The participatory turn in radioactive waste management: Deliberation and the social-technical divide

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National policies for long-term management of radioactive waste have for decades been driven by technical experts. The pursuit of these technocratic policies led in many countries to conflict with affected communities. Since the late 1990s, however, there has been a turn to more participatory approaches. This participatory turn reflects widespread acknowledgement in the discourse of policy actors and implementing organisations of the importance of social aspects of radioactive waste management and the need to involve citizens and their representatives in the process. This appears to be an important move towards democratisation of this particular field of technological decision making but, despite these developments, technical aspects are still most often brought into the public arena only after technical experts have defined the 'problem' and decided upon a 'solution'. This maintains a notional divide between the treatment of technical and social aspects of radioactive waste management and raises pressing questions about the kind of choice affected communities are given if they are not able to debate fully the technical options. The article aims to contribute to better understanding and addressing this situation by exploring the complex entanglement of the social and the technical in radioactive waste management policy and practice, analysing the contingent configurations that emerge as *sociotechnical combinations*. Drawing upon empirical examples from four countries that have taken the participatory turn - Belgium, Slovenia, Sweden and the United Kingdom – the article describes the different ways in which sociotechnical combinations have been constructed, and discusses their implications for future practice.

Keywords: public participation; sociotechnical combinations; radioactive waste management; Belgium; Slovenia; Sweden; United Kingdom

Introduction

The aim of this article is to examine critically the burgeoning practice of stakeholder engagement in radioactive waste management (RWM). This apparent turn away from technocratic decision making calls for closer scrutiny. In particular we focus on the way

in which the relationship between the technical and the social strands of RWM is constructed in different contexts, and explore the consequences of these different configurations. To do so, we examine developments in Belgium, Slovenia, Sweden and the United Kingdom, drawing on the findings and collected data of two collaborative research projects.[1] Both projects employed qualitative research methods, and gathered data through document analysis, interviews with concerned actors and key players, and group discussions between engaged participants from different countries that took place during several workshops held over the course of the projects.

Since the early 1970s efforts to investigate potential sites for the final disposal of radioactive waste have in most Western countries encountered strong local opposition; opposition that in many cases continues to this day. By the mid-1990s, mishandling of the nuclear waste problem and in particular of national repository siting programmes had resulted in an impasse in many countries. This was particularly the case for high-level waste (HLW) and spent nuclear fuel (SNF), with notable examples including the lasting controversies around the Yucca Mountain repository project in the USA and the Gorleben project in Germany (Strandberg and Andrén 2011). The picture for low and intermediate level waste (LILW), for which many countries had operational repositories by the end of the 20th century, has also been problematic as siting new facilities has also been controversial in countries such as Belgium and Slovenia, which only started their

[1] CARL (2004-2007) was a comparative social sciences research project co-sponsored by the national RWM agencies of the participating countries and by regulators and two concerned municipalities from Sweden, and involving citizen stakeholder groups from all four countries (Bergmans et al. 2008). InSOTEC (2011-2014) was a collaborative social sciences research project funded by European Atomic Energy Community's 7th Framework Programme FP7/2007-2011 under grant agreement n°2699009 (see www.insotec.eu).

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siting efforts at the beginning of the 1990s (Bergmans 2008; Kos, Polič and Železnik 2011).

This resistance has very often been regarded by waste managers, nuclear proponents and policy makers as a 'NIMBY' (Not In My Back Yard) reaction, with all of the attendant negative value judgements. However, as many researchers have now pointed out, such responses should not be interpreted simply as expressing selfish self-interest or irrational fear arising from ignorance, but that people often have good reasons for not wanting to live in the vicinity of a radioactive waste repository (Kemp 1990; Lidskog and Elander 1992). Negative responses in potential host communities have been linked to responsible agencies' neglect of the 'social aspects' of the waste problem, but also to differences in views on the need for and importance of the proposed disposal technology (Bergmans et al. 2008). Controversy has led in several countries, notable among them Sweden and Belgium, to a participatory turn in RWM strategy, one that other nations facing similar problems have subsequently sought to emulate (Elam and Sundqvist 2007, 2009).

But what is meant by this participatory turn? Our starting point is that public participation processes in relation to controversial technology in general and RWM in particular are not well understood, either in practice or in social science research. On the one hand, participation is often understood as something good in itself, without discussing what participation should be about (Irwin 2006; Jasanoff 2003; Marres 2007). On the other hand it is often viewed as a strategy for political manipulation and the exercise of power (Durant and Fuji Johnson 2009); for example, it has been argued that the participatory turn in RWM has merely been about moving the debate away from the national political arena in order to single out potential host communities and cultivate highly localised support for a putative solution to a problem with national and

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even international dimensions (Hunold 2002; Blowers and Sundqvist 2010). In this article, however, beginning from a position informed by actor-network theory, which takes a symmetrical approach to the associations between human and material elements that make up the world, we suggest that the participatory turn can also be about coming to recognise the *entanglement* between the dimensions of the problem presented as being distinctively technical or social, and about searching for ways of addressing this (Barthe 2009). Rip, conceptualising entanglement as 'associations that last longer than the interactions that formed them' (after Callon and Latour 1981, 283), elaborates by noting how the dynamics of such interactions 'get *entangled* so that patterns (in processes) and "structures" emerge [which] then enable and constrain further actions and interactions' (Rip 2010, 381, emphasis in the original). Importantly he also observes that although the entanglements that emerge are a very contingent outcome of these interactions, the resulting patterns and structures can assume a long-term stability that becomes taken-for-granted and resistant to change; furthermore, he argues, despite the interdependencies which are formed, such long-term configurations can be characterised by conflict as much as by cooperation or consensus. The participatory turn may be seen as being an attempt to reconfigure just such antagonistically entangled associations between citizens, agencies and radioactive waste. However, as we shall see, the new configurations that are in turn produced are not without their problems.

In what follows we argue, therefore, that wider participation in RWM should be not only about addressing social aspects – such as public information, trust and acceptance – but also about how social aspects are connected to technical aspects in what we call *sociotechnical combinations*. As Rip's description of the dynamic nature of entanglement suggests, despite all being associated with RWM, such combinations may assume a variety of configurations; examples of these are explored by examining

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developments in the four countries, and the consequences of each particular combination are critically assessed.

First of all, however, in the next section we set the participatory turn in RWM in context with reference to research on participation processes in general, and continue in the third section with some theoretically-informed ideas on sociotechnical combinations. In the fourth section we present examples of how the participatory turn has been configured in the four nations included in our study, and in the following fifth section we analyse issues raised by these different sociotechnical combinations. The sixth and final section offers brief conclusions about the implications and prospects of our approach.

The participatory turn

Over the last decade of the 20th century, a change could be observed in framing the radioactive waste problem, from a technical problem, investigating possible solutions, to a controversial social problem in need of acceptance and legitimacy.[2] This seems to have led to a change in policy arrangements for regulating, planning and implementing RWM. Particularly with regard to siting repository facilities, we have witnessed across the European Union (EU) a shift from a purely technical approach to one that includes stakeholders and the public in the decision making process and aims to integrate, to a bigger or lesser extent, the technical with the social. These initiatives must be seen as responses to public criticism of existing top-down approaches and what could be called

[2] This change took place in parallel to international moves to reframe and rehabilitate nuclear energy by recontextualising it as (part of) the solution to the treats of climate change and energy insecurity (Bickerstaff et al. 2008).

the technocratic failure of RWM. New siting programmes have been set up and involvement of at least concerned local citizens is an important part of these initiatives (Landström and Bergmans 2012).

Three main benefits have for a long time been associated with widening participation in decision making on controversial risk issues: (a) increased legitimacy of decision outcomes; (b) better decisions as a result of enhancing the knowledge base; (c) the securing of democratic values and creation of 'true democratic citizenship' – instead of alienating concerned publics from decision making that affects them in their daily lives (Fiorino 1990; Renn, Webler and Wiedemann 1995; Stern and Fineberg 1996). It has furthermore been argued that participation could contribute to a reduction of vulnerability to risk by enhancing citizens' competences for dealing with technological, organizational, cultural, societal and other components of risks (Pearce 2005; O'Brien 2000).

Many researchers studying citizen and stakeholder participation have tended to focus on the fairness and effectiveness of the process, asking, for example, who has access and how the relationships of the actors are shaped by power and trust. More recent studies have shifted the focus of attention to ask what participation is *about* (Irwin 2006). This can be traced through empirical studies addressing issues such as: why do we need this technology, how could it be modified, who will pay the costs, and how are risks distributed? (Jasanoff 2003; Stirling 2005; Wynne 2003)

This shift in focus is important since engagement then becomes not only about possibilities to participate, but also about determining which issues to deliberate upon (Marres 2007; Sundqvist and Elam 2010). Careful scrutiny of the framing of the problem, including the technology itself – what it is, the public meaning of it, and what

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risks are involved – therefore becomes fundamental to any analysis of participatory processes. Rather than simply greeting developments involving greater participation as examples of 'good practice', therefore, we need to examine carefully how issues are framed and identified by the actors involved, and what connections between the social and technological aspects of the problem are deliberated upon. We therefore agree that there is need for more sceptical and critical examination of the 'new' mode of governance, rather than a naïve defence of the participatory turn (Cooke and Kothari 2001; Irwin 2006; Collins and Evans 2007, Kaiser 2012), a stance which is endorsed by reports of disillusionment with participation and the emergence of 'participation fatigue' in some of the cases analysed here (e.g. Polič, Kos, and Železnick 2006).

In this paper, we will therefore examine more closely what exactly is taking place within these new configurations in RWM, not merely in terms of the social processes of participation and decision making, but also crucially in terms of how these processes mediate the relationship between the social and technical aspects of the problem. While a participatory turn in RWM would appear to be making steady progress, and recognition of the importance of social aspects of RWM in the EU is practically universal (see e.g. NEA 2010), one cannot but notice that the long-standing consensus within the international community of nuclear experts on geological isolation being the best available technique and the only solution that can be envisaged for disposing of any type of high-level and long-lived waste has survived the change of management procedures. Various authors have therefore argued that many of these participatory initiatives are mainly driven by a need to secure legitimacy and increase acceptance for already technologically agreed solutions (Durant and Fuji Johnson 2009; Blowers and Sundqvist 2010).

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In order to take the next step we therefore need to present some ideas on how to understand sociotechnical combinations.

Sociotechnical combinations: separation and integration

Governing any technology, particularly controversial technology such as nuclear power, is a task that is simultaneously technical and social. While often presented as purely technical, in these processes we never find 'pure' technical or 'pure' social factors. We should therefore look at these processes and technologies as hybrid 'sociotechnical combinations' (Latour 1993).

In actor-network theory (ANT), one of the liveliest theoretical traditions within the academic field of science and technology studies (STS), the ambition is to dissolve, or at least be agnostic to, the separation between technical and social aspects. Therefore, ANT studies sociotechnical combinations in the making, addressing social and technical factors as entangled in a development process where no one has priority (Callon 2009). What is usually called technological innovation also includes innovation of identities, social roles, decision making processes, and institutions that are adapted to the technological object. What goes on in such an innovation process is mutual adaptation between many factors gathered together in one and the same process. But why is it so difficult to overcome the urge for separation, just as much for social scientists studying participatory processes, as it is for scientists and engineers discussing 'their' technological projects in public?

Latour (1993) attributes this need for separation to modernization and the tendency for specialization in modern societies, a reasoning we also find with authors stressing the functional differentiation of society and the subsequent difficulty of communication between different social systems (Luhmann 1982). However, Latour

argues that in spite of this tendency for separation, it is often difficult to achieve in practice, because things tend to be more blurred, resulting almost inevitably in various degrees of integration (Latour 1993). When studying entangled sociotechnical combinations it is therefore useful to distinguish between *separation* and *integration* as two *framings* that inform the approaches taken by actors.

From the perspective of *separation* the issue at stake is framed and treated as if there is a clear boundary between social and technical factors. According to Latour separation is a means of simplification, of trying to get a grip on a complex and intertwined reality (Latour 1993). From this perspective, the kind of accepted involvement of non-experts in decision making on 'technical' issues is after the fact, instrumental and about increasing legitimacy and creating trust. This frame constructs a situation where an apparently 'ready-made' technology is to be implemented. Conflicts and negative attitudes around technological projects, framed as 'pure' technical activities, are understood as part of the context and identified as something outside of the project. This does not mean that so-called social aspects are considered less important or ignored, but they are seen as less manageable: such social factors are typically framed as external obstacles or barriers that can block technical activities for a long time and even terminate them (Kos 1999).

It is worth noting that separation as a frame is also found among 'social' actors, such as politicians and citizens, and, as argued above, among social scientists studying the participatory turn in connection to controversial technology. These usually focus on social factors, such as participation, legitimacy and decision making. From the perspective of STS, and not least ANT, a separation framing is never telling the full story while it hides the necessary existing connections always taking place between divided actors and activities, designated as being distinctly 'technical' or 'social': there

is no separation without integration. Nevertheless, as already noted, separation is a common strategy used by actors in a modern society in order to present their activities as having clear boundaries and as being independent of extraneous influences.

The frame of *integratio*n presents the social and technical aspects as being co-produced, i.e. that they are shaping each other through an interdependent process. Such co-production means that social aspects influence technical projects, while a technical project simultaneously supports and justifies the corresponding social project. Developing a technical project also means shaping society (Bijker and Law 1992; Callon and Law 1982; Jasanoff 2004). This framing means, therefore, that the actors involved do not behave as if they belong to two distinct spheres or phases. Technical experts are part of a social project, that influences their work, and political representatives, environmental organisations and citizens make claims that are not only emotional or socioeconomic, but based on technical details as well as opinions on what the technical project is all about. Within this integrative type of combination, lay knowledge is neither treated as being of secondary interest nor does it stand apart from technical knowledge production. Thus what had been framed as 'context' is reframed as 'content' (Wynne 2003, 410).

Latour and others argue that entanglement is what happens in practice. Both separation and integration are ways of responding to this entanglement. As a consequence we see hybrid forms of governance systems emerging, using different ways of dealing with entanglements – recognising them, dividing and sorting them out – in order to find a solution to the problem of governing controversial technology. Separation may not even be intrinsically problematic if there is acknowledgement that it is a simplification and awareness of the more complex entanglements existing behind it. On the other hand, for integration to be more than a rhetorical framing by powerful

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actors aiming to achieve legitimacy, it must allow lay people's contribution to be as much about framing the issue as about, for example, enriching expert knowledge. From an STS perspective, therefore, it is of great importance to examine not only the frames that are employed but also to how these are enacted, investigating how, if integration is claimed, actors are *recognising* this or, if integration is not claimed, how activities are presented as being of a separated kind.

In the following two sections we will address in more detail how social aspects are framed and understood, and how they are related to the technical aspects in national activities dealing with radioactive waste, by examining approaches to governance in Belgium, Slovenia, Sweden and the United Kingdom, and the ways in which participation and the prevalent sociotechnical divide figure in these approaches.

In doing this we will use the notions of separation and integration as two different ways of framing the complex and entangled relationships between the technical and the social. We will follow in the footsteps of the actors in the four countries to see how they deal with the relationship, to see the specific configurations that result, and to explore the variations in how these sociotechnical combinations are constructed, understood and presented.

Sociotechnical combinations: four national examples

After the failure of a technocratic top-down approach, which happened at different times in the four countries described below, it looked as if consensus emerged around the shortcomings of a technically-driven siting process. Both implementers and opinion groups apparently agreed that the agencies responsible had been focused only on technical issues and had not paid enough attention to social aspects. Therefore, programmes were reset on a new 'participatory' basis, with due attention paid to

societal interests and concerns and, by implication at least, with the possibility that technical criteria could be adapted in some way to social factors. In the following description we focus on how and when shifts to more participatory approaches occurred in Belgium, Slovenia, Sweden and the United Kingdom. We consider these shifts as formative periods and therefore do not give full historical descriptions of RWM in the four countries. Instead we explore how social aspects are incorporated in these 'technical' programmes understood in new ways, and analyse the sociotechnical combinations configured through these shifts and formative periods. In this we focus on specific mechanisms developed for dealing with the entanglement of the social and the technical.

Before describing these four cases, it would be appropriate to outline the reasons that they were chosen as the focus of the research and of the analysis presented here. Firstly, there was what we might call a criterion of similarity: all of these countries shared the essential characteristic of having seen a marked participatory turn in radioactive waste management policy, developing an approach to siting that gave communities a voice in the process but that also came to focus on communities hosting existing nuclear facilities. Secondly, a criterion of diversity: in each country there were significant differences in the national context, in the way that participation took place and in the ways that the prevalent divide between the treatment of the social and the technical was dealt with. The process in each of these countries has also at some time been viewed from outside as being in some respect exemplary. The additional fact that they have all participated in several European research projects on radioactive waste and societal governance issues also signals a sustained interest in the social aspects of nuclear waste among waste management agencies, engaged community stakeholders and social scientists in each of these countries. Taking all of these characteristics into account,

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these four countries represent particularly rich cases through which to explore the production of and variation in sociotechnical configurations.

Turning now to our cases, we start in Sweden, where the shift from technocracy to a more inclusive strategy in radioactive waste management first took place.

Sweden

Based on the key word of voluntarism, the new mechanism for integrating social and technical issues launched in 1992 by Sweden's RWM company, the Swedish Fuel and Waste Management Company – SKB, soon turned into a success (Sundqvist 2002; Elam and Sundqvist 2007). This mechanism was called 'feasibility studies' and by a stepwise process municipalities were invited to define themselves, on a voluntary basis, as possible stakeholders in the process of siting spent nuclear fuel. The SKB strategy made clear that social factors were of interest to the municipalities and that they had to decide about these by themselves, independently of SKB and the technical knowledge of the company. The municipalities should decide on their own whether to take part in a feasibility study, and after the completion of the study once again decide whether or not to continue with more detailed studies of bedrock conditions. This meant a clear division of labour between SKB and the municipality, and also a separation between technical and social issues. While municipalities discuss social factors – such as possible socioeconomic benefits and risks for achieving a social stigma – SKB evaluates technical facts and the geological potential of the municipality. Both SKB and the municipalities appear to be of the opinion that guaranteeing safety is not something to be left to local politicians or ordinary citizens, and therefore they should not be expected to offer opinions about bedrock conditions and long-term safety (Elam and Sundqvist 2007).

During the period of nine years (1992-2001) feasibility studies were conducted in eight municipalities leading to a selection of two sites, Oskarshamn and Östhammar, for more detailed investigations including extended bedrock drillings. These later studies were ended in 2007 and in March 2011 SKB applied to the government authorities for permission to start construction work for a final repository of spent nuclear fuel in the municipality of Östhammar, 150 km northeast of Stockholm, which already hosts three nuclear reactors and the final repository for low- and intermediate radioactive waste. The new voluntary approach launched in 1992 has positioned SKB in a world-leading situation of having municipalities competing for hosting a repository for spent nuclear fuel and finally selecting one of these as the final site.

Slovenia

A new start of the siting process in Slovenia began in 1996 when a so-called 'mixed mode' site selection process was set up by the public waste agency, ARAO – Agency for Radioactive Waste Management. This process concerned site selection and planning of a repository for low and intermediate level waste.[3] The mixed mode approach gives local municipalities a clear and crucial role in the siting process (Polič, Kos, and Železnik 2013) . On the other hand, participation is not about being involved in technical work, but about being informed on these activities and reacting to what is presented by the experts. This approach is similar to the Swedish feasibility studies and

[3] At the time – and even today – the repository for HLW was not yet considered. There are governmental documents dealing with this problem but no real activities. The reason for this is that national disposal of the relatively small quantity of HLW produced in Slovenia is not considered rational. This attitude could be summarized as: HLW is "too big a problem to fail", while Slovenian HLW production is "too small to act".

means a separation of technical and social issues, where local participation is about accepting or rejecting ready-made technology.

After some rounds of negotiations between municipalities, responding to a siting bid, and ARAO, the number of potential hosts shrank from ten to three. Later only two localities remained in the game – two municipalities which for more than twenty years have been hosting Slovenia's only nuclear power plant.[4] In these municipalities local partnerships were established, initially designed following the Belgian example (see below), which added a mechanism for organizing actors in relation to the mixed mode approach. The purpose of this participative institutional framework was to enable integral, integrated and equal dialogue between all involved groups. Local partnerships were evidently designed to re-establish trust and communication between interest groups with particular regard to bringing closer social and technical views on the repository. But as evaluation of the established local partnerships confirmed, the intended integration of the social and the technical failed (Korže, Plut, and Jesenšek 2008). The new attempt to work towards an integral sociotechnical solution was very much 'path dependent', i.e. driven by a historical socio-political legacy. Therefore, the local partnership did not eliminate the competition to control discourse on the nuclear repository. Dichotomies like social versus technical experts, politics versus civil society institutions (NGO), local versus national interest groups persisted, with informal political networks linking local and national actors playing a very important in the outcome. The complex structure of the local partnership was in fact harming deliberation, because it was fully controlled by local political professionals. As a

[4] The nuclear power plant is located in Krško municipality but very close to the border of Brežice, and in practice both are considered as 'nuclear' municipalities.

consequence some of the most affected groups were marginalised. Moreover, the compensation anticipated for the local community hosting the repository gave rise to new tensions. A substantial part of the lay public remained uninformed, while technical experts remained largely unmoved by the attempt to reframe radioactive waste as a sociotechnical issue. As soon as the location for the repository was formally selected, the partnership in Krško was shut down and the idea that lay groups are not competent to participate in the decision making process revived (Kos, Polič and Železnik 2011) The final outcome of the Slovenian partnership was thus a not-particularly-harmonious or trusting relationship between affected actors, one that did not break out of the frame of a strong social and technical divide.

Belgium

In the late 1990s the Belgian Agency for Radioactive Waste and Enriched Fissile Materials (ONDRAF/NIRAS) changed its approach and invited potential host communities to set up 'local partnerships', bringing together local politicians and representatives from the local civil society in order to investigate and consider the technical and social feasibility of implementing a repository facility for low and intermediate level, short-lived waste (LILW) in their municipality (Bergmans, Van Steenberge and Verjans 2006; Bergmans 2008; Bergmans and Barbier 2012). Three such partnerships were created, involving four municipalities.

All three partnerships developed, together with ONDRAF/NIRAS, an integrated concept for a repository project, encompassing societal preconditions (related to social as well as technical aspects), and advised their municipal councils positively on the feasibility question. Two municipalities, Dessel and Mol, subsequently decided to put themselves forward as potential host communities. In 2006 the Belgian federal government choose the site in Dessel, and acknowledged that the partnership approach

should continue during the further elaboration and implementation of the repository project, as well as during its operation. Given that the other candidate site, Mol, is a neighbour to Dessel, both partnerships (STORA in Dessel and MONA in Mol) stay involved in the further development of the repository project (Bergmans and Barbier 2012).

In the preparatory phase, the RWM agency worked together with its local partners within one partnership, thus giving the local actors a firm hand in the agenda setting and a voice in the definition of both problem and solution (Bergmans 2008). The partnership was the carrier of all kinds of investigations and proposals, developing as well as assessing results. It was the sole forum for negotiations and decision making, bearing in mind that the municipal council and the government at a later stage were to decide on the issue. However, within this strong focus on integration we also find examples of separation. This has for example been present in the veto ONDRAF/NIRAS insisted on with regard to the technical feasibility of any design proposals made by the community partners. Another example is the role of the regulatory body, FANC, which refused to take part in the initial discussions on the repository design, to safeguard its 'objectivity' in making a technical judgement on the safety of the facility, when a licence application would be submitted (Bergmans, Van Steenberge and Verjans 2006). During the following phase of development (including the preparation of a licence application) and implementation, a triangular relation has come about between a locally embedded ONDRAF/NIRAS project team and the two partnerships as 'watchdogs', with the initiative and agenda setting back in the hands of the RWM agency, relying on its legal responsibility and obligation as care taker of the waste (Bergmans and Barbier 2012).

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United Kingdom

In 2001, following the failure of earlier siting programmes, the UK Government launched a new programme, Managing Radioactive Waste Safely (MRWS), with the aim of developing a strategy for intermediate and high-level wastes that would not only be technically sound but would also command public confidence and therefore be implementable. Central to MRWS therefore was a commitment to involve as wide a range of stakeholders as possible from an early stage of the process. A new advisory body, the Committee on Radioactive Waste Management (CoRWM), was established in 2003 and initially mandated to review the options for the long-term management of radioactive waste and to make recommendations to Government on the best option, or combination of options. The Committee decided to consider the entire range of potential technical options, including those that had earlier been ruled out by a number of authoritative bodies. In addition to this open approach to technical options CoRWM also explored a range of social and ethical considerations associated with these options (Butler and Simmons 2013). It also notably involved a much greater degree of engagement with stakeholders and the public, in relation to both technical and social aspects of the problem, than any comparable consultation process. Importantly, for its evaluation of short-listed options CoRWM conducted what it described as a holistic evaluation, an extended deliberative process with input from stakeholders and citizens, the results of which were compared with those of a formalised multi-criteria decision analysis (MCDA):

> An holistic assessment enabled a more discursive and intuitive approach where ethical, scientific and public forms of knowledge could be brought together in reaching conclusions. Overall, it was CoRWM's task to integrate the variety of knowledge streams in making its final recommendations. The

> recommendations, then, are not simply an expression of expert knowledge and judgement. (CoRWM 2006: 6-7)

In its report to Government CoRWM recommended geological disposal as the technical endpoint for long-term radioactive waste management but with the proviso that research and development (R&D) continue with the aim of reducing the uncertainties surrounding geological disposal – and that national and international R&D should be monitored with a view to identifying alternative management options (CoRWM 2006). This was combined with the recommendation that a staged, voluntary approach should be taken to siting, with a benefits package for potential host communities and a right of withdrawal up until the final stage of the process. CoRWM's options appraisal process combined the simplification of formalised MCDA with the identification and discussion of technical, social and ethical complexities during the holistic process. By not drawing a strong boundary between social and technical aspects of the issue and by building both into its recommendations, it could therefore be seen as an integrative sociotechnical combination.[5]

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[5] Unlike the other cases discussed, the stages of the UK's MRWS process outlined here focused on policy formulation rather than site selection. Subsequent steps in a process of voluntary site identification resulted in an expression of interest by three local councils in West Cumbria. A local partnership of elected councils and various stakeholder groups was formed in March 2009 to investigate and advise on the implications of entering the process. Reflecting the strategy of integration, it consulted extensively and considered the views and evidence both of local citizens and stakeholder groups and of independent experts on technical and socioeconomic aspects of the proposal. Although the decision in January 2013 by the Cabinet of Cumbria County Council not to proceed brought the process to a halt, Government subsequently reopened the volunteering process with the publication of a revised implementation framework. However, the consequences for the configuration of a sociotechnical combination based on integration are yet to be seen.

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Sociotechnical combinations: four critical issues

Thus far we have seen that approaches in Slovenia and Sweden are based on maintain separation between social and technical factors, while in Belgium and the United Kingdom examples of integration could be found. The picture is more complex, however, and before drawing final conclusions we need to elaborate further on the ways in which activities in these four countries enacted the relationship between social and technical aspects. Four issues and their associated problems seemed to be critical. The first two are most relevant to situations where the sociotechnical combinations are framed and understood in terms of a strong divide between social and technical factors, while the last two relate to more integrative examples. These four issues complicate the two framings of separation and integration, but showing that these complexities are of importance in our four nations contributes to a more nuanced understanding on how actors are dealing with the social and the technical in the creation of sociotechnical combinations.

Concealment of social aspects

One implication of separation may be that technical agencies embed social commitments within technical choices in a non-transparent way. In Slovenia and Sweden municipalities, as part of the process of finding a solution to the waste problem, were given the right to accept or reject proposals from the waste agencies. However, in neither case did this lead to a broad discussion of technical issues. It was just about accepting or rejecting proposals from ARAO and SKB. SKB has strategically reassessed its view on safety issues and geological bedrock conditions, shifting from a focus on finding the *best possible* site to identifying a suitable or *'good enough'* site (Sundqvist 2002: ch. 5). The same shift was observable in the Slovenian siting procedure. This illustrates the technical actors were trying to adapt to the social aspects

of the problem. This adaptation (some would call it a downplaying) of the bedrock criterion to what is socially achievable is not a pure scientific matter. In Sweden, this strategic choice was made solely by SKB. In Slovenia the choice of the mixed mode approach, including a first rough technical screening that also involved assessing and deciding on social issues, was proposed and conducted by ARAO without including municipality representatives and citizens in the process. Why choose such a strategy? What was the motivation behind it? How could a method for ranking potential locations be developed? These questions are not purely scientific, but also very much about what is achievable in a society where, in most communities, radioactive waste is considered an unwanted product which is to be shunned. Where separation is the existing mode of operation, these strategic questions tend to be concealed within what are presented as technical issues and therefore decided by technical experts alone. This is an important consequence of activities framed and presented as being based on a strong social and technical divide.

Our first complexity shows a sociotechnical combination in which the social aspects are concealed by a project presenting itself as being more technical than it is.

Subordinating social aspects

One thing that seems hard to avoid is that social aspects are made to take a lower priority, and considered as something to add, at a later stage, to already well developed and defined technical projects. This has been called ‘downstream’ engagement, i.e. adding social flavour to existing and stable technological programmes (Stirling 2005; Wilsdon and Willis 2004). One reason for this to happen is that the technology is mature; technological R&D programmes had already been established back in the 1950s and geological disposal has been the main reference option since it was judged in 1957

by the US National Academy of Sciences to be the safest method for disposal of high level wastes (NAS 1957). At that time 'the waste problem', including making social choices and formulating social strategies, was delegated to technical experts. When, much later, public consultations were held in various countries, giving the impression that all options remained open for discussion, it was forgotten that many actors long ago had made up their minds on important and strategic issues such as technical options (choosing geological disposal) and best possible sites. All too often these basic assumptions and strategic choices have remained unchanged over time, leading to social aspects being stripped of strategic substance, and consultations being narrowed to giving support, acceptance and legitimacy to old sociotechnical combinations disguised as purely technical solutions.

This second complexity shows a sociotechnical combination that gives priority to the configurations produced by experts, while downplaying possible new contributions from 'social' actors in a later stage.

Fragmented and incremental process (isolated integration)

Integrative initiatives are often set up as a response to crises and when these are overcome things tend to go back to business as usual, with technical experts advising government decision-makers. In both Belgium and Slovenia partnerships were established, but only in relation to short-lived waste. Spent nuclear fuel and high-level waste have not yet been part of any kind of integrative initiative, although in Belgium some very preliminary steps have been taken. Moreover, in Slovenia the focus is on siting, while technological options are not really discussed with involved municipalities. It is indicative in this respect that the partnership established in Krško was terminated immediately after the site was officially confirmed by the local community and by the

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State.

Another example of what could be called ‘isolated integration’ is the possibility for a strong decision maker to independently decide in a way that does not rely on what has been achieved by earlier integrative initiatives. The decision taken by the Belgian Government in June 2006, choosing surface disposal in Dessel as the preferred option, was largely based on the partnership reports and municipal decisions, but also added new elements (such as criteria on the size of the proposed terrain), raised by the waste manager’s director general in a confidential note to government and not agreed up front within the partnership process (Bergmans 2006).

In Sweden, the decision to choose Östhammar as the preferred site was taken independently by SKB and did not include the two municipalities being considered, despite them having been involved in consultation processes for many years as part of feasibility studies and site investigations. In the UK the context has changed somewhat since the MRWS process was initiated and CoRWM began its deliberations. The timetable for the closure of existing nuclear power stations, Government demands for acceleration of the national programme of site decommissioning, the inclusion of new nuclear build in UK energy policy, and the policy of economic austerity that has resulted in widespread cuts in public expenditure all put pressure on MRWS and, specifically, on the Nuclear Decommissioning Authority’s Radioactive Waste Management Division to speed up the process (see, e.g. NDA 2011). Given the arrested progress with finding a volunteer community, it is nevertheless too early to evaluate whether these pressures will result in the MRWS process becoming isolated within a stronger technically-driven framing advanced by parties wanting to realise geological disposal as soon as possible, and preferably close to existing facilities.

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This third complexity shows a sociotechnical combination that is not well connected to other combinations important to its existence and the way it is framed.

Integration disguising separation

The motivation to initiate integration activities such as partnerships is often based on the aim of restoring public credibility for scientific and technological projects. Nevertheless, despite rhetoric that promises collaboration among equals, old boundaries between technical and social aspects are often protected. It is reasonable to assume, from contacts with the expert community, that in the case of the Belgium partnerships many technical experts started out with that mindset. But whilst the position of ONDRAF/NIRAS remained privileged, being viewed as the architect of the facility and the one that has answers to technical questions due to its strong technical competence, the local participants did keep a critical eye on it. They challenged claims made, looked for second opinions, or asked for complementary, independently-conducted research. They even asked for technical changes in the repository design, due to their different appreciation of what constitutes safety. But whilst the local community and the waste manager agreed on a new sociotechnical combination, the regulator, who had remained out of the discussions to protect its independence, subsequently based its initial safety assessment purely on existing criteria, ignoring the new elements proposed by concerned citizens as being essential for safety, elements more based on controllability and the possibility for active intervention. In Slovenia ARAO maintains its position as manager of the process but the decree of compensation made it more attractive for municipalities to join what was described as a common partnership. The Slovenian case clearly demonstrates that there is always a risk that 'partnership' becomes a new label for an old division of labour, where technical agencies are not only strong in relation to

their technical competence but also protect fundamental strategic sociotechnical choices as their own business.

This fourth complexity shows a sociotechnical combination that is presented as integration but still maintains partial or virtually complete separation in practice.

Conclusions

We began by questioning the notion, often taken for granted in RWM, as in the governance of controversial technology more generally, of a self-evident distinction and consequent divide in practice between social and technical aspects of the situation. Instead we proposed a view of the relationship between social and technical that is more interactive and entangled. We further problematised the way in which the relationship between the social and the technical is enacted in RWM, exploring this relationship in terms of their relative integration or separation in four national cases, identifying different configurations of integration and separation within the resulting sociotechnical combinations produced in each of the four different contexts, and reflecting upon the critical issues raised by each. In this final section we conclude by reflecting upon some of the implications and potential applications to which the perspective outlined here gives rise.

A first, analytical implication is that in order to achieve a better understanding of the entanglements of the social and the technical and to foster greater transparency in the field of radioactive waste management we should be prepared to acknowledge the complexity in their performances. Although focusing on such complexities undoubtedly creates new challenges, we would argue that it is essential to do so when faced with a technology which may well be in the process of shaping, in significant measure, our collective future. We offer the concept of sociotechnical combinations and their variable

and complex configurations as one theoretical tool with which this complexity can be analysed and better understood.

Many national RWM programmes are now focused on implementing geological disposal of long-lived higher-activity wastes. In most countries where this is the case the disposal technology was determined long before any participatory turn, although in many countries the specific site, type of host rock and detailed design characteristics are still the subject of investigation. We should therefore first acknowledge that the existence of this prior framing of the solution to long-term RWM and the associated commitments in terms of legislative frameworks, research and development programmes, and expertise 'closes down' the problem (Stirling 2005) and limits the scope for formal citizen participation to influence the resulting sociotechnical configuration. The response of citizens to such commitments in many countries has been, as already noted, informal participatory activity expressed in controversy and conflict. However, even where the choice of disposal option is (re)opened to formal public deliberation, as it was in UK case outlined above, it does not necessarily lead to the changed configuration, for example around some form of long-term storage technology and associated institutions and cultural practices of stewardship, that opponents of geological disposal desire to see.

Nevertheless, even where geological disposal has been confirmed as the disposal technology of choice, sustained participation can constitute a hybrid forum (Callon and Rip 1992), within which the combined sociotechnical nature of issues such as long-term safety can be recognised and the issue opened up, deliberated and potentially re-problematised (Barthe 2009) in order to work towards sociotechnical combinations - that is, configurations of actions, interactions and practices - that better reflect and integrate the concerns of affected citizens. Such combinations will of course be

contingent and, as noted by Rip (2010), precarious; they will also likely present, as did our examples above, critical issues that will need to be addressed; all of which is an argument for fostering an awareness of the entangled nature of the issues and its consequences in order that the risk of lock-in or of some unintended and inflexible form of path dependency is reduced. This is not then a simple or a simplistic recipe; in fact not a recipe at all but a theoretically-based, empirically-grounded proposal for an approach to the task of developing what has been referred to as *technical democracy* (Callon, Lascoumes, and Barthe 2009) in the long-term management of radioactive waste.

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