV in its political responsibility, the German site selection procedure provides for the following three actors who can influence the discourse through their respective roles:

- The BGE is responsible for ensuring that, in addition to the status of work in the respective procedural step, dissents or potential dissents are communicated precisely and in accordance with the needs of the interested public (cf. also [10]). In the opinion of the ESK, this includes explaining, limiting and assessing the relevance of a dissent for repository safety, and any conflicts of objectives.

- According to the legal situation, BASE is not only the supervisory and licensing authority, but also the public agency in charge of public involvement. In the opinion of the ESK, it is therefore responsible for organising and moderating the discourse.

- The National Citizens' Oversight Committee - (*Nationales Begleitgremium - NBG*) should receive early indications of potential dissent in order to be able to fulfil its role of mediating and independent monitoring and thus foster trust in the implementation of the procedure [1, § 8 (1)].

The basic requirement for dealing with dissent is that it is clearly stated by those involved. This may also require skilful moderation, for example in participation formats - even the definition of the question can be controversial, as can be the question of what exactly is recognised as a solution [11]. Ideally, the thought processes and hypotheses behind positions should be disclosed. Explanations based on different types of knowledge among the actors (e.g. on individual phenomena or on the system as a whole) require transparency,

patience and time. It is legitimate for interests to be represented in the discourse or for conflicts of interest to exist, but the positions must be transparent. Disclosure of the interests and motivation behind communicated positions to avoid the effects of hidden agendas is desirable but will often not be achievable.

Communicating consensus is just as important for the process as clearly stating dissent.

Tools and methods of discourse in different arenas can include expert hearings and workshops, statements from neutral bodies, peer reviews and stakeholder consultations. The basic prerequisite is an open, systematic and respectful approach to discourse. In the ESK's view, these elements are increasingly being utilised as part of participation in the site selection procedure. Special votes may contribute to the communication and documentation of the decision-making process. Closure requires the traceability of findings and decisions as part of adequate knowledge management and is ideally linked to clear communication about the consideration of dissent by BGE or BASE.

Decisions, e.g. by courts, authorities or political decision-makers, may not pacify or end dissent. Transparency and participation can be more effective in dealing constructively with scientific dissent than delegating decisions to the courts. However, delegating issues to specialist authorities, for example, is necessary and legitimate in a highly specialised society.

In the opinion of the ESK, it is important that the resolution of dissent should be driven forward swiftly and purposefully, also in view of the current discussion on the potential for optimising the site selection procedure.

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