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Exploring key considerations and perspectives regarding the (financial) participation in onshore underground energy storage projects in the Netherlands

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Abstract

A fundamental challenge in the successful implementation of large-scale energy storage (LSES) in the Netherlands is the required public support for underground activities of Dutch citizens. In this study the key considerations and perspectives regarding the (financial) participation, as a means to increase public support, were explored by conducting interviews among the key stakeholders of onshore underground energy storage projects. An empirically grounded, explanatory framework for understanding the role of perceptions of justice in the dynamics of controversy, introducing two assessment trajectories (the formal and the informal) was used to analyse the results. The study found that the definition and perception of technical risks of onshore underground energy storage projects vary considerably. In addition, four overarching themes (national coordination, the damage-handling process, the division of roles and responsibilities, and the distribution of benefits and burdens) were identified. Among the generic characterisation of the themes, there is agreement among the stakeholders. Concerning the conceptualisation of the values, the research findings show that the opinions and perspectives differ. Two processes were identified that are key to the existence of controversies and the effects these have on energy policies, 'controversy spillover' and 'backflowing'. Perspectives and considerations, even if supported by years of experience, will differ from reality when drawing on physical experiences. Therefore, it is essential that in the future, when new procedures and policies regarding onshore underground energy storage projects are introduced, stakeholders' considerations and perspectives are re-examined. Any new insights or themes identified will support the required adaptation for regulations and policies over time.

Executive Summary

The current Dutch energy system heavily depends on fossil fuels. Under the Paris Climate Agreement, the government has set out measures and actions that enforce a 49% CO_2 emission reduction in 2030 compared to 1990 (NL Government, 2019). To build a future energy system that can guarantee a sustainable, efficient, secure and affordable energy supply, the implementation of renewable energy sources (RES) and electrification practices should be accompanied by large-scale energy storage (LSES) capabilities that can match the fluctuating supplies with the dynamic consumer demand. A fundamental challenge in the successful implementation of LSES is the required public support of Dutch citizens (Yeşilgöz-Zegerius, 2021; van Gessel et al., 2021). Fueling public support for LSES is particularly challenging in the Netherlands, as the suitable locations for the necessary energy storage facilities are the same as those currently used for producing and storing natural gas. Local governments and residents no longer trust the national government and operators due to past experiences and, as a result, show an unsupportive attitude towards governmental plans associated with underground energy activities (van Buuren, 2009; Roovers & Duijn, 2021; Winters et al., 2020).

The concept of distributive justice, which concerns the socially just allocation of resources, can support the improvement of social acceptance of LSES (Winters et al., 2020). In other countries, financial participation became an effective form of creating distributive justice (Jobert et al., 2007; Brannstrom et al., 2022; Devlin, 2005). Distributive justice is not yet adequately covered in the formal permit procedures shaping the Dutch energy system (Correljé, 2018; McCauley et al., 2013; Jenkins et al., 2016). Potential implications for and requirements of the introduction of financial participation in the Netherlands are therefore yet unknown. To foster the adequate implementation of financial participation in the Netherlands, this research aims to explore and understand what implementing this financial participation entails for LSES projects in the Netherlands.

To obtain these key considerations and perspectives on implementing a financial participation model in future onshore underground energy storage projects in the Netherlands, 17 interviews were conducted among the stakeholders. The stakeholder groups identified are the national government (Ministry of Economic Affairs and Climate, the National advisory, supervision and damage authorities), provinces, municipalities, water authorities, operators, researchers, Non-Governmental Organizations (NGOs) and residents. Experts from these stakeholder groups participated in various ways as part of the permitting procedures, exploration or supervision of the mining activities, or their residence within the close vicinity of a project. The experts interviewed were all involved, in different ways, in one or more of the following mining activities; underground gas storage (UGS) in depleted gas fields onshore, UGS in salt caverns onshore, underground hydrogen storage (UHS) pilot in a salt cavern onshore, and salt solution mining in salt caverns (salt solution mined caverns serve as UGS or UHS). Through document research and interviews, the study has gained insight into the themes surrounding financial participation in onshore underground energy storage in the Netherlands.

Although a significant part of the underground energy storage will be implemented and executed locally, involving operators, municipalities, and residents, challenges within the (national and regional) underground energy storage transition make a central approach desirable. The study found that the definition and perception of technical risks of onshore underground energy storage projects vary considerably and are based on social-scientific mechanisms. In addition, four overarching themes (national coordination, the damage-handling process, the division of roles and responsibilities, and the distribution of benefits and burdens) were identified, pointing at three tasks governing participation. These are the coordination task, the task of operationalisation (i.e. distributing roles and responsibilities), and the task of distributing benefits and burdens. Numerous issues surround all these tasks.

It was found that the definition and perception of the technical risks, as well as controversies surrounding the four overarching themes identified, can be explained using social-scientific mechanisms. The leading social-scientific mechanisms that govern underground energy storage projects are based on recent literature. The framework brought forward by Pesch et al. (2017) introduces two trajectories of valuation in decision making on energy projects, the formal and the informal. To understand controversies and their dynamics and to implement future policies that adhere to the perceived justice in both assessment trajectories, it is essential to recognise the three justice-related attributes of the two trajectories. These are (1) the logic through which concerns are articulated and values are expressed, (2) the starting point from which the dimensions of energy justice are considered, and (3) the democratic principles providing the moral authority for the justice-related claims. In addition, the existence and dynamics of controversy spillover, as explained by Cuppen et al. (2020), indicate that the role of perceptions of justice in the dynamics of controversy is not limited to the energy technologies and locations and controversies will spill over. This affects the informal assessment of future energy projects and, according to the framework developed by Pesch et al. (2017), also affects the formal assessment, a process referred to as 'backflowing'.

The framework developed by Pesch et al. (2017), successfully helps understand the controversies and dynamics surrounding the varying definitions and perceptions of risks, the national coordination on subsurface activities, the damage-handling process, the division of roles and responsibilities (i.e. participation in concrete projects) and the distribution of benefits and burdens. Expressing technical risks in different ways is explained by the first and second justice-related attributes. The first theme identified, the national coordination on underground energy storage is explained using all three justice-related attributes. The second theme, handling damage claims, is explained using the first and second justice-related attributes. The third theme, the division of roles and responsibilities, is explained using the first and second justice-related attributes. And finally, where concrete concerns and considerations were discovered in the interviews about the previously analysed issues, the distribution issue is characterised by opinions on a possible outcome. As there is no physical example of regional benefit sharing for onshore underground energy storage projects, only thoughts and considerations regarding the future implementation have been discovered. The difference in the logic through which concerns are articulated, and values are expressed, the fact that both assessment trajectories take different dimensions of energy justice as their starting point, and the difference in terms of the democratic legitimation of assessment trajectories, facilitate a better understanding of how controversies emerged. In addition, identifying the process dynamics through the lens of the framework offers concrete action perspectives for the specified tasks. The existence of the process known as controversy spillover, as described by Cuppen et al. (2020), plays a role in all the issues identified.

This framework, which explains existing processes and energy system controversies that have emerged, proved to be of great value when formulating policy arrangements for financial participation. Expectations and considerations have been identified. Considering the three justice-related attributes allows the creation of a set of rules and policies that can adapt to the expected dynamics of energy justice. Drafting policies in close consultation with the various stakeholders and carefully listening to their considerations and dilemmas should enable the government to foresee the process known as overflowing. Overflowing describes the emergence of concerns in society, not adequately safeguarded in the prevailing rules that are part of dominant institutional practices (Callon, 1998b). Ensuring that the policy safeguards the societal and ethical risks, not considered done in the eyes of stakeholders belonging to the informal assessment trajectory, will result in more successful policies, perceived as just by all stakeholders. Backflowing can be limited in that way, ensuring transparent and long-term policy arrangements.

The earlier mentioned drawbacks of missing examples of financial participation in the Netherlands and examining a process regulated by a yet-to-be-introduced Act requires a dynamic policy. The Ministry of the Interior and Kingdom Relations is advised to allow for the adaptation of the policy over time. Only then will it ensure that recent projects where regional benefit sharing has been introduced can be evaluated and lead to improvements and modifications of existing policies. Furthermore, the changing zeitgeist also asks for a re-evaluation of policies to adapt for yet unknown opinions and values. Especially considering this politically fragmented society, where opinion-forming is strongly driven by 'identity' as is the perception of values such as affordability, reliability and justice, and where social media are extremely powerful in creating 'audiences' with their own political representation around specific issues.

Considering the required dynamic character of the policy, it is essential to define and underline 'the why' behind current policy regulations. The government should be very clear in the justification of why the policy is necessary for the energy system so she can calibrate it, and every few years, she can revise the policy if necessary, based on a clear 'why' statement. However, it is critical, considering the long life span of underground energy storages and the huge investments required, that the policies in place adhere to proper and consistent administration. Therefore, the government should make very explicit what the grounds were for choosing a certain policy. And also indicate how and why these grounds might change in the future, and what the consequences might be.

In future research on the key considerations and perspectives regarding the implementation of (financial) participation in onshore underground energy storage projects in the Netherlands, it will be essential to consider how the timing of the information-gathering process plays a critical role in study findings. Furthermore, as the experts interviewed drew on personal experiences, this study does not claim that the identified considerations and perspectives tell the whole story. In addition, future research and expert interviews conducted by a more experienced researcher may identify dilemmas and perspectives missed during this research. The introduction of the new Environment and Planning Act, under which participation in onshore underground energy storage projects is regulated, is being postponed for the fifth time and is now scheduled for the 1st of January 2023. Perspectives and considerations, even if supported by years of experience, will possibly differ from reality when drawing on physical experiences. Therefore, it is essential that when the new Environment and Planning Act is introduced, stakeholders' considerations and perspectives are re-examined. Any new insights or themes identified will support the required adaptation of regulations and policies over time.

Contents

1 Introduction

The current Dutch energy system still heavily depends on fossil fuels. Although the Dutch government laid down a renewable energy (RE) share of 14% in the EU context for 2020, only 11.1% of the primary energy demand was produced by renewable energy sources (RES) that year (CBS, 2021). The relative slow transition and failure to achieve carbon dioxide emission reduction targets led to the Urgenda climate case against the Dutch government in 2019, which Urgenda won: the court ruling forced the government to take more effective action on emission reduction. This case was the first global example in which citizens established that the government has a legal duty to significantly reduce emissions in line with its human rights obligations (Urgenda, 2019). In combination with the growing pressure from (inter)national stakeholders and citizens, the court ruling has led to the construction of the ’Klimaatakkoord’, an essential part of the Dutch implementation of the Paris Climate Agreement. Under this agreement, the government has set out measures and actions that enforce a 49% CO_2 emission reduction by 2030 compared to 1990 (NL Government, 2019).

To achieve these set reduction targets, the current system requires the implementation of RES on a much larger scale and the electrification of various sectors within the energy system. However, the energy supply from RES fluctuates and is not naturally aligned with consumer demand. As a result, the move towards RES and electrification will generate a future energy system characterised by intermittent and inflexible low-carbon electricity generation. To realise a future energy system that is not solely effective for the reduction targets but also guarantees an efficient, secure and affordable energy supply, the implementation of RES and electrification practices should be accompanied by system capabilities that ensure the fluctuating supplies match the consumer demand. In addition to interconnection and demand response, solving the misalignment between supply and demand requires implementing large-scale energy storage (LSES) (Hart et al., 2016; IEA, 2014; Zeyringer et al., 2018; Thomas et al., 2019; van Gessel et al., 2021).

The implementation of LSES is inevitable, according to all energy system scenarios described and analysed in extensive studies recently carried out by Nederlandse Organisatie voor toegepast-natuurwetenschappelijk onderzoek (TNO) and Energie Beheer Nederland (EBN) on behalf of the Ministry of Economic Affairs and Climate (van Gessel et al., 2021). Due to its physical, technical and economic properties, hydrogen is expected to become the primary future energy carrier (Yeşilgöz-Zegerius, 2021; van Gessel et al., 2021; NL Government, 2019; Groenenberg, Juez-Larre, et al., 2020). However, due to hydrogen’s low density, large storage volumes will be required, which exceed the capacity of surface-based storage facilities (Groenenberg, Koornneef, et al., 2020). Subsurface reservoirs such as gas fields, aquifers and solution-mined salt caverns are the only feasible option to provide the large storage volumes required (Groenenberg, Koornneef, et al., 2020). Apart from storing energy for short-term mismatches (i.e. day/night and short periods with cloud coverage and low wind speeds), hydrogen storage also allows for long-term energy storage (i.e. seasonal), making it an ideal energy carrier. In the existing energy system, underground storage – in this case, natural gas – already forms a crucial component of the central energy infrastructure.

A fundamental challenge in the successful implementation of LSES is the required public support of Dutch citizens (Yeşilgöz-Zegerius, 2021; van Gessel et al., 2021). In the past, low local acceptance has hindered the development of renewable energy projects (REP) in the Netherlands (i.e. wind farm or solar park constructions), directly affecting the targeted generation capacity (Grashof, 2019). Likewise, the diminishing public support of Dutch citizens has become an essential barrier to producing natural gas and carbon capture utilisation and storage (CCUS) (Correljé, 2018; van Buuren, 2009). Citizens generally tend to perceive underground activities related to energy (i.e. natural gas production or storage) as a threat to their safety (e.g. damage to property as a result of earthquakes) and, as a response, object to them (Roovers & Duijn, 2021; Thomas et al., 2019).

Fueling public support for LSES is particularly challenging in The Netherlands, as the suitable locations for the required energy storage facilities are the same as those currently used for producing and storing natural gas. Areas suitable for storing hydrogen are (existing) salt caverns and depleted gas fields which are predominantly present in the northeast of the Netherlands (Groenenberg, Koornneef, et al., 2020). Local governments and residents no longer trust the national government and operators due to past experiences and, as a result, show an unsupportive attitude towards governmental plans associated with underground energy activities (van Buuren, 2009; Roovers & Duijn, 2021; Winters et al., 2020).

To improve public support that is fundamental to the transition towards a renewable energy system, the government needs to work on social acceptance of LSES (Winters et al., 2020; Yeşilgöz-Zegerius, 2021). In response to the growing dissatisfaction among Dutch citizens, the social debate increasingly introduces the phenomenon of energy justice next to the affordability, reliability and sustainability of a Dutch energy supply (Correljé, 2018). Under energy justice falls a distributive and procedural justice and a justice through recognition. In the past, this distributive justice, which concerns dealing with the (spatial) distribution of benefits and burdens of energy supply and energy use among groups of people, has not been considered in the Dutch decision-making process (Correljé, 2018; McCauley et al., 2013; Jenkins et al., 2016). An example of the changing debate is a recent statement from the Provincial Council of Groningen. Within the statement, the Provincial Council made clear that it will only accept a required lower-than-planned decrease in natural gas production from the Groningen gas field if the proceeds flow back into the funds for local government and residents (van Erven, 2022).

This sentiment is reflected by the phenomenon PIMBY (Please In My Backyard) found in a study by Van der Loo (2001) on research on mediation in the context of wind energy park constructions. PIMBY arises when citizens consider wind parks as a source of income and, as a result, show support for their construction. Likewise, scientific research into factors of success in French and German wind park case studies shows that procedural and distributive justice increases local acceptance and that being able to reap the benefits of such a project ensures local support (Grashof, 2019). The concept of financial benefit is just one factor that influences social acceptance; others are the possibility for stakeholders to participate in the wind-energy project (Morthorst, 1999), to have ownership of the wind farm (Brunt & Spooner, 1998; Morthorst, 1999; Devlin, 2005), and ownership of the land (Devlin, 2005; Brunt & Spooner, 1998). In addition, the knowledge level of local citizens, the previous use of the chosen site (Wolsink, 1996), the perceived quality of communication with the public (Krohn & Damborg, 1999; Zoll et al., 2001), and local participation in the planning process for wind farms all play a role (Hammarlund, 1999; Zoll et al., 2001; Wolsink, 1996).

The above indicates that financial participation and community benefit received are decisive factors when trying to increase social acceptance for onshore underground energy storage projects. This research assumes that financial participation can aid the implementation of onshore underground energy storage projects in the Netherlands. In 2020 for the first time in the Netherlands, a community (area) fund was considered to benefit the region with a social plus once gas production started (NAM, 2020). Although potentially effective, the national government and operators had not considered any form of distributive measures to achieve public support in the past. One exception is the oil extraction in Schoonebeek by the NAM (Nederlandse Aardolie Maatschappij, a partnership between Shell and ExxonMobil), who implemented social performance strategies (including generous compensation in case of damages) which led to a firm social license to operate and grow. Apart from these two examples, all benefits are still shared nationwide, while the burdens of energy projects are predominantly carried by local citizens (i.e. mainly the northeast of the Netherlands). Recently, local governments and residents increasingly demand compensation for the burdens they carry (van Erven, 2022). The question arises about the implications of introducing financial participation in onshore underground energy storage projects in the future. Implications regarding the institutional, regulatory and social aspects of the energy project development have to be investigated so that an advice can be formulated for the Ministry of Economic Affairs and Climate. This research focuses on societal concerns and dilemmas governed independently or within participatory aspects of the regulatory trajectory. The main research question, therefore, is as follows:

“To what key considerations and dilemmas should the Ministry of Economic Affairs and Climate adapt its policy on implementing a financial participation model in future onshore underground energy storage projects in the Netherlands?”

The remainder of the report is structured in the following manner. First, a review of recent literature on incentive schemes to improve social acceptance of renewable energy projects is given in chapter 2, highlighting the current knowledge gap. Second, in chapter 3 the conceptual approach, based on recent literature, is presented and explained. The conceptual approach forms the basis for applying the qualitative exploratory research method (interviews), which is described in detail in chapter 4. This chapter presents the sub-questions, which served as a guiding structure for answering the main research question. Next, in chapter 5, I describe how the various stakeholders define, measure, and perceive the technical risks of onshore underground energy storage activities. The relation to the social scientific mechanisms described in the conceptual approach is analysed here. The key considerations and perspectives brought forward by the various stakeholder groups interviewed are presented in chapter 6. The interviews are complemented by document research, references to which are included in the text. This study does not claim that the identified overarching themes and issues are the only relevant points for consideration. Precisely because this exploration focuses on new and future activities in which new technology, ambitions and incomplete knowledge play a role, not all future dilemmas can be foreseen. The issues and themes identified do, however, provide pointers for thinking about the implementation of financial participation models. Then, in chapter 7 the sub-questions and main research question are addressed. Finally, the key considerations and dilemmas identified are discussed in chapter 8 where recommendations for future research and policies are presented.

2 Literature Review

This chapter provides a review of recent work on incentive schemes to improve social acceptance of renewable energy projects. Subsection 2.1 first explains how relevant literature for the review is selected. The chapter continues with the outcomes of the review, analysing the recent focus on social acceptance and the incorporation of energy justice in REP across Europe and the rest of the world (RoW). It is shown that financial participation is one of the key factors in achieving social acceptance, however the manner of implementation and perception of benefit play important roles in the achieved level of public acceptance. Specific legal and societal elements of LSES in the Netherlands as well as Dutch examples of financial and community benefits are analysed which lead to the identified knowledge gap and main research question as stated in chapter 1.

2.1 Literature selection and review method

Throughout the literature review, use is made of Google Scholar, ScienceDirect and the TU Delft repository. No specific limits have been applied in the search with respect to dates or year of publishing. However, due to the recent large-scale implementation of RES, most literature dates back only a few years. With respect to language, English and Dutch are considered. Furthermore, all types of studies (e.g. qualitative, quantitative or human studies) are researched. Literature reviews and systematic reviews are excluded during this phase, since they are not directly focused on the topic and they are not original research articles. The inclusion criterion is that the applied research method allows for relating the investigated remuneration or financial incentive scheme to an increase or decrease in public acceptance regarding specific energy infrastructure related projects. Also, the focus lies on energy infrastructure projects that affect (i.e. visually, spatially or risk related) the municipality and the inhabitants surrounding the project.

2.2 Traditional energy policies and social acceptance

Originally, to guide the successful large-scale energy transition, a substantive amount of research was focused on the energy policies or support schemes used by governments to stimulate investors and the industry. Research on the effectiveness and use of Feed-in-Tarrifs (FiT), Contracts for Difference (CfD) and green/carbon certificates is carried out extensively (Ragwitz & Steinhilber, 2014; Yang & Park, 2020; Jenner et al., 2013). These forms of subsidy or financial support for companies and stakeholders have proven successful in accelerating the development of RES.

Given the success of the implemented policies on government and industry, one may wonder what still hinders the large-scale implementation of REP. Recently it has become clear that social acceptance, which is absent in the traditional energy policies, plays an important role in the successful implementation of REP. The realisation of social acceptance depends on several factors (Thomas et al., 2019; Roovers & Duijn, 2021; Curry et al., 2005; Jobert et al., 2007). These factors are related to the NIMBY attitude (Krohn & Damborg, 1999; Deegan, 2002; Spowers, 2000), PIMBY (Van der Loo, 2001; Brannstrom et al., 2022; Jobert et al., 2007), possibility of participating stakeholders (Morthorst, 1999), ownership of the project (Brunt & Spooner, 1998; Devlin, 2005), ownership of the land (Devlin, 2005; Brunt & Spooner, 1998), knowledge level of citizens (Wolsink, 2000), previous use of the site (Wolsink, 1996), quality of communication (Krohn & Damborg, 1999; Zoll et al., 2001) and local participation in the planning process (Hammarlund, 1999; Zoll et al., 2001; Wolsink, 2007).

2.3 Energy justice

Another more recently introduced factor proposed in literature is the perception of energy justice. Decisions concerning the siting of infrastructure developments or the use of natural resources have the potential to damage a community's social well-being if the outcomes are perceived to be unfair. Justice is accepted as central to the good functioning of society with fairness being an expectation in day-to-day interactions. Outcomes that are perceived to be unfair can result in protests, damaged relationships and divided communities, particularly when decisions are made which benefit some sections of the community at the perceived expense of others (Correljé, 2018; McCauley et al., 2013; Jenkins et al., 2016; Gross, 2007; Segreto et al., 2020).

Wind farm development projects, however, being an excellent example of how local opposition can hamper development and increase project costs, have shown that an option to invest in the park and reap the benefits of the exploitation can have a positive impact on public support and acceptance. The latter is implemented widely in Denmark and more recently in Germany (other examples exist in Brazil and Sweden) and indicates that despite the burdens, if the local municipality or citizens are able to reap the benefits, this raises acceptance in general and thus aids in the large-scale development of RES (Jobert et al., 2007; Brannstrom et al., 2022; Devlin, 2005). There has been a study carried out by Cass et al. (2010) on RE development in the UK which investigates what community benefits are fulfilling and how they are perceived by the different stakeholders present during the development and approval process. According to Cass et al. (2010) among the participants a high degree of ambivalence towards the benefits and the reasons of providing them exists.

2.4 The idea of distributional justice extended

As stated before, it was found that the benefits and burdens should be distributed equally amongst citizens. The various studies presented below in Table 1 and Table 2 show that creating a financial benefit for carrying the burden and distress of implementing RES or REP in the community is an important stimulus for local support. Examples of a financial benefits are opportunities for employment, tax returns, the possibility to invest through bonds or shares, lower energy rates and setting up of an area fund.

Table 1: Review and summary of literature investigating the effect of distributional justice and economic interest on social acceptance (1/2).

Study	General view and conclusion
1	Distributional justice is the dominant factor for community acceptance of wind parks. They investigated if a form of financial participation could increase public acceptance of a wind park by contributing to the distribution of the REP benefits and costs among citizens, three different models were implemented. It concludes that while a financial participation model of collective nature and low-risk aversion was preferred, there was no significant increase or decrease in local acceptance between the wind park without a financial participation model and those that were given treatment. There is only some experimental evidence to demonstrate that promoting distributional justice through financial participation models, such as a wind resource tax, increases acceptability, and even then, not substantially. The consensus is that financial participation alone is not an influential factor in social acceptance, however, it should still be considered to positively influence investors with high-risk aversion and other target groups. For instance, risk-averse people are significantly more likely to accept a wind park when a wind resource tax exists. Moreover, centre-progressive voters are more likely to accept when any financial participation model is implemented. The study concluded that distributional justice remains an institutional factor in local acceptance and the perception of equity in benefits and costs among locals is crucial.

2	This study revealed that community-oriented projects would receive greater local acceptance with a substantial community benefit beyond support for local events. The acceptability would increase if individuals in the community could benefit financially, even in a small part.
3	Interestingly, this study claims the results support the notion that local consumers are willing to pay higher electricity rates in a renewable energy community configuration that includes a substantial proportion of solar-generated power.
4	Economic, environmental and social benefits for the community are among the most important determinants of social acceptance in a small-scale agro-energy system. A large influence in local acceptance are citizens' expectations of a reduction of taxes and energy costs since local energy demands are satisfied. Another perceived benefit that increases social acceptance is the potential contribution to the economic development of the community and attainment of energy self-sufficiency.
5	The socioeconomic impacts of RES greatly influence the level of acceptance in a community. This study revealed that a financial benefit, such as 2.5% of annual revenue awarded to municipalities, offers a strong incentive for local authorities to accept wind farms or other RES. The creation of employment is another economic benefit that is greatly valued by locals, primarily by stakeholders.
6	The study affirms that the following determinants have a small but positive impact on acceptance: impacts on individuals' economic situation, and impacts on local profits and income generation.

2.5 Financial compensation is indispensable in creating social acceptance

The outcome of these studies confirm that local citizens either expect financial benefits or a significant community benefit before accepting the development of RES or REP. It was found that although the contribution to the local community by RE developers positively influences public support, a financial incentive is the strongest driver in accepting REP. The perception of the benefits and burdens also plays an important role in the support (Cass et al., 2010). For example, creating jobs for the community is unusual for REP developers, but can influence the community's perception of the project as an opportunity for financial gain and the receipt of other benefits.

Table 2: Review and summary of literature investigating the effect of distributional justice and economic interest on social acceptance (2/2).

Study	General view and conclusion
7	Contrary to the first case study, financial participation has been a common driver for community acceptance, as shown in eight cases out of ten. The results show that a positive effect on the local economy is considered "important" or "highly important" for all practices. For instance, the creation of jobs in the local economy is a driver of acceptance.
8	Lack of national incentive is largely the reason for rejection in three regions of Europe: northern, central and eastern, and southern.
9	The implementation of run-of-the-river hydropower faces social acceptance barriers. Most participants support hydropower because of its environmental benefits and its contribution to achieving energy self-sufficiency. However, respondents also agree that locals should receive part of the profit or receive financial compensation directly or indirectly through economic development. For instance, they value low energy prices and job creation in the region.

10	This study reveals that the distribution of costs and benefits among the local community can be a controversial issue. In this context, operators of wind farms must compensate for the negative effects or economic losses to the municipality. However, some respondents expressed distrust and claimed that payments are used to buy people’s votes or interests. Most respondents agreed there was a need for transparency regarding the distribution of costs and benefits. For instance, revenues should be set aside for disclosed specific purposes. Experts have indicated that parties should also compensate neighbouring communities that are affected by the wind farm.
11	The perceived benefits and costs of an REP to the community is a crucial determinant of local acceptance. Using the cost-benefit analysis to determine the negative potential effects that a wind farm would cause on the local economic sectors, residents considered the benefits of the wind parks against the potential negative cost to their industry.
12	The costs and benefits for the local community associated with a REP are certainly the most critical factors in building public acceptance. Economic evaluations performed by local communities and considering local needs associated with a REP are the most influential factors on public acceptance of a REP installation. Depending on whether the project would lead to economic gains or losses, the public would either accept or oppose the project development.
13	A strong majority (62%) of the respondents were willing to pay higher costs to obtain green energy. Additionally, nearly 30% of respondents were willing to pay up to 10% more in taxes to obtain it. These results prove that some raw economic factors, at least the price of electricity, are not the only factors that affect public acceptance, and that some populations are willing to sacrifice their economic interests for environmental benefits.
14	The study reveals that a negative economic impact of RE technology can “strongly reduce its acceptance.” For instance, the national attitude towards hydropower projects was more negative when the perceived costs of the technology were higher. However, losses and benefits of a REP are not only financial. The costs and benefits of a REP can be measured in a variety of forms, such as the visual impact on the landscape, decreased values of surrounding properties, the creation of a number of jobs, an increased or lower price for energy, an equal distribution of the benefits or costs among the community, environmental impacts on surrounding areas, and health consequences.

Table 3: Articles belonging to literature studies of Table 1 and Table 2

Study nr.	Corresponding source	Nr. Of Citations
1	(Vuichard et al., 2019)	24
2	(Lennon et al., 2019)	51
3	(Azarova et al., 2019)	65
4	(Prosperi et al., 2019)	11
5	(Delicado et al., 2016)	83
6	(Leiren et al., 2020)	28
7	(Maleki-Dizaji et al., 2020)	7
8	(Suškevičs et al., 2019)	52
9	(Venus et al., 2020)	8
10	(Scherhaufer et al., 2017)	73
11	(Jobert et al., 2007)	600
12	(Zoellner et al., 2008)	588

13	(Moula et al., 2013)	124
14	(Ribeiro et al., 2014)	99

2.6 Legal and societal elements of LSES in the Netherlands specifically

The successful realization of LSES projects requires that legal and societal elements are productively incorporated into their design from the start. New storage initiatives should be sufficiently supported by clear laws and policies, permitting procedures and contracts (Winters et al., 2020). Furthermore, the response of the local community towards a large-scale subsurface energy storage initiative has a decisive impact on the project's success (Winters et al., 2020). A recent report published by Winters et al. (2020) presents the observations and conclusions on the legal and societal challenges of LSES and examines three topics: How does the current legal framework, and more specifically the permit procedures, support the development of these two types of subsurface energy storage: Compressed Air Energy Storage (CAES) and Underground Hydrogen Storage (UHS)? What is needed to meet the societal requirements (at the generic level and the project level) of large-scale energy storage in the subsurface? How does the legal framework interact with the societal requirements for the development of large-scale subsurface energy storage projects?

On minimum legal requirements for societal embeddedness and the participation strategy

The legal framework sets minimum requirements that the participation process must meet. The new Environmental Act will include new requirements for participation at an early stage (the exploration phase) in addition to the decision-making phase and demand that all stakeholders should have the opportunity to provide alternative solutions to the underlying problem. Although the new rules structure the process and provide guidance, the legal requirements do not guarantee societal embeddedness of large-scale subsurface energy (storage) projects. This research project shows the importance of involving the local community well before, during, and after the decision-making process. At the start of a project, the societal playing field (stakeholder analysis, cultural and historical background, community dynamics) must be considered. From this knowledge, a level of participation and the participation strategy can be determined. The law facilitates the participatory process, but with minimal requirements. Consequently, the level of participation must be determined from the societal playing field; the participation strategy should be incorporated into the overall project strategy.

On the importance of policy ambitions

In order to develop societal embedded large-scale subsurface energy storage, not only is the participation process at project level, important, but the policy choices prior to the project and the process by which they were made, are also. The literature study underlines the significance of discussing the importance, usefulness and necessity of LSES at various levels: national, regional and local. In the current circumstances, national governments focus on their facilitative role. To further support LSES, government agencies at all levels should formulate policy ambitions and support initiatives which fit within these ambitions. Formulating policy ambitions is also a participative process, in which societal engagement must be guaranteed. Because of the missing link between national regulation and local projects, policy-related discussions take place around a specific project at the local level. By doing so, local projects are less burdened with questions around the importance of these types of storage in general and can focus on the discussion that is relevant for their specific project; e.g. alternative tracing for above-ground pipelines, limiting noise pollution etc.

On long permit procedures

The (pre-) development phase of large-scale subsurface energy storage projects is long due to 1) the complexity of these projects and 2) the duration length of the permit process and 3) the interaction with the local community.

2.7 The perception of financial or community incentives

It has become clear that financial or community incentives can increase public acceptance and lead to the successful implementation of large-scale underground energy storage projects in the Netherlands. The latter reference to the Netherlands important as the way the Dutch government has been managing natural gas production has resulted in a deep lack of trust between the national government, the NAM (or other exploration and production companies) and the local municipalities and their citizens. Important to note is that a financial benefit does not stimulates acceptance in all cases. Are they seen as an effective strategic element in negotiations around planning consent; as a right for communities whose resource is being exploited, or who are experiencing the disbenefits of technology implementation; or as a way of bribing or buying off protestors or key decision-makers? Research shows that not all local residents value a financial benefit equally, however risk-averse people and target groups that usually hinder the process seem to be positively influenced (Vuichard et al., 2019). Municipalities can directly benefit from these kind of projects through tax payments and rent, only if the land is publicly owned (Jobert et al., 2007). Furthermore, job creation is often promised. Taken together these do not seem to effectively raise public acceptance. The effective number of jobs created for locals is often very limited as is the amount of tax payments or rent received by the municipality. Furthermore, the option to co-invest in the project excludes those who are financially disadvantaged. The normative case for providing community benefits appears to be accepted by all involved, but the exact mechanisms for doing so remain problematic (Cass et al., 2010). A case study on wind energy expansion in Austria showed that some respondents expressed distrust and claimed that payments are used to buy people’s votes or interests (Scherhaufer et al., 2017).

2.8 Dutch examples of financial participation

It has been shown that financial participation and received community benefit are a decisive factors worth considering when trying to increase the level of social acceptance for REP. In this research it is assumed that financial participation can aid the implementation of underground energy storage projects in the Netherlands. In 2020, for the first time there, a link has been made between the exploitation of a gas field and the establishment of a community (area) fund to designate the region with a social plus when gas production starts (NAM, 2020). In the ‘regeerakkoord’ for the period 2020 –2024 it was explicitly stated that “we are completing the procedure around Ternaard". Time will tell if the project will be supported by the local community and its residents, now or in the future. A clear Dutch example of how received financial benefits have led to a social license to operate is the Schoonebeek Oilfield operated by the NAM. Throughout the second half of the twentieth century the largest onshore oilfield in Western Europe, located in the small rural community of Schoonebeek, was exploited by the NAM. More than 200 million barrels of oil were extracted, and with generous compensation paid by the NAM, the municipality and local community strongly benefited financially leading to increased prosperity (Veenker & Vanclay, 2021). However, there were also negative social impacts, including: an influx of outsiders; changes to social structure, social fabric, social cohesion, and community identity; disruption to the peaceful rural setting; and industrialisation of the landscape (Veenker & Vanclay, 2021). Nevertheless, the oil pumping installations (‘jaknikkers’ or nodding donkeys) ultimately became positive symbols of local place identity. Despite the negative social impacts, oil production came to be viewed positively by most local people, and a high level of trust developed between the host community and NAM because of the social performance strategies that were implemented: NAM employed many local people; minimised physical displacement; provided generous compensation for economic displacement; respected the social, cultural and religious wishes of the host community; and quickly addressed any social or environmental issues that developed. These actions meant that NAM gained a strong social licence to operate and grow. The question arises over what the implications will be of introducing financial participation broadly in future underground energy storage projects. Underground energy storage projects tend to have a much weaker and more uncertain business case compared to the production of oil and natural gas. Implications regarding the institutional, regulatory and social aspects of the energy project development have to be investigated so that advice can be formulated for the Ministry of Economic Affairs and Climate. In this research the focus lies on societal aspects, governed independently or within participatory aspects of the regulatory trajectory.

2.9 Scope of the main research question

The scoping of the main research question, stated in chapter 1, towards 'onshore underground energy storage' projects, is specific, due to a couple of reasons. First, the report issued by van Gessel et al. (2021) and in the governmental documents (Yeşilgöz-Zegerius, 2021; NL Government, 2019) indicate that in all future energy scenarios the implementation of large-scale underground energy storage is inevitable. This is a direct consequence of the intermittent nature of RES. Furthermore, due to physical, technical and economic properties, it is expected that hydrogen will be the main future energy carrier and that large-scale underground storage of hydrogen is the solution to the future misalignment between demand and supply (van Gessel et al., 2021; D. Yeşilgöz-Zegerius, 2021; NL Government, 2019). However, a future energy system running on hydrogen is still far from reality and natural gas is seen as the transition energy carrier in the Netherlands, also the EU and the RoW (Yeşilgöz-Zegerius, 2021; van Gessel et al., 2021). The amount of CO_2 released into the atmosphere when burning fossil fuels depends on how much carbon the fuel source has – more carbon produces more CO_2 . Natural gas has a high hydrogen content and a low carbon content. So for the same amount of energy produced, burning natural gas emits significantly less CO_2 into the air than other fossil fuels (The Natural Gas Solution, 2018). Secondly, offshore underground energy storage has huge costs related to required offshore infrastructure (e.g. pipelines, wells, maintenance etc.) which would make these projects economically unsustainable and would therefore only hamper the development of RES (van Gessel et al., 2021). At last, CCS is left out in this specific example as it has faced so much resilience among the Dutch local governments and residents (e.g. abandoning a CCS demonstration project in Barendrecht by the minister of Economic Affairs in 2011) that the national government agreed on limiting CCS projects to depleted gas fields offshore (van Buuren, 2009; Pesch et al., 2017). It can be concluded that in the future most REP will have to do with the underground storage of gas or hydrogen instead of the extraction of oil and gas and therefore this research focuses on the key considerations regarding the implementation of a financial participation model in 'onshore underground energy storage' projects.

3 Conceptual Approach

This chapter presents and explains the conceptual approach based on recent literature. The conceptual approach forms the basis for applying the research method, which is described in further detail in chapter 4. First, in subsection 3.1 the study analyses the relevance of improving energy justice and defines energy justice in the setting of energy production and usage. Then, in subsection 3.2 the dynamics of energy justice are described, highlighting the role of varying perceptions of justice in justice-related claims. Third, in subsection 3.3 an empirically grounded, explanatory framework for understanding the role of perceptions of justice in the dynamics of controversy developed by Pesch et al. (2017) is presented. In addition, in subsection 3.4 I elaborate on the justice-related attributes of the two trajectories. At last, in subsection 3.5 the study analyses how the public responds to projects by drawing on earlier experiences using a similar technology elsewhere or with earlier experiences with other technologies in their vicinity.

3.1 The relevance of improving energy justice

As mentioned before in the introduction, the public debate regarding energy projects is increasingly centred around the phenomenon of energy justice. The traditional energy policy objectives include the (un)affordability, the (un)reliability and the (un)sustainability of the energy system, now and in the future (Correljé, 2021). The notion of justice deals with how the burdens and benefits of the energy system are divided and encountered amongst different groups of businesses and citizens (McCauley et al., 2013).

Especially in any energy transition, where experts expect swift and extreme changes, energy justice is recognised as a critical policy objective. Significant differences will exist in how various (groups of) citizens, and businesses feel the consequences of the transition, depending enormously on their specific social and economic circumstances, interests, and location of residence (Pesch et al., 2017; Correljé, 2021). Lack of perception of justice among all stakeholders has led to costly delays, hampered the swift energy transition, and gave rise to severe trust issues between citizens, utility companies and governmental organisations (van Buuren, 2009; Roovers & Duijn, 2021; Pesch et al., 2017).

In the literature, energy justice has been put forward as a conceptual framework to analyse energy system processes and determine if stakeholders perceive these as just, justifiable or not (Correljé, 2021; McCauley et al., 2013; Jenkins et al., 2016; Gross, 2007). The goal of focusing on energy justice as the primary policy objective is "to provide all individuals, across all areas, with safe, affordable and sustainable energy" (McCauley et al., 2013, p.1).

When analysing whether a particular energy system project or process is ‘just’, it is essential to define energy justice in the setting of energy production and usage. The literature describes three pillars which find their origin in climate justice; distributive justice, procedural justice and justice through recognition (McCauley et al., 2013; Jenkins et al., 2016). (1) *Distributive justice* concerns how to deal with the (spatial) distribution of benefits and burdens of the energy supply and energy use among different groups of people. (2) *Procedural justice* requires that traditionally excluded groups, frontline communities, and those otherwise marginalised due to the energy system, work with policymakers to co-create and co-design a fair process for inclusion in energy decision making. (3) *Justice through recognition* calls us to acknowledge who is affected by energy decision making (considering that different groups of residents require different approaches and policies) and who is responsible for this. "Here, we refer to recognition in relation to the capacity of social groups to define their own identity and their own terms" (Pesch et al., 2017, p.8). Recognising the validity of experiences of vulnerable individuals or communities affected by policy choices is crucial to achieve a fair energy system, and recognition is a precondition for trust, involvement and providing compensation. An essential element in this is the choice of location for an energy project. For example, a resident who already has negative experiences with energy projects in their proximity in the past will value future projects differently from someone who lives at some distance and only has an opinion from a particular conviction.

3.2 The dynamics of energy justice

The starting point of the proposed research is that, at present, in the Dutch energy system, distributive justice is not adequately ensured in the formal permit procedure. Furthermore, as extensively argued in chapter 2, a form of financial participation and received community benefit is a crucial factor regarding the level of social acceptance for energy projects. However, it is essential to realise that the three pillars of climate justice are closely related to each other, and care is needed so that enhancing distributive justice (by explicitly focusing on that form) is still not perceived as unfair by specific interest groups (Cass et al., 2010; Scherhaufer et al., 2017).

For example, justice by recognition as a group or social community, is in many cases articulated in terms of redistribution and not as recognition per se. According to Pesch et al. (2017) "protesters might feel the need to adapt their vocabulary to dominant policy approaches, or they might have difficulty to express their genuine concern" (p. 6). This explains why a compensation scheme can be perceived as a form of bribery (i.e. it excludes the emotional bond and community identity among residents) (Cass et al., 2010). The substantial variation in the perception of justice highlights the fact that negotiation on compensation is more likely to succeed if it is acknowledged that the community or group has a unique identity and if their specific understanding of the proposed changes to the energy system is respected (i.e. adhering to justice through recognition as well) (Pesch et al., 2017).

The above shows that improving energy justice in general (i.e. to aid the development of energy projects) is not as simple as securing the three individual pillars and implementing improvements and initiatives within each basic form of justice. The solid mutual interaction, overlap of concepts, and vagueness of terminology, require that new policies must always be carefully and widely tested to prevent certain groups from feeling excluded or bypassed.

3.3 Formal and informal assessment in energy projects

The previous paragraph calls attention to the role of varying perceptions of justice in justice-related claims. Research has shown varying perceptions of justice in justice-related claims cause controversy in two thoroughly analysed energy projects in the Netherlands. Pesch et al. (2017) and Gross (2007) argue that "many recurrent controversies are a consequence of ignoring or underestimating the moral implications in the planning and development of energy projects, which especially seem to relate to the fact that different project-owners and affected publics articulate divergent justice claims" (Pesch et al., 2017, p.1).

An empirically grounded, explanatory framework for understanding the role of perceptions of justice in the dynamics of controversy was developed by Pesch et al. (2017). The framework finds its origin in the concept of ‘overflowing’, as first described by Callon (1998b). Overflowing describes the emergence of concerns in society, not adequately safeguarded in the prevailing rules that are part of dominant institutional practices (Callon, 1998b). These rules create the frames that ensure that the various actors agree on a common goal, and they define paths of action seen as appropriate. In doing so, the rule-sets ensure coordination in the behaviour of the different stakeholders in specific settings (Callon, 1998a). In new energy projects, settings, or new experiences, may cause societal concerns to be embraced by interest groups that will protest against the existing frame and the institutions (e.g. utility companies, national government) that administer it. Two representative cases in the

Netherlands (CCS in Barendrecht and the exploration of shale gas in Boxtel and Haaren) confirm that the adoption of societal concerns is, according to Pesch et al. (2017) "to a significant extent motivated by the injustices perceived by societal actors, which can lead to the mobilisation of groups that oppose intended projects" (p.2).

Expanding on this notion of overflowing, the framework developed by Pesch et al. (2017) introduces two trajectories of valuation in decision making on energy projects. The first is the trajectory of formal assessment in which a range of procedures, standards, tools, and policy arrangements are used to create a collective assessment of new technology (Taebi et al., 2016). Overflowing will then lead to the formation of an informal value creation trajectory, characterised by the advocacy for public values that some groups perceive as underrepresented in the formal assessment trajectory. According to Rip (1986), controversy regarding energy projects can be interpreted as an informal assessment, as it "articulates the conflicting values at stake and reveals unanticipated societal and ethical risks" (Pesch, U., Cuppen, E., 2017, p.2). Hence, in public controversies, the formal and informal assessment trajectories strongly interact.

Added to how the formal valuation trajectory may flow over, which leads to the emergence of concerns and issues in the informal valuation trajectory, the informal trajectory can also lead to adjustments and redesign in the formal trajectory (e.g. a revision of legislation and regulations). This process is referred to as ‘backflowing’. The most important observation made by Pesch et al. (2017) is that the two valuation paths express, rank and legitimise justice claims in entirely different ways. A thorough understanding of these differences ensures the development of policy arrangements that are adaptive to overflowing, which is crucial for future public support in energy projects in the Netherlands (Pesch et al., 2017).

3.4 Justice-related attributes of the assessment trajectories

To understand controversies and their dynamics and implement future policies that adhere to the perceived justice in both assessment trajectories, it is essential to elaborate on the justice-related attributes of these two trajectories. These can be seen as drivers of controversies. By analysing two representative cases of energy controversies in the Netherlands (CCS in Barendrecht and the exploration of shale gas in Boxtel and Haaren), Pesch et al. (2017) identified these justice-related attributes. The justice-related aspects, derived from the notion of energy justice that include justice as distribution, procedure and recognition, are visualised in Figure 1 below.

The first attribute in the framework explains that the two trajectories differ in terms of the logic through which concerns are articulated, and values are expressed (Pesch et al., 2017). Values are expressed following judicial rationality in the formal trajectory, whereas the informal trajectory takes a narrative rationality. These different logics result in mutual denial of justice claims forwarded by the other trajectory.

The second characteristic describes that the trajectories take different dimensions of energy justice as their starting point (Pesch et al., 2017). In the formal trajectory, procedural justice is the starting point from which the dimensions of distributive justice and justice through recognition are considered. In the informal trajectory, the dimension of justice through recognition is taken as the starting point from which the other dimensions are considered.

The last attribute shows that the moral authority of the claims in both trajectories is based on different democratic principles (Pesch et al., 2017). In the formal trajectory, the authority of claims is based on institutionally and legally established procedures that are effected by delegated actors. In contrast, the authority of the informal trajectory is derived from the moral autonomy of the residents that make up a community. As stated before, the framework introduced above helps understand the role that justice-related claims play in the emergence of controversy in decision making on energy projects. Hence, the framework is helpful when investigating how the key stakeholders will perceive the implementation of financial participation models in underground energy storage projects in the Netherlands.

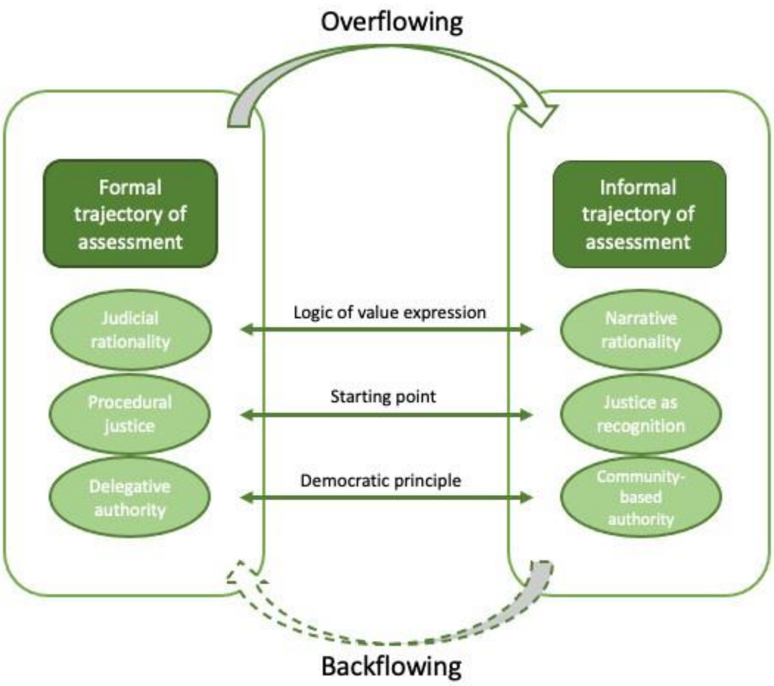

Figure 1: Three justice-related attributes shaping the interaction between the formal and informal valuation trajectory (Pesch et al., 2017).

3.5 Controversy spillover

The framework developed by Pesch et al. (2017), visualised in Figure 1, draws upon two specific energy projects in the Netherlands and leads to important insights for policy making and adjustments to the formal trajectory. The question arises whether this framework is generally applicable in current and future energy controversies in the Netherlands and elsewhere (e.g. underground hydrogen storage).

According to Cuppen et al. (2020), "publics respond to projects by drawing on earlier experiences with a similar technology elsewhere, or with earlier experiences with other technologies in their vicinity" (p.1). This dynamic concerning energy controversy is called 'controversy spillover'. The notion of controversy spillover helps to understand how the discursive space of controversy changes over time. The existence and dynamics of controversy spillover, as explained by Cuppen et al. (2020), indicate that the role of perceptions of justice in the dynamics of controversy, being identified in two specific Dutch energy projects, is not limited to the energy technologies (CCS and fracturing) nor to locations governing those cases.

Therefore, it is expected that these controversies will spill over into the future underground storage of gas and hydrogen. An essential factor in this spillover will be the Groningen crisis (i.e. earthquakes, damage and severe trust issues), which is strongly linked to gas production and storage in general and thus future storage of gas and hydrogen (i.e., another form of gas). Furthermore, this controversy spillover will affect the informal assessment of future energy projects and, according to the framework developed by Pesch et al. (2017), as a result of backflowing, also affect their formal assessment.

Social scientific mechanisms governing underground energy storage projects

To conclude, the leading social scientific mechanisms that govern underground energy storage projects based on recent literature are listed. During the energy transition process, experts expect swift and extreme changes and energy justice is recognised as a critical policy objective. In the literature, three pillars are defined, which find their origin in climate justice; distributive justice, procedural justice and justice through recognition. The dynamics of energy justice highlight the role of varying perceptions of justice in justice-related claims. Second, it is shown that varying perceptions of justice in justice-related claims cause controversy and an explanatory framework for understanding the role of perceptions of justice in the dynamics of controversy is described.

The framework brought forward by Pesch et al. (2017) introduces two trajectories of valuation in decision making on energy projects, the formal and the informal. In order to understand controversies and their dynamics and implement future policies that adhere to perceived justice in both assessment trajectories, it is essential to recognise the three justice-related attributes of the two trajectories. These are the logics through which concerns are articulated and values are expressed, the starting point from which the dimensions of energy justice are considered, and the democratic principles providing the moral authority for the justice-related claims.

Lastly, the existence and dynamics of controversy spillover, as explained by Cuppen et al. (2020), indicate that the role of perceptions of justice in the dynamics of controversy is not limited to the energy technologies and locations, hence will spill over. This affects the informal assessment of future energy projects and, according to the framework developed by Pesch et al. (2017), by backflowing, also affects the formal assessment.

4 Research Method and Approach

This chapter presents the research method and approach that allows for a thorough analysis of the issues identified in chapter 3 regarding onshore underground energy storage projects in the Netherlands. At first, sub-questions guide the research and provide a structured path to answering the main research question. Then, in subsection 4.1 the need for an exploratory research method is investigated. This is followed by subsection 4.2, I describe why qualitative interviews are central in answering part of the sub-questions .Lastly, in subsection 4.3 I present who is interviewed, how the interviews are held, and an example of the type of questions asked during the interviews.

Sub-questions

Various sub-questions are composed to support the main research question. These sub-questions are drafted as:

1. Who are the main stakeholder groups participating in onshore underground energy storage projects in the Netherlands?
2. What are the technical aspects of (induced) seismicity and soil subsidence that explain the occurrence of earthquakes in the Netherlands?
3. How are the technical challenges and possible risks of underground energy storage related to social acceptance?
4. What are the perspectives, expectations and perceived dilemmas per stakeholder group from participation in onshore underground energy storage projects in the Netherlands?
5. What are the perspectives, expectations and perceived dilemmas per stakeholder group of implementing a financial participation model in an onshore underground energy storage project in the Netherlands?

Desk research was carried out to investigate the main stakeholder groups regarding participation in underground energy storage projects onshore. This will mainly focus on scientific publications and articles accessed using Google Scholar or ScienceDirect. Furthermore, this research studied reports issued by the government or other research institutions and university depositories (TU Delft, Rijksuniversiteit Groningen). Then, exploratory interviews were held among all the key stakeholder groups to answer the fourth and fifth sub-questions. At last, an answer to the remaining sub-question was formulated by thoroughly analysing the interviews and constructing an overarching picture of the key considerations and dilemmas regarding future policy.

4.1 Exploratory research method

The existence of the two assessment cycles as defined by Pesch et al. (2017), and described in chapter 3, address the need for an exploratory research method to identify key considerations, varying perspectives and dilemmas regarding the possible implementation of financial participation models in underground energy storage projects. Only by properly identifying the concerns and issues from the perspective of the various stakeholder groups (belonging to the formal or informal trajectories) can future energy policies be designed so that overflow and backflow are prevented as much as possible or anticipated in advance. The existence of controversy spillover, as described by Cuppen et al. (2020), once more highlights this approach, as future energy projects (possibly concerning new energy technologies) are strongly influenced by current energy controversies. Starting from the belief that two interacting trajectories exist and by applying exploratory research methods, this ensures the capture of a complete set of opinions, assessments and perceptions. A descriptive approach is less successful in the identification of the various perceptions and considerations as it is never clear to which extent the identified values and concerns (making use of literature, governmental documents, case research and earlier surveys/interviews) are exhaustive or representative of the range of values held by the population. Ex-ante, one cannot quickly identify a group that endorses particular values and concerns, let alone a representative (Pesch et al., 2017). Descriptive research is preplanned and structured in design, so the information collected can be statistically inferred from a population (surveymonkey, 2022). However, it will not give unique insights on the issues for which exploratory research methods allow (surveymonkey, 2022). In the following subsection, 4.2, the qualitative exploratory approach is explained in more detail.

4.2 Qualitative Interviews

Central to the proposed research is the public acceptance of REP in the Netherlands. Understanding and improving this acceptance requires insight into what the key stakeholder groups find important and their attitudes, considerations and perceptions regarding implementing REP's financial and community benefits. Because the proposed research intends to map stakeholders' concerns and perceptions, the research is qualitative by nature. According to Bortz & Döring (2007), qualitative methods are to be used when (1) verbal data needs interpretation, and the subject under study has been poorly investigated, up to then, or (2) when the specific individual perspective of the research subjects is the focused. A qualitative research approach allows the researcher to identify what people – in the case of this research, the key stakeholders of an underground energy storage project – find important, based on their experiences (Silverman, 2020). A set of exploratory interviews were held among the key stakeholder groups from which considerations, perceptions and perspectives were retrieved. Then, these insights were organised and brought together to construct overarching views and expectations. Identifying general themes allows us to analyse for each one how different stakeholder groups or formal institutional components of these are related to or confront each other. In short, we intend to construct the general perception and critical considerations of implementing a financial participation model in future underground energy storage projects in the Netherlands. Furthermore, to translate these in terms of dos and don'ts and issues and themes. And these, in turn, lead to important insights for future energy policy created by the Dutch government.

4.3 Set-up empirical research

The stakeholders belonging to underground energy storage projects were analysed and are listed below. Throughout the formal and informal assessment trajectories of onshore underground energy storage projects, experts from these stakeholder groups participated in various ways, either as part of the permitting procedure, exploration or supervision of the mining activities, or as residents in the close vicinity of a project. In total, 17 interviews were conducted, covering all stakeholder groups, exploring opinions, concerns and key considerations about participation in future underground energy storage activities in the Netherlands. The experts interviewed were all involved, in different ways, in one or more of the following mining activities; UGS in depleted gas fields onshore, UGS in salt caverns onshore, UHS pilot in a salt cavern onshore, and salt solution mining in salt caverns (salt solution mined caverns serve as UGS or UHS). The interviews were complemented by document research.

The interviews were recorded with the stakeholders' permission, after which the recordings were converted into anonymous transcripts. Quotations were only made anonymously and with the consent of the interviewees. All tapes and anonymous transcripts were deleted after the completion of the research.

Key stakeholders in underground energy storage projects

- National government

- Local government (province, municipality, water authorities)
- Regulating and advisory authorities
- Commercial parties
- Scientific and research groups
- Interest groups (i.e. NGOs)
- Residents, public advocacy groups

Types of questions asked during the interviews

- What do you think about how participation will be designed and regulated in the new Environment and Planning Act?
- What are possible solutions and bottlenecks regarding the participation?
- How do you view the distribution of burdens and benefits in underground energy storage projects?
- How does timing possibly affect the opinions and concerns regarding participation in underground energy storage projects?

5 Definition, Measurement and Perception of Risks

This chapter describes how the risks of onshore underground energy storage activities are defined, measured, and perceived by the various stakeholders. The technical aspects of (induced) seismicity and soil subsidence that explain the occurrence of earthquakes in the Netherlands and result in hazards and risks are described in Appendix A. In subsection 5.1, given what is happening underground, the research describes how risks are defined, measured, and observed. Then, in subsection 5.2 I analyse how those risks are perceived and judged by the stakeholders who belong to both the formal and informal assessment trajectory, explaining how the social interpretation of risks is based on the social-scientific mechanisms described in chapter 3.

5.1 Hazard and risk assessment for induced seismicity

Probabilistic seismic hazard analysis

Within northeast Netherland, natural seismicity as a result of plate tectonics without any human intervention does not occur (Dost & Haak, 2007). As thoroughly explained in subsection A.2, earthquakes in that region are caused by human activity. Not only the sudden release or 'slip' of faults but also, the source of the stress build-up stems from human activity. Poro-elastic stress changes induced by pressure depletion in a gas reservoir, enable local normal faulting reactivation (Roest & Kuilman, 1994). In subsection A.2 we explain how regionally various but similarly oriented fault patches, in combination with shallow hypocenters and soft top soil layers, lead to large magnitude events. Important to note is the effect of the soft top soil layers on the amplitude of the shear stress wave (S-wave), causing strong peak accelerations at the surface which may damage houses and infrastructure, as explained in subsection A.2.

Therefore, when performing a seismic risk assessment, one starts with determining the threat of specific peak accelerations. A geophysical model is used to analyse the chance of occurrence of an earthquake with a specific magnitude. Then, another geophysical model is used to calculate how the seismic waves of energy, Primary and Secondary, will propagate upwards to the surface, travelling through Earth's layers. A third model allows for the calculation of the expected peak (horizontal) accelerations, mainly caused by the S-waves. Knowing the possibility of an occurrence of an earthquake with a specific magnitude and the corresponding expected peak accelerations at the surface, allows for creating maps that point out where the peak accelerations would occur and where the chance of an acceleration with a specific magnitude is largest (Muntendam-Bos et al., 2022). Usually, when investigating natural seismicity, one plots the frequency of occurrence against the amplitude of the oscillation on a log-log scale and draws a line through the events. This method is applied to probabilistic seismic hazard analysis for induced seismicity as well. The line can be extended to find out whether a severe earthquake may occur with a specific magnitude of peak acceleration. However, this log-log relation, also known as the Gutenberg-Richter law, was developed for natural seismicity, but not induced seismicity, as explained in subsection A.2 (Muntendam-Bos et al., 2022).

Endless calculations have been performed on the statistics of the occurrence of a certain magnitude vibration, its propagation to the surface (oscillation effect), its movement at the surface and its negative affect on the foundation and the structural integrity of houses. These models then allow a calculation for the personal risk (chance of death of a person), by determining what magnitude of peak accelerations may cause a house to collapse. To calculate, experiments were carried out to determine the influence of specific peak accelerations on various types of homes built in the Netherlands. The possibility of dying by induced seismic events must be less than 10^{-5} per year, the Meijdam standard (Kamps, 2015). The safety standard was advised by the Meijdam commission, which had the task of recommending safety standards for buildings in the earthquake area of Groningen to the Minister of Economic Affairs and Climate. Once every one hundred thousand years, a person may die in a collapsing house due to an earthquake. Of course, all kinds of other factors are involved, such as the density of people, and whether someone is inside or outside the house. Operators have the legal obligation to adhere to the standards. By having that legal obligation, the operators are wholly focused on staying within the limits of the Meijdam norm during and after any mining activity.

Risk monitoring network

By law, an operator is responsible for monitoring seismicity. In most places, the monitoring is done by the nationwide network, which is supervised and maintained by the Royal Dutch Meteorological Institute (KNMI). However, due to the irregular and inconsistent way the network has been installed over time, as a result of local requirements for operators and industries, the network's detection capabilities differ strongly between places (Muntendam-Bos et al., 2022). This hinders the identification of the full extent of seismicity, a prerequisite for explaining the non(occurrence) of induced seismicity. As explained in subsubsection A.2.2, the detection threshold directly relates to the ability to detect seismic events in UGS and UHS. An inability to measure seismic events below a magnitude of 1.0 does not mean that these events do not occur.

5.2 Varying perceptions of risk among stakeholders

Risk definitions vary among stakeholders

In the current situation, the operators are reinforcing houses that breach the Meijdam norm according to their complex statistical models. The national government underlines this risk assessment method and strongly believes residents are safeguarded by applying the standard. Local governments and residents often do not understand this way of operating. First, it is hard to imagine that buildings that look externally similar are built differently or have different foundations: 'Why is a crack in my house not reinforced by the operator, but other homes without damages are repaired?'. This incomprehension is a consequence of the complex risk calculations, which are typically far beyond the grasp of residents. In addition, for years, probabilistic seismic hazard analysis failed to capture the geophysical processes in the subsurface that caused earthquakes which has resulted in declining confidence in the models by municipalities, NGOs and residents. When residents in the '90s reported the first earthquakes in the Groningen gas field, the operators and national government did not believe them. They suggested that the observations must be related to loud bangs from the airbase in Leeuwarden.

Secondly, local governments and residents feel that the stress caused by the damage is not taken seriously by the operators or national government. Payment for repairs does not cover the inconvenience and stress caused by the damages inflicted. The residents' trust in the national government keeps declining further, according to a recent report published by Stroebe et al. (2022). There will always be a mismatch between real (geophysical) risks and the perceived risk by local stakeholders. In the following subsection we try to explain how the process of overflowing, leading to the formation of an informal assessment trajectory, characterised by the advocacy for public values that some groups perceive as underrepresented in the formal assessment trajectory, strongly influences the varying risk definitions and causes controversy.

Explanation of findings on varying risk perceptions, based on framework

The findings on the damage handling theme can be explained using the framework developed by Pesch et al. (2017), which is set out in the following paragraphs. Within the formal assessment trajectory, the reasoning is mainly based on an engineer's (numerical) point of view, adhering to the Meijdam standard. In contrast, a resident does not worry over a potential death risk of 10^{-5} per year but is rather concerned with visible cracks in their house, which make them feel less safe and cause personal stress. The standards and tools described in subsection 5.1 are used to create a collective assessment of the risks involved. Overflowing has led to the formation of an informal assessment trajectory, characterised by the advocacy for public values that local stakeholders perceive as underrepresented in the formal assessment trajectory (Pesch et al., 2017).

An expression of the technical risks claims in entirely different ways is partly explained by the first justice-related attribute from the framework. The first attribute describes how the two trajectories differ in terms of the logic through which concerns are articulated, and values are expressed (Pesch et al., 2017). Within the formal assessment trajectory a probabilistic seismic hazard analysis guides the assessment of risks and determines whether activities within the subsurface can take place and which houses need reinforcement. These models fail to capture the societal concern raised in the informal assessment trajectory; the lack of trust in the correct determination of risks by the models. Considering the judicial rationality which is followed in the formal trajectory, whereas the informal trajectory takes a narrative rationality, this inevitably results in mutual denial of justice-related claims forwarded by the other trajectory.

The fact that local stakeholders do not feel they are taken seriously when expressing the stress caused by visible cracks, and the inconvenience of dealing with reinforcements and repairs can be explained by the second justice-related attribute. In the formal assessment trajectory, procedural justice is the starting point from which the dimensions of distributive justice and justice through recognition are considered. Adhering to procedural justice focuses on equal treatment of all groups in society, assuring no one is excluded or marginalised due to the energy systems. However, the perception of stress and hassle is very individualistic. In the informal trajectory, the dimension of justice through recognition is taken as the starting point from which the other dimensions are considered. This is based on recognising the validity of experiences of vulnerable individuals and acknowledging that different groups of residents require different approaches and policies. Taking different dimensions of energy justice as their starting point, explains the controversy surrounding the perceived stress and the aggravation of reinforcement and repair work.

Lastly, controversy spillover, a process described in subsection 3.5, plays an essential role in the varying perceptions of the (technical) risks concerning UGS and UHS, by affecting the informal assessment trajectory. The most accurate hazard and risk assessment models can be created. As described in subsection A.2, these models would clearly show that the risk of earthquakes with a magnitude equal to that experienced during gas extraction in Groningen is much less when undertaking UGS in depleted gas fields and almost negligible during salt solution mining, and UGS or UHS in salt caverns. If the residents do not believe the complex risk assessment models, one will improve them by making the models even more complicated, but this will not help to create social acceptance for future energy projects. An essential factor in this spillover will be the Groningen crisis (i.e. earthquakes, damage and severe trust issues), which is strongly linked to gas production and storage in general and thus future underground storage projects for gas and hydrogen.

According to Cuppen et al. (2020), "publics respond to projects by drawing on earlier experiences with a similar technology elsewhere, or with earlier experiences with other technologies in their vicinity" (p.1). An example of this is the belief amongst residents that salt caverns may be used for storage of (nuclear) waste in the future. During the ’70s, nuclear energy and how to deal with nuclear waste was a controversial topic in the Netherlands. The government suggested storing the nuclear waste in salt caverns, as was done in the Asse mine in Germany in the 1960s and 1970s. Nowadays, salt caverns are considered the ideal place to store natural gas or hydrogen. Residents keep asking the operator what their plans are and fear that (nuclear) waste might be stored in the salt caverns in the future. A resident interviewed as part of this research said the following: "So there is a kind of nationwide thinking in people’s heads. We have holes there, we can put our waste in them, just as they do now with wastewater in Twente. I do not trust them as, up until now, we have been surprised by decisions and plans. Why would this change in the future?" This underlines that even if an operator has never had a concrete plan to store waste in their salt cavern, residents tend to draw on earlier experiences or stories for their beliefs.

5.3 Summary

The previous chapter has shown that the definition and perception of (technical) risks of onshore underground energy storage projects vary strongly and are based on social-scientific mechanisms identified in chapter 3. This explains how the technical challenges and possible risks of onshore underground energy storage are related to social acceptance. The next chapter presents the perspectives, expectations and perceived dilemmas per stakeholder group of (financial) participation in onshore underground energy storage projects in the Netherlands. It gives us insight into the overarching themes and surrounding issues according to the various stakeholders. This creates an understanding of whether participation is a mechanism that can guide the varying perceptions of (technical) risks and eventually collate them, reaching consensus and creating social acceptance.

6 Results

Through document research and interviews, the study has gained insight into the themes surrounding participation in onshore underground energy storage in the Netherlands. Although a significant part of this storage will be implemented and executed at a local level, involving operators, municipalities, and residents. Challenges within the (national and regional) underground energy storage transition make a central approach desirable. Generally speaking, four overarching themes were identified pointing out there are three tasks governing participation. These are the coordination task, the task of operationalisation (i.e. distributing roles and responsibilities), and the task of distributing benefits and burdens. Numerous issues surround all of these tasks.

In this chapter, the study does not aim to provide answers to these issues. Instead, I highlight the key considerations and dilemmas of the parties involved in the (joint) tasks of onshore underground energy storage and how they view these tasks from various perspectives. The insights presented in this section are the result of the interviews conducted during the study. In order to analyse the results, energy justice has been suggested as a conceptual framework to analyse energy system processes and determine if stakeholders perceive these as just, justifiable, or not. In chapter 3, it was shown that improving energy justice in general (i.e. to aid the development of energy projects) is not as simple as securing the three individual pillars and implementing improvements and initiatives within each basic form of justice. An empirically grounded, explanatory framework for understanding the role of perceptions of justice in the dynamics of controversy was developed by Pesch et al. (2017) and is applied in this chapter to explain the results obtained from the interviews.

The study revealed four themes regarding the (financial) participation in onshore underground energy storage projects in the Netherlands. Firstly, in subsection 6.1, the national plan and damage handling themes, belonging to the coordination task, are presented and analysed. Then, in subsection 6.2, the study examines and investigates the theme concerning spatial integration. Lastly, in subsection 6.3, the distribution of benefits and burdens is presented and analysed.

Before I describe and analyse the results, I present the abstract framework and describe how it will be used to analyse controversies and their dynamics in onshore underground energy storage projects in the Netherlands, for each of the themes identified. The framework originates from the concept of 'overflowing', which describes the emergence of societal concerns, when not adequately safeguarded within the prevailing rules that are part of dominant institutional practices (Callon, 1998b). The framework introduces two trajectories of assessment in decision making on energy projects. The first is the trajectory of formal assessment in which a range of procedures, standards, tools, and policy arrangements are used to create a collective assessment of new technology (Taebi et al., 2016). These rules form the frames that ensure that the various actors agree on a common goal, and they define appropriate paths of action. Considering underground energy storage projects and the themes identified, these policy arrangements consist of the national vision on subsurface activities, the damage handling procedures of the Landelijke Commissie Mijnbouwschade (LCM) and Instituut Mijnbouwschade Groningen (IMG), the Mining Act, and the new Environment and Planning Act.
A visualisation of the assessment within the formal trajectory is presented in Figure 2 below.

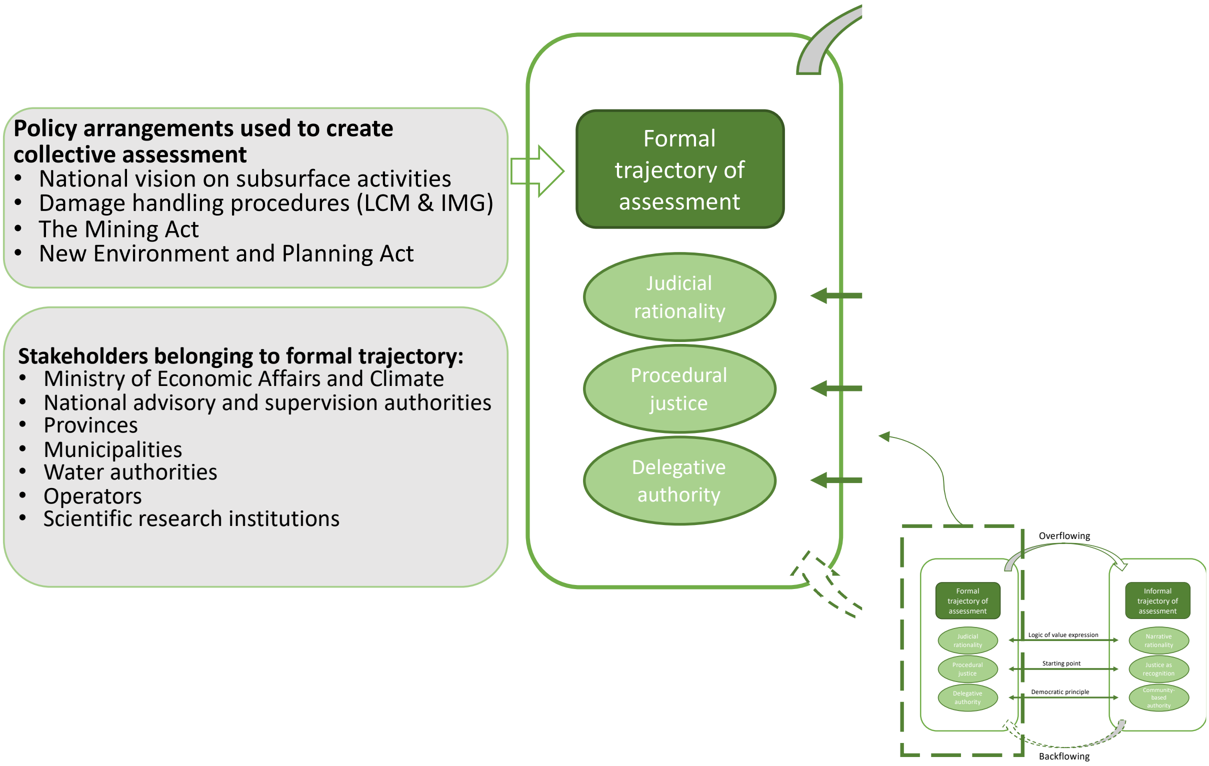

Figure 2: Visualisation of the policy arrangements (i.e. rules) used to create a collective assessment, and of stakeholders belonging to the formal assessment trajectory.

Overflowing will then lead to the formation of an informal assessment trajectory, characterised by the advocacy for public values that some groups perceive as underrepresented in the formal assessment trajectory. In new energy projects, new settings, or new experiences, the societal concerns may be embraced by interest groups that will protest against the existing frame and the institutions (e.g. utility companies, national government) that administer it. According to Rip (1986), controversy regarding energy projects can be interpreted as an informal assessment, as it "articulates the conflicting values at stake and reveals unanticipated societal and ethical risks" (Pesch, U., Cuppen, E., 2017, p.2). Hence, in public controversies, both formal and informal assessment trajectories strongly interact. A visualisation of the informal assessment trajectory is presented in Figure 3 below.

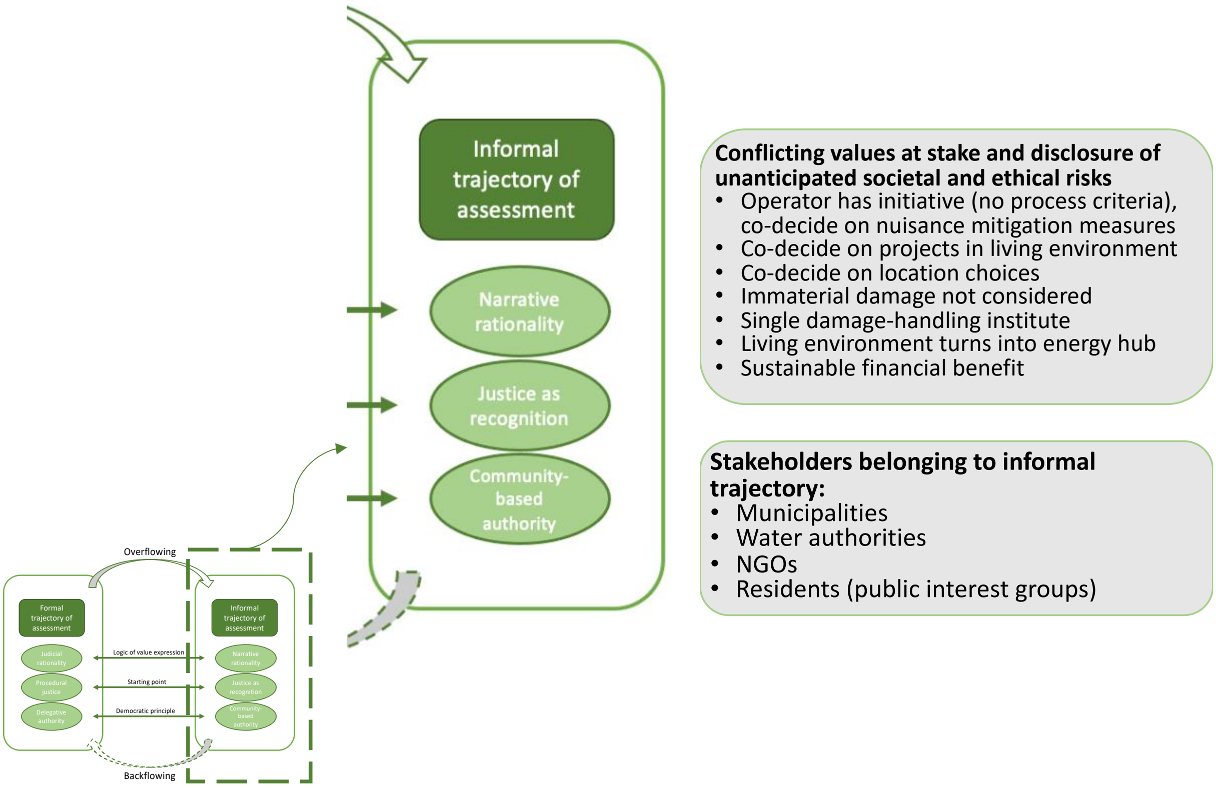

Figure 3: Visualisation of the formation of the informal assessment trajectory as a result of societal concerns, and stakeholders belonging to the informal assessment trajectory.

As well as how the formal valuation trajectory may flow over, which leads to the emergence of concerns and issues in the informal valuation trajectory, the informal trajectory can also lead to adjustments and redesign in the formal trajectory (e.g. a revision of legislation and regulations). This process is referred to as 'backflowing'. The most important observation made by Pesch et al. (2017) is how the two valuation paths express, rank and legitimise justice claims in entirely different ways. To understand controversies and their dynamics and implement future policies that adhere to the perceived justice in both assessment trajectories, it is essential to recognize the three justice-related attributes of the two trajectories. These are the logics through which concerns are articulated and values are expressed, the starting point from which the dimensions of energy justice are considered, and the democratic principles which provide the moral authority for the justice-related claims. The justice-related attributes can be seen as drivers of controversies and are used to analyse the information, statements and dynamics gathered for each theme.

Rationalisation of framework

The framework was developed to understand how justice-related claims play a role in the dynamics of controversy in energy projects. Having explained the framework and the formation of the formal and informal assessment trajectories for the specific case of onshore underground energy storage projects in the Netherlands, I now elaborate on the usefulness of applying the framework for this specific study. The varying justice-related claims brought forward for each of the identified themes by the stakeholders have in the following subsections been linked to the three justice-related attributes of the two assessment trajectories. By linking the narrative statements to the attributes, it quickly clarifies how divergent justice claims lead to controversy. This allows for a more structured analysis and understanding of the results obtained. A thorough understanding of these differences linked to the attributes then allows for a guided proposition of policy arrangements and assessment of current regulations for the individual themes identified.

6.1 Issues of coordination in participation

The transition towards storage in the deep subsurface serves to make the Dutch energy system future-proof. Under current conditions, this transition will probably take the form of a gradually developing patchwork of various energy storage projects (i.e. technologies) that will be embedded above ground in the existing gas and electricity infrastructure.

At the moment, the Regional Energy Strategies (RES), drawn up by municipalities and provinces on behalf of the national government, to let the 30 energy regions make their own choices on how to contribute to the realisation of the energy transition, serve as a guide for operators to judge projects' desirability. During the study, it became clear that all stakeholders call for a national vision to be coordinated by the national government, a national plan for the transition to the deep subsurface. Where are the specific types of projects which would create an efficient, sustainable, affordable and just energy system desired? Nuclear energy is an example where this national coordination does exist; an initiator knows in advance which areas are eligible for development.

Although participation in onshore underground energy storage projects was explicitly discussed during the interviews, the subject of dealing with damage inevitably came to the fore. Questions such as: 'what are the risks of damage?', 'which institution can residents turn to in the event of damage?' and 'how is the damage claim settlement regulated?' were on the minds of local stakeholders who were asked about the process of participation in onshore underground energy storage projects. Interestingly, operators and national government institutions consider damage settlement and participation as separate issues, whereas provinces, municipalities, water authorities, NGOs and residents always mention the organisational and financial settlement of damage without explicitly asking about it. In the eyes of local stakeholders, damage handling is inextricably linked to underground energy storage projects, and discussion of participation is impossible without a well-designed and trusted damage settlement.

When the task of creating sufficient public support for the transition to the deep subsurface is considered an alignment issue, it is not surprising that the two themes identified here relate to, (1) national coordination of the transition to the deep subsurface, and (2) the organisational and financial settlement of damage claims. First, I describe the findings, then I try to explain them through the lens of the framework developed by Pesch et al. (2017).

National coordination on underground energy storage

Municipalities and residents indicate that they feel they are only involved in a project when the operator and the national government have already agreed about its type and the associated choice of location. Early participation, before the choice of location has been made, is seen as essential for obtaining sufficient support among regional stakeholders. This should remove the feeling of 'pushing projects through' and 'favouritism in The Hague (residence of national government)'; these irritations lead to a decrease in trust.

Provinces, municipalities and residents expect to be able to co-decide on location choices and, therefore, also on whether or not a project will eventually be realised. Here, the perspectives vary widely between the various stakeholders upon on what can and cannot be co-decided or how they can participate.

The ability to draw out the deep subsurface of the Netherlands, taking into account existing initiatives in regions, and geological characteristics, is crucial to realise an efficient, affordable, sustainable and just energy system. All stakeholders recognise that national coordination of underground energy storage is necessary and that not wanting a project at all is sometimes impossible. The national government is expected to coordinate in close consultation with provinces, municipalities, water authorities, interest groups and residents. Regions must feel they have a say and see local assets as an opportunity for their local and regional economies.

“The RES is also just a collection of municipal decisions and a sum of the initiatives that were there.” (Local decision maker, Interviews, 2022)

In drawing up and fine-tuning this national and detailed vision for the transition to the deep subsurface, clear agreements must be made about the aspects which are permitted as subjects of participation. For example, the choice of location (e.g. in the case of salt caverns, bound by geological salt formations and connection to the gas roundabout) should not be part of the participation, but how the project fits into the surface and what is done to mitigate any nuisance should be open for discussion. Clear agreements prevent stakeholders from entering the table with divergent expectations and thus confronting each other at an early stage. Operators are open to reducing the impact of projects on the living environment as much as possible and mitigating any nuisance, but this must be accompanied by protection against endless procedures after an initial agreement has been reached. By clarifying the amount and level of participation, it should no longer be possible to submit opinions at a much later stage, which often have little to do with the project itself — a point of attention that operators actively mention.

The drawing up of a national plan can also remove another significant irritation among municipalities and residents: the unintended accumulation of activities which turn certain areas into veritable ‘energy hubs’. By mapping out the Netherlands in detail, it becomes clear which initiatives will take place, and national coordination can ensure that local stakeholders are not confronted with a salt cavern at first, followed by wind turbines and a solar park later.

In addition, a national plan will make it easier for operators and government agencies to explain why an initiative should take place in a particular place, thus answering the frequently asked questions at information evenings: "Why is this necessary, and why does it have to be here?". Operators and government agencies can thus tell a clear collective story. It will also give residents the confidence that not everything happens ‘in their backyard’ but that each region, in its own way, contributes to the national task, depending on regional (subsurface) characteristics.

The role of national and regional politics in telling this story should not be underestimated. If such a national plan is drawn up in close cooperation with local stakeholders, the politicians must also give it broad support. It does not help the residents’ trust if national or regional representatives continue to speak out openly against plans for fear of losing voters. It is unavoidable that projects involve risks and that only certain regions are suitable for a specific technology. However, realising these projects is necessary for a successful transition to an efficient, reliable, sustainable and just energy system.

The Dutch government recognises the importance of the national vision on the transition to the deep subsurface storage and is busy drafting what is the Program Energy System (PES). However, this requires much time and attention and must be done in close consultation with local stakeholders. In addition, studies are underway to answer certain technical and economic questions: can it be done offshore, and to what extent should the connection with, for example, Germany be sought. The plan is expected to be finished in approximately two years (2024). However, the energy transition will not wait this long, and another question is, what effect another two years of ‘pushing projects through’ will have on the confidence and support among local authorities and residents. It is, therefore, important that the national and decentralised governments and elected representatives no longer hide behind the reality. The large-scale deployment of underground energy storage facilities, which will be realised in north-eastern Netherlands for geological reasons, is inevitable, and that story must be communicated.

"We just need a minister with guts who says large-scale underground energy storage is going to happen, and we are going to make sure it is properly regulated."
(Regional decision maker, Interviews, 2022)

Explanation of findings on national coordination, based on framework

The findings on the national coordination theme can be explained using the framework developed by Pesch et al. (2017), which is set out in the following paragraphs. Given the existence of the social scientific mechanism known as controversy spillover, described by Cuppen et al. (2020), it is expected that in the future, during which the national plan is being drafted, this spillover will play a crucial role. Public response to projects draws on their earlier experiences which affects the informal assessment trajectory of future energy projects. Regarding the national coordination on the use of the Dutch subsurface, this informal assessment trajectory is characterised by concerns among municipalities, water authorities, NGOs and residents, not adequately safeguarded by the dominant institutional practices. Three varying perceptions of justice, resulting in controversy, were identified. These concerns will inevitably spill over into future projects, resulting in more controversy and unwanted delays.

To start, provinces, municipalities and residents expect to be able to co-decide on location and type of project choices and, therefore, also on whether or not a project will eventually be realised. The perspectives of the various stakeholders on what can and cannot be co-decided and their participation levels, can vary widely which leads to controversy. This can be explained by the fact that the moral authority of the claims in both trajectories is based on different democratic principles in which the two valuation paths legitimise justice-related claims in different ways (Pesch et al., 2017). Within the formal assessment trajectory, institutionally and legally established procedures that are effected by delegated actors determine where a project is realised and the level of participation. In contrast, the authority of the informal trajectory is derived from the moral autonomy of the residents who make up a community. The community-based authority results in the expectation among the local stakeholders that they can decide what type of projects are realised at specific locations.

Secondly, local stakeholders express concern over the unintended accumulation of activities turning certain areas into veritable ‘energy hubs’. This concern is, according to these stakeholders, not adequately safeguarded by the prevailing set of rules. The justice-related attribute that explains these divergent justice-related claims is that the two trajectories take different dimensions of energy justice as their starting point (Pesch et al., 2017). In the formal trajectory, procedural justice is the starting point from which the dimensions of distributive justice and justice through recognition are considered. The accumulation of activities affects all who live in a specific municipality or region equally, which creates the perspective that procedural justice is acknowledged and no groups or communities were excluded, ensuring a fair process for inclusion in energy decision making. From the perspective of local authorities and residents, the justice through recognition, acknowledging who is affected by energy decision-making (considering that different groups of residents require different approaches and policies) is the starting point from which the dimensions of distributive justice and procedural justice are considered. Therefore, local stakeholders articulate concerns regarding the validity of experiences of vulnerable individuals or communities, as they feel their specific and unique situations are not recognised.

Lastly, it was found that divergent perceptions of justice in answering "why is this project necessary, and why does it have to be here?" causes controversy. Operators and government agencies tend to answer these questions, following a judicial rationality (i.e. there is a concession here and these types of projects are desired for the Dutch energy system). The rules form the frames that ensure that the various actors agree on a common goal, and adherence to the dominant institutional practices is seen as an appropriate path of action. However, local authorities, NGOs and residents express values following a narrative rationality (i.e. the project can take place elsewhere and we don't want salt caverns), which leads to divergent perspectives and thus expected answers. Following rules instead of telling a story can be explained by analysing the first justice related attribute; how the two assessment trajectories differ in terms of the logic through which concerns are articulated, and how values are expressed (Pesch et al., 2017).

Summary

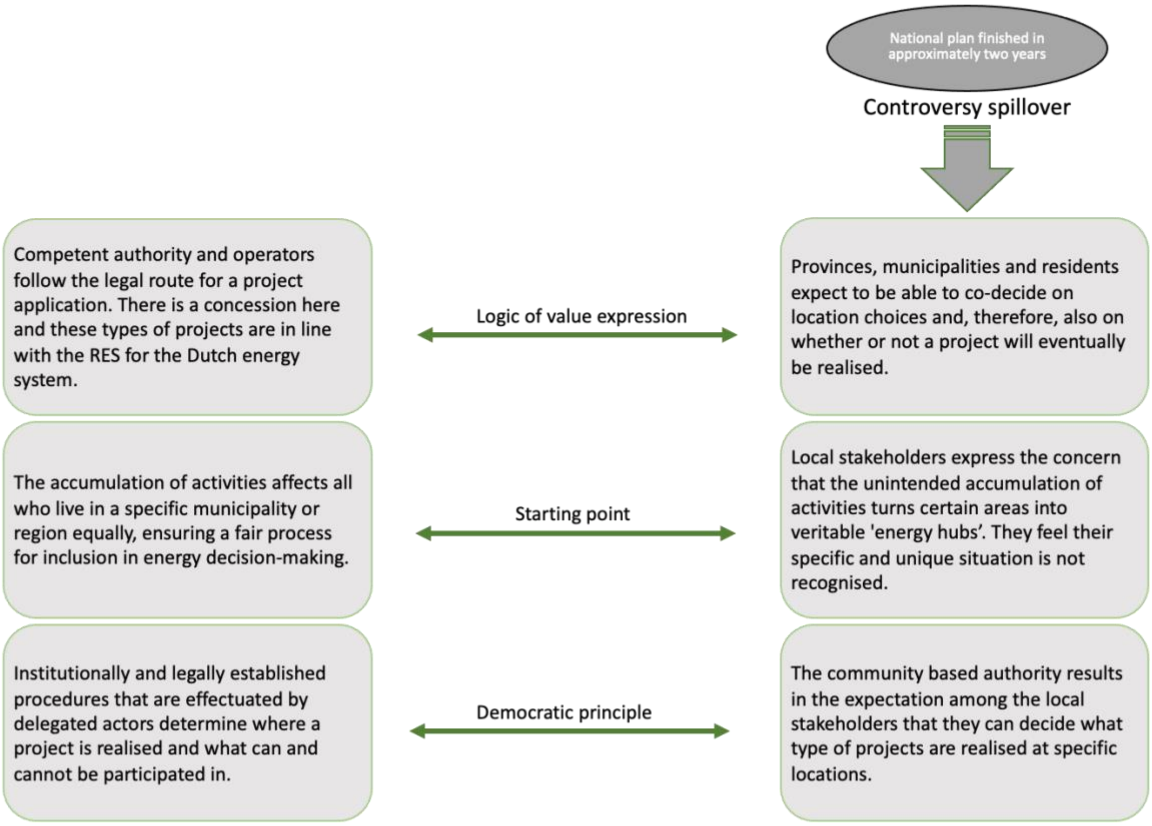

Figure 4: Visualisation of statements made during the interviews that link to the justice-related attributes. These help to understand the role of perceptions of justice in the dynamics of controversy.

Coordination on damage handling: organisational and financial

The second theme identified is the organisational and financial settlement of damage claims. First I describe the findings, then I try to explain them through the lens of the framework developed for understanding the role of perceptions of justice in the dynamics of controversy. It is clear from the interviews that for provinces, municipalities, interest groups and residents, a fair damage settlement is a crucial issue in the social acceptance of underground energy storage facilities. A broadly supported organisational and financial settlement of damage claims is essential in creating trust and public support. While operators and national government authorities feel that the damage-handling process is well underway and it is just a matter of time before the problems surrounding it diminish, local stakeholders feel that this process is not well organised. Residents link the problems and dissatisfaction surrounding the settlement of damage claims from gas production with other activities in the subsurface.

"*From the beginning, the citizens, in particular through the Groninger Gasberaad and the Groninger Bodem Beweging, have argued for one damage handling institute. However, if you create a single institute that settles damage repair, compensation and reinforcement, the regional authorities' role becomes minimal. And it is mainly the regional authorities that have said they want to have a role in the damage settlements." (Regulating/damage-handling authority, Interviews, 2022)*

When the first damage claims were handled, the NAM responded to them in a very judicial manner. Local stakeholders do not understand this approach and feel that the government does not support their values and interests. Settling damage claims in court, facing expensively dressed lawyers, hired by operators, feels unfair and impossible to win. In their eyes, the national government, which for years profited from the misery they suffered, did not support them at all and is not there to protect their interests, while their values are at stake. This is the strongest driver for diminishing trust in government authorities in the region. The settlement of damages for projects related to gas from the Slochteren field has, as a result of widespread national dissatisfaction, been moved away from the operator and placed under the control of the Instituut Mijnbouwschade Groningen (IMG). Concerning other subsurface activities, residents have to turn to the Landelijke Commissie Mijnbouwschade (LCM).

For residents, it is utterly incomprehensible that there are different operating institutes, let alone that these institutes use divergent procedures, which leads to different regulations and settlement of damage claims. For example, one street is governed by the IMG and the next by the LCM. The question is whether it is acceptable to introduce such distinctions into our system, which are almost impossible for the resident to understand.

"Transparency is a buzzword, but the clarity of legal rules is part of justice."
(Regulating/damage-handling authority, Interviews, 2022)

Municipalities and residents feel that the presumption of evidence, which the IMG uses, should be applied more widely throughout the region and the province. This is an excellent protection for residents because it is very difficult to prove that damage is not a result of mining. However, it is also very difficult to prove that damage is a result of mining. The national government and operators point out that the introduction of the evidence presumption has taken on a life of its own and that nowadays, local residents unfairly point to the operator in cases of any form of damage. This is strongly fuelled by national and regional politics and media.

"Justice must be done to people but also to businesses."
(Central decision maker, Interviews, 2022)

It is a widely held opinion among stakeholders that a resident should be unburdened, a popular cry that has also led to the high costs of damage settlements. IMG's protocol, agreed by the government with civil society organisations, prescribes the use of independent experts and the assignment of case supervisors. There is nothing wrong with this approach, but it explains the high litigation costs. Operators and national government bodies emphasise that the use of a standard and damage models is necessary to prevent arbitrary and unjustified continued compensation. Non-structural damage to houses occurs all over the country and is the result of dehydration and peat oxidation. After all, residents live in a delta. Always pointing at the mining activity is technically incorrect, endangers future projects and does not help remove the subsurfaces' negative characterisation. Once again, operators, national government authorities and researchers feel that national and regional representatives have an essential role in telling an honest story.

"Groningen is a special case, those people have had to deal with the earthquake misery.
The Netherlands has earned a lot of money from this part of the country. Everyone will
understand if the government says, we will do something in return.
And that does not mean we are doing that in the whole of the Netherlands."
(Regulating/damage-handling authority, Interviews, 2022)

If the damage has been reported and experts are trying to establish the cause, it is crucial that, if the conclusion is not the result of mining activities, another cause is indicated. This ensures more understanding among residents in the event that a claim is rejected. If indicating another source causing the damage is not possible, residents should not be the ones to suffer, and claims should be handled generously. Operators seem to agree with such a working method and emphasise that they have often done this in the past. The enormous mountain of damage caused by the earthquakes demanded a more effective arrangement whereby the speed of action was prioritised to eliminate the increasing dissatisfaction resulting from years of denial. In the future, operators and national government authorities emphasise that strict standards and assessments based on knowledge should be more decisive. That new knowledge leads to changing insights, and an adjustment, in areas that are or are not entitled to compensation, is inevitable and legally necessary.

"If the judge, the IMG is a kind of semi-judicial body, has to conclude based on new data that something cannot be earthquake damage. Then the judge will say, I am not awarding this". (Regulating/damage-handling authority, Interviews, 2022)

"One always gets a discussion. Even if an area is allowed to decide who gets what and who doesn't, one will always get a borderline case. I think one has to let the government determine the boundary, not the company because they are not trusted. Also, not citizens themselves because then they will not draw a line." (Operator, Interviews, 2022)

Municipalities and residents agree that the government should guarantee financial handling of the damage claims. By reserving an amount from the paid-up profits of all mining companies active in the Netherlands, concerns about bankruptcies and foreign owners can be dispelled. Despite the fact that the legal entities are based in the Netherlands, residents indicate that they trust Dutch companies related to the government much more than foreign investors. Foreign parties create what is described as, 'a smash-and-grab area', where companies run off with the profits and the residents are left with the burden and possible negative future consequences.

Finally, it is vital to consider the immaterial damage caused by the physical damage. National government agencies and operators think paying for the damage solves the problems. Although there has never been a fatal accident due to collapsed buildings, recent research by Stroebe et al. (2022) emphasises the effects of stress caused by the disturbance. These include headaches, sleeplessness, heart palpitations, stomach problems, and depression or anxiety. Ultimately, these complaints can also lead to significant health problems and an increased risk of death, for example, through cardiovascular disease or suicide (Stroebe et al., 2022). Overall, residents with multiple physical damages feel less safe and perceive more risks than residents without damages (Stroebe et al., 2022). Research by Stroebe et al. (2022) shows that reinforcement does not lead to an improvement in health and safety. Municipalities and residents feel that the inflicted immaterial damage, is not recognised by operators and national government authorities.

"I actually have quite a desire to repair those cracks. However, I also dread the inconvenience of the whole thing, emptying those rooms. Nevertheless, the worst thing is the prospect that after I have repaired it, there will be another earthquake next year, and I can start all over again. Moreover, it remains to be seen whether I will be reimbursed in the future." (Resident, Interviews, 2022)

The immaterial damage done to residents demands damage claims to be dealt with in the form of actions and not by monetary payments. Municipalities and residents ask for this and emphasise that this dramatically reduces the hassle. Emptying your house, temporarily moving and repairing the damage can take months and be a real battle of attrition. Furthermore, compensation in the form of deeds reduces the risk of fraud with schemes and thereby helps to reduce the fear from operators that their payments end up in the wrong place.

Explanation of findings on damage handling, based on framework

The findings on the damage-handling theme can be explained using the framework developed by Pesch et al. (2017), which is set out in the following paragraphs. Residents link the problems and dissatisfaction surrounding the settlement of damage claims from gas production with other activities in the subsurface, a dynamic process known as controversy spillover (Cuppen et al., 2020). The ongoing dissatisfaction is driven by the slow settlement of claims and uncertainty in regulations. Even though improvements are promised by the government, municipalities, NGOs and residents do not believe it. Controversies surrounding damage settlement will therefore arise in every type of future subsurface activity. Even if the damage settlement process is completely revised, controversies will still arise due to the spillover effects. The different institutions and divergent procedures are a result of a concept known as backflowing in which the emergence of concerns and issues in the informal assessment trajectory can lead to adjustments and redesign of existing policies within the formal assessment trajectory. However, the revisions have, up until now, not been effective in reducing concerns and creating trust. Three issues, indicating varying perceptions of justice regarding the handling of damage claims and leading to controversies, were identified in the interviews.

The first issue concerns the logic through which concerns are articulated and values are expressed. This can by explained by the judicial rationality applied in handling damage claims within the formal assessment trajectory, whereas the residents in the informal trajectory articulate concerns using a narrative rationality. National government organisations and operators feel that strict standards and tools based on expert knowledge should be the guide for assessing damage claims. If a type of damage can not be caused by mining activities, operators do not have to compensate. Municipalities and residents instead express claims that as operators and the government profit from activities in their surroundings, any negative impact should be compensated. Even if, according to experts and statistical models, the damage is unlikely to be the result of mining activities, this should not matter when compensating as they already have to deal with the project affecting their living environment. The community has an unique identity and the negative impact inflicted on its living environment asks for a situation-specific assessment and for generous compensation. These different logics through which concerns are articulated result in mutual denial of justice-related claims and divides operators from residents (Pesch et al., 2017). Residents perceive this approach as if their moral implications are ignored and underestimated and the validity of their experiences is unrecognised.

The second issue identified is related to the different dimensions of energy justice that the formal and informal assessment trajectories take as their starting point. Until recently, the immaterial damage inflicted on residents was not of concern among operators and the national government. If damage is not caused by mining activities, no reimbursement is required. Within the formal assessment trajectory the judicial rationality covers the settlement of damages following strict standards and regulations. Treating everyone equally is prioritised, so there is little regard for the individual. The fact that, for some people, damage has a much greater impact and affects the quality of life more than others, is missed. In the informal assessment trajectory, justice as recognition is prioritised, acknowledging that social groups define their own identity and their own terms. Immaterial harm caused by the damages is a concern not safeguarded in the eyes of local stakeholders. Recognising the immaterial damage inflicted and ensuring that stress and hassle are reduced, regardless of the fact that the stress and hassle caused by damage is actually inflicted by mining activities, is expected.

The third issue identified, concerns the divergent perspectives on how the handling of claims should be organised (evidence presumption) and can again be explained by the different dimensions of energy justice that the formal and informal assessment trajectories take as their starting point (Pesch et al., 2017). In the informal assessment trajectory in which the starting point is justice through recognition, energy justice is carried out by acknowledging who is affected and who is responsible for damage. Having significantly less damages in the region before the subsurface activities started and knowing that these activities can lead to damage, residents and other local stakeholders expect that operators are responsible. However, in the formal assessment trajectory, procedural justice is the starting point and treating all cases equally to ensure no groups or individuals are excluded and justice is done to operators as well, is dominant. Residents ask operators and the national government to consider how different groups of residents require different approaches and that in some cases a more generous compensation makes more sense than adhering to legislation and strict procedures. This leads to controversies and explains the issues surrounding the current damage settlement rules and practices.

Summary

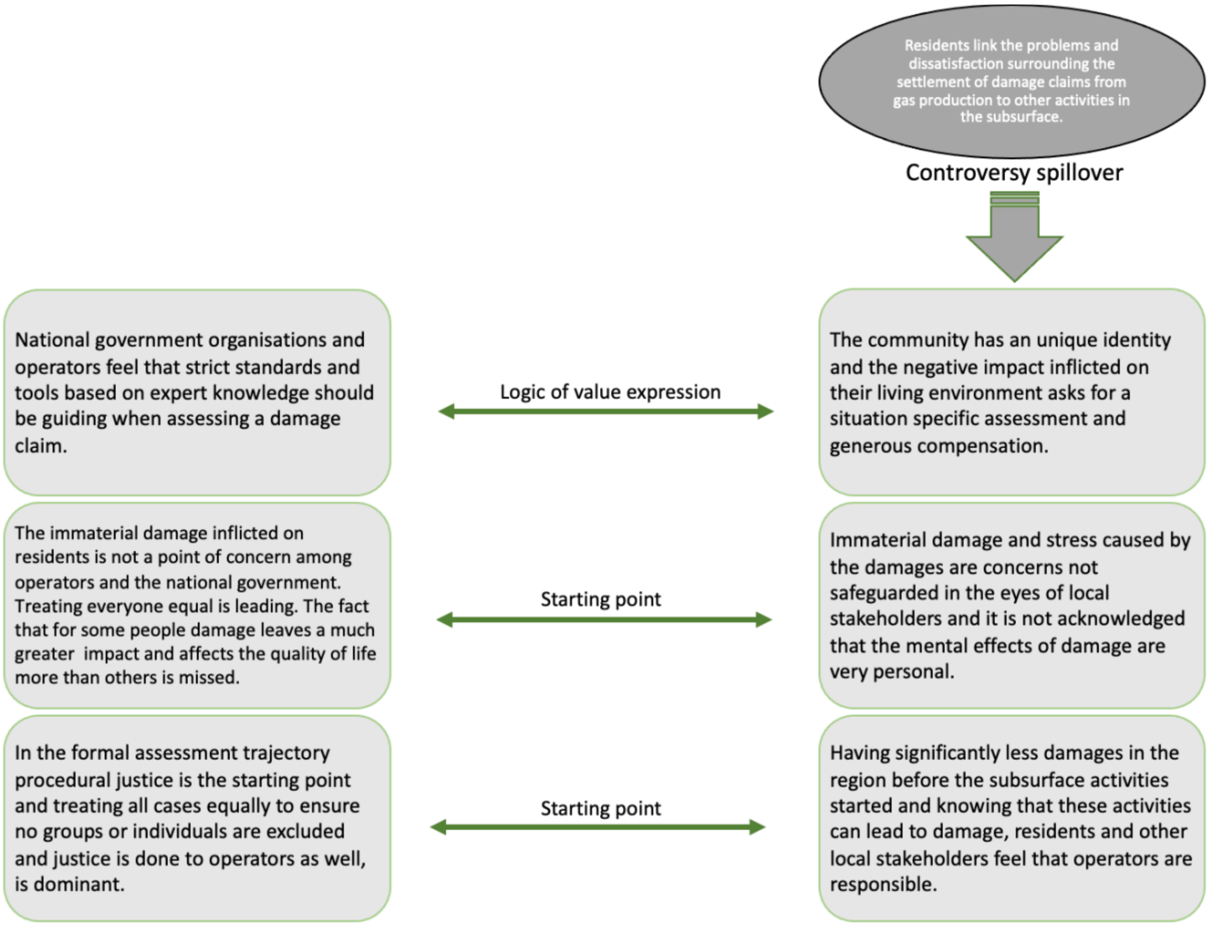

Figure 5: Visualisation of statements communicated during the interviews that link to the justice-related attributes. The attributes help to understand the role of perceptions of justice in the dynamics of controversy.

6.2 Issues surrounding the division of roles and responsibilities in participation

The third theme identified is the division of roles and responsibilities in participation. First I describe the findings, then I try to explain them through the lens of the framework developed for understanding the role of perceptions of justice in the dynamics of controversy. Operators of underground energy storage projects show a great willingness to work closely with local authorities, interest groups and residents to minimise the impact on the living environment. They realise that it is crucial to engage with the neighbourhood, listen to fears and objections and find solutions that avoid perceived risks and limit nuisance. Municipalities and residents want to be able to co-decide on how a project will fit into the living environment. Participation leads to involvement and results in more support. Municipalities and residents underline this.

"We always did 'decide', 'discuss' and 'deliver'. That is, of course, the wrong order. What one should actually do; 'discuss' (when would it suit you, are there alternatives for the location), then 'decide' (should be binding then) and finally 'deliver' (stick to your agreements)." (Operator, Interviews, 2022)

When the new Environment and Planning Act ('Omgevingswet') comes into force, the National Coordination Regulation ('Rijkscoördinatieregeling') will be replaced by the Project Procedure. The project procedure consists of five steps: 1) notification of the intention, 2) notification of participation, 3) exploration, 4) preferred decision, and 5) the project decision. A new feature of the project procedure is that the competent authority, in the case of underground energy storage facilities, the Minister of Economic Affairs, will give everyone the opportunity to propose other possible solutions to the underlying problem within the period indicated in the notification. The competent authority will provide the starting points for a reasonable assessment of the proposed solutions. A more detailed description of the new Act can be found in Appendix B.

Embedded in the project procedure is the notification of public participation. The competent authority indicates how residents, companies, NGOs and administrative bodies will be involved. In any case, the competent authority will address the following: 1) who will be involved, 2) what will their involvement be, 3) at what points will they be involved, 4) what is the role of the competent authority and the initiator in involving these parties, and 5) where is additional information available. The notification of participation shall be made in a manner determined by the competent authority. This way, the authority must communicate with the relevant public as well as possible. However, the law does not impose any substantive requirements on public participation. The basic principle of the legislator is that the participation process requires customisation per project and location and that checklists should be avoided.

Within the new Environment and Planning Act, the initiator is the central figure, and the initiator is obliged by the competent authority to participate. What immediately generates problems is that there is no definition of what it means to participate. If there is no framework for testing what constitutes good participation, this naturally becomes a problematic issue. It is well-meant; as an initiator, one must enter into dialogue with your surroundings. However, if the government does not provide a framework for the rules, some parties will be disappointed. Stakeholders then enter the playing field with their expectations pattern, which can never be individually aligned.

"My image of the new Environment and Planning Act is that participation is set up as follows; 'dear initiator, go and explain yourself that it is a good idea'. I think that is a fatal way to go, because then you leave the operator hanging. Operators do not always possess the knowledge and skills and are not familiar with this kind of process. As a result, all kinds of accidents will happen, not because operators are malicious, but because they do not know how to do it." (NGO, Interviews, 2022)

The new Environment and Planning Act offers every opportunity to carry out the participation process with involves parties according to one's insights and in line with the local (project) dynamics. However, in practice, not every initiator knows how to apply the outlined process criteria. An additional concern is that some parties in the market are trusted because of a long history of activities in the Dutch underground, while foreign parties are generally less trusted. The disadvantage of this freedom is that the quality of the local development and participation process depends on the experience and qualities of the initiators and the efforts of the competent authority. Significant regional differences will thus arise depending on the operator and the local community. For local authorities, interest groups and residents, the freedom offered without legal frameworks is a worrying weakness in the new Act. Operators are not happy with the freedom and responsibility either. According to them, the competent authority must ultimately weigh up the interests and decide. Thinking that operators and residents, whose starting points differ in all ways, will eventually reach some form of consensus is overly optimistic. The operators also have an economic interest at stake (i.e. time and resources), so they benefit from a short project procedure. If one starts participating, the procedure is extended, and that adds to costs. The allocation of time and resources plays an important role in assuring an efficient and short participation procedure.

"What worries me is that there is a gap between the new Mining Act and the new Environment and Planning Act. How these tie in with each other is not yet properly regulated. The Environment and Planning Act primarily concerns the local Government, which is the competent authority for the installations (e.g. pipes, buildings). The Ministry of Economic Affairs is the competent authority for activities in the deep underground. In the Mining Act, local governments, i.e. provinces and municipalities, have an advisory role and cannot stop a project."
(Scientific research group, Interviews, 2022)

In the new Environment and Planning Act, it is mainly the local government (i.e. municipality) that is the competent authority for installations above ground. In the Mining Act, the competent authority for storage in the deep underground is the Ministry of Economic Affairs and Climate. Strategic groundwater reserves are the province's responsibility. Underground energy storage has an underground and an above-ground element which is inevitably connected, so it will have to deal with three levels of government. Coping with three levels of the government can cause unwanted disputes among authorities and confusion for residents that have no idea to whom to turn.

Previous research by Puts et al. (2021) has revealed several essential process criteria for the proper embedding of underground energy storage in society: 1) identifying local values and interests, 2) making use of local area knowledge and experience, 3) responding to the level of knowledge within the local community, and 4) striving for a good balance between costs and benefits for the local community as a result of the proposed project. In addition, 5) it is essential that everyone has access to the process and can participate in the discussions. The research also confirms 6) the importance of involving the local community at an early stage. This sometimes clashes with practice, in which the preparation of plans for underground energy storage often takes place within closed and restricted circles. The project procedure, for that matter, offers more leverage for involving the local community at an earlier stage in the development and decision-making process. In addition, the project procedure 7) invites transparency about the process and about how stakeholders can contribute during the participation process.

The Mining Act and the new Environment and Planning Act do not create any barriers to applying the process criteria. Although neither the Environment and Planning Act nor the process criteria prescribe a detailed approach, both perspectives show that explicit attention is needed because (underground) interventions take place locally, at and around the area where people live, work, relax, have interests and pursue values.

Local authorities, interest groups and residents point out that the operator in each project must carefully examine the spheres of influence and impact on the whole living environment. Using municipal or provincial boundaries or applying fixed spheres of influence of predetermined distances leads to local stakeholders being excluded when determining who will be involved. For example, a local interest group or environmental organisation whose head office is located just outside the defined radius, or a resident living outside the municipal boundary, are not informed. Once again, operators and local authorities have an essential role in the adequate distribution of information to ensure broad engagement.

Problematic in ensuring a broad residents' engagement is their lack of interest up until the moment the work really begins. Operators point out that throughout the regular permitting procedure there is relatively little engagement by residents. However, as soon as activities start and impact their living environment, opposition arises and concerns are articulated. Realising that people generally do not care until it affects them personally underlines the importance of distributing information. Various information channels have to be used as the regular 'information evenings' are attended by the same group of people. This way important considerations and perspectives remain unidentified until the project begins.

"You need time and knowledge to really participate fully; that is where I think a huge challenge lies." (Central decision maker, Interviews, 2022)

According to municipalities and residents, the outcome of the participation process must be individual to the project and requires custom work. Customisation enables one to respond to environment-specific wishes and to mitigate the nuisance perceived by the residents as well as possible. One will never reach a complete consensus, and there will always be actors that feel unheard or disadvantaged.

Explanation of findings on the division of roles and responsibilities, based on framework

The findings on the division of roles and responsibilities can be explained using the framework developed by Pesch et al. (2017), which is set out in the following paragraphs. Considering the issues surrounding the division of roles and responsibilities in participation, the interviews have revealed that stakeholders enter the playing field with their own expectations pattern, which can never be individually aligned. Thinking that operators and residents will eventually reach some form of consensus is overly optimistic. One will never reach a complete consensus, and there will always be actors that feel unheard or disadvantaged. These varying perceptions are analysed and can be explained by the first justice-related attribute (Pesch et al., 2017). This attribute explains that the two trajectories differ in terms of the logic through which concerns are articulated, and values are expressed. Within the formal assessment trajectory time, resources and costs play an important role in the participation process, and concerns and values are expressed following a judicial rationality. Following the dominant institutional practices and set of rules that are part of the project procedure is prioritised. However, within the informal assessment trajectory, the stakeholders care less about existing practices and regulations. Their view on participation is more narrative and local stakeholders feel that the societal concerns and values are not safeguarded. The community has a unique identity and the negative impact inflicted on their living environment asks for a situation-specific assessment and approach. As the logic through which the values are expressed and concerns are articulated differ, reaching consensus without clear process criteria is impossible and this inevitably leads to the emergence of controversies.

Furthermore, the required customisation and the fact that the quality of the local development and participation process depends on the experience and qualities of the initiators and the efforts of the competent authority, highlights the missing process criteria. Considering the second justice-related attribute, which describes that the two assessment trajectories take different dimensions of energy justice as their starting point, the missing process criteria explains the emergence of controversy (Pesch et al., 2017). In the formal trajectory, procedural justice is the starting point. However, if there are no range of procedures and policy arrangements to create a collective assessment, overflowing (i.e. the emergence of concerns within the informal assessment trajectory) will still occur. Within the informal trajectory, this leads to varying expectations and uncertainty regarding the outcome of participation. Controversy spillover explains why the informal assessment is characterised by a lack of trust in a just outcome (Cuppen et al., 2020). Drawing on experiences with other projects in their vicinity, municipalities and residents indicate that they feel participation is seen as an obligation to operators.

Participation, they believe, is used to persuade fierce opponents and ensure the swift approval of a permitting procedure.

Summary

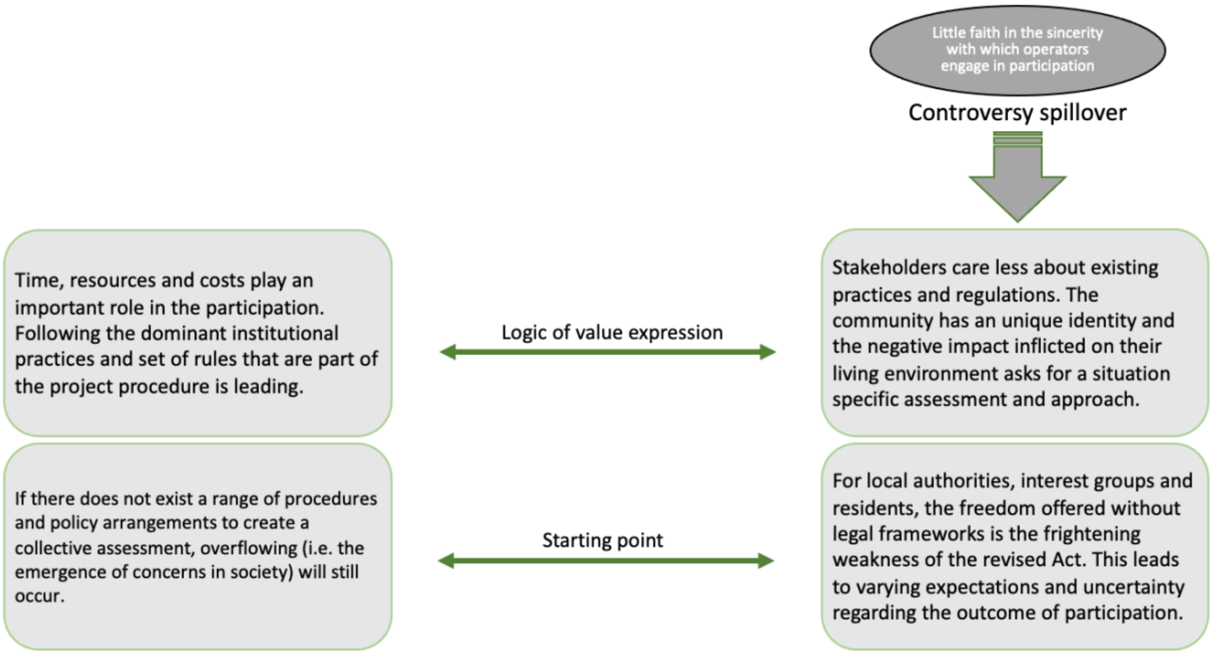

Figure 6: Visualisation of statements mentioned during the interviews that link to the justice-related attributes. The attributes help to understand the role of perceptions of justice in the dynamics of controversy.

6.3 Distributional issues of benefits and burdens in participation

The last theme identified is the distribution of benefits and burdens in participation. First I describe the findings, then I try to explain them through the lens of the framework developed for understanding the role of perceptions of justice in the dynamics of controversy.

1. Why regional benefit sharing is desired

In general, there is consensus on the importance of a fair distribution of burdens and benefits in developing onshore underground energy storage facilities. For many years, treasures in the subsurface were seen in the Netherlands as a collective good; income from underground activities flowed directly to the state. Examples abroad (e.g. windmills in Denmark and nuclear power plants in France) underline the importance of regional benefit-sharing in creating social acceptance.

Looking at the history of mining in the Netherlands, we see that, despite much damage in Limburg, there was little controversy at the time. In Limburg, the people from the region worked in the mines, the manager lived in their street, their children went to the same school, and the presence of the company ensured economic revival for the region. Three days in advance (unthinkable now), residents were told that they would have to leave their homes for the weekend to collapse an abandoned corridor safely. Afterwards, the damage was measured and immediately repaired. In Groningen, the error was made in creating an automatic system. This has resulted in little employment and has created a distance between contractors and the surrounding area, which fuels the feeling of it being a 'smash-and-grab area.'

"It does seem that in our region, all decisions always fall in the wrong direction."
(Resident, Interviews, 2022)

The controversies in Groningen and the importance of the sustainable use of the subsurface have resulted in agreement amongst stakeholders on a mutual gains approach. Part of the proceeds must flow back to the region. Residents are not only burdened by underground energy storage facilities but are also regularly confronted by other decisions that adversely affect their living environment. If a school has to close because of the above-average costs per child, this occurs in northeast Netherlands. In that region, the healthcare costs per patient are also above average, causing regional medical expertise centres and hospitals to disappear. Few passengers lead to the closure of public transport routes, which harms mobility in the area. If part of the revenue flows to the region, the living environment can also be positively influenced, improving on this perception of it being a 'smash-and-grab area'.

2. Key considerations regarding the organisation

It is clear that a fairer distribution of costs and benefits should occur, but opinions and perspectives on how this should be done differ. Most operators already try to be decent neighbours and support local initiatives. For example, by renovating the neighbourhood centre or sponsoring the local sports club. Another form of benefit sharing is establishing an area fund, as in Ternaard (NAM, 2020). A one-off or periodic sum of money is paid into an area fund, and an appointed board with regional representatives decides how the earnings are spent. Agreements on how much should flow to what kinds of initiatives, what the maximum support for a project should be and who takes place on the board are made in close cooperation with the local community. Crucial for the success of an area fund is regional representation and control.

Another frequently heard proposal that goes a step further than a stand-alone area fund is the establishment of cooperatives. In this way, the local community becomes a shareholder in the project and, therefore, its owner. This ensures that the local community can have its say as a member and have an input on the decision-making process. A second advantage is that cooperatives often have long-term visions. Cooperatives already exist in the Netherlands for wind turbines and solar parks. Provinces, municipalities and operators warn that cooperatives are difficult to realise for underground energy storage facilities due to the large investments required. Also, as an owner you are partly responsible for the risks and possible costs in case of damage or bankruptcy. Operators and national government agencies who see a lesser risk in this, point out that the share in the project should be 'given' to the neighbourhood and the region can be insured against bankruptcy and possible losses. This way, no large investments are required, actual ownership is created, and projects are valued by municipalities and residents as assets for the regional economy. The latter is crucial for social embedding (Winters et al., 2020).

3. Key considerations in how to distribute.

If an environment fund or cooperative is established, the distribution question arises. Operators say they find this issue complex. Frequently heard points of attention and dilemmas will be discussed below. Clearly, opinions on the exact design differ, and it is impossible to satisfy everyone.

"How you fill up that area fund, we will work it out. But how do you distribute it among the people in the neighbourhood? And who gets what part of the pie, so to speak. That is really something that we do not have a clear picture of, at least at the moment."
(Operator, Interviews, 2022)

First of all, it becomes clear that there has to be some general rule or working principle. Otherwise, municipalities and residents will have to negotiate on each occasion with operators, which leads to regional differences. The last thing municipalities and residents want is to get involved in a court case with whom they see as powerful operators if they cannot reach an agreement. Operators also indicate that they do not want to end up in such a situation and recognise that a national regulation with clear frameworks is desirable.

Secondly, it is important to determine a projects' sphere of influence. After all, a resident living on top of a salt cavern or right next to a wind turbine experiences more nuisance than other residents in the same municipality. Is it fair, then, for the revenues to be collated into a common area fund? The nuisance experienced is difficult to quantify, and there are considerable personal experience differences. It is therefore essential that municipalities, NGOs and residents together agree on the sphere of influence. People do not welcome involvement by operators and national government authorities. Boundaries are necessary, so some will always be excluded but this is up to local stakeholders.

The third point worth attending to is the difference in the profitability of varying types of subsurface projects. Regular gas storage yields considerably more than the strategic storage of natural gas or hydrogen. However, the realisation of both types of projects is essential for a reliable and independent energy system. Municipalities, interest groups and residents prefer profit-making projects since the region will benefit from these. Preference for a particular technology leads to unwanted discussions and jeopardises the underground's most efficient, sustainable, affordable and fair organisation. In addition, the region must not bear the brunt of implementing the national plan (PES), and the creation of significant regional differences is undesirable. Differences may be possible if one project has a much greater (i.e. negative) impact on the living environment than another, but that is more related to what was discussed previously.

The fourth point of consideration mentioned by municipalities, interest groups and residents is that people do not want to be deceived. The area fund payment must be proportional to the operator's profits. A percentage of the turnover is seen as an elegant solution, how much must be decided in close consultation with all stakeholder groups and not by the government in consultation with the operators, because municipalities and residents do not trust mutual agreements made by these parties.

The last point of attention is that the distribution of burdens and benefits should not feel like bribery. This is how municipalities and residents perceive a one-off payment into an area fund. After all, at some point the money will have run out, and the region will once again be left with only the burdens. Especially in the case of underground energy storage facilities that have a lifespan of several decades. According to provinces and municipalities, a sustainable interpretation of the area fund with a previously mentioned annual percentage of the revenues is desirable. Personal transfers and one-off contributions to temporary initiatives should be avoided. After all, the projects and, therefore, the burdens are intergenerational, which speaks for sustainable use of revenues for the environment. The income can be used to support lower-income groups, for example, by reducing their energy costs or regional taxes, an excellent example of how the fund can be used sustainably. Investments in the natural environment, culture, public transport, infrastructure and healthcare are also mentioned. Municipalities and residents want to decide for themselves how the revenues are spent. Each region differs; wealthier areas may decide to spend it on nature and culture, while less wealthy areas may use it to reduce living costs or build facilities (e.g. a swimming pool).

"If you say we are going to divide the revenues and we are going to give the people who have a bit less a bit more. That results in quite a lot of support. So giving back to the region is also a very nice opportunity to work on a kind of social foundation."
(NGO, Interviews, 2022)

Explanation of findings on the distribution of benefits and burdens, based on framework
The process known as controversy spillover does play a role in the expectations and considerations discussed in the interviews. Forms of financial participation relating to other technologies (e.g. wind parks) already exist and the stakeholders interviewed tended to draw on these experiences when expressing opinions on how regional benefit sharing should be implemented. However, for the last theme identified in the interviews, no real controversy or widely varying perceptions have been discovered.

In the previously analysed issues, no concrete concerns and considerations were discovered from the interviews, the distribution issue is characterised by opinions about a possible outcome. As there is no physical example of regional benefit sharing for onshore underground energy storage projects, only opinions and considerations regarding the future implementation have been raised. The formal assessment trajectory has still to emerge as there is no procedure or policy arrangement in place to create a collective assessment. Therefore, the concept, known as overflowing, has not yet led to the formation of an informal assessment trajectory in which the conflicting values which are at stake are articulated and unanticipated societal and ethical risks are revealed.

A thorough understanding of how the two valuation paths express, rank and legitimise justice claims in entirely different ways ensures the development of policy arrangements that can adapt to overflowing, which is crucial for future public support in energy projects in the Netherlands and also for trust in the government and operators (Pesch et al., 2017).

7 Conclusion

The concept of distributive justice, which concerns the socially just allocation of resources, is not adequately covered in the formal permit procedure shaping the Dutch energy system. A form of financial participation is crucial for social acceptance of onshore underground energy storage projects. To foster the adequate implementation of financial participation, fundamental to onshore underground energy storage projects, this research aimed to explore and understand what the implementation of financial participation entails for these type of projects in the Netherlands. Driven by this goal, the research has generated a complete picture of the key stakeholders' considerations and perspectives on the implementation of financial participation in onshore underground energy storage projects in the Netherlands.

This chapter offers a general conclusion for these key considerations and perspectives. To do this, I first present the answers I found to the sub-questions in subsubsection 7.1.1. Here, I elaborate on the use of the social-scientific mechanisms in explaining the results obtained. Combining the answers to the sub-questions results in the formulation of the answer to the main research question, presented in subsection 7.2:

"To what key considerations and dilemmas should the Ministry of Economic Affairs and Climate adapt its policy on implementing a financial participation model in future onshore underground energy storage projects in the Netherlands?"

7.1 Stakeholders and their considerations and dilemmas regarding financial participation

This paragraph presents the answers to the sub questions guiding the answer to the main research question. The presentation of the answer to the sub questions is guided by three sub paragraphs. First, I present the answers that set the scope and foundation of the research. Building on this, I provide the key stakeholders' considerations and perspectives on the implementation of financial participation.

7.1.1 The scope of identifying stakeholders' considerations and dilemmas

The research started with exploring how the key stakeholders participated in onshore underground energy storage projects in the Netherlands, to better understand and shape the scope in which the search for key considerations and perspectives with regard to financial participation should be conducted. To get a complete understanding, eight groups of stakeholders are important: the national government – including the Ministry of Economic Affairs and Climate, the National advisory, supervision and damage authorities – provinces, municipalities, water authorities, operators, researchers, NGOs and residents.

The scope of the research is not only determined by the set of the key stakeholders, but also by the factors that drive the lack of social acceptance. In the end, financial participation is a means to improve the social acceptance for onshore underground energy storage projects in the Netherlands. When investigating the key considerations and dilemmas regarding the financial participation, it is therefore essential to understand what factors cause Dutch residents to reject onshore underground energy storage projects. In general, residents who reject energy projects in the Netherlands are convinced the technical characteristics of these projects pose risks to their living area and their well-being. However, literature shows that the definition and perception of these specific technical risks of onshore underground energy storage projects vary widely among the key stakeholder groups. The Groningen crisis (i.e. earthquakes, damage and severe trust issues) is strongly linked to gas production and storage in general and thus future storage of natural gas and hydrogen is the root cause of the difference in definition and perception of these technical risks. The presence of this variety of risk perceptions can be explained with the use of social-scientific mechanisms, that describe how the formal and informal assessment trajectories interact, leading to public controversies around onshore underground energy storage projects in the Netherlands. The interpretation of the considerations and the perceptions held by key stakeholders during the research, is therefore guided by these social mechanisms.

7.1.2 Considerations and dilemmas on (financial) participation in onshore underground energy projects

Given the set of key stakeholder groups and having clarified the perceptions of technical risks associated with underground energy storage projects, I explored stakeholders' considerations and perspectives on the implementation of financial participation. The considerations and perspectives identified during the interviews with stakeholders can be formulated in terms of four overarching themes. Among the generic characterisation of the themes, there is agreement among the stakeholders. Concerning the conceptualisation of the values, the research findings show that the opinions and perspectives differ. The implementation of policies and regulations highlights how varying perspectives of justice result in public controversies and cause unwanted delays and termination of onshore underground energy storage projects.

The values found in the informal trajectory have been placed on a timeline and are linked to the formal trajectory timeline; see Figure 7 below for a visualisation. Although the new Environment and Planning Act has attempted to embed improved participation in the formal trajectory, the means and the timing do not match the expectations and perspectives from the informal trajectory. To successfully transition towards a sustainable Dutch energy system it is extremely important that the formal and informal trajectories are temporally aligned and that the considerations and perspectives expressed by the varying stakeholders are thoughtfully considered and safeguarded in the revision of policy arrangements and regulations.

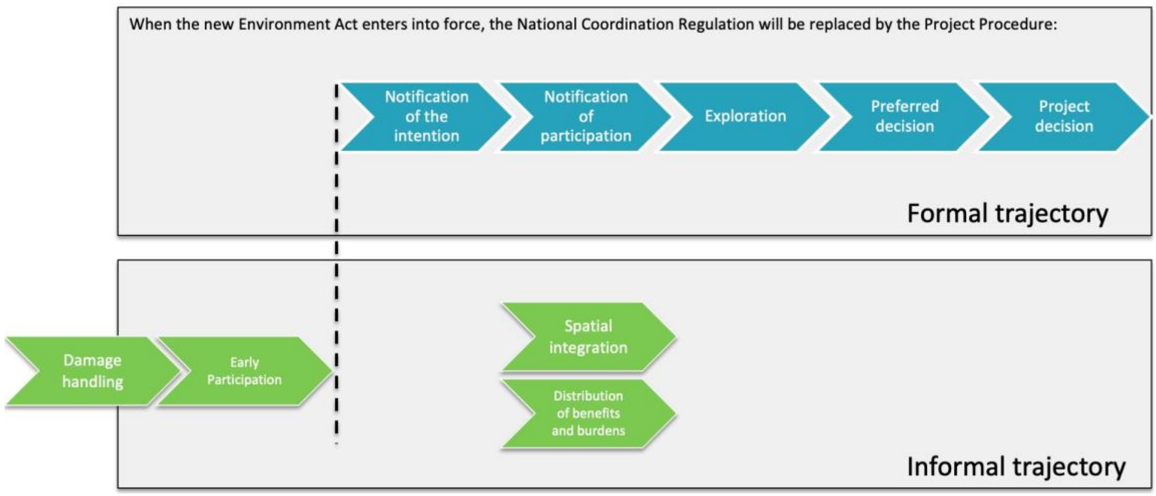

Figure 7: Misalignment between the themes identified in the informal assessment trajectory, and the project procedure of the formal assessment trajectory

Damage handling: organisational and financial

A broadly supported organisational and financial settlement of damage claims is essential in creating trust and public support. While operators and national government authorities feel that the damage-handling process is well underway and it is just a matter of time before the problems surrounding it diminish, local stakeholders think that the process is poorly organised. Looking at Figure 7, the importance of resolving the issues surrounding the handling of damage claims is stressed. A broadly supported organisational and financial settlement of damage claims is essential in creating trust and public support.

For residents, it is utterly incomprehensible that there are different institutes, let alone that these institutes use divergent procedures, which leads to various regulations and settlement of damage claims. Municipalities and residents feel that the presumption of evidence, which the IMG applies, should be adopted more widely throughout the region and province. The national government and operators point out that the introduction of the evidence presumption has taken on a life of its own and that nowadays, residents unfairly point to the operator in cases where there is any form of damage. This is strongly fuelled by national and regional politics and media.

Finally, it is vital to consider the immaterial harm caused by damage. National government agencies and operators think paying for the damage is sufficient. Although there has never been a fatal accident due to collapsed buildings, recent research by Stroebe et al. (2022) emphasises the effects of stress caused by the anxiety and hassle. The immaterial harm suffered by residents demands damage claims to be dealt with in the form of actions and not by monetary payments. Furthermore, compensation in the form of deeds reduces the risk of fraud within schemes and thereby helps to reduce the operators' fear that their payments may be misdirected.

The framework developed by Pesch et al. (2017), is successful in understanding the controversies and dynamics surrounding the handling of damage claims. The logic through which concerns are articulated, and values are expressed, and the fact that both assessment trajectories take different dimensions of energy justice as their starting point, facilitate a better understanding of the emergence of controversies. In addition, identifying the process dynamics through the lens of the framework offers concrete action perspectives for each identified task. The existence of the process known as controversy spillover, as described by Cuppen et al. (2020), strongly influences the emergence of controversies. An essential factor in this spillover is the Groningen crisis (i.e. earthquakes, damage and severe trust issues), which is strongly linked to gas production and storage in general, and thus also to future storage of gas and hydrogen (i.e., another form of gas).

National coordination on underground energy storage (i.e. early participation)

Municipalities and residents indicate that they feel they are only involved in a project when the operator and the national government have already reached a mutual agreement about a type of project and the associated choice of location, and expect to be able to co-decide. Early participation, before the choice of location, has been made, is seen as essential for obtaining sufficient support among regional stakeholders. From Figure 7 it becomes clear that the issues surrounding early participation have to be resolved before actual participation in an onshore energy storage project is possible. This ensures that the topics are no longer mixed up and that the discussion of participation in concrete projects proceeds in a more efficient and orderly manner.

Operators are open to reducing the impact of projects on the living environment where possible and mitigating any nuisance, but this must be accompanied by protection against endless procedures after an initial agreement has been reached. By clarifying what participation is allowed, it should no longer be possible to submit opinions at a much later stage, which often have nothing to do with the project itself — a point of attention that operators actively mention. The drawing up of the national plan may also remove another significant irritation among municipalities and residents: the unintended accumulation of activities which turns specific areas into veritable 'energy hubs'. In addition, the national plan makes it easier for operators and government agencies to explain why an initiative should happen in a particular place. It is, therefore, important that the national and decentralised governments and elected representatives no longer hide behind the reality. The large-scale deployment of underground energy storage facilities, which will be realised in northeastern Netherlands, is inevitable, for geological reasons, and that narrative must be communicated.

The framework developed by Pesch et al. (2017), is successful in explaining the controversies and dynamics surrounding national coordination. The difference in logic through which concerns are articulated, and values are expressed, the fact that both assessment trajectories take different dimensions of energy justice as their starting point, and the difference in terms of the democratic legitimation of assessment trajectories, help better understand the emergence of controversies. In addition, identifying the process dynamics through the lens of the framework offers concrete action perspectives for the specific task. The existence of the process known as controversy spillover, as described by Cuppen et al. (2020), underlines the importance of the next decade in preventing delays and the emergence of controversies.

The division of roles and responsibilities in participation (i.e. spatial integration)
Operators of underground energy storage projects are willing to work closely with local authorities, interest groups and residents to minimise the impact on the living environment. Operators realise that it is crucial to engage with the neighbourhood, listen to fears and objections and find solutions that avoid perceived risks and limit nuisance. Municipalities and residents want to be able to co-decide on how a project will fit into the living environment, as participation leads to involvement and results in broader public support. According to municipalities and residents, the outcome of the participation process must be able to differ per project and requires custom-designed work. Customisation enables one to respond to environment-specific wishes and to mitigate the nuisance perceived by the residents as much as possible.

In the new Environment and Planning Act, the initiator is the central figure, who is obliged by the competent authority to participate. It is well-meant; as an initiator, you must engage with your surroundings. But if the government does not provide a framework for the rules, some parties will be disappointed. Stakeholders then enter the situation with their pattern of expectations, which can never be individually aligned. Previous research by Puts et al. (2021) has revealed several essential process criteria for the proper embedding in society of underground energy storage. The Mining Act and the new Environment and Planning Act do not create any barriers to applying the process criteria.

Another disadvantage of the freedom offered is that the quality of the local development and participation process depends on the experience and qualities of the initiators and the efforts of the competent authority. Significant regional differences will thus arise depending on their differences. Local authorities, interest groups and residents point out that the operator in each project must carefully examine the spheres of influence and impact on the whole living environment. Once again, operators and local authorities have an essential role in adequate distribution of information to ensure broader engagement.

The framework developed by Pesch et al. (2017), is successful in understanding the controversies and dynamics surrounding the division of roles and responsibilities in participation. The logic through which concerns are articulated, and values are expressed, and the fact that both assessment trajectories take different dimensions of energy justice as their starting point, facilitate a better understanding of the emergence of controversies. In addition, identifying the process dynamics through the lens of the framework offers concrete action perspectives for the specific task. The existence of the process known as controversy spillover, as described by Cuppen et al. (2020), underlines the importance of the next decade in preventing delays and the emergence of controversies.

Distributional issues of benefits and burdens in participation

Generally speaking, there is consensus on the importance of a fair distribution of benefits and burdens in developing onshore underground energy storage facilities. Residents are not only burdened by underground energy storage facilities but are also regularly confronted with other decisions that adversely affect their living environment.

A form of mutual gains sharing includes establishing an area fund, as in Ternaard (NAM, 2020). Another frequently heard proposal is the establishment of cooperatives. With this proposal, the local community becomes a shareholder in the project and, therefore, an owner. The share in the project should be 'given' to the neighbourhood, and the local stakeholder would have to be insured against bankruptcy and possible losses. This way, no large investments are required, actual ownership is created, and projects are seen by municipalities and residents as assets for the regional economy. The latter is crucial for social embedding (Winters et al., 2020).

If an environment fund or cooperative is established, the distribution question arises. Operators say they find this issue complex. Frequently heard points of attention are; (1) a generic framework ensuring equality, (2) local agreement on the sphere of influence, (3) differences in profitability of varying types of subsurface projects, (4) payment to the area must be in proportion to the projects' profits, and (5) the distribution of burdens and benefits should not feel like bribery .

The process known as controversy spillover does play a role in the expectations and is a consideration mentioned in the interviews. Forms of financial participation with other technologies (e.g. wind parks) already exist and the stakeholders interviewed tended to draw on these experiences when expressing opinions on how regional benefit sharing should be implemented. As the shareholding in a wind farm is very different from the envisaged and desired financial participation in underground energy storage facilities, the opinions and views found are not all-encompassing.

However, for the last theme identified in the interviews no real controversy or widely varying perceptions were discovered. As there is no physical example of regional benefit sharing in onshore underground energy storage projects, only opinions and considerations regarding the future implementation have been discovered. The formal assessment trajectory has still to emerge as there is no procedure or policy arrangement in place to create a collective assessment. Therefore, the concept known as overflowing has not yet led to the formation of an informal assessment trajectory in which the conflicting values at stake are articulated or any unanticipated societal and ethical risks are revealed.

A thorough understanding of how the two valuation paths express, rank and legitimise justice claims in entirely different ways ensures the development of policy arrangements surrounding regional benefit sharing that adhere to the perceptions of justice in both trajectories. In addition, considering the dynamics of controversies and revelation of unanticipated societal and ethical risks, future policy arrangements should adapt to overflowing and backflowing. This is crucial for future public support in energy projects in the Netherlands, and also for trust in the government and operators, as conflicting values can be avoided.

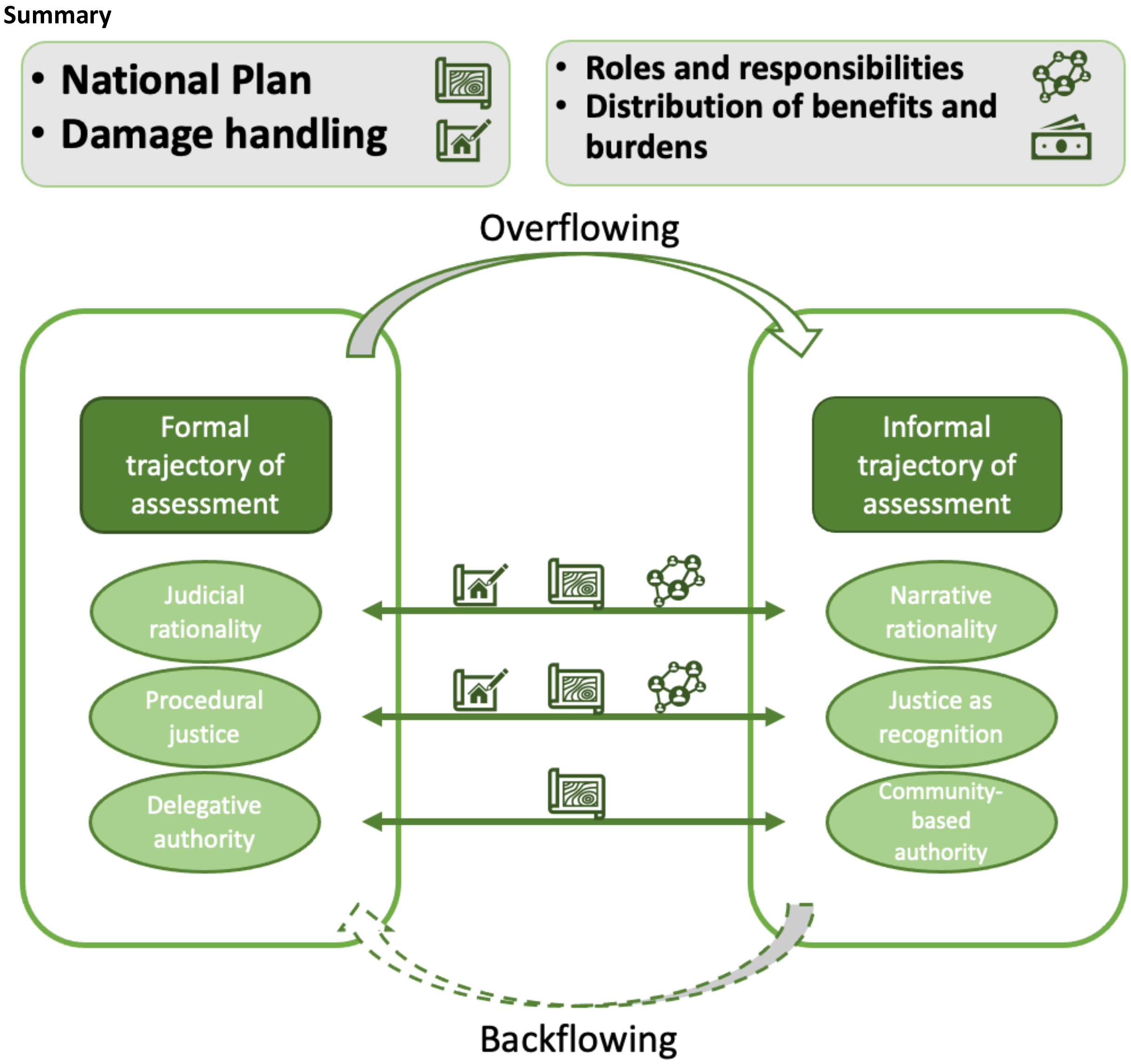

Figure 8: Visualisation of themes discussed during the interviews, linked to the justice-related attributes that play a role in the emergence of controversies.

7.2 The implications of stakeholders' considerations and dilemmas for future policy arrangements

Firstly, the drafting of the PES enables operators and the national government to commonly and clearly answer the questions 'why is it necessary?' and 'why here?'. The coordination of the deep subsurface that should lead to an efficient, affordable, sustainable and just energy system will result in regional differences due to geophysical characteristics. Future policy should minimise these differences and prevent the undesirable accumulation of activities.

Secondly, concerning the settlement of damage claims, the policy must ensure that there is a single institute which applies a fixed and transparent procedure. The approach must facilitate how new knowledge leads to an adjustment of existing standards and that no longer underestimate immaterial damage. The citizen must be operationally unburdened and mentally supported, if necessary.

Thirdly, future policy should guard against the legal gap between the Mining Act and the new Environment and Planning Act. In the latter, it is mainly the local government that is the competent authority for installations above ground. In the Mining Act, the competent authority for storage in the deep underground is the Ministry of Economic Affairs and Climate. Strategic groundwater reserves are the province's responsibility. Underground energy storage has an underground and an above-ground element which is inevitably connected, so it will have to deal with three levels of government. Coping with all of these can cause unwanted disputes among authorities and confusion for residents who do not know to whom to turn.

Fourthly, the new Environment and Planning Act offers every opportunity to carry out the participation process with involved parties according to past experiences and in line with the local (project) dynamics. The downside of the freedom offered is that the quality of the regional development and participation process depends on the experience and qualities of the initiators and the efforts of the competent authority. Therefore, any future policy must incorporate and apply the process criteria described by Puts et al., (2021).

Fifthly, future policy should prevent significant regional differences due to revenue sharing with the area. It must also ensure that the revenues generated are used sustainably. The great future financial uncertainty and changing zeitgeist require a dynamic policy that the ministry can adjust over time.

Finally, it is crucial to describe the 'why' in concrete terms in the policy choices. In our substantiation of 'why do we want to create that support', the policy must be very clear to justify any future changes to the residents, operators and other stakeholders involved. In this way, it is possible to respond to the changing zeitgeist, the uncertainty in (technical) risks identified, and the unknown shape of the future Dutch energy system.

8 Discussion and Future Recommendations

In this chapter I discuss the results, propose policy arrangements and elaborate on the study limitations and suggestions for future research. In subsection 8.1, I propose policy arrangements, based on insights gathered and recommendations made during the interviews, and assess the outcome of these and current regulations for the themes identified, using the framework developed by Pesch et al. (2017). I analyse whether this is an 'ideal situation' and assess whether the emergence of controversies can be avoided. I also present generic policy recommendations that are fundamental for the policy arrangements and indicate more general improvements. Then, in subsection 8.2, I discuss the limitations of this research and give advice for future work. Lastly, in subsection 8.3, I present a scientific reflection on the use of the framework for our research.

8.1 Policy recommendations

Here, in early paragraphs, I propose policy arrangements and assess current regulations for the individual themes identified. In the last three paragraphs I present more generic recommendations.

National coordination on underground energy storage

The first issue identified is that local stakeholders expect to be able to co-decide on location, and type of project choices, while currently, operators and the Ministry of Economic Affairs and Climate make these decisions together before involving the public over how the project may fit. It became clear that all stakeholders require a national vision coordinated by the national government. Currently, the government is drafting a national plan in close consultation with provinces, municipalities, water authorities, interest groups and residents. This will ensure justice is perceived by both trajectories by where the moral authority of the claims is based on shared democratic principles. Reaching all stakeholders and achieving broad engagement among residents in specific places is challenging and requires the use of various information channels. Spreading information and ensuring engagement using social media and door-to-door flyers is advised. The competent authority, in this case the Ministry of Economic Affairs and Climate, is responsible for reaching all stakeholder groups. Since this ministry is experienced in working with companies and other government bodies, it is important that the knowledge needed to reach out to residents is either acquired in-house or cooperation is sought with other ministries more acquainted with operating at this level.

Secondly, the national plan will address local stakeholders' concerns on the unintended accumulation of activities which turn some areas into veritable 'energy hubs'. This map clarifies for residents where initiatives will take place in the (nearby) future, and which, so they will no longer experience surprises and operators and government authorities are able to share one narrative. This detailed subsurface plan allows the government to foresee the development of specific areas, ensuring that other energy projects who negatively impact the living environment can be spread out across the country. This form of national coordination of initiatives ensures that local stakeholders are not confronted with a salt cavern at first, followed by wind turbines and a solar park later. The perfect distribution will not exist due to geological differences, existing energy infrastructure and demographics, which results in some local stakeholders feeling disadvantaged. Reaching a complete consensus is impossible, so the concern that specific areas will contribute more to the Dutch energy system will never fully be eradicated.

Lastly, divergent perceptions of justice in answering "why is this project necessary, and why does it have to be here?" cause controversy. When completed, the national plan will enable stakeholders within the formal assessment trajectory to answer these questions by sharing a clear narrative that was drawn up in consultation with stakeholders from the informal assessment trajectory. There will always be stakeholders who disagree with how the future Dutch energy system is shaped, as it is impossible to adhere to everyone's preferences and opinions, including those who do not want any projects and point at other solutions (e.g. import of energy and continuous use of fossil fuels). These varying opinions will always exist, which once again highlights how reaching complete consensus is unrealistic. However, the issues that have been identified, will lead, in the future, to less controversy when the national plan is rolled out.

Damage handling

In the following paragraphs I sketch an ideal situation regarding the organisational and financial handling of damage claims, based on insights gathered and recommendations discussed during the interviews. The framework for understanding the role of perceptions of justice in the dynamics of controversy is used to analyse this 'ideal situation' and assess whether the emergence of controversies can be avoided.

There must be one single damage handling institute whose working principle is similar to that of the LCM. The resident hands over the claim to this institute, after which they take over. Independent experts assess the damage and judge whether the damage is a result of mining activities or is caused by something else. Newly gathered information should always lead to an adjustment of the applied standards and used models. If the damage is caused by mining activities, compensation is paid in deeds instead of money. The latter helps reduce the hassle, a crucial factor in immaterial damage and ensures payments are used for damage repairs. Local contractors should be employed as much as possible to ensure the regional economy can profit, reducing the idea that only experts and companies from the 'Randstad' profit from damage settlements. A fund guaranteed by the national government covers the claims. The bill is then forwarded to the operator by the government. If due to an accumulation of activities, it is unclear which activity has caused the damage, the bill must be split by the operators. Operators must be obliged to pay the bill and cannot proceed against it. A guarantee by the national government, and an obligation by operators to pay when independent experts hold their activities accountable for the damage, is essential in realising the trust required.

If the damage is not caused by mining activities, the damage handling institute must point out the cause. This ensures broader support amongst residents. Furthermore, it reduces the negative characteristics of the underground by telling an honest story; not all damages are the result of mining activities. The State Supervision of Mines (SodM) could play a role in monitoring the negative social and psychological effects on residents and safeguarding them. In their advice, the SodM increasingly incorporates these risks already, but it is not clearly defined as their responsibility. Protecting residents from negative social and psychological effects is vital to ensure immaterial damage is taken seriously and trust in the government and operators is restored.

The damage handling institute should be represented regionally to ensure more generous settlements in specific and individual cases that ask for it. Too regional is unwanted as humans tend to be extra helpful to the people close to them. On the other hand, having one central institute in The Hague does not allow for a more personal and generous approach when one is required.

Considering the proposed policy arrangement, the framework is used to analyse whether the issues are resolved, indicating varying perceptions of justice, regarding the handling of damage claims and leading to controversies identified in the interviews. No matter how well the handling of claims is regulated, there will always exist situations where local residents are dissatisfied (i.e. do not agree) with the settlement of the claim. Since it is precisely the negative experiences that spill over, the informal valuation process will continue to be shaped by controversy spillover. The first issue identified relates to municipalities and residents who express claims that as operators and the government profit from activities in their surroundings, so they should compensate for any negative impact. Even if according to experts and statistical models, the damage is unlikely to be the result of mining activities, this should not matter for compensation as residents already have to cope with the effects on their living environment. In the proposed procedure of handling damage claims, independent experts assess the damage and judge whether the damage is a result of mining activities or caused by something else. Operators will simply not accept paying for all damages in an area, especially when considering that the Netherlands live in a delta. This issue will never be completely resolved.

In the proposed operating procedure, a more generous settlement in specific and individual cases is foreseen. For some people damage has a much greater negative impact and affects the quality of life more than others. The very personal character of immaterial damage makes is impossible to satisfy everyone. Therefore, this issue will not be completely resolved either. The last issue concerns how having significantly less damages in the region before the subsurface activities started and knowing that these activities can lead to damage, residents and other local stakeholders assume that operators are responsible and expect them to prove their innocence. The evidence presumption is not part of the proposed procedure and therefore the last issue will not be resolved.

To conclude, the proposed procedure fails to fully solve the issues identified. However, having one single institute and clear operating procedures, generously compensating in specific individual cases, and acknowledging immaterial damage, will lead to far less controversies. There will always be people who feel excluded or treated unfairly, however, it is expected that this group will be much smaller under the proposed damage handling procedures.

Division of roles and responsibilities

The new Environment and Planning Act will reveal any flaws after implementation and give rise to yet undiscovered considerations and perspectives, which inevitably asks for revision of the policies in place. In the new Environment and Planning Act, the initiator is the central figure, and the initiator is obliged by the competent authority to participate. It is well-meant; as an initiator, you must engage with your surroundings. But if the government does not provide a framework for the rules, some parties will be disappointed. Stakeholders then enter the situation with their pattern of expectations, which can never be individually aligned. Previous research by Puts et al. (2021) has revealed several essential process criteria for the proper embedding of underground energy storage in society. The Mining Act and the new Act do not create any barriers in applying the process criteria. Ensuring these process criteria are embedded within the project procedure reduces the tensions that arise as a result of how the two assessment trajectories differ in terms of the logic through which concerns are articulated, and they take different dimensions of energy justice as their starting point. One will never reach a complete consensus, and there will always be actors that feel unheard or disadvantaged.

Distribution of benefits and burdens

In the following paragraphs I sketch an ideal situation regarding the distribution of benefits and burdens, based on insights gathered and recommendations discussed during the interviews. The framework for understanding the role of perceptions of justice in the dynamics of controversy is used to analyse this ‘ideal situation’ and assess whether the emergence of controversies can be avoided.

Considering the distribution of burdens and benefits, cooperatives are an elegant way to ensure regional benefit sharing and create ownership. A fixed percentage of the revenues should flow to an area fund. Of this fixed percentage, a part should be paid to a local area fund, and the other portion to an area fund for the entire province. The area funds should be managed by a local board consisting of residents and municipalities. Within the province area, fund management should consist of province and municipality representatives and residents. Every few years, the board should change or be elected to ensure all opinions and desires are considered over time. The area fund must be able to decide for itself how to spend the earnings. If some regions want to spend it on energy bill reductions while others on art installations or a swimming pool in the municipality, this should be a choice.

Considering the proposed policy arrangement, the framework is used to analyse whether controversies are expected to emerge. Where in the previously analysed issues, concrete concerns and considerations were discovered from the interviews, the distribution issue is characterised by opinions about a possible outcome. As there is no physical example of regional benefit sharing for onshore underground energy storage projects, only opinions and considerations regarding the future implementation have been gathered. Frequently heard points of attention were; (1) a generic framework ensuring equality, (2) local agreement on the sphere of influence, (3) differences in profitability of varying types of subsurface projects, (4) payment to the area must be in proportion to the projects' profits, and (5) the distribution of burdens and benefits should not feel like a bribe (i.e. a one-off payment). The proposed policy arrangement adheres to the points of attention. The formal assessment trajectory has still to emerge as there is no procedure or policy arrangement in place to create a collective assessment. Only time and experience with physical examples will reveal how successful the proposed arrangement is in safeguarding all considerations and preferences the stakeholders identified.

General policy recommendations

This framework, which explains existing processes and energy system controversies that have emerged, turns out to be of great value when formulating policy arrangements for financial participation. Expectations and considerations have been identified. Considering the three justice-related attributes allows the creation of a set of rules and policies that can adapt to the expected dynamics of energy justice. Drafting policies in close consultation with the various stakeholders and carefully listening to their considerations and dilemmas should therefore enable the government to foresee the process known as overflowing. Ensuring that the policy safeguards the societal and ethical risks in the eyes of stakeholders who belong to the informal assessment trajectory will result in more successful policies, perceived as more just by all stakeholders. In that way, backflowing can be limited which ensures transparent and long-term policy arrangements. The difficulty is in developing governance structures that are flexible enough to take into account different viewpoints and learn from controversies, and to enable a dynamic balance between the formal and informal trajectories.

The earlier mentioned drawbacks of missing examples of financial participation in the Netherlands and examination of a process regulated by a yet-to-be-introduced Act asks for a dynamic policy. The Ministry of Ministry of the Interior and Kingdom Relations is advised to allow for adaptation in the policy over time. Only then can it ensure that recent projects, where regional benefit sharing has been introduced, can be evaluated and this leads to improvements and modifications of existing policies. Furthermore, the changing zeitgeist also asks for re-evaluation of policies to adapt for yet unknown opinions and values. This is especially important considering our politically fragmented society, where opinion-forming is strongly driven by 'identity' and the perception of values, such as affordability, reliability and justice differ, and where social media are extremely powerful in creating 'audiences' with their political representation around specific issues. However, it is critical, considering the long life span of underground energy storages and the huge investments required, that the policies in place adhere to proper and consistent administration.

Therefore, considering the required dynamic character of the policy, it is essential to define and underline the 'why' behind current policy regulations. The government must make very explicit what the grounds were for choosing a certain policy. And also indicate how and why these grounds might change in the future, and what the consequences might be. The government will have to draft dynamic policies, but one has to provide good grounds as a policy maker or government to be legitimised to make adjustments and possibly compensate for them. This can always work both ways, with advantages and disadvantages for both the operators and the government. And in a certain sense, of course, it's also a kind of normal policy risk or entrepreneurial risk, which you have in any market. If a car manufacturer is suddenly confronted with stricter emission requirements, then yes, you will have to go along with that. However, the market has to know that if things change, the government can and will reconsider current policies. As an operator, you can then incorporate that into your risk assessment and by doing so anticipate on it in some way.

8.2 Limitations and suggestions for further research

Firstly, although throughout the research, all stakeholder groups active in onshore underground energy storage have been interviewed, the timing of the information-gathering process plays an essential role in the study findings. The experts interviewed provide a good representation of the key considerations and perspectives regarding implementing financial participation in onshore underground energy storage. However, as only a few examples exist of financial participation in the Netherlands, it is yet unknown how these considerations and perspectives may change in the future. In later research, drawing on realised projects and examples will allow discovery of emerging considerations and perspectives.

Secondly, as the experts interviewed drew on personal experiences, this study does not claim that the considerations and perspectives identified tell the full story. Some of the experts interviewed were more actively involved in relevant processes than others or have been active in the field for longer. A new set of interviews, held among the same stakeholder groups but with different participants, could therefore lead to identifying perspectives and considerations that are so far undiscovered in this study.

Thirdly, in all interviews, the interviewer is crucial in safeguarding the process of information gathering by exploring opinions and watching for leading questions. Being new to the field of social sciences and holding interviews as part of the information gathering process, it is inevitable that the quality of the interviews has played a role in the objectivity of the information gathered. Future research and expert interviews conducted by a more experienced researcher will allow for identifying dilemmas and perspectives missed during this research.

Lastly, the introduction of the new Environment and Planning Act is being postponed for the fifth time and is now scheduled for the 1st of January 2023. Perspectives and considerations, even if supported by years of experience, will differ from reality when drawing on physical experiences. Therefore, it is essential that when the new Environment and Planning Act is introduced, stakeholders' considerations and perspectives are re-examined. Any new insights or themes identified will support the required adaptation for regulations and policies over time.

8.3 Scientific reflection

The framework was developed to understand how justice-related claims play a role in the dynamics of controversy in energy projects, and was based on two case projects (CCS and shale gas) in the Netherlands. When reflecting on what this scientifically formulated theoretical framework contributes to understanding and interpreting controversies in onshore underground energy storage projects, two aspects are highlighted.

The first aspect relates to the selected qualitative research approach in which exploratory interviews are the main information source. Qualitative research yields many statements in narrative form. The framework has been very useful in structuring, analysing and explaining the large amount of research information gathered. The second aspect concerns the fit of the framework to onshore underground energy storage projects. CCS and the exploration of shale gas are closely related to underground energy storage projects as these technologies are subject to the same laws and regulations, and therefore share identical project procedures. The justice-related attributes (i.e. drivers of controversies) that add to the dimensions of energy justice, have been very useful for analysing the statements of various actors. By linking the narrative statements to the attributes, it quickly clarifies how divergent justice claims lead to controversy.

Added insights for the future application of the framework

Furthermore, two elements have been identified that were important in the analysis of this research, which were originally not part of the framework. The first relates to how the framework assumes that stakeholders know the risks and the set of rules (i.e. dominant institutional practices) that guide the collective assessment within the formal trajectory, and by overflowing results in concerns forwarded in the informal trajectory. For new technologies (e.g. UHS) and policy arrangements (e.g. financial compensation), there are no set of rules, and therefore no collective assessment. If there are no rules, an informal assessment arises that is based on expectations and opinions rather than on considerations and dilemmas. Controversy spillover in these cases plays an important role, as this dynamic is the driver of expectations and opinions that emerge within the informal assessment trajectory. The framework can thus be used to write policy arrangements and regulations that form the formal trajectory, taking into account the expectations, views and opinions that have already arisen within the informal one. This ensures overflowing and backflowing are limited, which is essential in ensuring legitimate, consistent and effective energy policies.

The second element relates to a suggestion for future research presented in the paper by Pesch et al. (2017) that introduced the framework. According to Pesch et al. (2017) "new research might, for instance, address the role of incumbent actors in forwarding new concerns" (p.7). Within the paper the focus was on the role of new groups that have been triggered by perceptions of injustice. Throughout this research it has become clear that incumbent actors (i.e. municipalities and water authorities) play an important role in forwarding new concerns. These actors are in close contact with the public, and often live in the same area, also influenced by underground energy storage projects. Therefore they tend to address and underline the societal and ethical risks discussed in the informal assessment trajectory and also forward new concerns (related to their expertise and area of interest). As these actors are government authorities, public controversies are not limited to divergent justice claims between residents and authorities. In the new Environment and Planning Act, it is mainly the local government (i.e. municipality) that is the competent authority for installations above ground. In the Mining Act, the competent authority for storage in the deep underground is the Ministry of Economic Affairs and Climate. Strategic groundwater reserves are the province’s responsibility. Underground energy storage has an underground and an above-ground element which is inevitably connected, so it will have to deal with three levels of government. Radiating discord among public authorities does not help to restore trust. The latter being a prerequisite in realising an efficient, affordable, sustainable and just energy system.

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APPENDICES

APPENDIX A: Technical Background: The Risk of (Induced) Seismicity

This chapter aims to describe the technical aspects of (induced) seismicity and soil subsidence that explain the occurrence of earthquakes in the Netherlands. The analysis and gained knowledge play a critical role in guiding the interview process by safeguarding the proper assessment and view of possible hazards and risks regarding onshore underground energy storage projects. At first, in subsection A.1 we dive into the geology of the Dutch subsurface and analyse (triggered) natural seismicity. Followed up by a thorough study of the complex mechanisms that lead to induced seismicity in various subsurface activities related to underground energy storage in subsection A.2. At last, indirect damage resulting from deep subsidence is described in subsection A.3.

A.1 Plate Tectonics and (triggered) natural seismicity

Geology of Dutch subsurface

Tensile tensions are produced on the earth's crust (lithosphere) above convection cells of magma in the asthenosphere (mantle). The plate boundaries that originate from these intermittent fissures in the earth's crust are characterised by divergent (pushing apart), convergent (subduction), and transform (lateral sliding) movements. A large amount of subsurface data has been gathered due to the numerous natural gas and oil deposits found in the Dutch subsurface and the subsequent exploitation of these areas. A perforated subsurface has been left behind by more than 5,000 exploration and production wells, and 3D seismic surveys cover nearly 60% of the nation. This wealth of data allowed the detailed mapping of the current lithostratigraphic and structural framework of the Dutch onshore (maps and datasets available at www.nlog.nl and www.dinoloket.nl) (Kombrink et al., 2012).

Data analysis revealed a system comprised of platforms, highs, and basin features from the Mesozoic and Cenozoic that had sediment thicknesses of up to 5 km (Kombrink et al., 2012). The structure and stratigraphy of the Dutch onshore and offshore subsurface have been impacted by four main tectonic periods over the history of tectonic activity (Wong et al., 2007). 1) The development of the Pangea supercontinent during the Caledonian and Variscan orogenies in the Palaeozoic, 2) Pangea's breakup during the Mesozoic rifting, 3) the Alpine inversion of the Late Crataesian and Early Tertiary, and 4) the Oligocene extension of the Rhine Graben rift system. The latter causing natural seismicity to occur in the southeast of the Netherlands.

Natural seismicity occurs in Oost-Brabant and Limburg in the Netherlands as a result of the Oligocene expansion of the Rhine Graben rift system. Here, Italy's separation from the African plate and collision with the Eurasian plate is causing the northern part of continental Europe to laterally expand. Tensile forces driving the subsurface apart have formed faults that have occasionally been reactivated. This process is comparable to stress building up at the bottom edge of a beam supported at both ends and loaded from above. This procedure is still in progress. An earthquake occurs when the shear stresses in these faults that have been slowly building up are abruptly released. Research by Houtgast et al. (2002) has shown that apart from the ongoing extension of the Rhine Graben to the southeast of the Netherlands, no tectonic activity occurred in the Netherlands.

Throughout history, the Netherlands formed the southern edge of large basins, which affected the distribution of deposited bodies of sediments (Geluk, M., 2000). Forming the edge of large basins has led to clear differences in subsurface sediments between the south and north of the Netherlands. In the northern half, the Permian Zechstein Group is present, which has thin clastics on its southern edge and has evaporated in the north (Muntendam-Bos et al., 2022). Located at the edge of salt water basins, the successive sedimentary development in the north has created salt structures of large thickness (up to 2 km thick). On top of that, a sequence of unconsolidated sediments of the North Sea group, predominantly composed of sand and clay and varying in thickness from 250-1500 m, has been deposited. The top layer, making up the shallow subsurface (30m in depth), consists of heterogeneous sediments (i.e. sand, clay and peat) deposited by the last major glacial epoch, or "ice age". Important to note, and analysed in more detail later in this section, is the discovery of the effect that the "relatively low shear wave velocities of these sediments amplify the propagating seismic energy resulting in increased surface ground motions" by Kruiver et al. (2017). The source of gas in Dutch gas fields are the deep coal layers of the Carboniferous formation; pressure and heat changed some of this carbon and hydrogenrich material into coal, some into oil (petroleum), and some into natural gas (Wong et al., 2007). The gas rose to the surface and in the sandstones of the Carboniferous Limburg formation, the Rotliegend sandstones, the Z2 and Z3 Zechstein Carbonate layers, the Lower and Upper Triassic sandstone layers, and the Lower Cretaceous sandstones, it displaced the water and remained there because the salt layer above it sealed it off.

Natural seismicity

Natural earthquakes are occurrences unaffected by human activity and arise from plate tectonics. As previously indicated, the Roer Valley Graben (Dutch: Roerdalslenk), which is bordered by two significant active faults, is the site of the majority of natural earthquakes recorded in the Netherlands. The Peel Boundary fault in the northeast is the first. The Feldbiss fault, located to the southwest, is the second. The Roer Valley Graben is part of the Lower Rhine Graben (Muntendam-Bos et al., 2022). The latter outlines the northeastern extend of the active Rhine Graben (Houtgast et al., 2002). The majority of earthquakes caused by seismic slip in the Roer Valley Graben are limited in magnitude ($M_L < 4.0$) and strike at depths slightly deeper than the Roer Valley Graben itself (10–20 km depth) (Hinzen et al., 2021). However, now and then more powerful earthquakes occur, M_L = 5.8 in 1992 just south of Roermond (Peel Boundary fault) and M_L = 5.0 in 1993 near Uden, which caused extensive damage at the surface (Heinz, 1937; Paulssen, 1992). According to Dost & Haak (2007) natural seismicity appears to terminate to the northwest of Uden, and outside these regions only incidental events were observed near Nijmegen and on the Dutch continental shelf (Muntendam-Bos et al., 2022).

Triggered seismicity

In areas with natural seismicity, earthquakes can be triggered by anthropogenic activities (e.g. post-mining water ingress, geothermal heat extraction and shale gas fracking). Removing rock during mining operations may bring nearby faults closer to failure due to a change in the state of stress in the surroundings. Furthermore, pumping out groundwater to keep the mines in operation lowers the pore pressure in the rock. Just lowering the pore pressure will increase the faults' strength and basically counteracts rock removal's effect, but poro-elastic effects may counteract this beneficial effect. The triggering of earthquakes may also occur after a mine is abandoned and pumping groundwater away is terminated. The recharge of natural groundwater leads to increasing water pressure along the stressed faults and thus a reduction in normal stress. As a result, the friction along the fault is reduced, and this can lead to fault reactivation, causing an earthquake (Muntendam-Bos et al., 2022). The increase in mass due to the rising groundwater could be an additional driving force of fault movement and thus the development of triggered seismicity. Considering geothermal heat extraction, the balance between injection and production causes only a minimal pressure change in the reservoir (except for the zones close to the wells). However, another potential source of earthquakes during geothermal production in areas with natural seismicity is the low(er) temperature of the return water (typically 30-50 degrees C back compared to 70-80 degrees C out) which in turn causes shrinkage of the rock. The major uncertainty about the exact location of (potentially stressed) faults in the Roer Graben and the uncertainty about "in-situ" stress states and material properties has led to a recommendation by the

"Commissie Helsloot" to declare a moratorium on geothermal operations in Limburg and Oost-Brabant. The Mijnraad supports this advice, but it is not yet a law or a cabinet decision.

A.2 Induced seismicity

In addition to "triggered earthquakes", where human activity results in the sudden release of stresses built up through natural processes (plate tectonics), we also encounter "induced earthquakes". In that case, not only the sudden release but also the source of the stress build-up stems from human activity, such as the filling of water reservoirs behind large dams, the subsurface disposal of large amounts of wastewater, or the production of large quantities of hydrocarbons without re-injection of gas or water for pressure maintenance.

A.2.1 Gas extraction

The Dutch onshore and offshore subsurface is home to a sizable number (over 450) of gas fields, 263 of which are still in production as of 2021 (87 onshore and 176 offshore), as seen in figure 9 (MuntendamBos et al., 2022). A whopping 3548.5 billion Nm3 of gas was generated between 1960 and 2021, and 62% of that came from the Groningen gas field (the largest onshore field in Europe and ranked ninth worldwide). The bulk of these fields are situated in a region where substantial Zechstein salt deposits seal the Rotliegend sandstone, as described in subsection A.1, and visualised in Figure 9. The other fields are located in sandstone and carbonate layers in the Triassic and Lower Cretaceous formations and the Zechstein formation, respectively (Muntendam-Bos et al., 2022).

The first seismic event related to gas production was recorded by the Royal Dutch Meteorological Institute's (KNMI) natural seismicity monitoring network on the 26th of December in 1986, near the town of Assen, with a local magnitude of 2.8 (Muntendam-Bos et al., 2022). A local network of geophones, devices that can convert ground movement (acceleration) into voltage, was installed. Right after, more and more events near gas fields in that area were recorded (Muntendam-Bos et al., 2022). By far the most seismically active gas field in the Netherlands is the Groningen gas field, with 1396 observed and registered events ($0.8 \leq M_L \leq 3.6$) to date (January 1st 2021) (Muntendam-Bos et al., 2022). The Groningen gas reservoir is located at a depth of 3 km within the Rotliegend sandstone (van der Voort & Vanclay, 2015). 3D seismic surveys have led to the identification of over 1100 faults within the gas field (de Jager & Visser, 2017). Analysing past induced events, it becomes clear that the earthquakes mainly occurred in the central and southwestern parts of the field, on fault lines of two NNW-SSE orientated graben systems within the Groningen gas field (Muntendam-Bos et al., 2022). Research carried out by Pickering (2015); Spetzler & Dost (2017); Willacy et al. (2019) has shown that most induced events occur within the reservoir layer. Furthermore, an analysis of stress concentration mechanisms derived for a subset of events performed by Willacy et al. (2019); Dost et al. (2020) shows that predominantly normal faulting mechanisms occur with occasionally a minor strike-slip component. The first (M_L = 2.4) occurred in 1991, just before the causal relationship between gas production and observed nearby earthquakes was acknowledged after research carried out by Roest & Kuilman (1994). Before that, experts believed that in the northern Netherlands, natural and thus induced seismicity, did not exist. After discovering the Groningen gas field, geophones were installed, which did not record any alarming movement. Therefore, triggering should not be possible, and most experts agreed that the large-scale production of natural gas does not result in earthquakes. Severe compaction and subsidence, as a result of reservoir pressure depletion, were expected and indeed occurred. However, the bowl-like shape that a large reservoir like the Groningen field would leave behind drops gradually over a vast area and period. This gradual and evenly distributed subsidence may disrupt the water management at certain places but does not cause earthquakes.

The gradual and even subsidence should, according to the then known models, even contribute to an increase in sliding resistance. As the grain pressure increased by removing the gas pressure, the sandstone layer was expected to compact in the same way vertically and horizontally. However, considering the entire system, it was eventually discovered that the various sublayers that build up the sandstone layer are vertically shifted with respect to each other. Over hundreds of millions of years, other earthquakes have caused these sublayers to slip, resulting in faults: shifted sublayers with a throw (vertical offset). This alone would not explain the magnitude of earthquakes observed recently. The most significant event to date (M_L = 3.6) occurred on 16 August 2012 (Muntendam-Bos et al., 2022). Researchers investigated the consequences and found that "the event caused significant nonstructural damage throughout the region and led to anxiety among citizens and substantial public turmoil" van der Voort & Vanclay (2015).

Roest & Kuilman (1994) using simple models showed that "due to poro-elastic stress changes induced by pressure depletion in a gas reservoir, the effective vertical stresses could increase much faster than the effective horizontal stresses, enabling local normal faulting reactivation of sub-vertical faults within the gas reservoirs". The decrease of normal stresses on a fracture due to gas production (instead of the previously expected increase) is caused by a combined "poro-elastic effect" whereby the increase of normal stress due to pore pressure reduction is more than compensated by a decrease due to horizontal "shrinkage" of the rock (Jansen et al., 2019). In-situation experiments carried out at Utrecht University pointed out that one specific sublayer just above the sandstone reservoir, containing anhydrite minerals, actually has a velocity weakening friction coefficient. An important aspect of the occurrence of an earthquake after the onset of slip on a fault is the subsequent loss of frictional strength (Scholz, 1998). So when that layer starts slipping, it will not experience a greater resistance but less. Most layers that move a little slow down and come to a halt, but the slip-weakening nature of some of these layers may cause them to slip suddenly and generate a seismic event. Due to ongoing gas extraction, the building up of stress on the faults (i.e. loading) occurs relatively homogeneously throughout the large field (Muntendam-Bos, 2020). It was shown by Muntendam-Bos (2020) that "regionally various but similarly orientated fault patches can be close to failure at the same time and induce a sequence of events or larger-magnitude events, within a limited region in a relatively short time frame". This explains the large magnitude earthquakes that experts were not able to explain beforehand. Furthermore, due to the soft topsoils in combination with shallow hypocenters, in the Netherlands events exceeding magnitude 1.5–2.0 may be felt by the public. This is because the soft topsoils cause the amplitude of the seismic shear waves to increase when propagating through less and less stiff layers. As a result, strong peak accelerations are experienced at the surface. These may be damaging to houses and infrastructure.

Van Eijs et al. (2006); van Thienen-Visser et al. (2012) conducted an elaborate statistical assessment of correlations between reservoir properties and induced seismicity and concluded that "besides the pressure depletion, the ratio between the overburden’s Young’s modulus and the reservoir’s Young’s modulus (the stiffness ratio) as well as the fault density could be key parameters for distinguishing seismically active from seismically inactive fields". Assessing the results from these studies, Muntendam-Bos et al. (2022) noted that a large number of fields had similar key parameter values to those of the seismically active fields but did not show any recorded seismicity. This points out that the knowledge of the material properties and physical processes in the Dutch subsurface is still too poor to fully explain the (non)occurrence of induced seismicity due to gas production Muntendam-Bos et al. (2022).

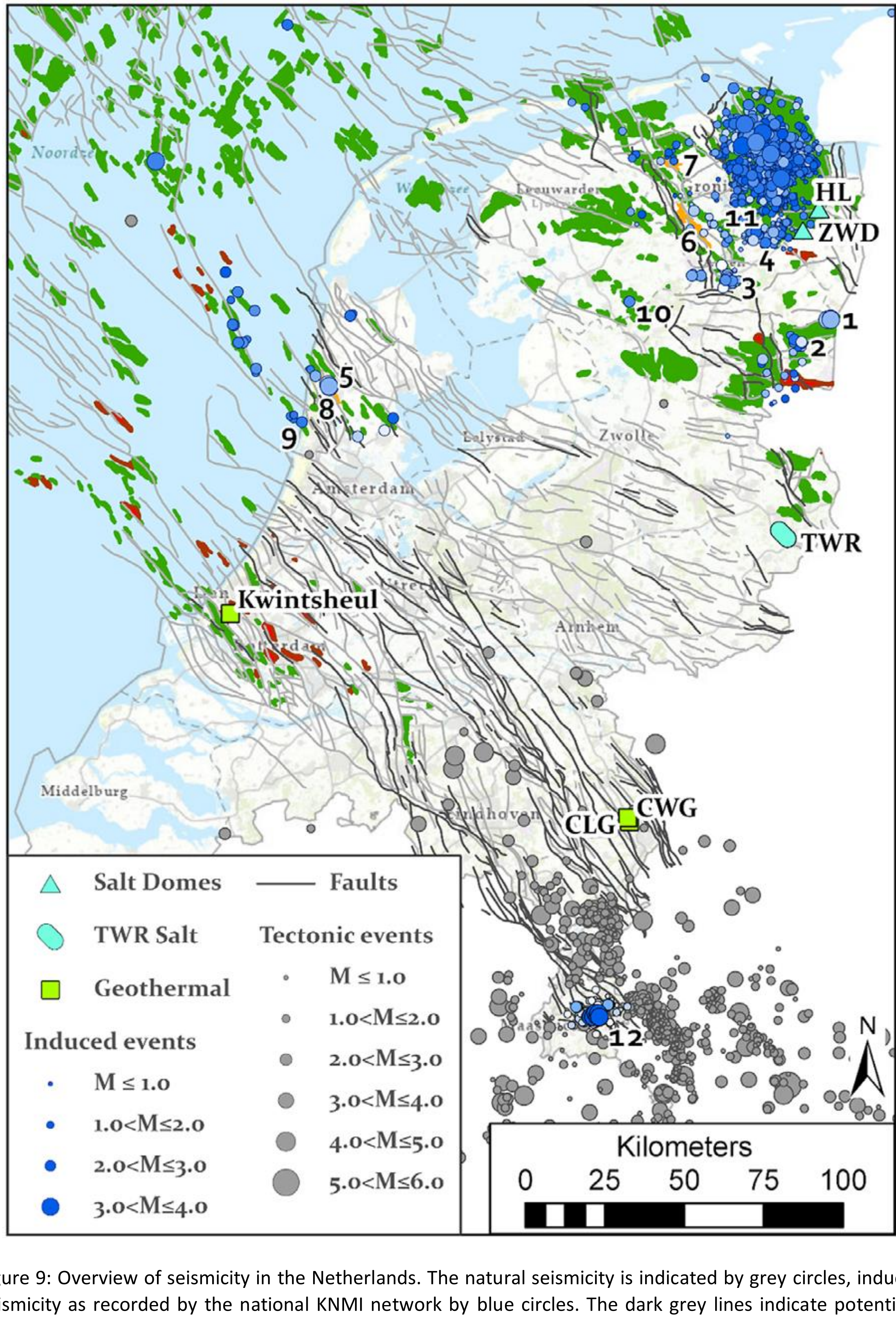

Figure 9: Overview of seismicity in the Netherlands. The natural seismicity is indicated by grey circles, induced seismicity as recorded by the national KNMI network by blue circles. The dark grey lines indicate potentially tectonically active faults; the light grey lines indicate faults in the Permian formations. Oil and gas fields are denoted in red and dark green, respectively; the underground gas storage (UGS) gas fields in orange: 1-Roswinkel, 2-Emmen, 3-Eleveld, 4-Annerveen, 5-Bergermeer, 6-Norg, 7-Grijpskerk, 8-Alkmaar, 9-Castricum Sea; 10-De Hoeve earthquake; 11-Midlaren seismic swarm; 12-post-mining water ingress induced seismicity. Geothermal doublets associated with seismicity are shown as bright green squares, salt domes with large solution mining caverns by cyan triangles, and the shallow solution mining area of Twente-Rijn by a cyan ellipse. CWG: Californie Wijnen Geothermie; CLG: Californie Lipzig Gielen; HL: Heiligerlee salt dome; TWR: Twente-Rijn; ZWD: Zuidwending salt dome. (Muntendam-Bos et al., 2022)

Currently, 38 gas fields in the Netherlands are associated with induced seismicity (Muntendam-Bos et al., 2022). Most observed earthquakes have a relatively small magnitude ($M_L < 2.5$) but can cause ground motion nuisance (and occasionally minor cracks and other non-structural damage). This is especially disturbing amongst a population that has never experienced seismic events and is not expecting earthquake shaking, and with a building stock that has not been designed to withstand earthquakes. Larger earthquakes ($M_L > 3.0$) occur less frequently but can cause structural damage to buildings and infrastructure. So far, in three Dutch gas fields induced seismic events with a local magnitude larger than 3.0 have been observed (Muntendam-Bos et al., 2022). These are the fields located near Roswinkel (up to 3.4), Bergermeer (up to 3.5) and Groningen (up to 3.6) (Muntendam-Bos et al., 2022). The frequency of occurred earthquakes varies significantly amongst the gas fields, and in most fields (30) less than five induced seismic events were recorded (see Figure 9).

Up to today, there is still considerable debate about the best method for determining the frequency of an induced earthquake of a specific magnitude. According to Muntendam-Bos et al. (2022) best practices comprise "short-term forecasting based on patterns and rates of recent seismicity in combination with a truncated Gutenberg-Richter magnitude-frequency distribution", as brought forward by Dost et al. (2013); Dost & Spetzler (2015); Petersen et al. (2016, 2017, 2018); van Eck et al. (2006). However, the Gutenberg-Richter magnitude-frequency distribution and the truncation of it was developed for natural seismicity and not induced seismicity. As the maximum magnitude of induced earthquakes results from the induced energy, one cannot just extend the fitted line connecting events to find out the frequency of occurrence of an earthquake of larger magnitude. Muntendam-Bos & De Waal (2013) confirmed this by showing that "an upper magnitude bound can not be derived with a statistical analysis of the Groningen seismicity data of that time". It was concluded by Muntendam-Bos & De Waal (2013) that earthquakes with magnitude up to $M_L = 5$ could not be excluded. Knowing that the induced earthquakes can be of severe magnitude, possibly resulting in surface damage and thus safety issues, the Dutch government decided to reduce the production from the Groningen gas field following the publication of the Muntendam-Bos report. Visible cracks in the structure of houses results in local citizens feeling less safe in their homes, these safety concerns, physically and mentally, are what causes the public support to decline drastically. In six consecutive ministerial decisions, the yearly production decreased from 54 bcm in 2013 to 21.6 bcm in 2017 (Muntendam-Bos et al., 2022). In 2018, the former Minister of Economic Affairs and Climate decided that production from the Groningen gas field should be terminated entirely in 2030 (Wiebes, 2018). However, only one year later, in 2019, the termination of production was promised to be in 2022 (Wiebes, 2019). As a result of the strong production reduction, the seismic activity in the Groningen gas field decreased. This relation is clearly visible for the Groningen gas field but does not hold for all (smaller) gas fields (Muntendam-Bos et al., 2022). Muntendam-Bos (2020) thoroughly investigated the seismic activity after the reduction and showed that larger-magnitude events ($M_L \geq 3.0$) and surges of lower-magnitude events ($0.5 \leq M_L \leq 2.5$) are still observed. This can be explained by the ongoing increase of stress on faults with ongoing gas production, be it at a lower rate. Moreover, the spatially uneven production of the Groningen field has caused an unbalance in the pressure distribution. This means that, even after stopping production altogether, pressure equalisation will cause slow changes in subsurface stresses, which therefore may still cause seismicity. Also, a gradual future rebuild of pressure in the water-bearing layer (aquifer) below the Groningen reservoir may potentially result in continued seismicity after the closure of the field.

A.2.2 Underground gas and hydrogen storage (UGS and UHS)

Dutch citizens are more aware of the risks associated with UGS and UHS as a result of the problems surrounding the gas extraction from the Groningen gas field, which highlight the dangers of induced seismicity and subsidence. It is generally known that the extraction of natural gas and salt from the subsurface results in subsidence. When investigating the cause of the subsidence, it was found that for salt caverns, the amount and rate of subsidence depend on the rate of salt creep. The rate of salt creep is determined by the pressure, temperature and type of salt in the cavern (van der Valk et al., 2020). Considering porous reservoirs, the amount and rate of subsidence are the result of compaction. The total compaction depends on several factors; 1) the pressure inside the reservoir, 2) the friction angle, 3) the type of reservoir rock, and 4) the properties of surrounding formations (Wang et al., 2012).

Underground, in compressed gaseous form, in salt caverns, and possibly even in depleted gas fields, hydrogen can be stored. Similar to natural gas, hydrogen may be stored in quantities ranging from tens of millions (salt cavern) to (perhaps) billions of m3 (depleted gas field). The technological potential for UHS in the Netherlands is significant: 277 TWh in depleted gas fields and 43.3 TWh in salt caverns (van Gessel et al., 2021). Four pure hydrogen storage facilities in salt caverns are now in use throughout the world, and experience with these locations has demonstrated that hydrogen can be securely stored in this manner for a long time (Groenenberg, Koornneef, et al., 2020).

Before hydrogen can be safely stored in salt caverns, a few critical challenges remain to be addressed. The thick salt layers are effective in trapping the universe’s lightest molecule; what remains to be researched is the integrity and durability of wellbore materials and interfaces, as the injection and withdrawal are expected to occur much more frequently and cyclically and at higher volumetric rates than is currently the case with natural gas (Groenenberg, Koornneef, et al., 2020). Although hydrogen has a higher energy density than natural gas (expressed in energy content per unit weigth), being the lightest molecule, hydrogen has a very low density. Therefore higher volumetric rates are required compared to natural gas (Groenenberg, Koornneef, et al., 2020). Hydrogen can potentially be stored in depleted gas fields, as was shown by recent demonstration projects in Argentina and Austria, where a mixture of hydrogen and natural gas was injected into a depleted gas field without adverse effects on installations and the environment (van der Valk et al., 2020). However, even though the mixture contained only up to 10% of hydrogen, not all hydrogen was recoverable due to diffusion, dissolution (into formation water), and conversion to methane. Currently, no depleted gas fields exist around the world where pure hydrogen is stored. Questions that remain to be answered and challenges to be addressed are regarding the influence of geo- and biochemical reactions of hydrogen with rocks, fluids and micro-organisms in depleted gas reservoirs and the potential (technical, environmental, and economic) risks associated with these reactions; in particular the formation of hazardous and/or corrosive fluids, and the degradation of injection and/or withdrawal performance, that may negatively impact feasibility (van der Valk et al., 2020).

The results of a literature review combined with geochemical modelling indicate several geochemical processes that are important in storing hydrogen in the Netherlands. These are 1) the reduction of iron minerals forming H_2S; 2) chemical reactions leading to sequestering H_2 and producing H_2O; and 3) reactions and H_2S formation that may affect the performance, safety, materials selection, facility design and economics of storage (van der Valk et al., 2020). To better understand the risks of these geochemical processes, it is essential to conduct laboratory experiments. The results of these experiments can be used to improve the accuracy of the geochemical models used.

Risks

The potential hazards and corresponding mitigation strategies were identified for UHS in salt caverns and gas fields in recent research by van der Valk et al. (2020). Six major risk themes related to hydrogen storage emerged from this assessment. These are: 1) material durability and integrity; 2) hydrogen leaking; 3) blow-out; 4) diffusion and dissolution; 5) hydrogen contamination; and 6) deep subsidence and/or induced seismicity (van der Valk et al., 2020). The risk themes highlighted were then used to compare UGS with UHS. Although the risk profiles for UHS and UGS are usually comparable, the study by van der Valk et al. (2020) discovered that there are certain differences and particular issues for UHS. These include hydrogen geo- and biological processes in the subsurface, hydrogen flame detection, the explosion danger related to hydrogen or methane leaking in confined places, the hydrogen flammability range and ignition energy, and hydrogen flame features and dimensions. According to van der Valk et al. (2020), "further research (laboratory experiments, numerical modelling, material testing, pilot-scale field tests) is required in particular on a) the long-term durability of rocks and (well) materials (steel alloys, cement, etc.) when subjected to hydrogen under an alternating pressure regime that causes mechanical and thermal stresses, and b) interactions of hydrogen with rocks, fluids and microbes in reservoirs and their effects on reservoir performance, quality and retrievability of the stored hydrogen, and integrity and durability of materials subjected to products of such interactions (e.g. H2S)".

Natural gas reservoirs

As clearly outlined in subsection A.2, induced seismicity in gas fields is often brought on by a decrease in reservoir pressure. The properties of the reservoir rock that differ in space are the cause of the uneven compaction at distinct points in the reservoir. Moreover, shear stresses may build up along pre-existing faults leading to aseismic (i.e. gradual) or seismic slip (earthquakes). When converted to an UGS, similar processes occur in porous reservoirs (i.e. depleted gas fields). When the storage pressures fall below the pressure at the moment of stopping gas production and switching to a storage reservoir, compaction may still occur. Similar to a too low pressure, the reservoir’s internal pressure should never exceed a set maximum pressure (called the lithostatic pressure) to prevent the rock from being fractured. A safe operating pressure range in the present UGS is decided in conjunction with the regulator. Research by Liu et al. (2014) pointed out that it is "key to remain within this operational pressure range to reduce the magnitude and rate of surface subsidence and/or induced seismicity". When operating between the minimum and maximum pressures and given that a similar approach for UHS is used as for UGS, no large differences between these two types of storage are expected considering subsidence or induced seismicity (van der Valk et al., 2020).

The Netherlands now operate four underground gas storage (UGS) systems at Norg, Grijpskerk, Bergermeer, and Alkmaar, which are all located in old natural gas reservoirs. According to Muntendam-Bos et al. (2022), the UGS sites of Norg, Grijpskerk, and Bergermeer (see Figure 9) are "associated with seismicity during gas production prior to conversion to a storage system." No earthquakes have been recorded anywhere in the peak gas installation (PGI) of the Alkmaar gas field. The Platten dolomite, which is part of the Z3 Zechstein Carbonate formation and contains the Alkmaar PGI, is known for its high permeabilities and relative stiffness (Young modulus of 40 GPa) (Muntendam-Bos et al., 2022). As a result, there is little compaction in the field, making it suitable for high-rate peak production (Muntendam-Bos et al., 2022). The other UGS in Norg, Grijpskerk, and Bergermeer lie in the Rotliegend sandstone formation. Before conversion to gas storage, an earthquake with a local magnitude of 1.5 was recorded in Norg by the KNMI network in 1993 as a result of gas extraction. At the end of the conversion into an UGS (i.e. initial injection to full capacity), one more event was recorded in 1999 (M_L = 1.1) (NAM, 2018). At Grijpskerk, a single event with a local magnitude of 1.3 was reported in 1997 when gas was still being extracted. In 2015, the KNMI network recorded a second earthquake (M_L = 1.5) during cyclical operation. Four induced seismic events were recorded by the national seismic network at the Bergermeer gas field when gas was being produced (M_L = 3.0 and M_L = 3.2 in 1994, M_L = 3.2 and M_L = 3.5 in 2001) (Muntendam-Bos et al., 2022). Production was stopped in 2007, the field was transformed into a UGS, and cushion gas injection began in 2010. Since the spring of 2015, the UGS Bergermeer has been fully operational, and in 2017 the operator (TAQA Energy B.V.) installed a six-level geophone string (capable of detecting M_L = -1.5 events) in an existing production well close to reservoir depth (Muntendam-Bos et al., 2022). Three hundred sixty-six induced events were recorded after installation, with the strongest having a local magnitude of 0.7 (Muntendam-Bos et al., 2022). Most of the events occurred inside or just above the reservoir layer. The geophone string and national seismic detection network's threshold strongly affect the detection of events. Further examination of the detection network at UGS Norg reveals the seismic threshold to be M_L = 1.0, which explains why just one event was noted after conversion in Norg. In addition to the sensitivity and spatial coherence of the installed seismic network, the reservoir depth significantly impacts the ability to detect seismic events of smaller magnitudes, as equipment breaks down at greater depths due to high pressures and temperatures.

Extensive research has been carried out on the relationship between induced seismicity and gas storage operations in Dutch gas fields. According to Muntendam-Bos et al. (2022) "the general consensus of the studies is that induced seismicity in the Rotliegend sandstone reservoirs is possible during the re-injection of cushion gas and the cyclic storage phase in which only the volume of working gas is produced and re-injected. However, magnitudes are expected to remain well below the level observed during depletion". The pressure inside the reservoir is kept between the initial pressure before extraction and the pressure after the first depletion, during the cyclic storage phase. This is crucial in preventing induced seismicity, which leads to earthquakes.

Salt cavern systems

Research carried out by van der Valk et al. (2020) points out that "in salt, stress build-up leading to faulting is highly unlikely because it behaves visco-plastically, i.e., it bends rather than breaks, and therefore the risk of earthquakes induced directly by the storage operations (as a consequence of cavern convergence) must be considered negligible". Although it is highly unlikely that stress would accumulate within the salt, prolonged plastic deformation in the salt could cause movement along existing faults in the brittle rock layers above the salt, particularly above and around salt domes, which are frequently very tall but laterally constrained (van der Valk et al., 2020). Data shows the formation of fractures and upward movement of seismic events over time (Muntendam-Bos et al., 2022).

Currently, there is one storage operation active in the Netherlands where natural gas is stored in salt caverns instead of depleted gas fields. The UGS Zuidwending facility (see 'ZWD' in Figure 9) is home to ten caverns (A1-A10, of which six are currently leached) located at a depth of 1-1.5 km, having radii between 50 and 80 m and being 300-400 m high (B.V., 2017). In the Zuidwending salt dome, the Zechstein evaporates rose to depths as shallow as 200 m. The six leached caverns contain flexible gas supplies and operate as UGS facilities, able to assist in matching short-term natural gas supply and demand. Energystock (a daughter company of Gasunie) will use borehole A8 in 2021 and 2022 to measure and verify the future storage of hydrogen (UHS) in salt caverns, a process that has been demonstrated in the USA and UK Hystock (2022). In borehole A8, Energystock investigates the effect of hydrogen on equipment, the materials used, the cement and the salt wall. Samples are used to check whether the quality of the hydrogen injected is affected by unwanted reactions, affecting the purity when extracted. Furthermore, the operator currently investigates whether and how hydrogen requires different working methods and inspection equipment than natural gas. For example, it is crucial that the shut-off systems remain tightly shut under pressure Hystock (2022). After all, hydrogen is the smallest element on earth. The molecules need very little space to penetrate anything (H2Bulletin, 2022). Only when it is successfully demonstrated that storing hydrogen within salt caverns of the ZWD can be done safely, Energystock will proceed with the development of large-scale hydrogen storage, starting in cavern A5 at the end of 2026. The current A8 borehole will eventually be converted into a salt cavern and can then be used for hydrogen storage as well. Cavern A5 is currently being leached by Nobian, a producer of salt and other products based in Delfzijl. This is done in such a way that the cavern can be used for hydrogen storage (conventional caverns leached for salt production are too large to be converted into an UGS/UHS). It is expected that four caverns for hydrogen storage will be needed by 2030 to meet the market demand for hydrogen Hystock (2022); van Gessel et al. (2021).

On January 9th 2019, on the southern edge of the Zuidwending facility salt dome at a depth of 1275 m, the first seismic event (ML = 1.1) was recorded (Ruigrok et al., 2019). The KNMI could not establish the mechanism by which the seismic energy was generated and hypothesised "that the brittle rock overlying the salt might have moved due to salt creep" (Ruigrok et al., 2019). After the earthquake, the two operators (Energystock and Hystock) set up a local (micro-)seismic monitoring array in the salt cavern consisting of six seismometers and two geophones (at 60 m and 90 m depth) to examine any potential future seismicity in greater detail. Since then, multiple geomechanical events of low magnitude (M_L < 0.0) have been detected. Small observed earthquakes are occasionally caused when fragments of the salt dome's inner wall break off and fall to the cavern's floor (for example, an earthquake with M_L = 0.4 was recorded in 2021). The detection of this breaking off and subsequent differentiation of the mechanisms producing seismic events are made possible by 3D ultrasound imaging of the inside of salt caverns.

Salt solution mining

The extraction of salt was typically regarded as an aseismic activity. None of the deeper caverns had any occurrences, and tension buildup appeared implausible given the salt's visco-plastic behaviour. It has since come to light, however, that there are hazards involved with salt solution mining. An abandoned salt cavern collapsed near Hengelo in 1991, slowly migrating upward until it breached the surface resulting in a sinkhole with a diameter of 30 m and a depth of 4.5 m (Muntendam-Bos et al., 2022).

Old salt caverns can be stabilised by filling them with waste materials from the salt-production process (Nouryon, 2021). It is possible to monitor the stability of these potentially unstable caverns by installing local networks made up of seismometers and geophones. A local network in Twente recorded a total of 59 events, with magnitudes ranging from 2.6 ≤ M_L≤ 0.0. Most of the shocks were geomechanical and likely related to movements along known faults in the region, possibly brought on by stress equalisation around the caverns. Ten occurrences were brought on by cracks in the caverns' footwall or roof. Seismic monitoring has not yet shown any cavern instability (Muntendam-Bos et al., 2022). At two new sites, four more seismometers were added to this network in 2019. It is interesting to note that a substantial amount of the Heiligerlee-C seismic events were located at the depth of the salt overburden interface rather than at the cavern's depth. The shocks at the bottom of the caverns were probably caused by the salt caverns' natural closure, which resulted in "rock-fall" and shear events of moderate energy (Bosq & Wijermars, 2020). The events at the salt dome's crest may have been caused by the dome's upward migration, which resulted in enormous strains in the crest and layers above it as well as shear cracks in the cap-rock of the salt dome, according to (Jackson & Galloway, 1984). However, the specific focus of the events around HL-C is striking and calls for more research. Data depicts the progression of seismic events upward in time and the creation of fractures (Muntendam-Bos et al., 2022). The SodM emphasises that before LSES in salt caverns can occur, additional research on the significant hazards that have been found is necessary.

A.3 Indirect damage

A report written by Kooi et al. (2021) reports on a study into indirect effects of deep subsidence above and in the vicinity of the Groningen field and gas storage facility Norg caused by the gas production and storage activities. The effects focus on building damage. The research was carried out to provide the Institute for Mining Damage in Groningen (IMG) with an initial recommendation concerning these effects. The IMG is the independent administrative body responsible for dealing with all damage caused by tremors, subsidence and ground movements of natural gas production and storage connected to the Slochteren field. The advice requested relates to two areas of concern where deep subsidence/rises have occurred but which lie outside the area where a minimum speed of vibration may have occurred due to earthquakes in the Groningen gas field.

It was concluded that all possible indirect effects of deep subsidence occur through changes in the ground and surface water system. These ground and surface water level changes are, in first instance, autonomous but can be followed by changes made by water management institutes (i.e. 'waterschappen') to mitigate the undesirable consequences of the autonomous development. The following three impact paths have been distinguished (Kooi et al., 2021).

1. Changes in relative storage basin levels (boezempeil) compared to polder water levels and groundwater levels in adjacent parcels. The storage basin is surface water that serves to collect and drain away polder water, and the storage basin level or target level is the level of a storage basin in relation to the Normaal Amsterdams Peil (NAP).
2. Changes in polder water level of water courses compared to ground level (drainage).
3. Changes in regional groundwater flow due to the creation of the subsidence basin.

APPENDIX B: Omgevingswet

The new Environment and Planning Act (Omgevingswet) has been described as one of the most significant legislative changes since the introduction of the Constitution in 1848. Previously, projects had to be assessed for noise nuisance, environmental impact, safety and building heights by 26 laws. These will now be replaced by a single law, the 'Omgevingswet'. This should make it faster and easier to convert a garage into a business space, build houses on a former industrial site or turn an empty plot of land into a playing field. The introduction has already been postponed several times, but minister Hugo de Jonge of Housing and Spatial Planning does not want any more postponement: on 1 January 2023, the law must come into force. This means that, at the moment, nobody knows which law will be leading on 1 January: the new one or the old one. As a result, governments must keep two different software systems in the air, prepare double application procedures and make multiple fee regulations for the service provided. They experience this as a duplication of effort and see precious time being lost.
When the new Environment and Planning Act enters into force, the 'Rijkscoördinatieregeling' is replaced by the Project Procedure. The project procedure consists of five steps: 1) notification of the intention; 2) notification of participation; 3) exploration; 4) preferred decision, and; 5) the project decision. The Minister of Economic Affairs and Climate and the Minister of Internal Affairs and Kingdom Relations are joint competent authorities for a project decision. Delegation to the provinces is possible, provided the province gives its consent. Municipalities have an advisory role. The possibilities for participation differ per step in the project procedure. The Uniform Public Preparatory Procedure of section 3.4 of the Algemene wet bestuursrecht (Awb) applies to the preferential decision. In other words, anyone can submit their views on the matter.

A new element in the project procedure is that the competent authority, in the case of underground energy storage facilities, the Minister of Economic Affairs, will give everyone the opportunity, within the period indicated in the notification, to propose other possible solutions to the underlying problem. The competent authority will provide the starting points for reasonable consideration of the proposed solutions. Those who have put forward alternative solutions with due consideration of these principles may ask the competent authority to seek the advice of an independent expert on these solutions. This step in the procedure forces the competent authority to think carefully about defining the task in the physical living environment.

Part of this phase is also the notification of participation. The competent authority indicates how the public, businesses, civil society organisations and administrative bodies will be involved. In any case, the competent authority will address the following: 1) who will be involved; 2) what they will be involved about; 3) when they will be involved; 4) what the role of the competent authority and the initiator in involving these parties is and; 5) where additional information is available. The notification of participation shall occur in a manner determined by the competent authority. The relevant public must be reached as well as possible by this method. However, the law does not prescribe any substantive requirements for participation. The legislator's starting point is that the participation process requires customisation per project and location and that checklists should be avoided. The Ow encourages local stakeholders' early involvement, preferably before the legally prescribed decision-making procedure starts (Boeve & Groothuijse, 2019). When the competent authority is not the initiator of the development, both can agree on their role in the participation process. The competent authority must communicate this division of roles.

The final project decision will describe how citizens, companies, organisations, and administrative authorities were involved in preparing the decision, the results of the exploration phase, and comment on the proposed solutions. Although the Ow does not prescribe what the participation process should look like, the competent authority will have to show that the interests of all stakeholders have been weighed equally and proportionately. This includes the interests of parties who have participated as well as those of the government, and voiceless interests such as those of non-participating citizens and nature, landscape and cultural history, for example. In addition, in the project decision, the Minister discusses the project's design, the relevant permanent or temporary measures and facilities to realise the project and the measures aimed at cancelling, preventing, limiting or compensating for the adverse effects. Finally, the Minister must explain how the environment has been taken into account and the extent to which the solutions put forward in the participation process have influenced the final project decision (Section 5.51 of the Ow and 5.6 Ob).

An appeal against a project decision can be lodged with the Administrative Law Division of the Council of State in the first and only instance. After that, an objection is not possible. This also applies to decisions which are prepared in coordination with a project decision in accordance with Section 3.5 of the Awb (new), such as the decision to agree to the storage plan. The appeal is only open to those whose interests are directly affected by the decision (interest groups). These interest groups must also have put their judgment and opinions in good time on those parts of the draft decision they challenge on appeal. If the initiator has breached the participation obligations, interest groups must also have pointed this out in their change of view. This safeguards the point of attention mentioned in subsection 6.1, that it should no longer be possible to prosecute endlessly against a decision if an agreement has been reached in close cooperation with the local community.