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Challenges of Communicating Safety Case Results to Different Audiences

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1. Introduction

Nowadays, nuclear politics and decision-making are often oriented at procedures which are linked to precautionary concepts and which reflect forms of “knowledge politics” (Böschen 2010). These precautionary concepts in most cases focus on robust societal decisions, which incorporate the principles of sustainability as a topic of public debate (Grunwald and Rösch 2012; esp. p. 10 and p. 12). The issue of high-level nuclear waste is under debate and confronted with public discourse, which integrates not only the knowledge of different stakeholders, but also accept certain forms of “Nichtwissen” (“nonknowledge”).

Interdisciplinary research has to observe these normative trends and also has to “contextualize” these questions before interpreting its research results for giving answers with practical relevance, esp. in communication with different social actors. Issues which are brought up in this field of nuclear waste management and their social context have to be analysed in two dimensions: (1) the dimension of professionalism and expertise, (2) the dimension of managing controversial debates (“knowledge politics”) and the preparation and implementing of robust decisions mostly by responsible governmental organisations. In this context on the one hand complex aspects of safety have to be communicated in their internal scientific logic and structure. On the other hand the different functional systems and collective actors of highly differentiated modern societies are engaged in controversial debates on advanced technologies like nuclear energy and technologies for waste disposal over long-lasting time periods.

Most safety and construction issues for final disposal of high-level waste, but also of waste management in general, are debated within professional “communities” of scientists and experts. But if their technological artefacts and their conceptual planning become issues of controversial and political debates in spheres which are outside the closed circle of high-level professionals and party politicians (which are in the end responsible for safety regulations, licensing and decision-making), and also collective actors from civil society begin to discuss the side-effects of technological decisions like an underground repository, power relations and knowledge politics become more and more important (Straßheim 2012, Stehr 2004).

The safety-case discussion and its inherent impacts on public debate are an instructive example for the challenges which nuclear waste management has to face, if the public debate can be classified as a controversy which has to overcome societal cleavages between different groups of experts and civil society - cleavages which are articulated by modern mass media, civil society organizations and professionals with pro-nuclear as well as with sceptical or offensively anti-nuclear positions. Under these conditions, communication between very different types of actors (experts and others) is essential, but accompanied by considerable challenges. Safety is an issue about which all the relevant actors claim that it is of utmost importance, but at the same time it is an area with a high potential for communicative challenges.

2. Description of one typical challenge concerning the interpretation and communication of safety case results

Safety assessment stands at the core of a safety case (OECD/NEA 2012, 2013, IAEA 2012). It addresses safety during the operational and closure phases as well as safety after repository closure. Diverging views and experiences exist about whether operational or post-closure safety is of more interest and concern for those stakeholders who are not directly involved in the application and licensing process (i.e. concerned laypersons, established interest groups, protest groups and NGOs and also intermediary actors like mass media and the new social media which organize the interested general public in society). Other issues such as environmental, economic or infrastructural impact might also be important. Beside the consensus that safety is always important, it is obvious that prominent stakeholders have different perceptions of safety problems. But their "framing" of the problems and the preferences and priorities for the problem solutions still need to be addressed by systematic case studies and empirical research (for the concept of framing see Benford / Snow 2000).

In any case, implementers have to demonstrate and authorities have to judge compliance for the issues of concern, including operational and post-closure safety. The implementer has to mobilize support for this concept in a way that the public, especially in the vicinity of the facility, recognizes the standards and methodologies applied within the professional safety case and assessment and at least to convince this local public to tolerate this type of assessment within a stepwise approach, where different modes of risk assessment and decision-making are integrated. This all happens under unpleasing conditions, which influence the societal debate about safety in a serious way. Their main characteristics are: (1) ongoing processes of "knowledge pluralisation", (2) different types of sub-rationalities favoured by certain collective actors and (3) the necessity to decide now under conditions of an undeniable presence of different degrees and types of uncertainty and non-knowledge (or better a systematic lack of specific, but relevant knowledge). These conditions describe the setting and in this sense important context variables for the impact of safety case concepts in a broader perspective. As safety case assessments are planned as instruments within iterative processes of decision-making, the three conditions mentioned above show that the instrumental logic within processes of planning and societal discourse challenge each other in a specific way, which is discussed here.

3. The Safety Case as a conceptual chance

For both operational and post closure safety, safety assessments operate with scenarios (i.e. systematically derived but still postulated events and resulting future evolutions of the system), with their likelihood of occurrence and associated consequences. The latter is mostly indicated by estimated entities such as annual individual effective dose, annual risk, collective dose, etc. ("indicators"). Judging compliance means, amongst other things, comparing calculated or estimated indicator values with yardsticks prescribed in regulations (OECD/NEA 2007, 2012b, ICRP 2013). However, a safety case, being "a formal compilation of evidence, analyses and arguments that quantify and substantiate a claim that the repository will be safe" (OECD/NEA 2013), contains quantitative as well as qualitative elements. Generating the named indicators means structuring, condensing and reducing a wealth of information and evidence supporting (or otherwise) the safety claim. Therefore, judging compliance cannot be reduced to a check whether or not indicators meet numerical criteria – the whole evidence as well as the methodology by which safety claims are derived from this evidence by means of the tool "safety case" is at stake.

Assessing operational safety for above-ground nuclear facilities is an established business. It is less established to achieve and assess operational safety for an underground nuclear facility, i.e. a repository. Specific challenges arise due to the necessity to address mining safety and nuclear safety at the same time. This paper, however, will focus on post-closure safety. When assessing post-closure safety uncertainties are higher and, consequently, calculated entities such as effective annual doses have a different meaning than usual (i.e. in classical radiation protection): “However, ICRP Publication 103 also warns that effective dose loses its direct connection to health detriment for doses in the future after a time span of a few generations, given the evolution of society, human habits and characteristics. Furthermore, in the distant future, the geosphere and the engineered system and, even more so, the biosphere will evolve in a less predictable way. The scientific basis for assessments of detriment to health at very long times into the future therefore becomes uncertain and the strict application of numerical criteria may then be inappropriate. In the very long term the dose and risk criteria are to be used for the sake of comparison of options rather than as means of assessing health detriment.” (ICRP 2013).

In post-closure safety assessments, indicators like the ones mentioned above (so-called “safety indicators”) but also others can be and are being calculated: In a recent review (OECD/NEA 2012b), the following types of “complementary” (to dose or risk) indicators are distinguished:

- concentration and content related indicators, that provide information on the radionuclide inventory and its distribution within compartments of the repository and the environment (e.g. total radioactivity content of the waste form or radiotoxicity concentration in groundwater);
- flux related indicators, that provide information on the transport of radionuclides between compartments of the repository and their release to the accessible environment (e.g. radioactivity flux from the engineered barriers to the geosphere or total integrated radiotoxicity flux from the geosphere to the biosphere over time); and
- status of barriers related indicators, that provide information on the functioning and containment capability of the barriers in the repository system (e.g. container life time or buffer swelling pressure).

This is perhaps a more helpful categorization than the conventional one (safety indicators, performance indicators, safety function indicators). The categorization can then further be refined by asking about the location or system component it is related to, its purpose, etc. As examples illustrating the wide variety of indicators might serve (OECD/NEA 2012a):

- Container lifetime (status of barriers related), which might aid design optimization.
- Stress state in the confining rock zone (status of barriers related), which allows component-related performance statements and aids system understanding and design optimization.
- Groundwater age (status of barriers related), which allows performance and safety statements and aids communication.
- Activity fluxes from waste container, concrete buffer, gallery, clay host rock, respectively (flux related), which allows for performance statements about single system components and supports system understanding.
- Radiotoxicity concentration in biosphere water (concentration and content related), which allows safety statements,
- Extent of the potentially contaminated zone in the biosphere and the part of the geosphere located outside the disposal system (concentration and content related), which allows safety statements and might aid communication

The review (OECD/NEA 2012b) shows that implementing organisations usually have a clear view and strategy about how to use indicators *internally* and in their reports. Details of such strategies and terminologies vary considerably, though.

However, it is much less clear which indicators are of which use for which audience (authorities, interested public, scientific community, concerned laypersons, …) and which meaning any yardsticks or criteria for such indicators might have to them. By default, authorities will focus on those indicators for which regulations expect compliance (safety indicators such as annual individual effective dose or annual risk). However, developing regulations might also be related to concerns of media, the wider public etc. An example illustrating how differently the indicators “risk”, “individual dose” and “collective dose” are perceived by different actors and audiences is provided in the following:
In 2010, the German Federal Ministry of the Environment, Nature Conservation and Reactor Safety BMU published its Safety Requirements for the disposal of heat-generating radioactive waste (BMU 2010). In a preliminary draft (BMU 2008), amongst other criteria two options for demonstrating radiological safety in the long term were offered between which the implementer was allowed to choose:

(i) The “conventional” or “traditional” approach: Based on estimating contaminant release and migration to the biosphere, it should be shown that the additional lifetime risk of an individual to suffer a severe health effect caused by the facility will not exceed 10^{-4} or 10^{-3}, dependent on the likelihood of the scenario leading to this risk (the former value for so-called “likely”, the latter for so-called “less likely scenarios”). In other words: the values address *conditional* risks (condition: the scenario under question will occur, its likelihood of occurrence is *not* aggregated into the value). Note that such conditional risk values are equivalent to effective dose values. According to (BMU 2008) they translate, using the ICRP 103 risk coefficient of 0.057 (ICRP 2007) to effective lifetime doses of 1.8 mSv or 18 mSv, respectively.

(ii) The “innovative” approach: An indicator was introduced addressing the radionuclides released from the so-called confining rock zone. The confining rock zone (in the English version of the draft: “isolating rock zone”) is a concept which strives to achieve confinement by geologic and geotechnical barriers, the performance of which over the timeframe of concern (up to 1 million years) can be forecasted with much more certainty than the evolution of overlying strata, hydrogeology or the biosphere. Consequently, BMU’s safety requirements allowed for safety demonstration supported by an indicator related to this zone, by such means avoiding less reliable modelling of the hydrogeology and biosphere. The indicator was defined as annual effective dose to be calculated under the assumption, that contaminated water leaving the confining rock zone (at some 100 meters depth) would directly go into a well which would provide for the whole water consumption of the individual under consideration. The yardstick was defined as 0,1 mSv per year.

In the ensuing discussion, this attempt to reduce uncertainties (approach (ii)) was hardly ever mentioned, as the reasons for this shift in arguing became not obvious to most of the actors. However, severe criticism was expressed concerning the risk values to be applied for approach (i). As a German daily newspaper has put it: “By this, many additional fatalities by cancer caused by a repository are possible, since the radioactivity released from underground might spread over large areas with thousands of inhabitants. Once initiated, the release might span over tens of thousands of years and would affect many future generations. After all, highly radioactive waste will remain hazardous for one million years.” (TAZ 2009, “Cancer and atomic waste repositories. Every thousandth individual may fall ill”, translation by the authors of this paper).

For radioactive waste specialists, indicators such as risk are embedded in a technical context which is often (as in the BMU draft) not explicitly stated. Selected aspects of this context are discussed below:

1. The requirement to meet numerical (e.g. risk) criteria is seen by specialists as just one amongst multiple lines of reasoning to be made in a safety case. The BMU draft spent only

one or two of its 25 pages on the requirement mentioned above. Nevertheless, discussions with decision makers, media, or other concerned laypersons tend to focus on numerical criteria. This was also the case when the draft safety requirements (BMU 2008) were discussed: The discussion was mostly restricted to three issues, two of which were directly related to the risk criterion: It was questioned whether or not the use of a risk criterion in itself was appropriate and whether or not the choice of the numerical values was appropriate. (The third issue, and the only one not related to numerical criteria, was about a retrievability requirement imposed in the draft).

2. Perhaps this misunderstanding on the role and importance of numerical criteria is caused by the perception that they are the only "hard" or "verifiable" safety requirements. Experts from the safety case community have a different view. Their calculation (or rather estimation) of risk (or dose) values in the far future has to rely on assumptions concerning the future evolution and states of the hydrological system as well as on pathways in the biosphere, food chains, exposure modes, nutrition habits etc. Especially the latter can hardly be predicted over timeframes exceeding a couple of years or, at the most, decades. Models for estimating dose or risk are based on "stylised assumptions" concerning these issues, against the choice of which they are often quite sensitive. Therefore, "... dose estimates should not be regarded as measures of health detriment beyond times of around several hundreds of years into the future. Rather, they represent indicators of the protection afforded by the disposal system" (ICRP 2007). BMU's approach (ii) described above aimed at circumventing the uncertainties associated with hydrogeological and biosphere models reaching into the far future. But while this approach with its merits and problems is until today extensively discussed by German experts, other audiences take hardly notice of the underlying general idea.
3. The stylised assumptions mentioned above aim at conservative estimates of radiological consequences. Therefore, they will often include variants in which as many as possible of the contaminants released to the environment are assumed to contribute to the exposure of only a few, but "highly" exposed individuals (e.g. self-sustained farmer models). The dose or risk yardsticks will then be compared to these exposure estimates. If they are met, it is likely (but admittedly not guaranteed) that other models in which the contaminants are more diluted and hypothetically expose "thousands of inhabitants" (TAZ 2009) would lead to much lower risk estimates.
4. The dose values equivalent to the risk target (effective lifetime doses of 1.8 mSv or 18 mSv) are by far lower (1.8 mSv) or in the order of magnitude of (18 mSv) the variability of exposition from natural background radiation. Epidemic evidence for deriving a dose-risk relationship for such low dose values is poor, by some it is even questioned whether such a relationship exists. Although – as recommended by ICRP - a linear dose-risk relationship is assumed as a basis for rulemaking, many specialists will probably not translate such dose values into a number of *actual* cancer cases but rather simply qualify them as "tolerable". Such an "experts' attitude" is also supported by their awareness that other (radiological and non-radiological) risks people are exposed to in daily life are often higher (and sometimes considerably higher). And if an expert does not think about *actual* cancer cases, he/she is not likely to change this attitude just because the timespan of concern is long.

As a consequence, the attitude of a radioactive waste specialist and his/her perception of the BMU risk criterion will be considerably different from the one expressed in (TAZ 2009). Specialists might even believe that risk indicators are better suitable for communication with non-specialists than dose indicators, because they can be compared to (known) risks of daily life, e.g. of traffic accidents. The newspaper article quoted above is an indication that this perception might be awfully wrong, and that much more care and skill is needed when communicating safety assessment results to non-specialists. One might even speculate that a severe criticism as described above had never been voiced if the BMU draft had used the dose criteria equivalent to the risk values from the beginning.

Responding to discussions in political bodies, with stakeholders, and with concerned laypersons, BMU revised its draft safety requirements. In the final version (BMU 2010), the risk values mentioned under (i) above were replaced by criteria for annual effective dose (10 μSv for likely and 0.1 mSv for less likely evolutions). In order to address concerns about contaminants affecting numerous people and despite of the concerns expressed by many specialists (e.g. ICRP) about the use (or rather uselessness) of collective dose in long-term safety assessment, BMU decided to use an indicator based on the concept of annual collective dose for limiting the releases from the confining rock zone (i.e. for approach (ii) from above) – the criteria are 0.1 person-mSv per year for likely and 1 person-mSv per year for less likely potential evolutions (scenarios).

This illustrates how differently indicators can be perceived by different audiences: While the specialists were focused on avoiding modelling uncertainties by introducing the alternative criterion (ii) and had no concern at all about the sufficiency of the "traditional" criterion named under (i), other audiences were totally "ignorant" of this aspect and instead emphasized on their misinterpretation of the meaning of the indicators (conditional risk or annual effective dose), especially for low dose values.

More questions can be asked about the relevance of different indicators:

Dose versus risk: It is often claimed that risk indicators are more suitable for communication compared to dose indicators since their values can be compared to other risks of daily life. On the other hand, risk values are entities which aggregate many different types of information: dose (by itself being an indicator), dose-risk relationship, and likelihood of occurrence. Is that too much information, given that already dose is an entity with a high degree of aggregation (release, migration, radionuclide uptake / exposure modes, radiology) and is therefore hard to understand? Which is indeed "better" for which audience? Does the example from above indicate that, on the contrary, risk indicators should be used and communicated with the same care as dose indicators?

It should also be noted that the "daily use" of the risk concept in other businesses (e.g. about traffic accidents) implies that some people indeed will be killed – but society accepts this since it is a small percentage of the total number of people concerned (e.g. by travelling by car). This is a concept different to disposal: There is just one facility to be constructed, the number of people belonging to a potentially exposed group remains small (at least if one point in time is considered – cf. above), and calculated risk figures multiplied by this number of people might result in a figure much smaller than 1 – which means that, provided that there is no risk dilution, most likely nobody is going to be killed (not to speak about the unclear dose-consequence relationship for small doses). What does this tell us about the risk indicator as a means of communication?

Values (or otherwise) of flux-related indicators: Do "flux-related" indicators in general convey the message intended? After all, disposal is about containment, not about release. Calculating releases might therefore be amenable to misunderstanding, especially since it is difficult to communicate that the calculated releases are "negligible". Wider audiences might either not know that there is such a thing like "negligible release", or they might disagree.

Confidence: More generally, the question arises about the confidence different audiences have into the safety assessment calculations. Such calculations do not forecast the future, rather, they are meant to demonstrate that uncertainties can be bound and containment will be achieved with a high degree of confidence. They are based on many assumptions (about scenarios, physico-chemical processes etc.) which have to be supported by different lines of evidence, tested against alternative assumptions etc. Usually, the modeller does not "believe" in the exact figures he/she produces, but nevertheless gains confidence ("Models are about insight, not about numbers.") The challenge is to organize the timeconsuming substantial debate with the interested public, independent experts, responsible authorities and stakeholders about the tracing pickets of orientation, generated by every professional safety case. What is the minimum of messages to be translated to, and discussed with, the general public?

Multiple lines of evidence in a safety case: The confidence issue explained above is one of the reasons for having created the modern concept of a safety case, in which assessment calculations form one of several lines of evidence. Which of these other lines of evidence (lab or field results, technical and natural analogues, in situ information e.g. about groundwater ages, engineering framework, quality assurance, verbal description of the safety concept, …) are helpful and understandable, which are more or less not?

Passive safety: Amongst specialists, the concept of passive safety (no reliance on active safety measures such as monitoring, surveillance, refurbishment) is considered as a strength of geologic disposal, amongst non-specialists this is not necessarily the case – many of them have more confidence in active measures. Can there something done about this inconsistency? Is it helpful to deviate from the idea of "definitiveness", like it is discussed in Switzerland?

Addressing uncertainties: Modern safety cases are about creating confidence by multiple lines of evidence. But they are also about systematically compiling and analysing uncertainties and open issues in order to derive strategies for addressing these issues. In fact, messages concerning the latter are main drivers of a disposal programme. Apparently, uncertainties have also the potential for miscommunication: If they are not well visible, perceptions like "these folks are over-confident" or even "they want to betray us" might be the result; if they are too much pronounced, perceptions like "decades of research, and these amateurs still know nothing" are possible (the authors already experienced both). What can be done about that?

In summary, and more generally, the following three questions can be asked about any kind of information documented in a safety case:

1. Is it understandable, or, in other words, does it carry across the same information for different people?
2. Is it considered relevant?
3. Is the information credible for different audiences? To what extent does its credibility depend on the trust in those who generate it (mostly waste management organizations)?

4. Is there a chance for professional concepts?

Especially the international discussion gives some important hints for concepts of professional communication about safety case concepts and the results of modern safety cases, which integrate social problems of nuclear waste management in their design.

It is generally agreed that a safety case documentation should be structured hierarchically. The French Dossier 2005 (Andra 2006) established a sophisticated example for doing so by establishing five levels of documentation:

1. A leaflet of four pages aimed at the general public,
   a brochure (38 pages) for concerned laypersons,
   a synthesis report (about 200 pages) for decision makers;
2. Three synthesizing and transversal reports (on architecture and management, phenomenology, and safety assessment, each between 500 and 700 pages)
3. Five "knowledge reports" on different issues (e.g. material sciences, geosciences, etc., each between 500 and 1000 pages)

4. 72 technical documents (some dozen – some 100 pages)
5. Several informal documents, articles in scientific journals etc.

From level 2 on downwards, the intended audience becomes increasingly specialized. For these "specialists", as well as for generalists trying to trace a certain information ("where does this sorption value come from?") traceability is paramount, and the way of distributing the available information amongst the different documents follows scientific standards and standards of "public understanding of science". The most interesting issue for our problem of communicating safety case results is, however, level 1: Which type of information has to be presented in which document and in which formats, all aimed at three different groups: interested public, concerned laypersons, and decision makers? How has this information to be presented? Furthermore, and going beyond issues connected with written documentation, the question arises about opportunities and challenges related to other media (mass media, world wide web, social media). How can consistency with the written documentation and related messages be ensured?

Nevertheless, the safety case framework which allows presenting different types of evidence in different formats opens possibilities for communicating safety-relevant messages to different audiences. However, it has to be ensured that these messages are consistent with each other (there is only one safety case at a time) and they are perceived in a consistent way. The central aspect is that the results and arguments coming from safety case analyses have to be accompanied by more (rather than less) intensive communication with the interested public and stakeholders over time. In our perspective the safety case tool in general is an analytical instrument for foresight and has an integrative and central function within the licensing procedure. But on the other hand the instrument also has its limits. As every case of foresight it is a professional assessment. It is based, *inter alia*, on science, engineering, and modelling, and from interdisciplinary risk research we know that "numbers" give orientation, but real-time processes and experiences on actual sites will have their own logic if the facility is once constructed. As so far no actual experience with high-level waste repositories has been made and decisions have to be taken now, all need a qualified dialogue about tools for gaining orientation and sufficient confidence (and by all its limits esp. as it is foresight), the professional quality of an assessment of this type has to be debated and the limits of this tool have to be documented. If decision-making is blocked over time, this non-decision is also a decision with often extremely negative side-effects. Lost resources (intellectual and financial), or, even more importantly, loss of safety and security of prolonged waste interim storage, can be such a type of side-effect.

5. Lessons for the real-time experiment

- The public is a highly relevant subsystem in the processes of technological and societal innovation esp. in cases like waste management. It is the third anchor beside polity and economy in the case of nuclear waste.
- Following the German sociologist Max Weber with his trias of polity, economy and culture we have to reflect, that the sense ("Sinnhaftigkeit") of collective action within these different systems influences the struggle for the correct solution for our specific type of waste as one type of high-problematic waste. As culture is on the one hand not only structured by one abstract and general binding rationality, but also by functionally differentiated sciences and their disciplines with their own systematic sub-rationalities, societal consensus and respect for different positions can be gained through dialogue. On the other hands forms of societal self-organization and constructive debate stabilize culture and form the bottom of society. All these forms of aggregation and organization by science and social self-organization offer a specific knowledge output. Mobilizing local citizenship initiatives, pre-political national

and/or sub-cultural networks or extra-parliamentary protest groups (or as an aggregated form social movements like the anti-nuke-movement) over time became part of these cultural networks and by this with their own knowledge and expertise part of the complexity of the problem, which has to be managed by radioactive waste actors. Culture in current modern societies (as a fact) is highly differentiated, structured by strong cleavages and enforced by a wide range of value patterns and stabilized by more or less closed and often technology based forms of (experts' and sometimes mass) communication.

- In this complex field of culture with its often more or less small integrating networks, four types of public are relevant to our safety case issues. These types of public have to be discussed separately: (1) *experts and scientists* (with their forms of institutionalization like universities and disciplinary associations), (2) *laypersons*, (3) *political public sphere*, (4) *mass media*.
- Experts and Scientists: In the last four decades nuclear waste management became a more and more institutionalized field of expertise with strong links to the power industry. Some authorities like civil protection authorities ("Schutzbehörden"), such as federal offices for radiological protection and departments of environmental ministries, and their private partners, which were hired continuously as consultants and service providers, were strongly connected with this field of expertise – one form of expertise, which was for a long time dominated by engineers and natural scientists. Often like a closed shop they were developing engineering and safety related research and developed solutions for the nuclear waste problem with a wide range of different characteristics. Their research was and is highly elaborated and in most cases structured by a limited number of dominant mainstream positions. Esp. in countries with stronger anti-nuclear opposition a subsector of counter experts has developed and been established over the decades and sometimes integrated in research and consultation. Often these counter experts founded small institutes with service units for environmental planning and consultation. Like the German Oeko-Institute (Freiburg/Darmstadt), they can be integrated in the national discussion about safety case development. Despite all difference in access to resources the level of expertise and quality of consultation is very near or in many cases on the same level like the traditional, well-established communities of nuclear scientists.
- Laypersons – and this is not surprising - in most cases are far away from these discourses, research and reflections; their level of knowledge of site specific safety aspects and the progress of nuclear waste management in this field is not very developed, as for example Eurobarometer data show for most European countries (Eurobarometer 2010, Eurobarometer 2005). The question is, which type of sorting indicators along the line "positive for public communication" / "challenging for public communication" can be more helpful for societal impact, i.e. showing the robust results of safety case studies. The question can only be answered by estimating in a rough way, as basic research and systematic empirical work on high-level standards is not available (see OECD/NEA 2012b: 70). Specific indicators like radiotoxicity concentration in groundwater or flux related indicators seem to be more helpful in public communication, as the lay people, at which communication is aimed, can have an idea about the context. But a very specific indicator generates information - indicators, which generate information by means of highly abstract numerical models rely on academic codes of communications and often the scepticism with this type of abstract information, where numbers are relative measures in complex systems, is too bulky. Following the suggestions to offer results from safety case analysis in practical examples (for local contexts or impact significance) and in the context of two way communication makes sense (see the instructive example in OECD/NEA 2012b: 55). On the other hand, from German experience it must be expected that there is a sometimes erratic "learning curve": Every communication in this sense generates new questions, which do not necessarily account for the messages learnt from the constraints that already were accepted when answering the previous question. Laypersons are

in many cases wise and headstrong enough to ask for unexpected futures or expositions in certain socio-economic situations, which are only interesting in an abstract way. They do this not for irrational reasons, they often have the wisdom to detect aspects which are really challenging also for the best experts in fields like nuclear waste (Wynne 1996).

- The political public differs enormously from country to country. This depends on collective experiences with civil nuclear energy and in some cases also with military interests. In Germany, the highly polarized conflict in party politics and society over more than three decades and the muddling through strategy by responsible governmental organizations (see Hocke / Renn 2009: 930) resulted in the fact that safety politics are also a field which follows a strategy of defense and/or scandalizing. The question of political majorities on state or national level seem to constantly dominate public discourse, mostly run by communication channels of (new and old) media. Professional expertise using numerical tools for assessing safety by indicators for specific contexts (like here waste disposal) are very likely to be important in spatial planning and licensing processes, as they fit to the general aims of planning and licensing on the base of safety standards. These procedures of planning and licensing have to be embedded in "robust" political decisions. But interest aggregation and the development of a very small number of alternative safety concepts do not seem to be issues fitting to the discourse of political profiling and gaining advantages in election campaigns, which are the precondition for political consensus on basic assumptions necessary for preparing robust decisions.
- Mass media (old ones like quality press, television or new like blogs and other social media) are important for connecting the individual members of a complex and differentiated society, esp. modern society with its high rate of "individualization" and "pluralisation". But their forms of selection modes are structured along a small group of news factors. Following the discussion and robust results from communication research there is no chance or only a very limited chance to get a reflected description of safety case research and communicating safety case results by mass media. News factors like "conflict", "crime" and "scandal" steers the selection of mass media coverage more than the relevance for technological policy (Eilders 2006). Under certain conditions mass media discourse offers the chance of strengthening convincing arguments (Böschen 2010: 118),

What is the conclusion of this analysis for safety case experts? One central message is that safety case experts have to be prepared for complex debates with very different groups of society. In these discussions their main duty will be to explain the complex safety case models as a professional assessment and method of foresight. This includes to be prepared to explain the sense of single indicators and the limitations of complex models on one hand, as well as the undeniable advantage of this type of safety calculations and safety assessment on the other. Honesty, especially about (yet) unresolved issues is strictly necessary, but has to go along with skilled communication about the reasons for the existence of such issues (despite of decades of repository research), their significance e.g. for safety (or otherwise), and perspectives to resolve them in the future (or otherwise). The necessity of being prepared for ongoing processes and often repeating translations of scientific knowledge in other types of knowledge, which can be understood by well-informed engaged academics with an open interest and other social groups, over time, will be one central task during the coming years and decades. For research, it is an open question whether communication about safety case issues can widen up the horizon of the respective national debate in countries developing nuclear repositories in a way that the two analytically challenging questions of, first, how to foresight evolutions of the disposal system and, second, how to find confidence in evaluation procedures become more important in siting and implementing than regional competition and dissent between political parties. Every collective decision taken by the current generation will be a decision accompanied by a number of uncertainties and will also be taken under conditions of uncertainty.

Political culture has to manage dissent on one hand and conflict and dialogue between different groups and stakeholder is a central tool in civilized societies to find robust and legitimate solutions.

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