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Repository Monitoring in the Context of Repository Governance

Work Package 5

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Abstract

This report summarizes the social scientific component of the Modern2020 project (work package 5). This package has four objectives: i) to **actively engage** local public stakeholders in repository monitoring R&D within the Modern2020 project, and to **analyse the impact** this has on both the participating stakeholders' and the project partners' understanding of, and expectations regarding, repository monitoring; ii) to **define** more specific **ways for integrating public stakeholder concerns and expectations** into specific repository monitoring programmes, iii) to **develop ideas on how to ensure accessibility and transparency of monitoring data** (of the type gathered through in-situ monitoring) to public stakeholders, and iv) to **learn lessons** on how local stakeholder groups could be engaged effectively with R&D programmes and projects **at an EU level**. A theoretical framework is presented, inspired by the emergent field of Responsible Research and Innovation (RRI), which makes explicit the increasing demand for research and innovation systems to reflect upon their role and position in society and to re-examine their course and goals. The concept of RRI is also supported by the European Commission. From this background and based on Delgado et al. (2011), five crucial questions to deal with concerning citizen stakeholder involvement in R&D programmes are developed: "Why should we do citizen engagement?", "Who should be involved?", "How should it be organised?", "When should it be done?", "Where should it be grounded?". We understand these questions as opening up tensions, since no clear or uncontroversial answers are to be found. Nevertheless, these questions are necessary to manage in practice, which requests sensitivity from responsible actors when organising and supporting citizen stakeholder engagement in relation to participants' demands and to contextual factors. This framework is made a resource when analysing the activities carried out by WP5, i.e. citizen engagement at the project level and additional home engagement activities, and the development of a stakeholder guide and an online interactive survey. In a chapter called 'lessons learned', our aim is to present reflections on how citizen stakeholder engagement could be integrated in a good way in similar R&D projects by drawing on concrete lessons learned from local stakeholder engagement in the Modern2020 project. Finally, in the fifth chapter, we present some concluding practical recommendations following from these lessons learned. We hope them to be of use when considering the engagement of (local) citizen stakeholder in other R&D projects at the EU level, beyond the scope of monitoring and geological disposal of radioactive waste.

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1. Introduction

This report summarizes the social scientific component of the Modern2020 project. The overall objective of this Horizon2020-EURATOM research project, was *"to provide the means for developing and implementing an effective and efficient **repository operational monitoring programme**, that will be driven by safety case needs, and that will take into account the **requirements of specific national contexts** (including inventory, host rocks, repository concepts and regulations, all of which differ between Member States) **and public stakeholder expectations** (particularly those of local public stakeholders at (potential) disposal sites)".*[1]

The bulk of the research in Modern2020 was dedicated to technical research, development and demonstration in view of developing technology suited for monitoring within or in close proximity to a geological repository for high-level nuclear waste or spent fuel (within the project generally referred to as repository monitoring). This is a particularly challenging task, as it is the specific aim of a geological repository to provide a passively safe environment in which the waste is isolated through a system of engineered and geological barriers. Therefore, any monitoring inside these repository components - be it the engineered barriers' system (EBS monitoring) or the host rock (near field monitoring) - should be so conceived as to not in any way interfere with the long-term integrity and safety of the disposal facility. As a consequence, the Modern2020 work packages 3 (monitoring technology) and 4 (demonstration and practical implementation) focussed their research on wireless data transmission technologies, new sensor technology (in particular optical fibre sensors), and longterm alternative power supply sources, as well as geophysical technologies (e.g. the so-called seismic tomography in combination with the seismic full-waveform inversion method).

Next to the development of technology, Modern2020 explored what strategies could be employed for the design and implementation of a repository monitoring programme and what role the output of such a programme could have on decision making (work package 2). In a similar logic to the technology research, the focus was here also on EBS and near field monitoring and their specific role with regard to decision making during the operational period of the repository.

This made Modern2020 a very expert driven technical research project, for which the research agenda was set from the start, based on the outcome of its precursor project, MoDeRn[2], and the needs of implementers, primarily from 'advanced countries' with regard to implementing geological disposal. However, monitoring is generally expected to play a major role in reassuring the public and in building public confidence in the repository (IAEA 2001, EC 2004).

The MoDeRn project had explored this through a literature review on the topic of citizen and stakeholder engagement with monitoring (Bergmans et al. 2012) and a set of exploratory workshops with citizens from communities hosting existing nuclear (waste) facilities and with prior experience as participants in radioactive waste management projects of a varying nature in Belgium, Sweden and the United Kingdom (Bergmans et al. 2013). This exploration made clear that performance monitoring is a subject of interest for a wide-range of stakeholders. In particular, local citizen stakeholders expect monitoring to provide continuous information on repository performance. As such, it was concluded that early involvement

[1] http://www.modern2020.eu/
[2] https://cordis.europa.eu/project/rcn/93569/factsheet/en

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may improve their confidence in the monitoring programme, as well as make clear what their concerns and expectations regarding such a programme are. With that in mind, a dedicated work package (WP 5) on societal concerns and stakeholder involvement was integrated in the set-up of Modern2020.

Through WP5, stakeholder engagement activity was organised in direct relation to the R&D work developed in work packages 2, 3 and 4 (see chapter 2). At various stages in the project, exchange meetings or workshops were set up, during which interaction between researchers in the different strands, concerned implementers and participating local citizens took place. With varying success, citizen stakeholders were invited from countries where a local organisation of stakeholders around RWM sites is already established: in Finland (Municipality of Eurajoki), France (Bure) and Sweden (Municipality of Östhammar). In addition, Belgian local stakeholders were incorporated. Geological disposal in Belgium is still in a research phase, but the municipalities of Dessel and Mol, and their local partnerships STORA and MONA, are hosts and neighbours to the centralised storage facility for HLW and to the HADES underground research laboratory.

The stakeholder engagement activities were organised and researched at two levels: (a) direct participation of a selected group of stakeholder representatives during Modern2020 meetings and workshops (see section 3.2.1), and (b) home engagement activities, in which selected groups were focused upon in relation to established local organisations, in order to further investigate local concerns related to monitoring (see section 3.2.2).

The work in WP5 contained the following three tasks:

Task 1: Organisation of stakeholder engagement within the project

From each community a small group of representatives were invited to directly interact with the Modern2020 project; at the community level existing structures were utilised (e.g. local thematic discussion groups) (see section 3.2). Throughout the project, WP5 partners worked in close collaboration with other WP leaders and specific task leaders to prepare engagement activities in direct relation to the 'technical' project meetings. This work aimed to identify relevant discussion topics. Documents about progress from different work packages have been produced as preparation for engagement activities. These documents have also been an important input to the production of the Stakeholder Guide, i.e. a handbook on repository monitoring for concerned public stakeholders (see Deliverable 5.2: Meyermans et al. 2019). Various Modern2020 partners and participating stakeholders have given input and feedback to this Guide (see section 3.3).

Task 2: Setting the scene

This research task aimed to investigate, mainly through literature review, participating stakeholder groups in relation to their national decision-making structure and processes regarding nuclear waste management; their interest and experience in discussing issues related to geological disposal, repository safety, environmental monitoring, and repository monitoring. The practical aim has been to help the participating citizens to understand similarities and differences between the contexts of their (national) situations. Furthermore, the extent to which stakeholder concerns are taken into account in other cases of monitoring infrastructures and underground storage facilities, with a focus on carbon capture storage, have been studied in order to further the understanding of the specificity of the type of monitoring addressed (see Deliverable 5.1: Lagerlöf et al. 2017).

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Task 3: Analysing stakeholder engagement within the project

This research task addressed the impact of the engagement activity on the Modern2020 project and the developed knowledge. The concerned community groups were invited to reflect on the usefulness of their engagement with Modern2020, on what they appreciated and what they would prefer to have been be done differently. This work has been carried out by help of the meetings and workshops with the stakeholders, but also through an interactive survey in which both citizen stakeholders and technical partners in Modern2020 took part (see section 3.4). Results from these activities address issues such as how to connect citizen stakeholders to the design, implementation and follow up of monitoring programmes, and how to capture citizens' concerns and expectations and calibrate them with those from technical experts and nuclear waste management organisations (see sections 4.1 and 4.2). Finally, and from a more general perspective, it has been investigated how local citizen stakeholder groups could be engaged effectively with R&D projects at an EU level (see section 4.3).

This report comprises five chapters, this introduction included. In the second chapter research objectives and methods are presented. In the third we focus on how citizen stakeholder engagement in R&D activities concerning repository monitoring was enacted within this project. This is done in four sections: i) providing a theoretical framework as background; ii) describing the engagement at the project level and through the home engagement activities; iii) explaining how a stakeholder guide was co-jointly produced; and iv) analysing the responses to an online interactive survey. In the fourth chapter, called 'lessons learned', our aim is to present reflections on how citizen stakeholder engagement could be integrated in a good way in R&D projects by drawing on concrete lessons learned from local stakeholder engagement in the Modern2020 project. Finally, in the fifth chapter, we present some concluding practical recommendations following from these lessons learned. We hope them to be of use when considering the engagement of (local) citizen stakeholder in other R&D projects at the EU level, beyond the scope of monitoring and geological disposal of radioactive waste.

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2. Research objectives and method

The research in work package (WP) 5 of the Modern2020 project focused specifically on the challenge of involving **local public stakeholders**, that is to say, **people in concerned communities this means either from potential repository host communities or communities hosting an underground research laboratory (URL)**. They represent the most directly concerned, and the closest representatives of the general public with regard to the future deployment of this monitoring technology. However, when it comes down to R&D activity and the development of the technology with which they will eventually be confronted, often they are the furthest away.

2.1 Research objectives

At the outset of the project, the objectives for this work package were defined as:

1. To **actively engage** local public stakeholders in repository monitoring R&D within the Modern2020 project, and to **analyse the impact** this has on both the participating stakeholders' and the project partners' understanding of, and expectations regarding, repository monitoring.
2. To **define** more specific **ways for integrating public stakeholder concerns and expectations** into specific repository monitoring programmes.
3. To **develop ideas on how to ensure accessibility and transparency of monitoring data** (of the type gathered through in-situ monitoring) to public stakeholders.
4. To **learn lessons** on how local stakeholder groups could be engaged effectively with R&D programmes and projects **at an EU level**.

2.2 Research method

The research method consisted of setting up a number of engagement activities throughout the project lifetime. Data were collected through participatory observations, dedicated group discussions, some interviews and a dedicated survey. Where possible, interviews and group discussions were recorded and fully described to facilitate thematic content analysis. An intensive analysis was also performed on the research notes from different collaborators and on the minutes of various project meetings to register possible effects of this engagement activity on the research work within the project. Through interviews, group discussions, document analysis, and a secondary analysis of a survey among project partners launched in work package 2, we furthermore gathered insights into how various concerned parties (including implementers and regulators) develop and influence policy, raise interests and concerns, and how that is related to national and local contexts.

It was the aim to build further on the much-appreciated direct interaction between (local citizen) stakeholders and technical researchers and nuclear waste management organisation (NWMO) representatives during a field trip to the Swiss URL's in the MoDeRn project[3]. Also because of the

[3] This field trip took place between April 23th and 25th 2012. During this event, hosted by NAGRA, eleven citizen stakeholders from three countries (Belgium, Sweden and the UK), five technical experts and four social scientists from the MoDeRn consortium visited the Grimsel and Mont-Terri underground rock laboratories, where they were shown in particular the experiments that were part of the MoDeRn research project. Each visit was situated and introduced beforehand, and followed by a group discussion. During this activity, views were shared on (a) the role of URL's and URL visits in the context of exploration, confrontation and dialogue; (b) expectations regarding

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specialized nature of the research and research topic, it was our intention from the start to work with only a small number of citizen stakeholders, recruited because of an expressed interest and a more than average level of knowledge about the problem of radioactive waste. For that reason, participants were drawn from the relatively small group of engaged citizens in concerned communities, rather than from the 'general public'.

The selection of concerned communities was to a large extent determined by national waste management programmes and related governance processes. As Modern2020 was an implementer lead project, all participating NMWO's (representing 10 European countries) were consulted on whether local stakeholder groups were active in their concerned communities and whether inviting them to participate in Modern2020 would interfere with the current stage of their national programme. The Italian, Spanish, Czech, German, UK and Swiss NWMO's did not consider it feasible or appropriate to engage local citizen stakeholders from their countries at this stage in their programmes. For Finland, France and Sweden this was not deemed a problem as the repository development process here is already in a more advanced stage. This is not the case in Belgium, but Belgian local stakeholders had shown a particular interest in monitoring based upon their experience with the siting and development of a low-level waste surface repository.

The group of citizens that did participate in the project can therefore not be seen as representative for the community at large, neither at the local, national, nor European level. The set-up of the engagement activity in Modern2020 thus remained to a large degree experimental and exploratory. The research furthermore generated qualitative data, the analysis of which cannot be claimed to provide a representative categorization of different opinions regarding repository monitoring and how to communicate about monitoring plans, activity and data with various stakeholder groups, again either at the national or European level. Nevertheless, it does provide insight into the understandings, concerns, reasoning and preferences of some concerned NWMO's, technical experts in the field, and affected citizens, which can be seen as indicative of the opinions and expectations of particular groups in society.

Throughout the project lifetime, a variety of engagement activity was deployed:

- A small core group of engaged community representatives regularly attended **project meetings and workshops** organised **at the European level**.
- Additionally, workshops (or so-called '**home engagement sessions**') were set up in the home communities of the interested public stakeholders in order to discuss their concerns and opinions about monitoring in nuclear waste repositories.
- Furthermore, all local stakeholders who participated in these events were given the opportunity to enter into **discussion with technical representatives** from Modern2020 in a workshop specifically designed to this end as a space of mutual understanding.
- The same local public stakeholders were offered the possibility to further share experiences and opinions about their involvement in the project by participating in an **online interactive survey**, organised in two rounds, to which all Modern2020 colleagues (i.e. the technical experts involved in the work of WP2, 3 and 4) also were invited to participate.

(repository) monitoring; and (c) science communication and communicating monitoring results. For a full account of these visits: see Bergmans et al. 2013.

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- Lastly, the local stakeholders were regularly consulted for feedback on a '**stakeholder guide**' (see section 3.3), as well as on other output produced in the project (such as workshop and research reports).

More detail on these different types of activity, how they were set-up and what results could be obtained from them, will be provided in chapter 3.

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3. Engaging local citizen stakeholders in R&D on repository monitoring

In this chapter we describe in a reflective and analytical way how engagement in this project came about in practice. We do this by the help of concepts and frameworks from research of relevance for understanding stakeholder engagement. This will work as a background, telling why stakeholder involvement is important in today's society, but also as a resource to better understand stakeholder engagement in an R&D project such as Modern2020. Repository monitoring strategies and technologies for geological disposal are an innovative strand of research touching upon larger questions of how society is to relate to this research, this is why we firstly draw inspiration from an up and coming area of research: *Responsible Research and Innovation* (RRI) (Stilgoe, Owen & Macnaghten 2013). We furthermore connect the questions of citizen stakeholder involvement in science and technology to the theoretical framework of *transdisciplinary knowledge production* and *knowledge alliances* (Novy, Habersack & Schaller 2013). Then we present the evaluation tools offered by Delgado, Kjolberg and Wickson (2011) and by Rowe and Frewer (2000) for appraisal of public stakeholder engagement in R&D. All this we do in section 3.1. In the following sections we look more closely at the engagement in the Modern2020 project: in project meetings and workshops (3.2), in the collaborative process of writing the stakeholder guide (3.3), and in the online interactive survey as a specific tool for dialogue (3.4).

3.1 Theoretical framework on engagement in R&D

Stakeholder engagement in research and development has been the focus of various strands within social sciences literature. Drawing on those allows us to situate our exercises within the broader governance dynamics of nuclear waste disposal projects, and assists us in finding a framework and indicators on what it means to realize public engagement 'effectively' and 'successfully' in practice. It also connects to the idea of transdisciplinary research and how to realize it.

Within nuclear waste management, repository governance has evolved from being led by a top-down technocratic discourse to an opening up of this discourse towards broader publics including local citizen stakeholders. The 'participatory turn' in nuclear waste management refers to a point in time around the late 1990s in which this approach was increasingly adopted by nuclear waste managers in various European countries who set up local public participation initiatives in which local stakeholders could express their concerns and suggest their own ideas about the repository project(s) in their community (Bergmans et al. 2015). However, how this local stakeholder engagement is effectively done involves several levels of involvement, in which the lowest level means top-down communication and a one-way flow of information, while the highest level is characterized by dialogue and a two-way information exchange (Rowe & Frewer 2000). In nuclear waste management, the lowest level of top-down communication from expert to public, also referred to as the 'deficit model' (Irwin & Wynne 1996), is increasingly being abandoned by nuclear waste managers who aim at involving local stakeholders in a more meaningful way.

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Responsible Research and Innovation (RRI)

The call for more local stakeholder involvement in repository governance has also extended to the research and development of concrete technologies for nuclear waste disposal, including repository monitoring. This relates to the emergence of the concept of 'Responsible Research and Innovation' (RRI) which tries to formulate an answer to the increasing demand for research and innovation systems to reflect upon their role and position in society and to re-examine their course and goals (D'Haese et al. 2018). Thus, the concept of RRI was introduced as a new way to conceptualise this science-society relationship. The European Commission (2012) defines RRI as "*societal actors working together during the whole research and innovation process in order to better align both the process and its outcomes, with the values, needs and expectations of European society*". In a broader sense, RRI is about "*taking care of the future through collective stewardship of science and innovation in the present*" (Stilgoe et al. 2013). In this way, RRI implies to help research and innovation systems to become more social sensitive and adaptive in relation to societal concern raised by engaged stakeholders. In short: to become responsible. As the most important principles, RRI stresses anticipation, reflexivity, inclusion and responsiveness (D'Haese et al. 2018).

However, these principles leave room for various interpretations and practical implementations. While RRI is a normative concept, with values such as ecological sustainability and social inclusion at its core, its normative anchor points remain blurred (D'Haese et al. 2018). In this light, the concept of 'co-created responsible research and innovation' (co-RRI) has been introduced by D'Haese et al. (2018) in the framework of the European FoTTRIS-project[4].

A basic value of co-RRI is a joint responsibility in creating knowledge and taking actions for solving grand environmental and social challenges, while respecting planetary boundaries (D'Haese et al. 2018). Assuming that problem-solving cannot only be based on the exclusivity of scientific knowledge production, co-RRI emphasizes that the necessary knowledge for tackling grand challenges lies scattered among a diversity of stakeholders and various forms of local knowledge. This makes transdisciplinarity a key characteristic of the concept. Co-RRI thus invites stakeholders to engage in a joint, consensus-oriented problem-solving process. The authors (D'Haese et al. 2018) stress that co-RRI should never be understood as a mere add-on to research and innovation as usual. Citizen and stakeholder engagement for co-RRI requires the co-creation of relevant knowledge and solutions for complex problems, and not only involving citizens in the final phases of a research project with the aim of 'educating' them into acceptance of the outcomes. Within this co-creating process the most important principles of RRI are: transparency and accessibility of data and other information, reflexivity about the political and ethical implications that come by making a certain choice, and inclusiveness of various actors.

Transdisciplinary knowledge production and knowledge alliances as a normative ideal

Strongly related to the concept of (co-)RRI is the literature on inter- and transdisciplinary knowledge production. Interdisciplinary refers to the collaboration between scientists of different academic disciplines (like engineering, geology and sociology). Transdisciplinary refers to collaboration between people working on a topic from a scientific/academic perspective and people who are not in science or

[4] FoTRRIS was a project funded by the European Commission under the Horizon 2020 programme 'Science with and for Society' (grant agreement no 665906). Its main objective was to develop and introduce new governance practices by co-creating transdisciplinary concepts, which are based in co-RRI and attuned to local needs, values and opportunities, and that mobilize and connect local stakeholders (http://fotrris-h2020.eu/).

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academia, but who are affected by or concerned about that topic in their daily life. In this sense, Modern2020 can be regarded as both an inter- and transdisciplinary research project in the broader framework of Responsible Research & Innovation (RRI). Over the past decades, attempts to join different disciplinary and knowledge perspectives have become more commonplace in the face of complex or 'wicked' problems (Rittel & Webber 1973), like poverty reduction or climate change. Given the high-level technical complexity, various social aspects, political-contentiousness and very long-time scales involved, the management of radioactive waste can also be regarded as a wicked problem (Bergmans et al. 2008).

Important authors within the field of science and technology studies (STS) point towards the inherent uncertainty and complexity of knowledge acquisition (e.g. Funtowicz & Ravetz 1992). Faced with considerable levels of uncertainty and high societal stakes the quality of scientific output cannot be solely measured by disciplinary peers, but should also be done by others that are involved and have a say about the relevance of additional information and perspectives, i.e. extended peer review. Indeed, people who are living or working in a certain area tend to possess a lot of experience and, often implicit, knowledge about this context that is relevant for the practical application of scientific models (Collins & Evans 2007). This literature suggests that an exchange between these different types of knowledge would not only benefit the processes of political decision making, but also the quality and practical relevance of the scientific output (Stigendal & Alwall 2015).

A concept related to this argumentation and recently proposed by social innovation authors such as Novy, Habersack & Schaller (2013) is the notion of 'knowledge alliances', interpreted as a practice-oriented operationalization of the transdisciplinary methodology. The larger purpose behind this idea of knowledge alliance is to

> "*innovate the relationships between science and society and foster the democratization of knowledge, as practitioners and citizens engage in the decision making about research topics, voice their opinion, share their experiences and engage in mutual learning exercises*" (Novy et al. 2013: 439).

A knowledge alliance thus aims at the creation of a *"sustainable learning and research partnership composed of researchers and practitioners in all their diversity"* (Novy et al. 2013: 432). Its quality and innovative capacity is assumed to come from the integration of various forms of knowledge in iterative processes where the problem and findings are re-identified and re-considered to bring qualitative and relevant research results *"to fruition"* (Hadorn et al. 2008: 35). An 'ideal model' of a knowledge alliance possesses a number of features, such as (1) a common overall concern, specific objectives and a clear division of labour; (2) the creation of time and space for exchange, democratic decision making about relevant steps in the research process; (3) a joint elaboration of research questions and aims; (4) the development of a collective understanding of terms that are relevant for the problem field; (5) collection and analysis of data materials; and (6) an evaluation and valorisation of the results and cooperation process (Novy et al. 2013: 433-434).

How to evaluate 'successful' citizen stakeholder engagement?

Despite these promising concepts that offer a theoretical basis for mutual dialogue and knowledge production in research and development projects, the notion of 'effective' or 'successful' citizen stakeholder engagement is surrounded by confusion and different perspectives that often reflect actor positions and interests (Rowe & Fewer 2000). If we would only focus on the final outcomes of participative decision-making processes it is not hard to imagine that public acceptance for building a new power plant would mean success for a representative of the nuclear industry. Activists of the anti-nuclear

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movement on the other hand, might regard this as a failure. According to them, a moratorium on new nuclear power plants would mean a success (cf. Rothstein 2007). It is therefore important to unpack these notions of success or effectiveness by asking the questions: Success for whom? Success in what regard, process or outcome?

Starting from the observation that there is a lack of appropriate benchmarks to compare the quality and success of stakeholder participation exercises, Rowe and Frewer (2000) propose a comprehensive set of criteria to be further refined, operationalised and tailored to particular cases. These criteria would mainly work as a way of evaluating various methods for public participation, listing the advantages and disadvantages that each method has to offer. The authors distinguish between two types of evaluation criteria: *acceptance criteria*, which relate to acceptance of the method among a wider public, and *process criteria*, which are related to the effectiveness of a procedure. Rowe and Frewer (2000) argue that both types of criteria are required for an adequate method evaluation of public participation in science and technology. If a procedure is effectively constituted but perceived by the public to be in some sense unfair or undemocratic (referring to the acceptance criteria), then the procedure may fail in alleviating public concerns. However, if a procedure and its recommendations are accepted by the public but the ultimate decision is attained in an ineffective manner (referring to the process criteria), then its implementation could prove objectively damaging for sponsors and public potentially leading to a refusal to implement the output in practice.

Acceptance criteria include: The representativeness of participants (*Is there a broadly representative sample of the affected public?*), the independence of true participants (*Is the process conducted in an independent and thus unbiased way?*), the criterion of early involvement (*Are people involved as early as possible, before key decision have been made?*), influence of final policy (*Can and does this procedure impact upon policy?*) and transparency of the process to the public (*Can the public see what is being done with their input and how decisions are being made?*).

Process criteria include: Resource accessibility (*Can participants access the appropriate resources and information in order to participate fully?*), task definition (*Is the scope of the participants' task clearly defined?*), structured decision making (*Does the participation exercise use appropriate mechanisms for structuring and displaying the decision making process?)* and cost effectiveness (*How cost effective is this procedure in comparison to other options?*).

Besides these evaluation criteria for participation methods offered by Rowe and Frewer (2000), Delgado et al. (2011) reflect on the tensions that come with realizing the theoretical promises of public engagement with science in practice. This serves the purpose of this report to reflect on the broader research question of effectively engaging local citizen stakeholders in nuclear waste management related R&D activities, beyond listing (dis)advantages of particular engagement methods. It is relevant to note that a growing number of scholars have expressed their concern between the rather normative, idealistic goals and gains of public engagements in the literature and the often messy, staged, imperfect and perhaps disappointing reality of it (Delgado et al. 2011).

Struggling with this feeling of frustration about the gap between the theory and practice of public engagement, Delgado and colleagues reviewed the state of research on public engagement and distilled a set of general key questions. These questions allow us to develop a conceptual map of the gap between theory and practice and to empirically see how the tensions that this gap brings about are played out in various contexts of public participation in science and technology. Delgado et al. (2011) employ nanotechnology as a paradigmatic case to help us explore these tensions. That case is relevant for

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comparison here because, like monitoring R&D, it offers *"a unique opportunity to put the theoretical propositions of inclusive governance into practice during an early stage of development"* (Delgado et al. 2011: 826). The authors identify five questions: "*Why should we do public engagement?", "Who should be involved?", "How should it be organised?", "When should it be done?", "Where should it be grounded?"*. These questions can also be regarded as topics of tensions in the discourse and practice of public engagement. Understanding these tensions can help to make informed choices about them and reflect upon how these choices influence other aspects of public engagement.

The **why** of public engagement in R&D mainly refers to the different motivations behind efforts to engage the public. The three rationales for public engagement distinguished by Stirling (2008) are the most telling in this regard: (1) an instrumental rationale, referring to the aim of achieving a particular predefined end, for instance restoration of legitimacy and public trust, (2) a substantive rationale, suggesting that public engagement will actually lead to substantively better results, and (3) a democratic rationale, proposing that public engagement is the 'right thing to do' by enhancing the democratic character of the decision-making process. Tension may particularly arise when there is a lack of transparency around the rationales motivating the public engagement exercise, or when it has been in principle argued for according to one rationale, but is then practically executed according to another (Delgado et al. 2011).

The second tension is that between different ideas of **who should be involved** in public stakeholder engagement (Delgado et al. 2011). As the direct involvement of all members of the public in techno-scientific development is clearly not feasible, tensions between different approaches of deciding who is a 'relevant' participant and what criteria this decision should be based on are expected to arise. The problem of achieving 'representativeness' in practical exercises of public engagement is particularly prominent in STS discourse. However, when there is a desire to include citizens that are interested, concerned and informed, this tends to favour the inclusion of particular 'interest groups', pulling against those preferring to gauge the opinion of a more 'neutral' majority.

The question of **how public engagement should be initiated** distinguishes between public engagement as either a top-down organised process or bottom-up grassroots phenomenon (Delgado et al. 2011). In line with this distinction, public engagement has also been presented as 'invited or uninvited'. Particular tensions may arise with instances of invited participation. Like this, invited forms of local stakeholder engagement not only predetermine who is a 'relevant' participant, but also carry implicit assumptions of how citizens should participate (aimed at reaching consensus for example). Organisers of invited participation also inevitably impose frames and meanings on to participants, which closes down possible alternative framings and opportunities to question fundamental issues, whilst uninvited participation leaves more possibility for the participants to question and challenge the often implicit politics of an official framing of an issue.

With regards to the question of **when is the right time for public stakeholder engagement**, there is considerable consensus among STS scholars on the importance of including citizens at an early stage of technological development, also referred to as 'upstream' engagement as this creates the opportunity for social values to be incorporated into technological development before particular trajectories become set (Delgado et al. 2011). The question then becomes how far 'upstream' it makes sense to go and whether upstream engagement is even possible for

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issues which are not perceived public 'matters of concerns' and for which citizens have to be actively invited to engage.

Lastly, Delgado et al. (2011) touch upon the question of **where public engagement should be grounded**. The idea that public engagement approaches should be context sensitive is well established within STS and refers to a claim for contextualization of engagement. For instance, it has been argued that particular political cultures should be taken into account when analysing public engagement initiatives and that there is a need to adjust the engagement to the concrete challenges that technological developments introduce in particular contexts. The possible tension to consider is about how context sensitive the engagement process in fact is.

The analytical concepts and tools presented in this theoretical framework each offer us a distinct and meaningful way to consider citizen stakeholder engagement in monitoring R&D and to effectively assess and evaluate the efforts that we have made to this regard in the Modern2020 project.

The rather novel concept of Responsible Research and Innovation (RRI) functions as a general theoretical backdrop against which the local stakeholder engagement efforts in WP5 can be considered. As RRI envisages that *"societal actors [...] work together during the whole research and innovation process in order to better align both the process and its outcomes with the values, needs and expectations of society"* (Horizon2020 website), we could say that the broad aim of WP5 was to put RRI into practice in repository monitoring R&D. In order to take the concept of RRI one step further, we presented above the idea of co-RRI as proposed by D'Haese et al. (2018). Co-RRI stresses that problem-solving cannot solely be based on scientific knowledge and that the necessary knowledge for tackling grand challenges lies scattered among different stakeholders. The concept therefore explicitly proposes the co-creation of relevant knowledge and solutions. Related to this argument is the notion of 'knowledge alliances' (Novy et al. 2013), which puts the rather vague idea of transdisciplinarity into practice. A knowledge alliance strives to integrate various forms of knowledge in an iterative process in which the solution to a certain problem becomes co-designed.

Our experiences with local stakeholder engagement in Modern2020 show that realizing this theoretical ideal of co-design is not always easy to do so. In order to adequately assess stakeholder engagement within Modern2020, we have proposed some evaluation tools which will, throughout this report, help us in finding a framework and indicators of what it means to realize public engagement 'effectively' and 'successfully' in practice. The framework of Rowe and Frewer (2000) offers us a perspective on the advantages and disadvantages that each participatory method has to offer and how to evaluate this. On the other hand, Delgado et al. (2011) point us to the frustrating reality of stakeholder engagement which often becomes riddled with tensions. Understanding and assessing these tensions for concrete cases of stakeholder involvement in R&D can strengthen our evaluation of such an exercise in public participation and offer us valuable lessons learned for future R&D projects.

In the next section we present citizen stakeholder participation in the Modern2020 project as it was done concretely after which we discuss two other primary instances of public participation in Modern2020, namely the iterative process in which the Stakeholder Guide was developed and the main results of the interactive Delphi survey which are structured around the tensions that Delgado et al. (2011) bring to the fore. The theoretical resources presented in this part of the report will be referred back to throughout the other chapters, although not in a systematic way. It is more so that they allow us to reflect back on the participatory initiatives in a systematic way whilst providing us with the tools to carry out an assessment and to come to some concrete lessons learned.

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3.2 Citizen stakeholder participation in project meetings and workshops

The stakeholder engagement activities in WP5 have focused on early engagement of citizen stakeholders in the development of repository monitoring programmes. As explained in chapter 2, we have sought to involve a small group of local stakeholders from different countries directly in project meetings on technical aspects of the work. This was complemented with communication of this involvement to wider groups at the specific localities participating. In this section, we describe in more detail how this engagement activity was put in practice and what its key elements were.

For the reasons explained in the introduction and chapter 2 we have sought to involve local stakeholders already engaged in radioactive waste issues from four different European nations: Belgium, Finland, France and Sweden. The engagement of these local stakeholders in an expert-driven technical research project such as Modern2020 was not always easy, in particular as a result of involving them directly with technical researchers. Firstly, it is quite challenging to find local stakeholder participants who are willing and motivated to attend and follow up on technically detailed workshops and project related documents which are often outside of their own comfort zone in terms of knowledge and interest. Secondly, the decision to specifically approach concerned citizens who were directly implicated in national waste management programmes meant that development at the national level needed to be taken into account. This, for example, led to the late entrance of French stakeholders in the project, and to a temporary hold in participation of the Swedish stakeholders at the time of the Environmental Court hearings and its related decision-making process. Nevertheless, we managed to engage two Belgian local stakeholders (citizens involved in a participatory platform on various radwaste projects in the municipalities of Dessel and Mol), and two Finnish local stakeholders (local politicians from the municipality of Eurajoki, following the development of the ONKALO facility from close by) on a very regular basis as well as bringing the topic of monitoring to the attention of concerned citizens and communities through various home engagement sessions which instigated some debate amongst these groups.

3.2.1 Engagement at the project level

At the beginning of the Modern2020 project, an interaction plan was prepared by WP5 team members in collaboration with the other WP leaders. However, it was at that stage not possible for all work packages to clearly communicate the content and set-up of all future meetings ahead. Commitment was given in principle to identify possibilities for engagement. In reality, and understandably, priority was given to project logic in planning meetings, and the potential for concrete stakeholder interaction sometimes only considered in second instance. The idea from the start had been to immerse the local stakeholders directly into the 'project action' itself. This was conceived as an ongoing experiment in the sense that we would adjust or correct this process of local stakeholder involvement when needed, but at the same time aimed at coming to results, conclusions and lessons learned about the conditions for successful stakeholder engagement in R&D by observing the interaction dynamics throughout these various engagement activities. After the first meeting attended by local stakeholders (see below) it was suggested they could be briefed in information sessions or via targeted documents prior to project meetings. However, we feared this could inadvertently lead to an imposed framing before the actual meetings would occur. Therefore, we advised against this and preferred the local stakeholder participants to have access to the same material as the project partners. Additional material and explanations could then be provided

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if needed. This was for example the case during the second workshop they attended, where NWMO partners explained in a dedicated session more in detail the differences between various national programmes. Furthermore, it also became apparent that preparing dedicated briefing material of each workshop in advance would not have been workable in the long run. Due to practical considerations and time constraints, draft programme's and related material for project meetings were often distributed quite late in the process, as the research to be discussed obviously was ongoing.

Instead of having the local stakeholders contribute to specific technical details and the progress of a delineated task, we chose to engage them in the project on a more ad-hoc basis whilst taking into account the local stakeholders' and the project consortium's wishes and needs for interaction. As a result, local stakeholder involvement intensified at certain moments throughout the project depending on the participants' needs. Each interaction moment at the project level meant a confrontation with outside views and expectations, thus offering an opportunity to learn for both sides, also in terms of communicating and discussing complex issues with people 'less submerged'[5] in the topic (see also section 3.4.2.2). Examples of how these 'confrontations' lead to new insights into how to communicate and discuss the ongoing work in the project include the development by WP2 members of a glossary on concepts and features of geological repositories related to repository monitoring, which was produced at the beginning of the project at the local stakeholders' request, as well as the technical 'index cards' explaining each group of technologies under development in WP3. These cards were developed by WP3 members to provide local stakeholders with an entry point into their work.

We furthermore focused on engaging a small core group of engaged community representatives (two from Finland, two from Belgium and one from Sweden) who regularly attended technical Modern2020 project meetings and workshops organised at the European level from relatively early on in the project. Here, we chose to engage them in more accessible project meetings such as those from WP2 and the General Assemblies. The local stakeholders did not attend any meetings from WP3 and WP4, as these meetings specifically deal with techno-scientific details which are often difficult for local stakeholders to comprehend. Below, we provide an overview of all project-level engagement activities at which local stakeholders were present. These include three WP2 workshops, the WP5 workshop organised in September 2018 and two General Assembly meetings. We will then take a closer look at each of these five engagement activities by describing its contents and main results.

Activity	Date	Participants
WP2 Workshop in Stockholm, Sweden	1-2 December 2015	Modern2020 partners: 21 technical experts working within WP2 WP5 research team Two Belgian local stakeholders and one Swedish local stakeholder

[5] We explicitly do not want to make use of the lay-expert juxtaposition here. For one, because some of the local stakeholders did have a considerable technical background. But also because there often was also quite some difference in opinion among the experts in the project. However, as the experts had more opportunity to interact and worked on a regular basis on these questions – some for quite some time already, there was inevitably more 'group alignment' among the project partners.

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WP2 Workshop in Oakham, United Kingdom	14-16 June 2016	Modern2020 partners: 16 technical experts working within WP2 WP5 research team Two Belgian local stakeholders, two Finnish local stakeholders and one Swedish local stakeholder
WP2 Workshop in Paris, France	1-2 March 2017	Modern2020 partners: 17 technical experts working within WP2 WP5 research team Two Belgian local stakeholders and two Finnish local stakeholders
General Assembly in Montpellier, France	6-7 June 2017	Modern2020 partners: 32 technical experts from the various work packages WP5 research team Two Belgian local stakeholders and two Finnish local stakeholders
General Assembly in Sargans, Switzerland	5-6 June 2018	Modern2020 partners: 38 technical experts from the various work packages WP5 research team Two Belgian local stakeholders and two Finnish local stakeholders
WP5 Citizen Stakeholder Workshop in Antwerp, Belgium	12-14 September 2018	Modern2020 partners: 5 technical experts working within Modern2020 WP5 research team 16 citizen stakeholders from Belgium, France, Finland and Sweden
Modern2020 Final Conference in Paris – WP5 Roundtable discussion, France	9-11 April 2019	Various participants: research partners from Modern2020, the WP5 research team, other academics (from various fields) and nuclear waste management professionals, and five local stakeholders from Sweden and Finland. The invited speakers to the roundtable included two local stakeholders from Sweden and Finland, a social scientist from WP5, a technical expert from Modern2020, two representatives from a NWMO and a regulatory body and an artist working with the nuclear waste issue. The roundtable was chaired by a Reader in Curating at Goldsmiths University of London.

WP2 Workshop in Stockholm, Sweden (December 2015)

The main aim of this workshop was to formulate repository monitoring strategies within WP2 and as a secondary ambition the meeting aimed at capturing how local stakeholder views could influence the strategy adopted for the repository monitoring programme. Three citizen stakeholders attended this WP2 workshop in Stockholm, namely two Belgian stakeholders (from Mol and Dessel) and a Swedish

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stakeholder (from Östhammar). The local stakeholders attended the five technical sessions that each dealt with a specific theme. In addition, WP5 fieldwork was carried out throughout the workshop with a twofold aim: (1) to capture citizens' views, outlooks and understanding of the technical ins and outs related to repository monitoring; (2) preparing for successful 'home engagement' activities and other project-related engagement initiatives by gathering this information. To this end, the participating local stakeholders were also provided with an evaluation scheme by which they could give feedback on the ways in which they were involved in this first workshop.

A first major outcome of this evaluation exercise relates to the lack of clarity and conceptual confusion surrounding the technical jargon that was used throughout the workshop. As such, the citizens were unanimously advocating for clearer information. From their viewpoint, a good understanding of the (technical) terms is crucial to allow for an efficient communication between all participants and for a meaningful contribution on their part. During the discussions, some citizens were not satisfied with their own contributions, but suggested that a better understanding of the technical content would allow them to improve their input significantly. Vague terms – examples include 'system performance parameters relevant for decision making' or 'generic decision support process' – need to be clarified and in the best case supported by examples.

A second outcome of this workshop was that the national differences presented in the various WP2 case studies – for example relating to disposal concepts, types of waste, status and history of the national disposal programme – rendered it more difficult for local stakeholders to follow the discussions. Even though the involved citizens are generally knowledgeable about the meaning of the safety case in their national context, the explicit role of monitoring and the monitoring strategy in their country's disposal concept was not sufficiently clear. As such, the participating stakeholders expressed interest in first gaining a further understanding of their country's monitoring strategy, and then compare and explain the differences between parameter choices and monitoring approaches in the respective countries.

Also other suggestions were given concerning the improvement of local stakeholder involvement at the 'project level' including the development of a comprehensible glossary of various key terms used throughout project discussions. The citizen stakeholders, in addition, proposed to have preliminary information sessions before each project workshop in order for them to enhance their input to the discussion. A (face-to-face) briefing and debriefing at home and a clear activity plan prior to the workshops was also proposed by some participants.

WP2 Workshop in Oakham, United Kingdom (June 2016)

The main focus of the Oakham workshop lied with the development of a parameter screening process with some particular attention to the question of how local stakeholders could be engaged in this screening process, and, by extension, in the overall project, which was the subject of a specific session during the workshop ("Stakeholder Engagement in Task 2.1"). The workshop was attended by five local stakeholders from Belgium, Finland and Sweden. The discussion involving technical experts and local stakeholders focused around the expectations that the participants have regarding the involvement of citizen stakeholders in the project, the possibilities they see for them to contribute to the project, the specific role that citizen stakeholders can take up and which criteria we could use for considering stakeholder engagement in the project as successful.

Participants pointed towards various points that are important to consider regarding civil stakeholder engagement in the Modern2020 project. As such, it was mentioned that early engagement of local

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stakeholders is crucial in order to increase the democratic character of the process as well as its substantive dimension by creating opportunities for constructing a shared problem definition. It was also mentioned that this will increase mutual trust-building, which might enhance social acceptance of the project in the end. There was some discussion about whether and how monitoring could work as a tool for establishing interactive dialogue between technical experts and local stakeholders, as well as about to what extent local stakeholders should have a certain amount of (techno-scientific) knowledge about the topic to be able to engage with it. As one local stakeholder mentioned, it is not possible to bridge this knowledge gap between experts and citizens entirely, so it comes down to trust, which needs to be built up gradually through open and transparent communication efforts coming from the expert community. Lastly, the participants listed some criteria for successful stakeholder engagement in the project, including increased knowledge of monitoring in geological disposal for local stakeholders and the formulation of local stakeholders' feedback on the plans and communication efforts of the participating nuclear waste management organisations.

WP2 Workshop in Paris, France (March 2017)

The topics discussed in the Paris workshop included the reporting of interim results from the screening test cases, an introduction of the work on performance measures and response plans, and WP2's work on decision-making methods, tools and workflows. Four local stakeholders from Belgium and Finland were present. In contrast to previous WP2 meetings, there was no specific session dedicated to citizen stakeholder interactions; instead, relevant discussion was incorporated into the technical sessions. Interventions made by WP5 researchers and local stakeholders mainly related to the decision-making workflow and focused on questions about what decisions require the involvement of (local) stakeholders at the governance level. Participants agreed that the identification of external decision makers (including regulators and public stakeholders) is relevant for all responses, not only in emergencies. Involvement of different parties will be shown on the decision-making workflow by a coloured symbol. Questions regarding to what extent raw monitoring data should be shared with local stakeholders were also asked and further discussed during this meeting.

General Assembly in Montpellier, France (June 2017)

The general aim of this general assembly meeting was for the various work packages to present the progress made within each WP so far as well as the future research activities planned. Apart from these plenary presentations (which were also attended by the present local stakeholders), WP5 organised several sessions in function of the WP5 research tasks. A session for discussing the first draft of the table of content for the Stakeholder Guide document (D5.2) was organised. In this session several topics relating to the guide were discussed in groups of participants of about 10 people each. The technical experts working within Modern2020 and the four Belgian and Finnish local stakeholders present at the general assembly were divided over these different break-out groups, in order to have at least one local stakeholder present in each group.

A second topic was also discussed in these break-out groups, focusing on the question 'what is to gain from local stakeholder engagement?'. In order to guide this discussion, the theoretical framework developed by Stirling (2008), focusing on the various rationales for organising public participation (normative – substantive – instrumental), was briefly presented and taken as a guidance throughout the discussions. The main results from these discussions showed a general support for the instrumental

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imperative which states that public participation can be used to increase trust and acceptance. When it came to the substantive imperative, which claims that public participation could help to improve the overall quality of the project, the opinions were more mixed. Some participants believed that the input of citizens could improve the design of repository monitoring whilst others did not believe this would make much of a difference. The conclusion here was that citizens and scientific experts should decide together what should and should not be discussed. Lastly, with regard to the democratic imperative of public participation (i.e. stakeholders have 'the right to participate'), we found little consensus in our discussion groups.

A last intention of the WP5 workshop within the general assembly meeting was to get a better view on local stakeholders' opinions and expectations of what, where and when to monitor as well as on the technical experts' (and local stakeholders') opinions of the national differences that exist between the various monitoring approaches. To this end, a graph was used in which the participants had to indicate on what locations and at what time they would consider monitoring for geological repositories.

General Assembly in Sargans, Switzerland (June 2018)

As this activity concerned a general assembly meeting as well, the main aim of this gathering was to present the progress made within each WP as well as their future plans. The present local stakeholders (four Belgian and Finnish local stakeholders) were invited to attend these plenary presentations. However, on the second meeting day, a WP5 session with the local stakeholders only (no technical experts present) was organised in parallel to the plenary presentations. In this session, we inquired the local stakeholders about various matters, including (1) an evaluation of the presentations which were held the day before: were the local stakeholder participants able to understand the information presented and would they be able to explain this to other local stakeholders?; (2) feedback on the new draft of the Stakeholder Guide (D5.2), which had been delivered to them in advance; (3) a discussion on the planned online Delphi inquiry: who do they think should be involved in this questionnaire and what topics should be addressed in this questionnaire?; and (4) a discussion on the WP5 workshop planned in September 2018: again we wanted to know the local stakeholders' opinions on who should definitely be invited to this workshop, what the format of the workshop should be and what topics should certainly be dealt with.

WP5 Workshop in Antwerp, Belgium (September 2018)

During two days, local stakeholders from four countries (Belgium, Finland, France and Sweden), in total 16 people, have been invited to share their opinions on monitoring with technical experts, and to express their experiences, remarks and recommendations for organizing stakeholder engagement within research projects, such as Modern2020. The general purposes of the workshop can be summarized as exchanging experiences and expectations regarding citizen stakeholder involvement in nuclear waste management, gathering local stakeholder's feedback on the work done in the Modern2020 project and reflecting on how to realize 'good' local stakeholder engagement in similar RD&D projects.

More c oncretely the workshop sessions were structured around three main topics: (1) *Exchanges with Modern2020 work so far*: A selection of the work produced within Modern2020 was presented and local stakeholders were given the opportunity to express their feedback on this work and the way it is communicated. Starting from this exchange local stakeholders and Modern2020 researchers further discussed why monitoring is important or not, and how and with what purpose it could be done; (2)

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Reflections on local stakeholder engagement within Modern2020: Using interactive discussion methods and concepts from social science, participants were asked to reflect on their personal experiences and opinions about the way local stakeholders have been involved in the Modern2020 project, but also in radioactive waste management in general; (3) *What is 'good' stakeholder engagement and how to realize it?* Building upon the earlier discussions we ended with more general discussions on 'good stakeholder engagement', with a particular emphasis on engagement within RD&D and where that fits in a broader governance perspective: What does it mean? What can be gained? How can we learn from the interactions between scientific and other types of knowledge? Under what circumstances could this be realized? Together with the participants we have formulated recommendations to the European Commission whose aim is to fund local stakeholder participation events in similar research projects.

Modern2020 Final Conference – WP5 Roundtable discussion in Paris, France (May 2019)

At the WP5 roundtable discussion, organised in a parallel session to the Modern2020 Final Conference, nine pannellists representing different positions within nuclear waste management were invited to discuss a variety of questions related to embedding knowledge of underground sites within cultures and communities. These participants included artists working on geological disposal of nuclear waste, along with citizen stakeholders, a social scientist and representatives of NWMOs and a regulator. The discussion was chaired by curator Ele Carpenter to consider how the panel works differently to make public issues of site marking and monitoring from the visual arts to local community engagement.

The main topics through which we sought to discuss different stakeholder perspectives on monitoring in geological disposal were **transparency and vigilance** (including knowledge preservation as well as the challenges of deep time and intergenerational communication). Thus, the main questions asked during the roundtable were: '*How to make the underground known: through data, over time and in the present? Who should be watching?*' The participants discussed these topics as well as a set of sub-questions in a dynamic way with room for the audience to intervene with comments and questions.

3.2.2 Home engagement activities

Besides the engagement of a quite limited number of local stakeholders in project meetings and other project-level activities, WP5 organised several 'home engagement sessions' in the home communities of interested public stakeholders in Belgium, Finland, Sweden and France in order to discuss their concerns and opinions about monitoring in nuclear waste repositories. Below, you can find a schematic overview of these different workshops as well as a short discussion of each meeting.

Activity	Date	Participants
Home engagement session with STORA and MONA in Dessel, Belgium	12 May 2016	WP5 research team (University of Antwerp) Two ONDRAF/NIRAS representatives and one Modern2020 technical expert 12 Belgian local stakeholders (both MONA and STORA)
Home engagement session in Östhammar, Sweden	16 May 2016	WP5 research team (University of Gothenburg) 4 SKB representatives 20 participants from the municipality of Östhammar

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Home engagement session with STORA and MONA in Dessel, Belgium	9 May 2017	WP5 research team (University of Antwerp) 13 Belgian local stakeholders (both MONA and STORA)
Home engagement session with STORA and MONA in Mol, Belgium	19 June 2017	WP5 research team (University of Antwerp) One ONDRAF/NIRAS representative and one Modern2020 project partner Approximately 10 Belgian local stakeholders (both MONA and STORA)
Home engagement session in Eurajoki, Finland	30 November 2017	WP5 research team (University of Antwerp) 8 Finnish local stakeholders from the municipality of Eurajoki
Home engagement session in Bure, France	22 May 2018	WP5 research team (University of Antwerp) 5 French local stakeholders from local organisation, Clis de Bure

Home engagement session with STORA and MONA in Dessel, Belgium (May 2016)

This first home engagement session in Belgium concerned an introductory workshop with the aim to a) find out how local stakeholders define 'successful' participation and how they would view their role within in the research of Modern2020, and b) quest their interest and knowledge on the topic of monitoring. A representative from ONDRAF/NIRAS agreed to create a presentation on the topic of the Belgian monitoring case and its influencing factors (legal, technical, host rock and other 'boundary conditions'), including an example for a parameter that is probable to be measured in a Belgian repository. This presentation by ONDRAF/NIRAS was preceded by an introductory presentation from the WP5 research team concerning an introduction to the Modern2020 project, the topic of monitoring, and stakeholder engagement in R&D projects. The home engagement session was split into two parts of one hour each. Each presentation was followed up by a discussion round, 'fueled' by questions to open up the discussion.

The main conclusion of this session is to take note that the citizens consider themselves on the one hand as middlemen and bridge builders to society at large and on the other hand as watchdogs. To successfully fulfil this 'job' they offered, to provide this critical-constructive voice of society, they need a transparent communication and detailed, comprehensible information, at best in the form of intermediate research results. In this regard it became clear that the endeavor of citizen involvement in Modern2020 is an activity which requires careful communication between work packages and keeping an eye on the 'processing' of technical data, so that citizens are able to authentically provide this constructive voice. It, furthermore, turned out that citizens found the division between repository monitoring and other forms of monitoring too artificial and found themselves unable to discuss the technical details of repository monitoring in depth.

Home engagement session in Östhammar, Sweden (May 2016)

The agenda for this workshop was co-developed with all involved partners. Thus, both SKB and local stakeholders were enrolled in the preparations to provide input into the planning of the sessions. The

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workshop started with presentations from the University of Gothenburg and the SKB. The purpose of the Modern2020 project was briefly presented. Then the University of Gothenburg made presentations of stakeholder involvement in technical projects and of the role of social science in technical projects such as Modern2020. SKB, in turn, presented its work on monitoring and how this relates to the KBS-3 method. The presentations were intended to serve the purpose of providing a basis for discussion. The workshop was intended to give members of the municipality's working groups the opportunity to comment on the structure and the results of the Modern2020 project, but also to open up for new ideas, perspectives and comments on monitoring. The University of Gothenburg had prepared for group discussions which should open up for broad discussions together with Östhammar Municipality and SKB.

Summing up the main conclusions of this workshop, it can be said that the monitoring issue was highlighted as a complex issue, just like the final repository issue in general. Not least, the complexity consists of the long periods of time that the final repository issue relates to. The participants also had different views on what a monitoring programme should look like (if it should even exist at all), what purpose it should serve and what should be done with the information produced.

Home engagement session with STORA and MONA in Dessel, Belgium (May 2017)

This workshop centred around two main topics. Firstly, a WP5 researcher from the University of Antwerp presented the main findings from the WP5 deliverable 5.1 'Monitoring the Underground. What role for repository monitoring in the governance of geological disposal for nuclear waste?', which was followed by a plenary discussion about the topics addressed in this research report. Secondly, another WP5 researcher from the University of Antwerp briefly presented the idea of developing a stakeholder guide on repository monitoring and public participation, after which the plenary discussion continued and feedback on this idea was received. In general, the discussions focused on the topic of geological disposal and the role of repository monitoring herein, as well as its connection to issues such as 'dealing with uncertainty', 'building confidence', 'it's relation to the safety case', 'time' and 'monitoring as a means to legitimize geological disposal of nuclear waste and further use of nuclear energy'. The idea of the stakeholder guide for repository monitoring was positively received and the development of such a book was generally perceived as a worthwhile activity.

Home engagement session with STORA and MONA in Mol, Belgium (June 2017)

This workshop consisted of two parts, the first one consisting of a presentation by a ONDRAF/NIRAS representative who briefly sketched how ONDRAF/NIRAS perceives the role of monitoring in the future Belgian repository for high-level nuclear waste, highlighting during what phases of the repository project and how there should or could be monitored. The second part of the workshop focused on the first draft of the table of content for the stakeholder guide for repository monitoring and public participation, which opened up other questions about the value of local stakeholder engagement in R&D – here, the discussion focused on talking about the various imperatives for public engagement as defined by Stirling (2008) (instrumental – substantive – normative distinction) – and about what local stakeholders would like to learn about repository monitoring and monitoring for geological disposal in general and what contents the stakeholder guide should include accordingly.

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Home engagement session in Eurajoki, Finland (November 2017)

This workshop centred around a presentation given by WP5 researchers from the University of Antwerp, which included a brief presentation of the Modern2020 project and the topic of monitoring in general, an introduction to the idea of developing a stakeholder guide of repository monitoring, and a country comparison of how the various NWMOs in Finland, France, Sweden and Belgium view the role of monitoring in their respective repository concepts. These topics were then opened up towards the local stakeholder public who discussed monitoring, but also, more generally, how they as citizens are involved in nuclear waste management and what ethical principles they find to be crucial herein. The results of this workshop mainly pointed towards the existence of a 'culture of trust' from the Finnish local stakeholders towards the responsible nuclear authorities in Finland. They mentioned the efforts from these authorities to be as transparent and informative as possible and the juridical certainty that comes with their local community accepting the repository. The participants found monitoring to be important in the context of geological repositories for nuclear waste but viewed this as a matter to be discussed by experts and not so much by themselves or their peers.

Home engagement session in Bure, France (May 2018)

Five CLIS de Bure members participated to this workshop entitled "control, monitoring and watching: what kind of monitoring systems do we want?". The general aim of this workshop was to inquire about the French local stakeholders' perceptions and expectations of monitoring for geological disposal, more particular their opinions about why, when, where and what to monitor in geological repositories. The workshop started out with a presentation from a WP5 researcher (University of Antwerp) who briefly presented the Modern2020 project and the concept of monitoring in the context of geological disposal. The discussion was quickly opened up and various opinions about why, when, where and what to monitor were expressed by the participants. The second part of the workshop focused on how the French local stakeholders could still be involved in the Modern2020 project, even if that meant joining the project in a later stage, and what expectations they have of this involvement. Our attention was brought to the issue of language as this formed the main obstacle for them to participate (common language used in the project is English). However, they did point out that it would be possible for one or two interested CLIS de Bure members to come to future workshops (such as the WP5 workshop in Antwerp in September 2018) who can then share their acquired knowledge with the community back home.

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3.3 Developing the stakeholder guide: a collaborative process

As part of WP5 the sociologist affiliated with the Modern2020 project coordinated the production of an (on-line) local stakeholder guide to repository monitoring in the context of geological disposal of high-level nuclear waste (D5.2: Meyermans et al. 2019).

3.3.1 How it was done

The work to produce the stakeholder guide took place in collaboration with the technical experts and local citizen stakeholders involved in the project. This guide is not only meant to communicate the state of the art on geological disposal and repository monitoring to a non-scientific audience. It should also serve to facilitate discussion between scientists and a variety of publics (such as citizens, policy-makers and journalists) about various, often interrelated technological and social concerns. In fact, the production of the guide has itself been an exercise in stakeholder participation that aims to clarify the different societal perspectives, interests and concerns surrounding repository monitoring.

In this collaborative process project partners and local stakeholders discussed the purpose, content and form of this particular Modern2020 product. During the writing process, the social scientists acted as pen holders, 'fed' with technical information by the other project partners, whereas the participating community representatives had the key role of pointing out what issues and questions they thought useful to address. An editorial board – composed of the project coordinator, work package leaders and one community representative – followed-up the writing process. Feedback from a broader group of project partners and community representatives was also obtained during a workshop partially dedicated to this product. The project partners took up the role as guardians of the technical accuracy of the sections on (repository) monitoring (techniques), where the citizen stakeholders primarily focussed on the clarity of the wording and usefulness of the information.

3.3.2 What was achieved

As a result of this joint writing process, involving project partners and participating community representatives, the nature of the stakeholder guide evolved from an explicit focus on (technical) repository monitoring to a broader reflection on monitoring in the context of repository governance and the role of public participation. Also, accounting for the many differences between national contexts (in terms of geology, the stage of technology development, legislation, legacies of stakeholder involvement, etc.), developing a shared conceptual framework on monitoring and dealing with the complexity and the very large (uncertain) timeframes of the geological disposal projects were some of the main challenges for this guide. This was among the reasons for the stakeholder guide to evolve from a manual like structure (offering the state of the art in an understandable language for a non-expert audience) to a more open, reflective document, showing not only what is known today, but also pointing out remaining knowledge gaps, uncertainties, etc., and making clear that there are and will remain differences between national programmes, and this for several reasons.

This general approach to the stakeholder guide is reflected in its final content. The first chapter, titled 'Radioactive waste and geological disposal: a matter of expert and public concern' briefly introduces the issue of radioactive waste and explains how geological disposal could be a possible solution. A

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description of all the actors involved in nuclear waste management makes it clear that this is a matter of concern for both experts and the public. It is argued to the reader that the viewpoints, needs and expertise of these different stakeholders should be included in the various phases of decision-making when building geological repositories for radioactive waste. The second chapter 'Monitoring in geological disposal' then starts with an overview of the different types and strategies for monitoring geological disposal sites. The various technical experts' and local stakeholders' views on why, how and to what extent waste repositories should be monitored is also discussed. Lastly, this chapter presents a selection of state-of-the-art monitoring technologies. We end the guide with a third chapter 'Public participation in monitoring R&D. How to engage people?', which draws on the real-life experiences of citizen stakeholders involved in the Modern2020 project to reflect on why and how the public can participate in different types of technology development. As a variety of strategies and methods for public stakeholder involvement and dialogue in the R&D of monitoring for geological disposal are identified and explored, readers are offered some concrete tools to help them engage reflexively in similar participatory processes themselves.

In view of a self-appointed role as watchdog and knowledge-broker (see sections 3.4 and 4.1), the aim of the stakeholder guide is to offer a tool to stimulate further interaction between (local) public stakeholders and repository developers and to create awareness of the concerns and expectations with regard to the governance of disposal processes in different contexts, and the process of producing it has given important results in this regard.

This process can be seen as an example of RRI (see section 3.1), but not co-RRI, since there was no aim to solve 'grand problems'. Nevertheless, it has clearly been about making R&D more social sensitive and to better adapt to societal concern raised by public stakeholders. It has been clearly a transdisciplinary effort and we can claim a knowledge alliance was established in the project group. However, it is less clear in what ways this guide will influence technical R&D work. Therefore, we have to acknowledge that there is a risk that this event is just an extra activity, a kind of added-on thing. Still, inspired by STS (e.g. Delgado et al. 2011) we have made it our ambition to make tensions visible: by showing that there are no simple answers to the why, how, when and where questions. The answers can vary according to the geological, social, political, technological and historical context, and such tensions are not necessary a negative thing, but important to make visible.

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3.4 An online interactive survey to stimulate dialogue

In the last year of the project, both the local stakeholders who had participated in at least one meeting relating to Modern2020 and all project partners (apart from the social science research team) were invited to take part in a dedicated online interactive survey. The survey was set up in English. A full overview of the questions asked in both rounds can be found in the Appendix.

3.4.1 How it was done

This combined research and engagement activity was organised through a two-rounds Delphi survey, using an online tool called Mesydel. The Mesydel programme allows an easy and manageable input of the survey questions, contact with the respondents, and analysis of the obtained data and answers[6].

An inquiry of this type is not a classical survey. It is a 'Delphi style dialogue' between the (technical) researchers and local stakeholder participants in the Modern2020 project in order to collect and respond to:

- views on what role geological disposal monitoring can play in repository governance in the process from 'conception' to 'closure' (and possibly beyond);
- appreciations of the stakeholder engagement activities in geological disposal monitoring generally and more specifically within the Modern2020 project;
- and lessons learned regarding the effective engagement of local citizen stakeholders in RWM related R&D activities.

In its original form, developed by the Rand Corporation, the Delphi method is a forecasting tool, a process of arriving at group consensus through multiple rounds of questionnaires send to a panel of experts. Each round builds on the previous one, as the aggregated anonymous responses are shared by the group facilitator after each round. Participants are invited to clarify or adjust their answers in subsequent rounds. The Delphi method has since evolved; it has been applied to other fields than forecasting, and the notion of participants has been expanded to include a broader understanding of expertise, views and interests regarding a specific topic (see e.g. Bayley & French 2008, Francois et al. 2013, Linstone & Turoff 2002, Hsu & Sandford 2007).

The aim with this online dialogue in Modern2020 was not to come to a full consensus on views, but to make explicit where (and potentially why) views correspond or collide and how this could affect engagement processes in nuclear waste governance, with a clear focus on R&D. This in combination with certain time constraints, made that in this case we have opted for a two-round survey. The results of this interactive survey obviously represent only a small, particular set of local stakeholders and technical experts in this matter (namely those participating in Modern2020), but they are nevertheless illustrative for how concerned actors of various backgrounds perceive the need and possibilities for local stakeholder involvement in R&D, and what expectations they have regarding repository monitoring. The format is comparable to an internal survey, e.g. in a company, where the full population is known and coordinates for all all to be invited are known.

[6] For more information see online: https://mesydel.com/en (accessed 14/11/2018).

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The first round of the survey was online for about a month (2-29 October 2018). Subsequently the anonymous responses were analysed, and a new survey round was prepared. A synthesis of similarities and discrepancies in views was presented back to the respondents for feedback in the second round, which ran from 7 January to 10 February 2019. At this stage, the emphasis was put on issues we as analysts and group facilitators thought demanding further deepening or clarification.

At each step, respondents were invited by email (one automatically generated by the Mesydel programme and one follow-up email from the social science research team to make sure the invitation was received). Respondents were notified of the deadline for submitting their answers via the invitation emails, two reminder emails, and personal email alerts before the online survey was closed. All invited to participate in the first round, were again invited for the second round. Respondents who participated only in the second round, were also asked to fill out the profile questions from the first round.

The data were treated anonymously. Some background data about the respondents were collected regarding their role and involvement in national RWM programmes, technical or scientific background, level of participation in Modern2020 and general opinions about RWM principles and strategies. These helped us to understand positions taken and to relate statements to a broader context from which they originate. It also gave the possibility to formulate hypothesis on differentiation between types of respondents. Respondents to the survey identified themselves as: local citizens, local politicians, NMWO representatives, TSO[7] experts, technical consultants or academics from varying nationalities). Besides this fixed set of possibilities to choose from, respondents were offered an alternative option 'other' which they could then specify.

3.4.2 What was achieved

The first round of the survey achieved a participation rate (percentage of respondents who answered at least one question) of 42%, which means that 37 out of the 88 invited respondents participated to the inquiry. The completion rate (the average percentage of response rates per respondent) of these respondents was 57%, which means that each respondent on average answered to somewhat half of all questions asked. Two elements have influenced this number. First, the survey contained a section for local stakeholders and one for technical experts. Therefore a 100% completion rate was not possible for any participant[8]. Second, a small number of respondents with a very low response rate brought down the average number even further. Refining the participation rate for the first round further, we see that 21 out of 38 invited technical experts (55%) participated to the survey, and 15 out of the 50 invited local stakeholders (30%)[9].

The second survey had a participation rate of 43%; 38 out of the 88 invited respondents participated here, with a completion rate of 44%[10]. It is worth clarifying that out of these 38 respondents, 30

[7] The term Technical Support Organisation (TSO) refers to specific organisations performing technical field work (e.g. inspections) on behalf of the regulatory agency.
[8] The highest possible completion rate for respondents who identified as 'local stakeholders' was 77%. The highest possible completion rate for respondents who identified as 'technical experts' was 66%.
[9] During the first survey round, we learned that the language barrier posed a real challenge for many of the local stakeholders. We nevertheless received responses from Sweden, Belgium and Finland, but not from France.
[10] These obtained participation rates, for both the first and the second round, correspond to the response rate of 30-40% that a internally distributed survey (i.e. to project members, employees, etc.) will generally receive, compared to an average 10-15% response rate for external surveys (i.e. customers, the broader public) (Fryrear, 27 July 2015: https://www.surveygizmo.com/resources/blog/survey-response-rates).

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participated to the first survey round as well, and 8 respondents only participated to the second round. For the second round, we see a slightly lower participation rate for the technical experts (19 out of the 38 invited respondents or 50%), whilst the participation rate for local stakeholders has risen to 38% (which means that 19 out of the 50 invited local stakeholders participated).

Both survey rounds consisted of two main parts; a first part in which we inquired about the respondents' expectations with regards to (repository) monitoring in relation to repository governance, and a second asking about the respondents' opinions on expectations regarding (local public) stakeholder involvement in R&D. We have adopted the same structure in our description and explanation of the online survey results below, subdividing each of these overarching themes in various topics of attention.

As an important issue that influences the developments as well as outcomes of RWM decision-making processes, we wanted to gain more insight into local stakeholders' perceptions and opinions with regards to (dis)trust in radioactive waste management. To this end, the final part of the survey questioned local stakeholders (only) specifically about their level of trust in RWM with a focus on broader repository governance and the place of monitoring therein. We have, however, not dedicated a separate section to the description of those results in this report, as the outcome was quite unequivocal and did not require much additional clarification. In summary, the local stakeholders who have been engaged in the Modern2020 project are quite trusting towards their national radioactive waste management organisation and national regulatory body and, in general, have positive opinions with regards to the levels of transparency and openness that these authorities have towards them. Most of them are of the opinion that both institutions provide sufficient information about their work to the citizens in the concerned communities and would turn to these institutions for expert advice on radioactive waste management.

3.4.2.1 Expectations with regards to (repository) monitoring in relation to repository governance

> *"A prerequisite for monitoring, according to me, is that the technology is good enough to use. And I think that it seems to be well on the way to that, but it is not my area of expertise. The same goes for the ability to interpret the results. Considering timeframe, my opinion is that if we are able to follow the repository even a few decades that is better than nothing. If something goes wrong during that time at least we were able to notice and act on that."* (local stakeholder)

In the first round of the survey, most respondents (73%) agreed that repository monitoring should be considered a priority in the national radioactive waste programme that they are involved with. Most respondents agree WHAT repository monitoring is, but answers indicate a disagreement with regard to WHY repository monitoring is actually done. In contrast to technical experts, local stakeholders showed a tendency to either use repository monitoring as an all-encompassing concept including near- and far-field, geo- and biosphere, or to emphasise the importance of all types of monitoring.

Interestingly, both among local stakeholders and technical experts, we find respondents who envisage repository monitoring to also take part after closure. Furthermore, over half of the technical experts and 65% of the local stakeholders considered all moments (before and during operation, as well as before and after closure) as relevant for repository monitoring.

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What types of monitoring are seen as relevant, and where should repository monitoring take place?

Most respondents considered environmental monitoring as well as monitoring of the (natural) geological barrier and the Engineered Barrier System (EBS) as equally relevant in their national nuclear waste management programme. Monitoring of the waste packages was seen as less relevant, more so by technical experts than local stakeholders (only 1 technical expert, compared to 4 local stakeholders found this relevant). However, other slight differences appear between technical experts and local stakeholders. Whilst more technical experts find monitoring of the (natural) geological barrier more important than EBS monitoring, local stakeholders prioritize this EBS monitoring over the monitoring of geological barriers. The respondents' reaction to these differences in prioritization in the second round of the survey was that these stem from differences in 'familiarity' with the disposal and monitoring concepts. Both technical experts and local stakeholders put 'relevance' as a first priority in decision-making on what to monitor. In general, all is considered relevant (including EBS monitoring), but there are differences between disposal concepts and geology which impact both the need and possibility for various types of repository monitoring, and for EBS monitoring in particular. The local stakeholders in general responded at the principle level of what they considered relevant or desirable, whereas most technical experts already made an interpretation in terms of what they considered in their national context to be technically feasible and achievable. In the second round, this difference was reflected upon by a technical expert in the following way:

> *"No contrast between technical experts and local stakeholders in terms of feasibility versus desirability: the technical experts are already a step further in the monitoring process in the sense that they have already screened the primary list of 'desirable' monitoring locations. However, they did find out that technical limitations make some monitoring locations and activities less favourable. Lastly, the relevance of monitoring waste packages, EBS, and host rock already differs in the different national disposal concepts – can lead to artificial inconsistencies."* (technical partner)

Half of the respondents (similar for local stakeholders and technical experts) considered all suggested locations (in situ, in a pilot facility, or in a more generic URL) as places for repository monitoring to take place. The URL as a separate response category was favoured more by local stakeholders (23%) then by technical experts (9%). This difference could emerge from the fact that technical experts view monitoring in an URL rather as leading up to the implementation of a pilot facility and geological repository, containing actual waste, whilst local stakeholders are generally of the opinion that the URL should continue its operations during the actual implementation and operation of the geological repository, as insights and information, relevant to the further development of the repository, can still emerge.

Monitoring is about confirming AND checking

> *"Repository monitoring is the checking tool to confirm the chosen disposal concept."* (local stakeholder)

> *"Through monitoring and checking we confirm the disposal concept."* (technical partner)

In the first round of the survey, both the statement "Repository monitoring offers a confirmation about the disposal concept as it has been developed in the safety case", and its counterpart "Repository monitoring allows checking whether everything in the repository is going according to plan", were agreed by most respondents (technical experts as well as local stakeholders). From the responses in the follow-up round, we can conclude that a majority of our respondents agrees that repository monitoring should serve both of these functions: (1) it confirms the adequacy of the disposal facility, through verification

of the model, and at the same time (2) keeps us alert for anything unexpected or extraordinary, and offers a possibility to check whether the disposal facility is functioning well.

Interestingly, a handful of respondents (3 technical project partners, and 2 local stakeholders) does not believe monitoring can in any way confirm or check the adequacy of the disposal system. The two local stakeholders expressing doubts about the use of monitoring fear that this may lead to greater anxiousness and feelings of unsafety. The three technical experts for their part pointed to the safety case as the only reliable source of information concerning long-term safety. This in contrast to the 'believers' among their colleagues, of which some suggested monitoring could serve to update the safety analysis and possibly to modifications in the disposal concept.

On the relation between monitoring and safety

> *"Monitoring contributes to safety but it does not make the repository safer." (*technical partner)
>
> *"Repository monitoring can make the repository safer (the disposal concept can be influenced or modified as a result of monitored deviation from expected values)." (*technical partner)
>
> *"It does not make the repository safer, but gives us more information and possibility to act faster if something happens.* (local stakeholder)
>
> *"Monitoring adds to safety as the implementer will positively anticipate when he is aware that his acts will be (thoroughly) controlled/monitored."* (local stakeholder)
>
> *"Monitoring has nothing to do with safety since it is not designed to maintain the integrity of the barriers designed to contain and retard harmful substances." (*technical partner)
>
> *"Adding monitoring equipment does not make the repository safer but it can lead to a more strict follow-up of the repository operations, leading to a more careful implementation of the repository design." (*technical partner)

With regard to the link between monitoring and safety, the survey showed a relatively wide spread in views, both among technical experts and local stakeholders, which was also observed during discussions throughout project meetings. When confronted with the statement 'repository monitoring makes the repository safer' the results were quite evenly spread between disagree and agree in both respondents' groups, with overall a narrow majority of the respondents disagreeing (50% among technical experts and 53% among local stakeholders). Local stakeholders either disagreed (53%) or agreed (47%), whereas 20% of the technical experts were not willing or able to answer the question – leaving 30% to agree with the statement. How to interpret this, if most do agree, as was just established, that monitoring is both about confirming and checking?

When confronted with this in the second round, most respondents suggested the spread to originate from different conceptions of what 'safer' means. Some technical experts linked this to a lack of knowledge or understanding of the safety case and the basics of repository design, thus suggesting the difference to be between technical experts on the one hand, and local stakeholders on the other hand. This, however, is clearly not the case, since broader and more restricted interpretations of what safety means could be found among local stakeholders and technical project partners alike (see also the quotes above). An additional explanation offered by some respondents is a difference in the reference disposal concepts the respondents had in mind. Although the spread in answers per disposal concept (taking the respondent's country as reference point) did not immediately corroborate this, we did see both

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explanations confirmed in the answers provided to the question "Whether or not monitoring could improve or contribute to the safety of a repository?" in the second round.

Where we did see a relatively strong difference between local stakeholders and technical experts, is that the former see less risk in repository monitoring jeopardizing the overall safety because of barrier intrusion (only 27% agreed with this statement[11], as compared to 40% among technical experts). However, the latter group is more differentiated on this issue (40% agreed and 15% couldn't or wouldn't answer), and this independently of the repository concept they work with.

Overall it seems fair to conclude that there is a general tendency among respondents (technical experts and local stakeholders alike) that monitoring does contribute to the safety of the repository, albeit indirectly, as it: (1) helps to think even more carefully about repository design from the start and during its implementation (monitoring as part of quality assurance), (2) offers the possibility to improve the concept along the way (keeping in mind that this differs between disposal concepts), and (3) serves as a safety valve (the possibility of timely awareness in case something does go wrong). This, several comments suggest, only provided monitoring technology is used which does not cause barrier intrusion. On that last point, it is worth noting that 30% of the technical experts and some 67% of the local stakeholders still expressed some doubt[12] about the availability of sufficiently good technology for repository monitoring today.

Lessons to be learned from repository monitoring

Most respondents (75% in both groups) agreed that repository monitoring could provide information to make an additional assessment of the state and evolution of the geological repository, and confirmed that it is possible to draw valuable lessons out of its data results. When asked in the second round to specify about which elements these lessons could be drawn, a wide range of issues was referred to[13]. No explicit differences were found here between local stakeholders and technical experts. The highest expectations were expressed regarding monitoring strategies and technology itself, and regarding design of future repositories (indicated respectively by 88% and 82% of all respondents). For both local stakeholders and technical experts, long-term safety (67%), modification of the existing repository design (59%), and operational safety (56%) were also seen as meriting from monitoring information. Interestingly, with 37% emplacement operations were seen as the least served by or in need of repository monitoring data.

In relation to these lessons learned, a majority of respondents (most explicitly among the technical experts) considered the timeframe within which repository monitoring will be possible and can provide reliable data significant as compared to the total life span of the repository[14]. On the question related to the cost of monitoring, only 2 respondents (one of each category) indicated they thought it too high. Many, however (35% of the technical experts and 47% of the local stakeholders), couldn't or wouldn't

[11] Respondents were asked in the first round what they thought about the statement "Repository monitoring may cause physical intrusion into the barrier system and can therefore jeopardize the overall safety of the repository". They were presented the following options: "I strongly disagree", "I disagree", "I do not want or cannot answer", "I agree" and "I strongly agree". In our analysis here we have taken the latter two categories together.

[12] We have interpreted this from the response categories "I agree" and "I do not want or cannot answer", and the fact that no one choose the option "I strongly agree".

[13] 60% of all respondents to round 2 answered this question.

[14] This question was actually put in a negative way "The timeframe we can monitor is insignificant in relation to the timescale of the overall geological disposal facility". 70% of the technical experts and 53% of the local stakeholders disagreed or strongly disagreed with this statement.

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take a position on this issue. As one respondent commented, this likely stems from the fact that the question was not related to a specific concept in a specific context. From the various responses and comments throughout both survey rounds, we nevertheless feel able to conclude that most technical experts and local stakeholders do consider repository monitoring as valuable. What type of repository monitoring and how valuable, depends on the repository concept and its (geological and social) context.

Interpreting monitoring data

Whilst the majority of technical experts confirmed that there exists a risk of misinterpreting the monitoring data (which might lead to wrong decision making), local stakeholders largely disagreed with this statement. When asked in the second round what could be the cause for this difference, a great number of the technical experts assumed this to be the result of a lack of understanding of and familiarity with monitoring data, data assessment and the complexity of interpreting results. However, if we look more closely at the various comments provided on this observation, we can deduce a more nuanced image.

First, most technical experts at the same time indicated that little uncertainties exist in the way monitoring data are to be collected, stored and interpreted (this is the same for local stakeholders). When asked in the second round how likely respondents considered the risk of misinterpretation to be, only 4 technical experts and 3 local stakeholders thought this to be a likely option[15].

Second, as most stakeholders (and some technical experts) suggested, local stakeholders too are aware of the fact that there are different layers of information, that anomalies may also rise from 'noise' in the data collection, and that there may not be an immediate consensus on how to interpret the data (particularly in the case of deviating results). On the follow-up question "How problematic do you consider the risk of misinterpretation of monitoring data to be?", around the same number, 4 technical experts and 4 local stakeholders, considered this to be very problematic[16]. Only 1 technical expert and 1 local stakeholder[17] furthermore considered high risk and high likelihood of misinterpretation of results to be a reason not to monitor.

Worth mentioning here is the following reflection, nuancing the detected difference in appreciation between technical experts and local stakeholders:

> *"There are two ways of using data from monitoring: direct (especially in operational phase, like dose, temperature, etc.) and indirect (monitored data are used for modelling). The probability of misinterpreting the data that are used in a direct way is very low. On the other hand, the outputs from modelling of repository long term development, (data from monitoring are the input to the modelling) could be misinterpreted (with low probability, but it can happen). My opinion is, that local stakeholders mostly perceived monitoring of data, that are used directly, and technical experts both."* (technical partner)

Lastly, from the various comments provided to questions analysed for this section, we deduce a plea for redundancy, for not relying on single source data, nor relying on single actor interpretation. Below a few examples to corroborate this interpretation:

[15] 58% of all respondents to round 2 answered this question. All but one, technical expert, opted for the option "likely" rather than "very likely".
[16] 56% of all respondents to round 2 answered this question. All but two, technical experts, opted for the option "high" rather than "very high".
[17] With 60% of all respondents to round 2 answering this question.

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> *"The monitoring of the repository has to be designed so that the risk of misinterpreting the data is addressed." (*technical partner)
>
> *"The possibility of misinterpretation should be considered during the design of the monitoring plan, e.g. by including different monitoring technologies ("redundancy" - different sensors that in theory monitor the same)." (*technical partner)
>
> *"It depends on the type of data - some of the monitoring methods can possibly be more risky in the case of misinterpretation." (*technical partner)
>
> *I am confident that a serious misinterpretation of monitoring results would result in very deep counter expertise and be overruled. Not monitoring would be a constant and everlasting misinterpretation!"* (local stakeholder)

Contribution of repository monitoring to public confidence

> *"I think monitoring is predestined to involve nontechnical people since it provides a tool to get more insights (for those who want) in what is going on instead of just trusting the experts. Although knowing that monitoring results need technical interpretation, but this is something everybody can ask for."* (technical partner)

The potential of monitoring to establish confidence in the geological disposal project at the local level is acknowledged by almost all participants (only 1 technical expert and 2 local stakeholders disagreed).

Based on several remarks throughout both survey rounds from local stakeholders, we assume that monitoring data have an important role to play in feeding the dialogue between implementers and stakeholders, which is seen as crucial in an open and transparent governance process. Monitoring data offer an opportunity for local stakeholders to check and follow-up the implementation and performance of the geological repository. This carries the potential to initiate a dialogue on the long term through which confidence and trust can be built. In a comment to the question on responsibilities for monitoring (analysed more in detail in the section below), we see this potential explicitly expressed:

> *"WMO's - because they know how to integrate it with the other operations they are carrying out; Local citizen stakeholder organizations - monitoring provides them with facts to ensure fruitful interaction with other stakeholders; it institutionalizes the long-term engagement/structures the cooperation/ensures long-term follow-up; Independent research organization: as a peer review of the interpretations done by the WMO's"* (technical partner)

Monitoring responsibilities and data management

> *"In my opinion, 'carrying out' as a physical act is the task of the operator (which is not necessary the WMO), but should be supervised by the authorities (local and national, when it comes to radiation protection). It makes sense to involve different stakeholders in one or the other way as well."* (technical partner)

Finally, we questioned our respondents about who they considered responsible for monitoring, for interpreting and keeping record of the collected data[18]. On this topic, some difference could be detected between technical experts and local stakeholders: 72% of technical experts thought the NWMO should

[18] For each of these questions in round 1, the following response options were provided: "NWMO", "national regulator", "municipality", "local citizen stakeholder organizations", "NGO's", "independent research institution", "university researchers", "all of those actors", "somebody else", or "I do not want or cannot answer". Multiple answers were possible. Respondents were furthermore asked in an open question to indicate why they chose this or these organization(s).

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be responsible for carrying out repository monitoring, compared to only 47% of the local stakeholders. Among local stakeholders, faith seemed higher in the national regulator; 59% of those respondents believe regulators should be responsible for carrying out monitoring. This percentage is lower among the technical experts, still some 36% of those respondents indicated regulators have at least a role to play in carrying out repository monitoring.

When asked in the second round to clarify their positions, respondents indicated to see the NWMO's as the main responsible actors for the repository, but that they should be supervised by either the national regulator (most people mention this), or an independent research institution (mentioned by some) to support the NMWO's in their interpretation of the data. Local citizen stakeholders are also seen as important to involve, since monitoring can provide a means for long-term engagement and a structure for cooperation and follow-up (e.g. the quote in the section above). An issue particularly raised by local stakeholders, is the fact that monitoring is very complex and should therefore involve all interested actors.

Worth mentioning is that involvement is not equated with being responsible. All respondents agree that monitoring data should be synthesized by the responsible monitoring body/organization, and 56% of all respondents consider the NWMO to be the primary responsible organization for maintaining and keeping record of the monitoring data[19], with the national regulator as a second important institution in this regard[20].

Even though 50% of the technical experts and 52% of the local stakeholders agree that monitoring data should not be provided to local stakeholders in their raw form, most respondents (75% of the technical experts and 81% of the local stakeholders) do think that raw monitoring data should be made available for counter-expertise. The question then arises which actor should take up this role of counter-expert? On this we did not get a clear answer. Some respondents referred to the national regulator, others to local authorities and independent organisations. Clearly, those were mainly understood as expert organisations within a peer-review process. While many of the responses from technical experts stressed the need for some restriction on the availability of data (for security reasons and avoiding false interpretations to spread ungrounded fear and anxiety), the local stakeholders put the emphasis on transparency and traceability, stressing the need for both the original data and the interpretation thereof to remain publicly available. This opinion was also shared by a number of technical experts.

3.4.2.2 Expectations regarding (local public) stakeholder involvement in R&D

In this survey we questioned both technical experts and local stakeholders involved in the project on their expectations regarding involvement of local public stakeholders in R&D, starting from their experience in Modern2020. As explained in the introduction and chapter two, the emphasis was put on concerned citizens, on people from communities directly concerned by national radioactive waste management plans, rather than on organised interest groups. However, as participatory cultures tend to differ between countries, it is likely that in the minds of our respondents a variety of local stakeholder types featured as well.

[19] 56% of all respondents to round 2 answered this question; all of which indicated the NWMO as responsible.
[20] Selected by 50% of the technical experts and all of the local stakeholders who answered this question.

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At first glance, one could conclude from the survey that a majority (some 60%) of both the technical project partners and the citizen stakeholder participants cling on to the so called 'deficit model', by stating that citizen engagement is primarily about providing people with information, but not about discussing the ins and outs of repository (monitoring) design.

> *"I am not sure that local stakeholders should decide on agenda etc. But it is probably a good idea to take into account the opinions and questions in the society. So involved, absolutely but perhaps not in the decision making."* (local stakeholder)
>
> *"To arrive at a social consensus on waste disposal, such participation is essential." (technical partner)*
>
> *"Involving local stakeholders throughout the process creates societal support. This is a first step towards societal acceptance."* (local stakeholder)
>
> *"What does it mean involved? Local stakeholders should be able to check all stages of repository development (ask questions and get answers, ...), but I do not see how they could be efficiently directly involved (they should do the research? they are not researchers) and technical things (same as for research). However, they should be able to ask for research to be performed (to satisfy their concerns)."* (technical partner)
>
> *"Participation is important when discussing about concerns. But local stakeholders are not professionals and they can't make decisions."* (local stakeholder)

However, when we look into this in more detail (as the analysis below shows), local citizens want to be included earlier in the process and in more technical details than recognized by many of the technical experts. Throughout their responses to the survey, we see that stakeholders do have trust in the technical capability of scientists and technical experts, but also that they want to keep them alert and answerable for what they are doing.

Different understandings of what local public stakeholder involvement means

In the first round, the majority of respondents (technical experts and local stakeholders alike) indicated that local stakeholders should be involved in both general nuclear waste management decision making processes and specific research and development programmes (such as repository monitoring).

The respondents furthermore defined what 'local stakeholder involvement' should entail for them. Most respondents indicated that local stakeholders do not hold the responsibility for making general decisions (on the general nuclear waste management level). With regard to involvement in R&D, a recurring opinion is that involvement should mean the opportunity for local stakeholders to be informed about developments within research projects, whilst they get to express their concerns and utter their critiques on the work of experts. Most respondents indicate that this does not mean that local stakeholders should be able to make decisions within the project, and that they should not be held responsible for certain decisions made.

> *"Designing technical systems and having rights in decisions at technical/engineering level cannot and shall not be the task of laypeople with restricted expertise (at best) who have no formal responsibilities, obligations or liabilities. There must be a clear division/definition of mandate and responsibilities."* (technical partner)
>
> *"Local stakeholders should be involved in the project, but eventually the experts should do the job. Local stakeholders can be informed and make recommendations, but the responsibility lies with the experts."* (local stakeholder)

Involvement in technical R&D

A large discrepancy was to be observed between local stakeholders and technical experts with regards to the extent to which local stakeholders should be involved on the technical/engineering level of a specific R&D project. 85% of technical experts in the first survey round did not think that local stakeholders should be involved in these matters (such as repository design or design of monitoring systems)[21], whilst 44% of local stakeholders did see a role for themselves here.

Moreover, local stakeholders were not only more eager to propose that they should be engaged also in connection to technical issues, a significant part of those respondents (35%) at that time were convinced that local stakeholder involvement in the R&D of monitoring has the potential to improve the design of the monitoring system, whilst only 9% of the technical experts shared this opinion.

When asked their opinion about these differences and possible explanation for it in the second survey round, many suggested a difference in understanding of the notions of 'involvement' and 'design improvement'. This is clearly demonstrated by the responses to other questions in the survey, to which we will turn later. Interesting to see also, was that some (technical experts) put the problem with the stakeholders, which they consider to be laypeople lacking the scientific knowledge to judge their technical design. Others (both local stakeholders and technical experts) put the blame on those technical experts because they (a) see technical knowledge as the only relevant knowledge in this matter and don't consider local stakeholders to be experts in their own right, (b) see local stakeholders as a homogenous group of laypeople, not realising there may also be people with technical expertise among them, (c) feel responsible and fear the quality of their 'product' to suffer from too much negotiation, and (d) have limited experience with 'co-design' processes and fear this will complicate the design process.

> *"It is difficult for a specialist to take advice from a non-specialist."* (technical partner)

> *"Technical experts trust their knowledge. They can't understand that questions from stakeholders could make them think more about how and what should be monitored."* (local stakeholder)

Involvement with technical issues (in R&D)

Whereas technical experts within Modern2020 were mostly of the opinion that the project results should be reported to local stakeholder AFTER the (technical) project work has been done, local stakeholders showed more interest in participating to this process itself (so that they can see how certain technical findings and results are being produced).

> *"I think it's fully normal that project results should be reported also DURING the running project work. That adds to the transparency and confidence of the public."* (local stakeholder)

When asked to comment on this observation in the second survey round, several technical experts referred to the fact that, in their mind, local public stakeholders in general do not possess enough knowledge and expertise for participation in a technical research project, or that this lack of knowledge at least complicates the R&D process and raises significantly the cost in terms of time and effort.

> *"In some cases the opinion or feedback of local stakeholders can help in the process of development (e.g. discussion on monitoring plan). Nevertheless, the process of repository development needs very specific and*

[21] Important also to note here, is that in the first survey round, among the technical experts 20% indicated they couldn't or wouldn't respond to the question of whether they agreed local stakeholders should be involved in general policy decisions. On involvement in specific R&D programmes, this was 25%; and in decisions on monitoring strategies 30%. With regard to involvement in decision-making on technical/engineering issues, this was only 10%.

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> *deep knowledge, that, I am afraid, many stakeholders do not have, and this fact could complicate the process."* (technical partner)

Others (both technical experts and local stakeholders) remained optimistic regarding early involvement:

> *"I do not see why the stakeholders cannot be informed or act as observers in the successive points of advancements of the R&D project."* (technical partner)

> *"In the discussions I have seen during Modern2020, there was some concern of technical experts that their work - as long as ongoing - should not be exposed to a larger outside world, mainly due to a number of practical reasons. However, I don't get the impression that during the technical meetings I visited (mainly WP3 and 4), stakeholders were not welcome to participate, and their questions and remarks were generally carefully answered."* (technical partner)

> *"Whenever a certain important stage of development in design of the monitoring system is prepared, local stakeholders should be informed."* (local stakeholder)

When probing somewhat further into the what and how of local public stakeholder involvement in technical R&D, some technical experts remained sceptic:

> *"I am not sure if local stakeholders can be usefully involved on a relevant participation level (i.e. beyond informing them, noting their suggestions and answering their questions) in European research project of this kind (complex, abstract and specialist) at the moment these are ongoing. In principle, there exists legal binding contracts on the works to be performed by each partner, so there is not much to alter or adapt on basis of stakeholder recommendations anyway."* (technical partner)

Others stressed the role of open communication (obtained by active involvement) in building confidence on both sides, or referred to the added value of having to explain your work to broader audiences and receiving feedback from non-peers. This was echoed by many comments from local stakeholders, who stressed it isn't or shouldn't be necessary to fully understand all scientific details in order to be informed about technical R&D in progress and to be able to ask questions and express concerns regarding issues such as health, safety or security.

> *"Openness is most important: the ones who are developing the project should be able to translate it to the people."* (local stakeholder)

A number of respondents (among both local stakeholders and technical experts) furthermore pointed to the role 'technically knowledgeable' local stakeholders who could act as an interface. Lastly, a few technical experts suggested it would be more successful to engage local stakeholders in particular for defining research priorities beforehand, and evaluating the overall results afterwards.

> *"So, the local stakeholder definitely should be involved in the phase where it is defined WHAT do we want to have, but I think it makes sense to let the technical experts define HOW to do it."* (technical partner)

When to involve local stakeholders?

The stage of agenda setting and selection of research questions had been indicated in the first round by a significant part of respondents (32%)[22] as an important point in time for local stakeholders to be involved in. About as many people (32%)[23] also indicated that local stakeholders should be involved 'when they desire to intervene'. In the second round we therefore asked how this second suggestion was seen

[22] 31% of the technical experts and 33% of the local stakeholders choose this as one of 8 options (with the possibility of choosing more than one option). 27% of the technical experts choose the option "never" or "I do not want to or cannot answer this question". No local stakeholder opted for either of these options.
[23] In this case 27% of the technical experts and 35% of the local stakeholders.

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to work in practice, since it assumes a very open and transparent process in which technical experts should always be prepared to receive questions and comments from local stakeholders and quickly respond. However, in order to be able to utter critiques and ask questions, local stakeholders would need to be almost constantly involved in the research project, at least as passive actors. But on what basis then to decide when to become active and confront the technical experts?

Responses here were somewhat divided. Constant involvement was considered by some technical experts and local stakeholders as an important guiding principle that should be strived for, even if it would mean that only a limited number of people could in this way be involved over the long run. However, most comments did question to put this in practice. Some because they saw this as unrealistic, others because they feared constant involvement will turn (local) stakeholders into insiders, losing their critical reflex. Nevertheless, some form of consensus seemed to develop around the need for an open and transparent process with periodic (higher of broader) involvement around specific milestones or hold points. Some, particularly technical experts, voiced a need for these milestones to be clearly defined and scheduled on a road map. Most seem to have done so with an implementation process for geological disposal in mind along the lines of the NEA's geological disposal strategy (OECD NEA 2017), even though no direct reference as such was made[24]. Others did mention particular stages in the process to be most likely for expressing concerns and critiques, but would also leave the possibility for active stakeholder intervention when deemed necessary. For that, some recognised, some kind of dedicated organisation or structure would need to be in place. In that respect reference was made to involvement of associations, setting up partnership structures such as STORA and MONA in Belgium[25], or making local governmental representatives responsible for informing other local stakeholders and organizing engagement processes at the local level (as is the case for Swedish communities involved in the siting process).

In order to get a better understanding of when it was deemed most useful and most likely for stakeholders to become involved, we made use of the notion of Technological Readiness Levels (TRL)[26]. Here we noticed a significant difference between the responses from technical experts and those from local stakeholders[27]. Where the majority of the technical experts concluded local citizen engagement is most appropriate in TRLs 5 to 9 (i.e. from large scale prototype testing to full commercial application), the local stakeholders found this appropriate at all levels, putting an emphasis on TRLs 0 to 7 (i.e. from the idea over technology formulation to demonstration in an operational environment). As indicated above, this clearly implies that local citizens want to be included earlier in the process and in more technical details than recognized by technical experts. It furthermore shows that delineating specific hold points or milestone moments in the process of technology development and implementation is not as clear cut. What constitutes a clear milestone for the one technical expert is not necessarily seen as such by the other local stakeholder.

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[24] Responses to other questions corroborate this reading, mentioning e.g. site selection as the most crucial (and for some final) hold point; defining a general monitoring strategy and policy; …

[25] For more information, see https://www.stora.org/en/content/stora-your-eyes-and-ears (in Dutch, English of French) and https://www.monavzw.be/ (only in Dutch).

[26] 'Technology Readiness Levels' (or TRL) is a scale that was originally defined by NASA in the 1990's as a means for measuring or indicating the maturity of a given technology. This 10 step scale (from TRL 0 "idea" to TRL 9 "full commercial application") has also been introduced into EU funded projects as part of the Horizon2020 framework programme.

[27] 58% of all respondents to round 2 answered this question. The exact results are as follows for the technical experts and local stakeholders respectively. Technical experts: TRL0 = 0%; TRL1 = 0%; TRL2 = 6%; TRL3 = 6%; TRL4 = 12%; TRL5 = 25%; TRL6 = 44%; TRL7 = 56%; TRL8 = 38%; TRL9 = 25%; I cannot or do not want to answer = 38% / Local stakeholders: TRL0 = 45%; TRL1 = 27%; TRL2 = 55%; TRL3= 27%; TRL4 = 45%; TRL5 = 81%: TRL6 = 36%; TRL7 = 55%; TRL8 = 18%; TRL9 = 27%; None of these levels = 18%.

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Stakeholder involvement in Modern2020

Respondents were given the opportunity to comment on the interactions between local stakeholders and technical experts in the project, and to provide further suggestions. The following are a few examples of the varying appreciations collected:

> *"I think that the involvement has been done in a good way. Mostly it has probably been a learning experience for the stakeholders, on the other hand also the WMO-side has learned from this. Still, in my opinion, the most important thing from this point of view has been establishing an open platform for more or less informal communication between the stakeholders and the WMO-representatives. Open communication, and communication in general is very important, in my opinion."* (technical partner)
>
> *"I have been heard and will have at least broadened the general view on the involvement of engaged stakeholders."* (local stakeholder)
>
> *"Most of the local stakeholders accepted all because of a lack of knowledge… Others criticized a lot despite of the same lack of knowledge…. But their presence allows the implementer to affirm that "they contacted the local stakeholders". This is no criticism, it is just a fact."* (local stakeholder)
>
> *"A more active role would have been more useful. Personally, I did not see them presenting their views for instance."* (technical partner)
>
> *"Suggestion: involve stakeholders into the review of deliverables. To my knowledge they were not involved in compiling deliverables within WP2, 3, 4."* (technical partner)

When asked (in an open question) about their motivation to participate in this project, local stakeholders put forward social responsibility and/or increasing their knowledge on the subject. Similarly, when asked (again in an open question) to describe their role in the project, local stakeholder participants mentioned information gathering on the one hand, and sharing experiences with technical experts and local stakeholders from other countries on the other. Concerning this sharing of experiences, local stakeholders pointed out they considered it their role to broaden the view of the experts on stakeholder involvement and to make clear to them what information is needed.

Roughly one third of the local stakeholder group stated they expected to be consulted on specific choices made during the research process. Another third mainly expected to be informed on what was going on, while the last group did not know what to expect. On clarity of expectations from the project regarding their role, towards the end, one participant responded he or she still hadn't a clue what was expected from them. For half of the group this was clear from the beginning. The other half indicated it to become clear gradually during and trough the first interactions[28].

On the personal level, local stakeholders indicated as most valuable that participation in the project helped them to be better informed. What they found most interesting was learning about monitoring, international comparison and sharing information with fellow local stakeholders. Over 70% of the participating citizens[29] indicated that they had learned relevant things regarding monitoring and other waste management programmes by participating in the project. At the project level local stakeholder respondents appreciated sharing information with project members and other local stakeholders, and to be able to question certain aspects of monitoring. 50% of the group indicated they very much appreciated the open communication about the relation of monitoring and uncertainties, unexpected outcomes,

[28] For this statement we combined the answers to two suggested options in the survey: "At first not, it became clear to me during the consecutive activities I participated in" and "I don't think there was a clear role set at the beginning, but we defined our role during the first interactions with the project team".
[29] With a response rate of 93%.

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difficulties, mistakes or accidents[30]. Other positive points referred to were: receiving useful information (chosen by 36% of all participating local stakeholders), receiving concrete, clear and detailed information of the state-of-the art of monitoring technology (29%), and receiving concrete, illustrative examples of how monitoring strategies and technologies would work in practice (21%). In line with the opening remark of the above paragraph, 21% of participating stakeholders felt they could have been engaged more in defining the research agenda and in setting research priorities.

Where the overall feeling of the local stakeholders about their participation in the project was largely positive, the technical experts were somewhat more reluctant to express their opinion. In response to a series of questions in round 1 regarding their interaction with the local stakeholders, on average, 90% of the technical partners provided an answer, but of this group, over a third to almost two thirds responded they couldn't or wouldn't answer this question[31]. A possible explanation for this result is that some technical partners – especially in WP3 and WP4 - did not meet local stakeholders that often, as the interactions were mainly concentrated around the work in WP2. When correlating the responses to questions relating to appreciation of stakeholder engagement in the project, to responses to questions on actual 'exposure'[32], a positive impact between the two could be observed.

Of those technical experts explicitly expressing an opinion, most valued in a positive way their interaction with the local stakeholders, e.g. by receiving valuable feedback, or learning to make their own work more accessible. Similarly, regarding the clarity of their own role in communicating with the local stakeholders, only a good half of the technical experts responded to this question and about one third of those indicated they wouldn't or couldn't answer that question. From some of the additional comments provided in this section of the survey, it became clear that the expectations of the technical partners with regards to the role of the social sciences team and the organisation of stakeholder involvement were quite divergent. Some had expected tips and tricks on science communication or stakeholder management. Quite a few even expected the social scientists to take up a role as translators between the technical experts and the local stakeholders. Others had hoped for a variety of engagement models to be tried and tested. Still others had assumed us to deliver plans on how to monitor public attitudes, socio-economic effects and the like in quantifiable terms. One respondent suggested this confusion among technical experts might have to do with the fact that no specific budget was set apart for technical partners engaging with local stakeholders:

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[30] The multiple answer question "Which of the following statements express the closest **your appreciation of the communication from the technical experts** within the Modern2020-project?" presented eight options, of which the one on open communication received by far the most votes. Another option was: receiving useful information (chosen by 36% of all participating local stakeholders).

[31] Technical partners were asked to position themselves vis-à-vis the following six statements - for each, we have added the response rate within that group (RR) to this question, and the percentage of responses in the category "I do not want or cannot answer" (PR): (1) "The interactions with the local stakeholders have encouraged me to reflect on my own work and place this in a bigger societal picture." (RR: 90% - PR: 47%); (2) "I have received some valuable feedback on my own work from local stakeholders who have been engaged into the project." (RR: 90% - PR: 37%); (3) "I think the engagement of local stakeholders in the Modern2020-project has been productive and has produced concrete results for the project." (RR: 86% - PR: 39%); (4) "Through the interactions with the local stakeholders, I have learned to make my work more clear and accessible for a broader public." (RR: 90% - PR: 47%); (5) "I have been able to develop a relationship of mutual trust with (some of) the local stakeholders involved in the project." (RR: 86% - PR: 56%); (6) "I think we succeeded in integrating the local stakeholders' remarks and concerns with regards to monitoring into the workings and results of the Modern2020-project." (RR: 90% - PR: 63%).

[32] Among the profile questions, we asked the technical experts to indicate in which work package(s) there work was mainly situated, on which occasions and with which frequency they had gotten into contact with the local stakeholders, what the intensity of those contacts were and how involved they felt with work package 5.

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> *"It has not been structured well with specific goals identified at the start. This has generally led to some confusion. There should have been more specific integration. This was mainly because at the project planning phase no resources were provided for technical staff to work on WP5 topics."* (technical partner)

A major reason for not providing these additional resources, was inevitably the constraint on the budget. However, at the planning phase it was also thought that not making a clear distinction between the budget for research and interaction would contribute to more integration of both activities (not restraining engagement to a separate activity in work package 5). The plan had indeed been to integrate as much as possible the stakeholder interaction in the regular project meetings and workshops (see also section 3.2.1). And participating in that interaction was considered (at least by the group taking the lead in the project set up) part of the technical partners' role in each of the (technical) research work packages. Admittedly, this may not have worked out exactly as planned. It seems to have provided some technical partners with an excuse to stay hidden in their labs and some reluctance remained for opening up technical work package meetings (especially in WP 3 and 4) for stakeholder interaction. The latter, however, was not only due to technical partners feeling they didn't have enough results to communicate yet, or thought the discussions would be to technical for stakeholders to grasp. It also had to do with volunteering stakeholders' agenda's becoming overloaded, and with them not being able to attend several multiple day workshops abroad per year.

Lastly, some technical partners in their comments referred explicitly to stakeholder engagement as an EU requirement that had to be fulfilled, and something they would otherwise not have signed up for. Important to retain from such comments, and the practical experiences within the project, is that clear expectations regarding involvement of concerned parties does put additional demands and pressure on researchers in terms of time, resources and skills. The limits to what can be achieved, should also be taken into account, and expectations might need to be adjusted accordingly.

> *"Is it the role of [technical] researchers to make this translation effort? Do not they already have enough to do? Does not this lead to a mix of genres and the absence of a clear demarcation between scientific debate and public debate?"* (technical partner)

Possible impact of stakeholder involvement in Modern2020

In the first round, 60% of the local stakeholders indicated that they feel they had been able to make **a substantive contribution to the technical work** of the Modern2020 experts. However, most found it difficult to see the direct consequences of their input and opinions for the project work. About six months prior to the projects end, it remained unclear to them how exactly technical experts took or would take into account local stakeholders' opinions on monitoring in the further development of their work.

Moreover, also the majority of technical experts indicated at that point in time not to know the extent to which they succeeded in integrating the local stakeholders' remarks and concerns with regards to monitoring into the workings and results of Modern2020. It was also difficult for technical experts to think of a concrete example of how interactions with and feedback from the local stakeholders influenced their personal work or the project as a whole. As also among technical experts several referred to the participation of the local stakeholders in the project as beneficial, a follow-up question in round 2 probed for concrete examples.

Two tangible project outcomes were mentioned: (a) the integration of stakeholder's opinions in project reports (for WP2 in particular), and (b) the co-writing of the stakeholder guide (deliverable D5.2). Furthermore, some impact beyond the project was suggested. This we saw both in the response that the

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local stakeholders had shown the technical experts the importance of trust building, and also in reference to at least one implementer taking this experience home and bringing in stakeholders in building its own R&D programme on monitoring. Someone furthermore warned that the presence of local stakeholders in such projects should not lead implementers to be assured they can now tick the box of 'having contacted local stakeholders'.

Regarding another way of creating impact, we asked the technical experts how they had experienced the communication with the local stakeholders in the project. Out of the 20 technical partners who responded to this question, 10 stated they found it easy to communicate their work in a clear and accessible way, 4 had experienced some difficulty (e.g. on the relationship between monitoring and the safety case, on how to select parameters to monitor, or more generally on very specific technical aspects requiring a scientific background from the audience), 2 indicated they didn't feel comfortable communicating to a non-peer audience and therefore preferred to leave this to other colleagues. Four experts responded they would have liked to interact with the local stakeholders in their work, but so far have not had the opportunity.

As already indicated in the previous paragraph, local stakeholder participants in the project generally considered they had learned a lot, but many of them did also state that they participated to get their views across. What then, did the technical partners learn from this experience? In that respect, we asked them how interactions with the stakeholders influenced their own work in the project, and what they considered the most important they had learned from this. The response rate on these questions was relatively low (some 35%), but the answers clustered around the following points:

- No influence and nothing to learn:
    - My work is 'deeply technical' and stakeholder feedback of no relevance
- Obtaining a more reflective attitude:
    - Realising the importance of the work in this project for nuclear waste management
    - Reflecting on technical work in a broader societal picture
    - Realising the importance of continuous involvement and transparency (in building trust)
- Improving one's skills to listen and engage/be engaging
- Better understanding of the needs and concerns of (local) stakeholders in relation to geological disposal and monitoring:
    - Developing a monitoring concept is something to be done in partnership
    - One should listen to and acknowledge stakeholder concerns, but not shift responsibility to them
    - Local stakeholders need enough (tangible and understandable) technical information to make up their own minds
    - (Some) local stakeholders are interested in very technical questions

Some technical partners commented they had actually hoped for a bit more criticism and opposition to challenge them, both from the local stakeholders and the social scientists participating in the project.

What to take from Modern2020 to future R&D projects of a similar nature?

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In spite of the remark from some technical partners that they had hoped for more confrontation from the side of the local stakeholders, only 42% of technical experts responded positively[33] to the question whether participants with controversial and unpopular views on the topic at hand should be invited to become involved in R&D projects. Among local stakeholders, this was 81%.

Most respondents (61%) agreed that it is important that whenever (local) stakeholders become involved in an R&D project, they should form a representative sample of the broader population affected by the topic of discussion. However, the majority of respondents (58%) in the first round also were of the opinion that local stakeholder participants should have a basic level of techno-scientific knowledge in order to substantially contribute to an R&D project. However, when asked what was considered "a basic level of techno-scientific knowledge", responses tended to diverge remarkably, with a small majority equalling this general secondary school education. A few respondents referred to a university degree (assumed in an engineering or natural sciences related domain), others to an understanding of radiation as essential. In a follow-up question in round 2, we asked our respondents to go more into detail on this seeming contradiction between a want for representativeness and a specific level of background knowledge. Responses here indicated that being representative was considered the most important requirement and that at least some representatives should have a techno-scientific background. Some pointed out that knowledge could and should also be obtained through engaging with an R&D project. Curiosity and a willingness to learn were in that respect seen as the most important prerequisites for potential stakeholder participants. A number of respondents in addition suggested that a mix of backgrounds should actually be strived for, as that would enrich the interaction.

> *"The citizen stakeholders panel should have people with a good scientific knowledge and other without: the mixture is interesting."*(technical expert)

Some suggestions were also made to assist a process of learning within the project and/or to cope with the differences in (technical) knowledge. Some initial training, briefing stakeholder participants and offering them accessible documentation in advance, was one example. Another was to encourage the stakeholder participants to divide the workload according to their specific interests and backgrounds. Lastly some local stakeholders raised that being able to rely on outside assistance for specific issues could be helpful.

On the question of knowledge, some comments were also made pointing to the fact that technical knowledge is not the only one that matters, and that it is exactly for that purpose, that other parties, such as local stakeholders, need to participate in R&D projects.

> *"Being interested is also an important aspect. People who want to be involved will want to get to know the subject more. Creative spirits can perhaps think 'out of the box' better than people who are too close to the matter"* (local stakeholder)

[33] By choosing either the option "I agree" or "I strongly agree" in the survey.

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4. Lessons learned

This chapter provides the main conclusions or key lessons learned from our analysis of the different engagement activities in Modern2020 as described in section 3 above. We do this by returning to the four research objectives set at the outset of the project, and applying the combined insights from the analyses in sections 3.2, 3.3 and 3.4. Section 4.1 draws conclusions on the role of engagement in this specific R&D project (research objective 1). The technical research programme did not allow for much spontaneous reflection on the question of accessibility and transparency of monitoring data, and few dedicated discussions on this particular issue could be recorded (research objective 3). However, we did capture various considerations on how monitoring could feed a dialogue between waste managers, regulators and local stakeholders (research objective 2). Below we will therefore treat both objectives together in one dedicated section 4.2. Finally, in section 4.3 we develop some considerations regarding local stakeholder engagement in R&D more generally (research objective 4), linking back the experience in Modern2020 to the theoretical framework described in section 3.1. To clarify further, this chapter aims at specifying the most important conclusions regarding local stakeholder engagement *within* the Modern2020 project and might, consequently, serve as recommendations for the organisation of local stakeholder engagement in national following up initiatives or projects concerned with repository monitoring in geological disposal. The next chapter 5, on the other hand, focuses on the formulation of more general recommendations with regards to the practical organisation of local stakeholder engagement in R&D projects which can be applied beyond the scope of repository monitoring and geological disposal projects.

4.1 Stakeholder engagement in this research project and impact on understanding of and expectations on repository monitoring

> *"Yes, we are talking about toxic matter! A strong involvement of the local population is important to keep the pressure on experts ☺"* (technical partner)

Throughout the project, the participating citizen stakeholders pointed out they consider themselves to be watchdogs over the development of monitoring, also with regard to the wellbeing of future generations. As being informed, knowledgeable bridge-builders and watchdogs, they see themselves as possible brokers between technical expertise and broader public groups. However, the local stakeholders participating in this project are aware that much of this topic is beyond their knowledge, but also that experts lack knowledge and often frame risk issues as being just about technical details. From our online interactive survey (see section 3.4), it was confirmed that the motivation for local stakeholders to participate in the project was driven by social responsibility (this role of bridge-builders and knowledge brokers), a felt need to increase their knowledge on the subject, and the opportunity to compare how this technology development is taken up in other countries and waste management programmes.

As discussed above (section 3.4.2.1), one could conclude from the survey that the so called 'deficit model' is quite persisting, as a majority of both the technical project partners and the local stakeholder participants are of the opinion that citizen engagement is primarily about providing people with

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information. However, where this drives the majority of the technical project partners to conclude local citizen engagement is most appropriate in Technological Readiness Levels (TRL) 5 to 9 (i.e. from large scale prototype testing to full commercial application), the citizen group finds this appropriate at all levels, putting an emphasis on TRLs 0 to 7 (i.e. from the idea over technology formulation to demonstration in an operational environment). This clearly implies that local stakeholders want to be included earlier in the process and in more technical details than recognized by technical experts.

Throughout their participation in the project and responses to the survey (see section 3.4.2.2), we see that stakeholders do have trust in the technical capability of scientists and technical experts, but also that they want to keep them alert and answerable for what they are doing. In order to develop trust in research and technology development, the local stakeholders in our project are not counting solely on receiving the end-results of an R&D project. They want to follow the process, they want to develop an understanding of what this new technology can and cannot achieve, and they want to be able to ask questions. This means to ask the kind of questions which technical experts often forget about, such as why should we do this, what are the benefits and for whom, what are the limitations, and why are national programmes assessing monitoring differently (see section 3.2)? Many of the technical project partners (but definitely not all) tend to frame the need to feed information to stakeholders as filling the knowledge gap, assuming that, with the same level of information/knowledge, they will come to the same conclusions as the experts and 'accept' the proposed technology. However, the questions mentioned above are not answered from such a technical frame. Most local stakeholders describe their need for information as a necessary step in enabling them to ask (critical) questions. Not to the level of discussing detailed technical matters, but to sound out to what extent issues such as social or environmental impact have been taken into account, what other options have been considered, why those options have been screened out, and how the potential for further technological development has been taken into account. This we see echoed in the way the stakeholder guide (see section 3.3 and Meyermans et al. 2019) was built up. As mentioned in section 3.4.2.2 a majority of the participating stakeholders indicated that through participating in the project they had learned relevant things on monitoring, as well as on other waste management programmes. Many furthermore indicated they very much appreciated the open communication about the relation of monitoring to uncertainties, unexpected outcomes, difficulties, mistakes or accidents.

Whether engaging local stakeholders in Modern2020 altered the course of the technical research and impacted on the outcome of the technical work packages is hard to say and almost impossible to fully assess. National programmes and nuclear waste management organisations' views regarding monitoring have evolved since the start of the project[34], but to what extent the participation of stakeholders in this project has had an influence is difficult to say. However, we can deduct from our analyses in sections 3.2, 3.3 and 3.4 that the local stakeholders' engagement activities were of great interest from a social science perspective, for the citizens involved and for the other project partners. Some important results have emerged as shown in this report, but we also want to highlight some problems to deal with when citizen stakeholders are involved in an R&D project, such as Modern2020.

[34] We draw this conclusion from comparing the presentations of various NWMO's programmes at the final conference in Paris (9-11 April 2019 – see Modern2020 deliverable D6.3) and the statements provided in a questionnaire held by WP2 at the start of the project, on which our analysis comparing four countries' programmes in deliverable 5.1 (Lagerlöf et al. 2017) was based.

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Honesty abides to admit that engaging local citizen stakeholders in a very expert driven technical research project was not always easy. Particularly, as we explicitly chose to have these local stakeholders participate in the actual project, in direct interaction with the (technical) researchers. Firstly, the choice to approach specifically directly concerned citizens implicated in national waste management programmes, meant that we had to take into account developments at the national level. This for example led to a late entrance of French stakeholders in the project, and to a temporary hold in participation of the Swedish stakeholders at the time of the Environmental Court hearings and related decision-making process. These were clear and explicit examples of the fact that the pace of a research project does not necessarily coincide with the agendas of the local communities and the availability of their representatives. Secondly, the nature of the project made many discussions and project related documents very technical. Both of these aspects had a clear impact on the extent to which community representatives could attend Modern2020 project meetings of various work packages and the time and ability as well as interest they had in reading up material beforehand or provide feedback on minutes of meetings or (draft) reports (see section 3.2).

Nevertheless, some rich interactions have taken place, the project has brought the topic of monitoring to the attention of concerned citizens and communities, and instigated some debate there (see sections 3.2 and 3.3). The interactive survey furthermore showed that the participating community representatives were overall positive about the chance to be involved at an early stage in this technology development even if their immediate impact on the technical level is likely to remain quite limited. The appreciation for and estimated value of the engagement activity among project partners was quite divergent, but the survey data do allow us to conclude that there is some positive correlation with the frequency and intensity of the interaction with the stakeholder participants.

4.2 Integrating stakeholder concerns (including views on the accessibility and transparency of monitoring data) into monitoring programmes

Throughout our engagement activities within the Modern2020 project (as described extensively in sections 3.2 and 3.4) we have found opinions and expectations regarding monitoring to be sometimes divergent between the participating local stakeholders and the technical experts involved in Modern2020. Their opinions seem to vary with regards to why, what and how to monitor as well as about what the accessibility and transparency of monitoring would mean in practice. We have tried to make this visible also in the stakeholder guide (see section 3.3 and Meyermans et al. 2019). Below, we present some of our most important findings with regards to these subjects.

In comparison to technical experts, local stakeholders throughout the various discussions (see section 3.2) and in responses to the questions in the on-line interactive survey (see section 3.4), showed a tendency to either use repository monitoring as an all-encompassing concept including near- and far-field, geo- and biosphere, or to emphasise the importance of all types of monitoring. They also find repository monitoring after closure to be more important than most experts do. With regards to the question of what to monitor, the local stakeholders put other accents on what aspects of the geological disposal system should be monitored. Whilst more technical experts find monitoring of the (natural)

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geological barrier more important than EBS monitoring, local stakeholders prioritize this EBS monitoring over the monitoring of geological barriers.

In the preceding MoDeRn project, one of the main findings was that local stakeholders emphasize the role of monitoring as checking up on the repository's safety, whilst the technical experts rather perceive monitoring as confirming safety. However, this result has been refuted by the new data gathered in Modern2020, showing that both of these functions of repository monitoring were deemed as equally important by both local stakeholders and technical experts. Our results also show that most participants see these two functions as working on a different level and in a different way: whilst the confirming function of monitoring refers to whether the acquired data fit to models used to predict the repository environment, monitoring as checking works at a somewhat 'lower level' referring to the ability of monitoring data to alert and understand if any unexpected or extraordinary situation would appear.

Something about which most participants agree as well is that monitoring data can have an important role to play in feeding the dialogue between technical experts and local stakeholders. This was expressed at various occasions (see sections 3.2 and 3.3) and made even more explicit through the online survey (see section 3.4). Monitoring programmes and the generated data offer an opportunity for local stakeholders to check and follow-up the implementation and performance of the geological repository. This carries the potential to initiate a dialogue on the long term through which confidence and trust can be built. Interestingly, local stakeholders situate monitoring in a framework of continuous research, which also leads them to insist that URLs should continue to operate during the implementation and operation of a geological repository as part of a broader monitoring programme. This view already came to surface early on in the preceding MoDeRn project (see Bergmans et al. 2014) and was explicitly expressed by the local representatives participating in the round table at the Modern2020 closing conference in Paris (see Modern2020 deliverable D6.3). On various occasions, this was also linked to forms of social monitoring, to make sure the governance system behind the monitoring programmes and repository facility would not fail.

In the survey, we have also been able to acquire some data about who the participants think should be responsible for managing the monitoring data (acquired through repository monitoring activities) and what it would concretely mean to make these data 'transparent and accessible'. Even though local stakeholders often deem the national regulatory body to be the most suitable actor for managing monitoring data – more so than technical experts – most participants seem to agree that the monitoring itself and the subsequent gathering of data should be performed by the responsible NWMO under control and supervision from the national regulator or, as mentioned by some, from an independent research institution. It should also be the national regulator who decides whether or not, how and to what extent the monitoring data can be used by other actors, for instance in order to produce counter-expertise. If monitoring data are to be delivered to the wider public, all participants agreed that they should first be synthesized by the responsible monitoring body/organisation before being made available to a broader audience.

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4.3 SE in R&D programmes and projects at EU level

In addition to the lessons we have learned regarding local stakeholders' understanding and expectations of repository monitoring and the questions of transparency and accessibility that connect to this, this section develops some broader considerations regarding local stakeholder engagement in R&D. It aims at formulating general lessons learned about how to organise local stakeholder engagement in future R&D projects in the context of Responsible research and innovation (RRI), as put forward in recent European Research programmes: *"societal actors work together during the whole research and innovation process in order to better align both the process and its outcomes with the values, needs and expectations of society"*[35]. In order to develop these arguments, we draw on concrete experiences and opinions from local stakeholders who have been engaged throughout the Modern2020 project and an analytical reflection through the use of the theoretical framework on public engagement offered by Delgado et al. (2011), presented in section 3.1 of this report. Though these authors confirm the general consensus on the importance of public engagement in science and technology discourse, they do identify tensions which arise through the existence of competing answers to the main questions of public engagement, namely why, how, when and where should it be done and who should be involved. We have adopted these 'topics of tensions' as the main questions in discovering how to make sense of the often discrepant opinions of local stakeholder involvement expressed by both local stakeholders and technical experts, and how to navigate through them in practice. Our intention here is to lay bare what choices and compromises can be made between competing theoretical ideals of public engagement in R&D in order to strengthen future local stakeholder engagement in research and innovation in its reflexive capacity and practical execution.

4.3.1 Why should local stakeholders be engaged?

> *"I think it is our role as a local stakeholder to confront the scientists with what we as citizens actually find efficient and effective. And to encourage them to think about how they are going to communicate their work towards the public, and implement it in such a way that citizens agree with the approach. I think this is in fact the mission (of stakeholder engagement)."* (local stakeholder, WP5 Home Engagement Activity, Mol (Belgium), June 2017 - original statement in Dutch)

The statement above serves as an example of what a local citizen might expect from being engaged in a technologically complex R&D project. Whilst this local stakeholder emphasizes that the importance of engagement lies in its mission to confront technical representatives with citizens' opinions and remarks in order to challenge the experts' approach and implementation of the project, not every local stakeholder might share this opinion. As came forward during the Modern2020 General Assembly in June 2017 (see section 3.2.1), the most fundamental tension in public engagement perhaps stems from different motivations behind efforts to engage the public (i.e. Why should public engagement be done?). Fiorino (1990) and Stirling (2008), for example, describes three rationales for public engagement: instrumental, substantive and normative. Public engagement is said to be informed by the instrumental rationale when its main aim is to achieve a predefined end, such as the restoration of legitimacy and public trust. The substantive rationale instead refers to the potential of public engagement to

[35] https://ec.europa.eu/programmes/horizon2020/en/h2020-section/responsible-research-innovation (accessed 15 May 2019)

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(substantively) improve the content of the project and its results. Lastly, the normative rationale evokes public engagement as 'the right thing to do'; its motivation is based on a particular normative commitment of democracy and consultation.

During the Modern2020 General Assembly in June 2017, it became clear that all present local stakeholders and technical experts agreed that local stakeholder engagement can and should be used to increase trust and acceptance. Explaining things in an understandable and transparent way could alleviate unfounded fears and suspicion, and help to ease the process. Thus, the attendees of this General Assembly supported the instrumental imperative, though most local stakeholders and some scientists added two important conditions. Firstly, communication should happen early, and should be completely honest and transparent. Secondly, there should be room for disagreement. It is possible that even after receiving more information, people will still dislike or distrust the project or technology. In that case, they should have the opportunity to voice their arguments and raise alternatives.

When it came to the substantive imperative, we saw a mix of different opinions. Some of our project colleagues believed that the input of citizens could improve their tasks and performances, and that it was important to consider the local stakeholders' views in this regard, whereas other experts did not believe this would make a difference. Most local stakeholders did think there was something to gain from a more interactive exchange, but some emphasised that they could not contribute to all topics. The conclusion was that citizens and scientific experts should decide together about what should and should not be discussed.

Lastly, with regard to the democratic imperative, we found little consensus in our discussion groups. While most participants agreed in general that it was important to have public discussions about important projects, many were not convinced that the practices of local stakeholder engagement make the process more or less democratic. There was some confusion about the exact meaning of this 'democratic imperative' and participants had different views about who should be involved (elected officials, ordinary citizens, experts) and at what policy level (local, regional, national). Clearly differences, however subtle, in political systems and cultures play an important role here. This makes a one fits all approach or recommendations on best practices for this rationale for engagement quite difficult to formulate, particularly for engagement at an international level, such as an EU (research) project.

Apart from the fact that tensions may particularly arise when there is a lack of transparency around the rationales motivating particular engagement practices, these tensions also become closely linked with the one between democratic openness and technocratic closure (Stirling 2005; 2008). Whilst some actors within Modern2020 emphasized the importance of public engagement in R&D to open up for deliberation between views, others focused on the mission of public engagement to close down dialogue by reaching a consensus for decision-making. Even though it is arguably important to combine both stages (Burgess et al. 2007), the problem of closure may acutely be present in practices of public engagement, which are specifically aimed at generating inputs for decision-making and therefore miss possibilities for plural framings and dialogue by having started off the goal of achieving consensus (Delgado et al. 2011). This may cause local stakeholders to feel as if they are only involved in order for the technical experts to tick the box of 'having included local stakeholders into the project'. Transparency about the existence of competing rationales for public engagement, and clarity about the specific goals of involving local stakeholders are therefore of particular importance for public engagement in future R&D projects.

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4.3.2 Who (which local stakeholders) should be included?

> *"I think people who don't know anything about it (the topic of nuclear waste management) should not decide. They can give advice or say "I have doubts or am not in favour" but you should not say too much (…). You can agree or disagree, but you cannot say that something is bad when you don't know anything about it."* (local stakeholder, WP5 Home Engagement Activity, Mol (Belgium), June 2017 - original statement in Dutch)

As the direct involvement of all members of the public in techno-scientific development is clearly not feasible – nor desirable perhaps – since tensions between different approaches to deciding who is a 'relevant' participant and what criteria this decision should be based on may arise. Whilst some authors such as Wynne (1996) insist on a radical dismantling of the expert-lay division, others remain more nuanced by distinguishing between various kinds of 'relevant' publics, which may relate to science in a variety of ways (Irwin & Michael 2003). The question of which publics to include in the public engagement exercises becomes particularly acute when decisions have to be made.

Here, the issue of achieving 'representativeness' becomes especially prominent. This may refer to a representativeness in terms of gender, socio-economic background or views about the topic at hand. In our online survey (see section 3.4), most of the respondents (61%) agreed that it is important that local stakeholders involved in an R&D project are a representative sample of the broader population affected by the topic of discussion. However, this statement becomes slightly complicated when also taking into account that a slight majority of our respondents (58%) were of the opinion that local stakeholder participants should have a basic level of techno-scientific knowledge in order to substantially contribute a R&D project, as is also illustrated in the quote of a local stakeholder above. This opinion correlates with the 'normative theory of expertise' as proposed by Collins and Evans (2002), who clearly state that only those citizens with some kind of relevant expertise should participate in 'technical' decision-making. The question then becomes what this 'relevant expertise' consists of; does this only refer to knowledge situated in a strict scientific frame or does it allow for other types of knowledges to be included, i.e. politico-institutional knowledge, enduring local expertise, etc.? Both technical partners and local stakeholders in Modern2020 mostly seemed to agree that this tension could be resolved by providing the participating local stakeholders with specific techno-scientific knowledge at the start of the project broadening this occasionally during the process, i.e. in the form of a training, an e-learning trajectory, or an informative book or leaflet. This might be helpful, but also may include the risk that some participants drop out early. Other project participants propose that only a slight majority of the participating local stakeholders should have a certain amount of technical knowledge in order to represent the others and in terms of expressing explicit technical and scientific concerns.

Concerns regarding representativeness also include the involvement of people with rather controversial or unpopular opinions of nuclear waste management. Most participants believed it was necessary for them to be included in the discussion, though within certain limits. Some said that if their opinions were too far removed from the general ideas of the public, they should not be allowed to dominate the discussion.

We could conclude here that having an open discussion about who to include and who not to include as a 'relevant' participant remains most important with transparency towards the local stakeholder participants about the criteria used for selection and the choices that will eventually have to be made. However, the criteria used will always be possible to question. The tensions involved when dealing with

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inclusion range from concerns of 'representativeness' to questions of techno-scientific expertise of participants.

4.3.3 What should be the role of local stakeholders in a R&D project?

In order to understand how local stakeholders have participated in the Modern2020 project and what could be the role for citizen stakeholders within a future R&D project, it could be helpful to draw on the distinction between 'invited' and 'uninvited' participation (Wynne 2007). This also refers to the next topic of tension that Delgado et al. (2011) identify as the difference between public engagement initiatives which have been framed and arranged by political authorities and those which are grassroots initiatives. Examples of invited engagement include events such as consensus conferences, focus groups, public consultations, etc., whilst uninvited engagement is most commonly organised through civil society organisations and networks of concerned citizens in the form of protest, campaigns and lobbying (Delgado et al. 2011). In case of the Modern2020 project, engagement of local stakeholders had to be actively sought out by the WP5 researchers. As monitoring cannot be seen as a techno-scientific issue that has become a public 'matter of concern', local stakeholders had to be actively contacted through existing networks and motivated to participate in the Modern2020 project, since no grassroots activities exist.

Being aware of this distinction is important in understanding how public engagement can be designed and executed in a R&D project and what the role of local stakeholders should be therein. Invited forms of public engagement not only predetermine who is a 'relevant' participant (see discussion above), but also carry implicit assumptions about how citizens should participate (Delgado et al. 2011). These are being developed from the outset of the project – in the project application for example – but also in discussions and concrete preparations of engagement activities throughout the project. Organisers of public engagement inevitably impose frames and meanings on to participants. For example, exercises are often designed as 'civilised' debates targeted to achieve consensus (Delgado et al. 2011). This emphasis on consensus can be fruitful when concrete decisions have to be made, but closes down possible alternative framings and opportunities to question fundamental issues throughout the engagement process. In this respect, preparing local stakeholders for their participation in a certain project session becomes a double-edged sword. They are being informed and prepared to follow and participate in the discussions on the one hand, whilst, on the other hand, a particular framing of the topic at hand is already being offered, which makes it more difficult for local stakeholders to call this into question later on.

In the Modern2020 project, this issue has (partly) been addressed by developing engagement activities with a twofold thematic focus: a) the monitoring strategies and technologies and b) the format of engagement, with the possibility for community participants to problematize and critically assess the state of knowledge (about both topics) as a concerned actor. With regards to the first topic of engagement, local stakeholders have been invited to discuss and give feedback on topics ranging from parameter development for supporting decision-making in WP2 to WP3 discussions of the technological state of the art in areas such as wireless monitoring technologies. However, this assumes that citizens are in principle interested and eager to get critically engaged in scientific issues, which is not always the case. This we have observed for some local stakeholders to whom the in-depth details of technical solutions were too complicated or too specific to be of interest or within their scope of competence.

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Nevertheless, in general, we find that the engaged local stakeholders considered it essential to be provided with the technical content of the various work packages throughout the project. They stress their 'right to information' and find the possibility to make critical observations and comments whenever they feel it is needed indispensable.

However, when it comes to decision-making about specific technical elements of the project, the online survey showed that most local stakeholders and technical experts were of the opinion that we should entrust nuclear waste management representatives and other experts with this. It is then the main responsibility of civil stakeholders to remind the technical representatives to take other matters into account as well, such as the concerns of local communities. Also concerning other types of decisions that have to be made within the project, most of the local stakeholders who participated in the online survey agreed that citizens should have the right to participate in a R&D project but should not be included in formal decisions, as is illustrated in the quote below:

> *"I think that everyone should be allowed to have a say and participate in the process, but I do not think that everyone should be involved in the decision making. I do not believe that it is a good idea to allow single individuals, small NGOs etc. to be part of the decision. I believe that in a democracy the elected persons should make decisions with the help of experts in the area. It should not be the loudest ones that decide."* (local stakeholder, Delphi questionnaire – Round 1, October 2018)

Local stakeholder involvement in R&D then becomes defined as local participants having the option of being kept informed of developments within the project as well as having the right to question and challenge the information they receive from the experts, without having the responsibility of making decisions. However, some of the participants did believe that elected individuals – including citizen representatives – should have the ability to get involved in a decision when appropriate or requested by the experts.

Another added value of participating to a European R&D project which has been thoroughly stressed by the local stakeholders is the ability for them to see and experience 'science in action'. Being involved early in the process and in close contact with techno-scientific researchers offers the local stakeholders a look on the inherent 'messiness' of scientific research and the interactions in this context. The local stakeholders emphasized that this shows authenticity which stimulates trust in the R&D project more than when they would a receive a clean 'marketing message' of the research outcomes at the end of the project. Seeing science in action also confronts local stakeholders with the challenges and complexity of the problem at hand. Opening up the process of knowledge production can show uncertainty, knowledge gaps or lead to the questioning of certain premises. But it also offers an opportunity to demonstrate good faith, seriousness, and genuine attempts to reduce or deal with uncertainty, to consider alternative options, etc.

This involvement in scientific research, even it is merely from the side-lines, also influences local stakeholders' preparedness to accept certain decisions when they are contextualised and made explicit throughout the research interactions. This is, for example, illustrated by the involvement of the Swedish local stakeholders in the project as they expressed some scepticism towards their NWMO's (SKB) reluctance to monitor the geological repository as it is planned to be built in Sweden. The result of their engagement did not lead to a complete change of SKB's opinion regarding repository monitoring. Instead, SKB has made a stronger case of why not to monitor after being challenged by the local stakeholders in this regard.

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4.3.4 Participating in a European R&D project as a local stakeholder

> *"It might be a provocative statement, but I don't think that the EU level is the most relevant one to discuss nuclear waste management programs and issues. That is not their business."* (local stakeholder, Local Stakeholders Workshop, Antwerp (Belgium), September 2018)

> *"I also wanted to add that I really enjoy to share knowledge with other countries. That is really appreciated."* (local stakeholder, Local Stakeholders Workshop, Antwerp (Belgium), September 2018)

The two statements expressed by local stakeholders above refer to the last tension we wish to discuss in this report, namely the one relating to the question of where public engagement should be grounded? The idea that public engagement approaches should be context sensitive is well established within the STS community (Delgado et al. 2011). It has, for instance, been argued that particular political cultures should be taken into account when analysing various forms of public engagement (Jasanoff 2005) and that there is a need to adjust public engagement initiatives to the concrete challenges that technological development introduces in particular contexts (Delgado et al. 2011). This need for contextualisation stands in contrast with the tendency to portray public engagement as a universal element of good governance, in- and outside of R&D projects, that becomes practically executed by means of various participatory models that are deemed to apply in various cultural settings.

This tension has partly been addressed in WP5 by offering the local stakeholders both participation at the European level in the project meetings (see section 3.2.1) and participation opportunities in their local communities in the shape of 'home engagement activities' (see section 3.2.2). Even though participation in the project meetings was evaluated as very positive by the regularly participating local stakeholders, there were some participants who reported that they would have liked to have had more meetings at the local level throughout the project.

The two quotes above also indicate the various appreciations that local stakeholders might hold of their engagement in a European R&D project. For some it is not entirely clear how their engagement at the local level relates to their participation in a European project, and their real interest lies with engaging in national policy processes for nuclear waste. Others consider their participation in a EU-context valuable since they learn from geological disposal projects and local stakeholders' experiences in other countries.

We can conclude that most local stakeholders involved in this project value strongly the importance to learn from each other across national borders, and to be inspired and challenged by the differences between national nuclear waste programmes, including how to assess and develop monitoring programmes. However, in relation to national differences it is important to be aware of the context, that for instance monitoring means different things in relation to different national programmes. This implies that questioning monitoring in relation to the French programme is very different from questioning monitoring in relation to the Swedish programme. In the former monitoring is a crucial activity, while in the latter it is more an add on activity, and not much discussed with/at the local level.

Besides this cross-country learning experience, one of our goals was also to establish the 'travelling of information' on monitoring between the local stakeholders who were engaged in project meetings and members of their home communities. In our Delphi survey, almost all local stakeholders who participated in Modern2020 indicated that they have shared their acquired knowledge with their peers at home. However, when asked to give an example of what information they had concretely shared with fellow community members, no clear responses were offered, which might nuance their previous statement. A suggestion here for future R&D projects is to establish a clear framework of how acquired knowledge

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from participating local stakeholders could be shared with the communities at home in order to give the learning experience a more sustainable character.

Lastly, the tension of participating as a local stakeholder to a European R&D project can also be linked to the extent to which involved local stakeholders feel they have been able to contribute to the Modern2020 project. If the technical project partners do not receive or establish a clear framework for incorporating local stakeholders' remarks and concerns in their project work, they often fail to include the local stakeholders in the project. This shortcoming was voiced as follows by a local stakeholder:

> *"We sometimes feel a bit like the 'fifth wheel'. It feels that the project partners see it as a nice extra and legitimation that we are there, but we are not really involved. For the time being there is no really 'equal' involvement of stakeholders in terms of presenting something from our perspective as well"* (local stakeholder, WP2 Workshop, Paris, March 2017).

It is also evidenced by our survey results as no technical expert – who participated to the survey at least - was able to give a concrete example of how local stakeholders' concerns and/or remarks had been integrated into the workings and results of the Modern2020 project.

The feeling of not quite belonging voiced by the local stakeholder above might also be connected to certain practical issues. For some local stakeholders, the language barrier has been difficult to overcome as the common language used in project meetings and engagement initiatives was English. Other local stakeholders were hesitant to participate because of logistical reasons which relates to the accessibility of the places where meetings were held, the time needed for getting there, participating and preparing, and the financial resources needed for traveling. Even if reimbursement is reassured, this does not always suffice if one first has to finance these travels oneself. This illustrates that the involvement of local stakeholders should be planned carefully and that sufficient resources should be made available to include them. At the same time some flexibility is needed in (re)scheduling to accommodate stakeholders, and in welcoming new stakeholders (see section 3.4.2: strong agreement among respondents to the Delphi survey that local stakeholders should be able to participate "when deemed necessary").

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5. Concluding recommendations

In a very focused expert driven technical research project it is a big challenge to engage concerned citizens in the research itself. However, that does not mean they could not be engaged in the research process. Even if it is in a more observatory role, we have observed throughout this project a process of mutual understanding and trust building (a little less on the technical partners' side, but then not all of the technical experts were as 'exposed' to the participating citizens). The atmosphere of openness and the ability for stakeholders to see a diversity of opinions, remaining open questions and uncertainties were highly appreciated.

In activities carried out in work package 5 we explicitly chose the difficult route of bringing local citizen stakeholders on board from the early stages of the project, so well before any well delineated, targeted communication of obtained results was possible. This put some strain on our technical project partners and often also demanded much from the citizen stakeholder participants. But it added tremendously to the latter's feeling of authenticity. It does of course also point to a number of limitations for this type of approach, which cluster around the crucial issues of motivation, language, time and resources – both from the perspective of the stakeholders, as from the perspective of the technical experts.

Below we summarize some **key conclusions** about citizen stakeholder engagement in technical R&D projects, based on our own observations throughout the project, responses from the technical experts to the online survey, and how the participating stakeholders assessed their role and engagement in the Modern2020 project. These conclusions are formulated at a more general level than the lessons learned in the previous Chapter 4 and can therefore be of use for the organisation of local stakeholder engagement in other R&D projects beyond the scope of monitoring and geological disposal of radioactive waste.

1. Local stakeholders felt their role in the project not being to influence the course of the technical research, but to understand what it was for and how it could affect their national waste management programmes.
2. Local stakeholder participants were not prepared to legitimate research outcome, but want to ask critical questions in order to increase understanding and also to give feedback.
3. This means they want to be engaged in the research process but not in the research itself in order:
    - to see how it is done and what it is for; to witness debate among researchers; to get a sense of the knowledge and the knowledge gaps
    - to confront the researchers with the real world outside the lab; to keep them alert and answerable and to take local stakeholders' remarks and comments into account
    - to gather information and knowledge to be able to play a role of bridge-builder or broker towards broader publics and stakeholder groups
4. To be involved early in the process, during 'science in action, in close contact with researchers implies 'messiness' in interaction, but this shows authenticity (no cleaned-up marketing messages), which stimulates trust.
5. The focus on reaching consensual strategies (in this case on repository monitoring, which is an explicit aim of Modern2020) risks to conceal national differences and also political interests,

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which thereby become disguised as technical issues. A concrete example of this, is that in the process of parameter screening developed in WP2, costs were considered to be part of a technical feasibility analysis.

6. In our survey, we found important differences between technical experts and local stakeholders concerning whether the latter should be involved on the technical/engineering level of a specific R&D project and how early in the process they should be involved. Local stakeholders were much more convinced than technical experts that they have the potential to improve the design of monitoring systems and that it is important for them to be involved early in the process compared to the assessment made by technical experts.

Finally, these results lead us to formulate the following **key recommendations** (issues to think about) on how to integrate citizen stakeholders' concerns in R&D projects more generally:

1. Accessible meeting places and adaptable planning (in view of availability of stakeholder participants).
2. Be realistic about 'how much' stakeholder involvement can be realised with available resources:
    - Suggestions of having more regular interactions with local stakeholders (e.g. organising discussion before and after every workshop) have to remain workable for both the technical experts and local stakeholders.
    - To what extent are technical experts able to invest time in 'translating' their work into accessible and understandable information for 'lay' stakeholders?
    - The planning for the current work of WP5 assumed that all of the work would be undertaken by social scientists. What room is there in the future for a closer collaboration between social scientists and technical experts in planning the work, and in cooperation with stakeholders?
3. The language barrier needs to be overcome (international R&D projects use English as working language). Projects need to consider costs for both R&D and interaction (e.g. translation).
4. Carefully assess on what topics, in what phases and for what reasons, local citizen stakeholders should be engaged. There must be something to negotiate. Otherwise, engagement risks to become 'tokenistic'.
5. Pay attention to realizing clear outcomes of stakeholder engagement within R&D projects (by validating the engagement efforts clearly into the project results), in order for both technical experts and local stakeholders to see how their efforts have paid off.
6. Be sensitive towards a too strong push on consensus; acknowledge what is not agreed upon, and show science in action in all its complexity and with all its uncertainties
7. Do not rush a process of engagement. Allow time for the participants and the project to get acquainted and adapt to one another.
8. Be sensitive also towards the tensions involved when dealing with the five crucial questions on how to organise local citizen stakeholder involvement in R&D programmes: the questions of why, who, how, when and where (Delgado et al. 2011). There are no clear and uncontroversial answers to these five questions. Nevertheless, they are necessary to deal with, which requests sensitivity from responsible actors in relation to participants demands and to contextual factors.

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9. As an overall comment we lastly would like to pledge for sensitivity towards delegation of decision power to technical experts only. This should only be done when there is broad agreement that technical experts are the right decision maker, i.e. when experts internally agree and are externally broadly trusted.

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Appendix: Full overview of questions asked in both rounds of the online 'Delphi' survey

ROUND 1

Section 1 – Profile questions

Questions asked to all respondents:

1.1 Which national radioactive waste management programme are you **mainly** involved with?

- Belgium
- Czech Republic
- Finland
- France
- Germany
- Italy
- Netherlands
- Spain
- Sweden
- Switzerland
- United Kingdom
- Other

1.2 In the national radioactive waste management programme, you participate **mainly** as:

- Interested citizen not related to any kind of association
- National NGO representative
- Local NGO representative
- Local Politician representative
- National Politician representative
- Public Official representative
- National Regulatory body representative
- Technical Support organisation representative
- Nuclear waste management organisation representative
- Free-lance technical consultant
- University technical research centre
- University social research centre
- Other

1.3 How long have you been engaged in questions related to radioactive waste management?

- Less than 2 years
- 2 years – 10 years
- More than 10 years

1.4 In the Modern 2020 project, you are considered as a

- Technical expert
- Social scientist
- Local stakeholder

Questions asked to local stakeholders only:

1.5 Do you have a technical/scientific background?

- No
- Yes, but not related to the nuclear field
- Yes, related to the nuclear field

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1.6 How many activities did you attend in Modern2020 project?
- Only 1
- 1-5
- More than 5

1.7 What kind of activities did you attend in Modern2020 project? Choose the relevant item(s)
- One or more home engagement activities (activities organized in your country)
- One or more General Assembly meeting(s) of Modern2020 project
- One or more international workshops of the Modern2020 project

1.8 According to you, what is the frequency of your contact with technical experts integrated in Modern 2020 project:
- I'm never in contact with technical experts.
- Very high
- High
- Neither high or low
- Low
- Very low

1.9 According to you, what is the frequency of your contact with social scientists integrated in Modern 2020 project:
- I'm never in contact with technical experts.
- Very high
- High
- Neither high or low
- Low
- Very low

Questions asked to technical experts only:

1.10 Please indicate in which Work Package (WP) your work is mainly situated:
- WP1 – Coordination and management of the Consortium
- WP2 – Monitoring Programme Design Basis, Monitoring Strategies and Decision Making
- WP3 – Research and development of relevant monitoring technologies
- WP4 – Demonstration of monitoring implementation at repository like conditions
- WP5 – Effectively engaging local citizen stakeholders in R&D/RD&D on monitoring for geological disposal
- WP6 – Modern2020 Dissemination

1.11 Your technical/scientific background is:
- Directly related to nuclear field.
- Not directly related to nuclear field.

1.12 Did you have any personal experience with local stakeholder engagement in radioactive waste management prior the Modern2020 project?
- Yes
- No

1.13 In the Modern 2020 project, when did you come into contact with the local stakeholders?
- During the General Assembly meetings at which local stakeholders were present
- During workshops organized by my own WP where local stakeholders were represented
- During engagement activities organized by WP5 within the Modern2020 project
- During engagement activities organized in a specific country, outside of the Modern2020 project
- I've never been in contact with local stakeholders involved in the Modern 2020 project.

1.14 According to you, what is the frequency of contact with local stakeholders integrated in Modern 2020 project
- Very high
- High
- Neither high or low
- Low
- Very low
- I'm never in contact with local stakeholders involved in the Modern 2020 project.

1.15 According to you, what is the frequency of contact with social scientists integrated in Modern 2020 project
- Very high
- High
- Neither high or low
- Low
- Very low
- I'm never in contact with technical experts involved in the Modern 2020 project.

Section 2 - Expectations and opinions about RD&D for a monitoring system for geological disposal

Questions asked to all respondents:

2.1 How would YOU define 'repository monitoring'?

2.2 In the national nuclear waste program I'm involved with, I consider that repository monitoring system should be an priority:
- Yes
- No
- I do not want to or cannot answer to this question

2.3 According to you, what should be monitor? Select one (or more) type of monitoring you consider relevant for the national nuclear waste programme you are most involved with:
- Environmental monitoring
- Far field monitoring which is a monitoring above the ground
- Geological barrier which is the natural barrier
- Engineered Barrier System which is the handmade technical barrier around the waste packages
- Waste packages
- All those types of monitoring are relevant
- All those type of monitoring are irrelevant
- I do not want to or cannot answer to this question

2.4 When should repository monitoring take place?
- Before repository operation
- During commissioning
- During the period of earliest waste emplacement
- After closure of the repository
- All those moments are relevant
- All those moments are irrelevant
- I do not want to or cannot answer to this question

2.5 Where should repository monitoring take place?
- In situ (site area that are hosted the industrial project)
- In underground research facility (site area that could be different from the industrial one)
- In pilot facility (underground facility identical to industrial site area)
- In industrial facility (underground facility)
- All those elements are relevant
- All those elements are irrelevant

- I do not want to or cannot answer to this question

*In this project, some technical experts and local stakeholders have already highlighted several **advantages** of repository monitoring. What do you think about those statements? (These are all single choice questions for which the respondents had to select one out of the following options: I strongly disagree – I agree – I do not want to or cannot answer to this question – I disagree – I strongly agree)*

2.6 Repository monitoring "offers a confirmation about the disposal concept as it has been developed in the safety case"

2.7 Repository monitoring allows "checking whether everything in the repository is going according to plan"

2.8 Repository monitoring "makes the repository safer"

2.9 Repository monitoring provides "information on the repository system and we can draw valuable lessons from this".

2.10 Repository monitoring establishes "public confidence in and social acceptance of the geological disposal project in its local regions"

2.11 Repository monitoring is "able to make an independent assessment of the state and evolution of the geological repository".

2.12 Do you see other advantages to repository monitoring?

*In this project, some technical experts and local stakeholders have already highlighted several **disadvantages** of repository monitoring. What do you think about those statements? (These are all single choice questions for which the respondents had to select one out of the following options: I strongly disagree – I agree – I do not want to or cannot answer to this question – I disagree – I strongly agree)*

2.13 "There is no or sufficiently good technology available for repository monitoring"

2.14 "Repository monitoring may cause a physical intrusion into the barrier system and can therefore jeopardize the overall safety of the repository"

2.15 "Monitoring data can be interpreted in the wrong way, leading to wrong decisions being made with regards to RWM."

2.16 "There are too many uncertainties in relation to how data should be collected, stored, interpreted and judged, and by whom".

2.17 "The cost price of establishing a repository monitoring system in GD is too high".

2.18 "The timeframe we can monitor is insignificant in relation to the timescale of the overall geological disposal facility".

2.19 Do you see other disadvantages to repository monitoring?

2.20 Who should be **responsible for carrying out** repository monitoring?

- National radioactive waste management organisations
- National regulator
- Municipality
- Local citizen stakeholder organizations
- Non-governmental organizations (NGOs)
- An independent research institution
- An independent laboratory
- University researchers
- All of those actors
- None of those actors
- I do not want to or cannot answer to this question

2.21 Could explain why the actor(s) you've selected should be responsible for carrying out repository monitoring?

Section 3 – Assessing citizen stakeholder engagement activities in the Modern2020 project

Questions asked to local stakeholders only:

3.1 What was your main motivation to participate in this project?

3.2 Did you expect to play an active role in this project?
- Yes, I expected to be consulted on specific choices made during the research process
- No, I mainly expected to be informed on what was going on in the project
- I didn't know what to expect

3.3 How would you describe your role as a local stakeholder in this project?

3.4 Was it clear to you what was expected from you as a local stakeholder participating in this project?"
- Yes, for me that was clear from the beginning
- At first not, but it became clear to me during the consecutive activities I participated in
- I don't think there was a clear role set at the beginning, but we defined our role during the first interactions with the project team
- I still haven't a clue what they expect from us

3.5 What would you say is the most valuable outcome of your participation in the project, on the personal and/or project level?

3.6 Which of the following statements express the closest your appreciation of the communication from the technical experts within the Modern2020-project (feel free to pick more than one!):
- "I have received concrete, clear and detailed, as well as tangible information on the state-of-the-art of monitoring technology development."
- "I have received too much information on monitoring strategies and technologies during my involvement in the project."
- "I was provided with enough concrete, illustrative examples of how monitoring strategies and technologies would work in practice."
- We were provided with a lot of information, but there was never a real dialogue
- "I consider the information that I have received from the technical experts during my involvement in the project, to be useful."
- "We only received information about the results and what they knew, not about the questions they couldn't answer"
- "I think the technical experts in the Modern2020-project have openly communicated towards us about the relation of monitoring to uncertainties, unexpected outcomes, difficulties, mistakes or accidents."
- "I feel they could have engaged us more in defining their research agenda and in setting priorities within the project"
- "There was enough room for dialogue and feedback from us on the research done in the project"
- "As a local stakeholder, I was mainly at the receiving end of the communication in this project, and that is how I think it should be."

3.7 Did you miss anything in the information received ?
- Yes
- No
- I wouldn't know

3.8 Do you have any remarks and/or suggestions regarding the interaction between technical experts and local stakeholders within the Modern2020 project?

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3.9 "I have the feeling that I have been able to make a substantive contribution to the technical work of the Modern2020 experts."

- I strongly disagree
- I disagree
- I do not want to or cannot answer to this question
- I agree
- I strongly agree

3.10 Can you give an example of a contribution that you have been able to make to the work of the technical experts on the development of monitoring strategies and/or technologies?

3.11 "I have been able to express my own opinions about the principles of monitoring (i.e. why, when, where and how to monitor?) during my involvement in the project."

- I strongly disagree
- I disagree
- I do not want to or cannot answer to this question
- I agree
- I strongly agree

3.12 "I have the feeling that the technical experts have taken into account my opinions on the principles of monitoring (i.e. why, when, where and how to monitor?) in the further development of monitoring strategies."

- I strongly disagree
- I disagree
- I do not want to or cannot answer to this question
- I agree
- I strongly agree

3.13 Can you give an example of how technical experts in the Modern2020-project have taken into account your opinions on the principles of monitoring (i.e. why, when, where and how to monitor?) in their work?

3.14 "In the Modern2020-project, I have the feeling that I have been asked to give input on things that were actually already pre-determined."

- I strongly disagree
- I disagree
- I do not want to or cannot answer to this question
- I agree
- I strongly agree

3.15 During your involvement in the Modern2020 project, did you learn something that is relevant for your engagement in RWM?

- Yes
- No
- I do not want to or cannot answer to this question

3.16 What did you find the most interesting as a local stakeholder participant in the Modern2020 project?

- International comparison
- Technical detail
- Learning about monitoring
- Exchange with the scientists
- Seeing how such an international project works

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3.17 "I have been able to share information acquired in the Modern2020 project with my fellow local stakeholders back home."
- I strongly disagree
- I disagree
- I do not want to or cannot answer to this question
- I agree
- I strongly agree

3.18 Can you give an example of some information on the Modern2020-project that you have shared and explained to your fellow local stakeholders back home?

3.19 Do you have any additional remarks and/or suggestions about the way in which local stakeholders have been involved in the project?

Questions asked to technical experts only:

3.20 I had a clear view on what was expected from me as a technical expert with regards to the communication and presentation of information to local stakeholders
- I strongly disagree
- I disagree
- I do not want to or cannot answer to this question
- I agree
- I strongly agree

3.21 Which of the following statements express the closest how you have experienced the communication with local stakeholders in the Modern2020 project (more than one answer possible):
- I found it easy to communicate my technical work to the local stakeholders in a clear and accessible way.
- I have experienced some difficulties in opening up my technical work for the local stakeholders.
- I don't feel comfortable communicating my work to a non-technical audience
- I was happy to leave the direct communication on our work to the local stakeholders to my colleagues
- I would like to communicate directly my work to the local stakeholders, but so far didn't get the opportunity

3.22 Can you give an example of something that you found difficult to explain to the local stakeholders?

3.23 Do you have any remarks and/or suggestions with regards to the way the interactions between technical experts and local stakeholders in the Modern2020 project were set up?

"Regarding …" (These are all single choice questions for which the respondents had to select one out of the following options: I strongly disagree – I agree – I do not want to or cannot answer to this question – I disagree – I strongly agree)

3.24 "The interactions with the local stakeholders have encouraged me to reflect on my own work and place this in a broader societal perspective".
3.25 "I have received some valuable feedback on my own work from local stakeholders who have been engaged in the project".
3.26 "I think the engagement of local stakeholders in the Modern2020-project has been productive and has produced concrete results for the project".
3.27 "Through the interactions with the local stakeholders, I have learned to make my work more clear and accessible for a broader public".
3.28 "I have been able to develop a relationship of mutual trust with (some of) the local stakeholders involved in the project".

3.29 "I think we succeeded in integrating the local stakeholders' remarks and concerns with regards to monitoring into the work and results of the Modern2020-project."

3.30 Can you give a concrete example of how interactions with and/or feedback from local stakeholders have influenced your personal work in the Modern2020-project?

3.31 Can you give a concrete example of how local stakeholders' concerns and/or remarks have been integrated into the workings and results of the Modern2020 project?

3.32 What would you say is the most important thing you have learned through your interactions with the citizen stakeholders involved in the Modern2020-project?

3.33 "I have been able to share the remarks and concerns of engaged local stakeholders with my technical colleagues outside the Modern2020-project"
- I strongly disagree
- I agree
- I do not want to or cannot answer to this question
- I disagree
- I strongly agree

3.34 At the beginning of this project, what did you expect from the involved social scientists?

3.35 "It is the role of social scientists to translate local stakeholders' opinions and remarks about monitoring to the technical experts."
- I strongly disagree
- I disagree
- I do not want to or cannot answer to this question
- I agree
- I strongly agree

3.36 Do you have any additional remarks and/or suggestions about the way in which local stakeholders have been involved in the project?

Section 4 – Engaging local stakeholder in the future

Questions asked to all respondents:

4.1 "I think participants with controversial and unpopular opinions and views of the topic at hand should be included in similar RD&D projects (such as Modern2020)?"
- I strongly disagree
- I agree
- I do not want to or cannot answer to this question
- I disagree
- I strongly agree

4.2 "For future projects, I think it is important that the involved local stakeholders are a representative sample of the broader population affected by the topic of discussion."
- I strongly disagree
- I agree
- I do not want to or cannot answer to this question
- I disagree
- I strongly agree

4.3 In order to contribute substantially to future research and development programs, I think that local stakeholder participants should have basic level of techno-scientific knowledge?
- I strongly disagree

- I agree
- I do not want to or cannot answer to this question
- I disagree
- I strongly agree

4.4 According to you, what is a basic level of techno-scientific knowledge?

4.5 "I think local stakeholders should be given the opportunity to take part in the agenda setting and problem definition of the issue at hand in future projects."
- I strongly disagree
- I agree
- I do not want to or cannot answer to this question
- I disagree
- I strongly agree

4.6 Do you have any remarks and/or suggestions about the way stakeholders engagement should be take into account in future R&D projects?

Section 5 – (Dis)Trust institutions

Questions asked to local stakeholders only:

5.1 Regarding the work of the national nuclear waste management organisation of your country:
- I have very low confidence
- I have low confidence
- I do not want to or cannot answer to this question
- I have high confidence
- I have a very high confidence

5.2 Why do you (dis)trust the national NWMO of your country?

5.3 Regarding the work of the national regulator/authority of your country:
- I have very low confidence
- I have low confidence
- I do not want to or cannot answer to this question
- I have high confidence
- I have a very high confidence

5.4 Why do you (dis)trust the regulator/authority of your country?

5.5 Who do you turn to for expert advise on radioactive waste management? Select one or most relevant items.
- National radioactive waste management organisation of my country
- National regulatory body / authority of my country
- International radioactive waste management associations
- International regulatory body association
- National independent NGOs
- International independent NGOs
- Independent research institutions
- Local citizen stakeholder organizations in my country
- Local citizen stakeholder organization of other countries
- Other

5.6 The national radioactive waste management organization (RWMO) in my country provides sufficient information about its work to the citizens in my community
- I strongly disagree

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- I agree
- I do not want to or cannot answer to this question
- I disagree
- I strongly agree

5.7 It is easy to receive information from the national radioactive waste management organization (RWMO) in my country

- I strongly disagree
- I agree
- I do not want to or cannot answer to this question
- I disagree
- I strongly agree

5.8 The national regulatory body/authority in my country provides sufficient information about its work to the citizens in my community.

- I strongly disagree
- I agree
- I do not want to or cannot answer to this question
- I disagree
- I strongly agree

5.9 It is easy to receive information the national regulatory body / authority in my country.

- I strongly disagree
- I agree
- I do not want to or cannot answer to this question
- I disagree
- I strongly agree

5.10 "I think nuclear waste management organisation or public institutions in charge to organize participatory activities in my country are transparent enough about their reasons and methods of organizing the participatory activities."

- I strongly disagree
- I agree
- I do not want to or cannot answer to this question
- I disagree
- I strongly agree

5.11 "I think the Modern2020 project organizers were transparent enough about their reasons and methods of organizing the participatory activities."

- I strongly disagree
- I agree
- I do not want to or cannot answer to this question
- I disagree
- I strongly agree

5.12 It's the end of the inquiry! Do you have any suggestion or additional comments you would like to share?

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ROUND 2

Section 1 – Profile questions

Questions asked to all respondents:

1.1 Did you participate to the first round of the questionnaire?
- Yes
- No

Additional questions for respondents who did not participate in the first round:

1.2 Which national radioactive waste management programme are you mainly involved with?
- Belgium
- Czech Republic
- Finland
- France
- Germany
- Italy
- Netherlands
- Spain
- Sweden
- United Kingdom
- Switzerland
- Other

1.3 In this national radioactive waste management programme, you participate mainly as... (please select one option)
- Interested citizen, not related to any kind of association
- Citizen in association
- Local NGO representative
- Local politician
- Local administration
- Nuclear waste management organisation representative
- Technical support organisation representative
- Technical consultant (private company)
- Academic researcher or member of a public research institute
- Other

1.4 How long have you been engaged in questions related to radioactive waste management?
- Less than 2 years
- years – 10 years
- More than 10 years

1.5 In the Modern2020 project, you are considered as…
- Technical expert
- Local stakeholder

Questions asked to local stakeholders (who did not participate in the first round) only:

1.6 Do you have a technical/scientific background?
- No
- Yes, not related to nuclear
- Yes, related to nuclear

1.7 How many activities of the Modern2020 project did you attend?

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- Only 1
- to 5
- More than 5

1.8 What kind of activities did you attend in Modern2020? Choose the relevant item(s).
- One or more home engagement activities (activities organized in your country by social scientists)
- One or more General Assembly meeting(s) of the Modern2020 project
- One or more international workshops of the Modern2020 project related to a specific topic or work package

Questions asked to technical experts (who did not participate in the first round) only:

1.9 Please indicate which Work Package (WP) your work is mainly situated in:
- WP1 – Coordination and management of the Consortium
- WP2 – Monitoring Programme Design Basis, Monitoring Strategies and Decision Making
- WP3 – Research and development of relevant monitoring technologies
- WP4 – Demonstration of monitoring implementation at repository like conditions
- WP6 – Modern2020 Dissemination

1.10 Your technical/scientific background is:
- Directly related to the nuclear field
- Not directly related to the nuclear field

1.11 Did you have any personal experience with (local) stakeholder engagement in radioactive waste management prior to the Modern2020 project?
- Yes
- No

1.12 In the Modern 2020 project, when did you come into contact with the local stakeholders? Several answers are possible.
- During the General Assembly meetings at which local stakeholders were present
- During workshops organized by my own WP where local stakeholders were represented
- During engagement activities organized by WP5 within the Modern2020 project
- During engagement activities organized in a specific country, outside of the Modern2020 project
- I've never been in contact with local stakeholders involved in the Modern 2020 project

Section 2 – Monitoring systems

Questions asked to all respondents:

2.1 Most respondents considered environmental monitoring as well as monitoring of the (natural) geological barrier and the Engineered Barrier System (EBS) as equally relevant in their national nuclear waste management program. Monitoring of the waste packages was seen as less relevant, more so by technical experts than local stakeholders (4.5% compared to 23,5% found this relevant). However, other slight differences appear between technical experts and local stakeholders. Whilst more technical experts find monitoring of the (natural) geological barrier more important than EBS monitoring, local stakeholders prioritize this EBS monitoring over the monitoring of geological barriers.

This leads us to the hypothesis that technical experts prioritize the different types of monitoring more in terms of feasibility and technical achievability, since EBS monitoring can be considered technically more challenging than monitoring the natural barrier of the underground. This stands in contrast with the local stakeholders who select the most relevant types of monitoring according to what, in their opinion, is desirable, expressed by the way in which they prioritize monitoring of the Engineered Barrier System and the waste packages when compared to the preferences of technical experts.

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We would like to hear your thoughts and comments about this analysis. Do you (dis)agree, and why?

2.2 Both the statement "Repository monitoring offers a confirmation about the disposal concept as it has been developed in the safety case", and its counterpart "Repository monitoring allows checking whether everything in the repository is going according to plan", were agreed with by most respondents (technical experts as well as local stakeholders). Can we conclude here that repository monitoring should serve both of these functions: (1) it confirms the adequacy of the disposal facility, and at the same time (2) keeps us alert and offers a possibility of checking whether the disposal facility is functioning well?

How do you view this difference between monitoring as 'confirming' and as 'checking' the geological repository? To what extent do these functions differ or correspond to each other?

2.3 In the first round of the survey, we asked whether you agreed or disagreed with the statement that 'repository monitoring makes the repository safer'. Even though a (very small) majority of the respondents disagreed with this statement, the results were quite evenly spread between disagree and agree (both for technical experts and local stakeholders).

How would you explain these very divergent results within both groups? Why do you think this is, and how does this relate to your personal opinion on this matter?

2.4 Following up on the previous question, we would also like to obtain some clarification about the relationship between repository monitoring and (un)safety.

If you disagree with the statement "repository monitoring makes the repository safer". Is this, in your opinion, primarily because (please select one option):

- Repository monitoring could make the repository more unsafe (because of the lack of adequate monitoring technologies for example, as some of you indicated in response to another question from round 1).
- You do not think that it is the function of repository monitoring to make the repository safer in the first place.

2.5 If you would like to add some additional comments with regards to the previous question, please feel free to do so here.

2.6 If you agree with the statement "repository monitoring makes the repository safer", why and how do you think repository monitoring could contribute to the safety of the repository?

2.7 Most of you agreed that repository monitoring could provide information to make an additional assessment of the state and evolution of the geological repository, and confirmed that it is possible to draw valuable lessons out of its data results.

About which of the following elements could valuable/additional lessons be drawn on the basis of repository monitoring results? (please select one or more options)

- Repository design: modifying the existing repository
- Repository design: in view of future repositories (e.g. for other NWMOs to learn from this experience)
- Emplacement operations
- Monitoring programmes/strategies
- Monitoring technologies
- Long-term safety
- Operational safety
- None
- Something else

2.8 If you see other issues for which lessons could be learned from repository monitoring, please specify here.

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2.9 Whilst the majority of technical experts confirmed that there exists a risk of misinterpreting the monitoring data (which might lead to wrong decision making), local stakeholders largely disagreed with this statement.

How do you view this disagreement between technical experts and local stakeholders? How would you explain this?

2.10 With regard to the risk of misinterpretation of monitoring data leading to wrong decision making), how problematic you consider the risk of misinterpretation of monitoring data to be? Please indicate how problematic you consider this risk to be on a scale from 'very low' (not problematic at all) to 'very high' (very problematic) (one option).

- Very low
- Low
- High
- Very high

2.11With regard to the risk of misinterpretation of monitoring data leading to wrong decision making), how likely do you consider the risk of misinterpretation of monitoring data to be? Please indicate the likelihood according to you on a scale from 'very unlikely' to 'very likely' (one option).

- Very unlikely
- Unlikely
- Likely
- Very likely

2.12 Depending on how likely and how problematic you consider the risk of misinterpretation to be, is this – in your opinion – a reason not to monitor?

- Yes
- No

2.13 Please feel free to comment on or specify your answer(s) above.

Section 3 – Assessment of local stakeholder engagement activities

Questions asked to all respondents:

3.1 In the first round, the majority of respondents (technical experts AND local stakeholders) indicated that local stakeholders should be involved in both general nuclear waste management decision making processes and specific research and development programs (such as repository monitoring).
However, there existed a large discrepancy between local stakeholders and technical experts with regards to the extent to which local stakeholders should be involved on the technical/engineering level of a specific R&D project. 85% of technical experts does not think that local stakeholders should be involved in these matters (such as repository design or design of monitoring systems), whilst 44% of local stakeholders do see a role for themselves here.
Moreover, a significant part of the local stakeholders (35,5%) are convinced that local stakeholder involvement in the R&D of monitoring has the potential to improve the design of the monitoring system, whilst only 9,1% of the technical experts shares this opinion.

What do you think about these differences in opinion between technical experts and local stakeholders? How would you explain these results?

3.2 The result (from the first round) that local stakeholders are more eager to propose that they should be engaged also in connection to technical issues whilst technical experts remain more skeptical about this, corresponds with the finding that technical experts within Modern2020 are mostly of the opinion that the project results should be reported to local stakeholder AFTER the (technical) project work has been done, whilst local stakeholders show more interest in participating to this process itself (so that they can see how certain technical findings and results are being produced).

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Considering this eagerness from many of the local stakeholders to be involved on the technical/engineering level and to participate throughout the process of knowledge production, how do you think this could be matched with the (rather contrary) opinion of most technical experts?

3.3 Following up on the previous question, what do you think this local stakeholder involvement in technical matters could be concretely? How can local stakeholders, in your opinion, contribute to the technical project work?

3.4 In the first round, one of the respondents (technical expert within Modern2020) mentioned the following:
"From my personal experience, it is important to communicate and to give to the local stakeholders all the information they require to have. I do not think it makes sense to invite the local stakeholder into the repository design process as they typically do not have sufficient qualification, but they should be involved into any discussion related to the safety procedures or any local practical problem."

Do you agree with this opinion? Why (not)?

3.5 If we suppose that local stakeholder involvement in a research project such as Modern2020 entails the possibility for local stakeholders to express their social concerns and issues, then what kind of social issues and concerns do you expect to communicate towards the technical experts (for local stakeholders) / receive from the local stakeholders (for technical experts)?

3.6 Using the concept of 'Technology Readiness Levels' as a chronological scale for technology development, please indicate the levels on which you think local stakeholders should have the opportunity to be involved (involvement = being informed, whilst getting the opportunity to express concerns and critiques)? You can select multiple options.

- TRL 0: Idea. Unproven concept, no testing has been performed.
- TRL 1: Basic research. Principles postulated and observed but no experimental proof available.
- TRL 2: Technology formulation. Concept and application have been formulated.
- TRL 3: Applied research. First laboratory tests completed; proof of concept.
- TRL 4: Small scale prototype built in a laboratory environment ('ugly' prototype).
- TRL 5: Large scale prototype tested in intended environment.
- TRL 6: Prototype system tested in intended environment close to expected performance.
- TRL 7: Demonstration system operating in operational environment at pre-commercial scale.
- TRL 8: First of a kind commercial system. Manufacturing issues solved.
- TRL 9: Full commercial application, technology available for consumers.
- None of these levels
- I cannot or do not want to answer

3.7 Besides the fact that a significant part of respondents (32%) were of the opinions that local stakeholders should be involved at the stage of agenda setting and selection of research questions, a similar amount of people (32%) also indicated that they should be involved 'when local stakeholders desire to intervene'.
The latter would imply a constant involvement on the part of local stakeholders in order to be able to intervene in the work of the technical experts (as local stakeholders should be informed about the project work at all times in order to do so). Furthermore, it could be interpreted as putting an extra burden on local stakeholders to take the initiative to follow up closely the national NWM progamme and all related activity and then estimate when best to intervene, allowing technical experts to take up a more reactive role.

What are your opinions about the interpretations given above? Do you think such a constant involvement is realistic, on the part of local stakeholders as well as for technical experts?

3.8 Even though the majority of respondents (50% of the technical experts and 52% of the local stakeholders) agree that monitoring data should not be provided to local stakeholders in their raw form, most respondents (78%) do think that raw monitoring data should at all times be kept available for counter-expertise.

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If monitoring data should not be provided to local stakeholders in their raw form, how should we interpret this 'availability' of monitoring data then?

3.9 Following up on the previous question, who/what institution should be responsible for maintaining and keeping record of the monitoring data? (please select one or more options)

- NWMO
- National regulator
- (Local) municipality
- Local citizen stakeholder organisations
- NGOs
- Independent research institution
- University researchers
- None of these actors
- Somebody else

3.10 Besides the actor who has responsibility over managing the monitoring data, who should decide whether or not, how and to what extent the monitoring data can be used by other actors?

- NWMO
- National regulator
- (Local) municipality
- Local citizen stakeholder organisations
- NGOs
- Independent research institution
- University researchers
- None of these actors
- Somebody else

3.11 As the Modern2020 project has not reached its end yet, it is probably too early to make any hard judgements about whether or not we succeeded in integrating local stakeholders' remarks and opinions about monitoring systems in the project work. However, in the meantime, 32% of the technical experts indicated that they "have succeeded in integrating the local stakeholders' remarks and concerns with regards to monitoring into the workings and results of the Modern2020 project".

For technical expert respondents: Can you give an example of how you succeeded in integrating the local stakeholders' opinions in your project work?

For local stakeholder respondents: Can you give an example of how you think the technical experts succeeded in integrating your (fellow stakeholders') remarks and concerns in their work?

3.12 Most of the respondents (61%) agreed that it is important that local stakeholders involved in an R&D project form a representative sample of the broader population affected by the topic of discussion. However, the majority of respondents (58%) also were of the opinion that local stakeholder participants should have a basic level of techno-scientific knowledge in order to substantially contribute to an R&D project.
We could say that these two opinions are not compatible since, as local stakeholders are deemed to be representative for the citizen group they come from, they cannot all possess a basic knowledge of technical matters?

How do you assess this contradiction? How should we assess the importance and the kind of basic knowledge needed?

3.13 If you would like to add a final comment, suggestion or specification about your answer(s) above, please feel free to do so here.