Project Acronym and Title:

M4ShaleGas - Measuring, monitoring, mitigating and managing the environmental impact of shale gas

REVIEW OF LESSONS LEARNED ON PUBLIC PERCEPTIONS AND ENGAGEMENT OF LARGE SCALE ENERGY TECHNOLOGIES

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Public introduction

M4ShaleGas stands for *Measuring, monitoring, mitigating and managing the environmental impact of shale gas* and is funded by the *European Union's Horizon 2020 Research and Innovation Programme*. The main goal of the M4ShaleGas project is to study and evaluate potential risks and impacts of shale gas exploration and exploitation. The focus lies on four main areas of potential impact: the subsurface, the surface, the atmosphere, and social impacts.

The European Commission's Energy Roadmap 2050 identifies gas as a critical fuel for the transformation of the energy system in the direction of lower CO_2 emissions and more renewable energy. Shale gas may contribute to this transformation.

Shale gas is – by definition – a natural gas found trapped in shale, a fine grained sedimentary rock composed of mud. There are several concerns related to shale gas exploration and production, many of them being associated with hydraulic fracturing operations that are performed to stimulate gas flow in the shales. Potential risks and concerns include for example the fate of chemical compounds in the used hydraulic fracturing and drilling fluids and their potential impact on shallow ground water. The fracturing process may also induce small magnitude earthquakes. There is also an ongoing debate on greenhouse gas emissions of shale gas (CO_2 and methane) and its energy efficiency compared to other energy sources

There is a strong need for a better European knowledge base on shale gas operations and their environmental impacts particularly, if shale gas shall play a role in Europe's energy mix in the coming decennia. M4ShaleGas' main goal is to build such a knowledge base, including an inventory of best practices that minimise risks and impacts of shale gas exploration and production in Europe, as well as best practices for public engagement.

The M4ShaleGas project is carried out by 18 European research institutions and is coordinated by TNO-Netherlands Organization for Applied Scientific Research.

Executive Report Summary

This report provides an overview of the lessons learned from other large scale energy technologies and considers how they might apply to shale gas development in Europe. Relevant literature relating to general public perception (awareness, knowledge, attitudes) as well as relating to local perceptions are discussed.

Results show that knowledge for similar technologies is usually low. This makes it difficult to have an informed public debate. Although providing unbiased and accurate information to the public might lead to more informed and stable opinions, the impact of knowledge on attitudes is limited: perceptions, especially those related to risks, play a larger role in influencing public opinions. Once developed, attitudes remain rather stable over time, although media attention due to large incidents can still influence public attitude.

Perceptions relating to local energy projects are likely to differ from global perceptions about a technology. Several factors influence these local perceptions. High place-attachment (the emotional bond that people have with their environment) may lead to more local opposition. A trustworthy project developer, fair procedure and fair distribution of local benefits and risks (e.g. by host community compensation) may have a positive influence on local acceptance. Finally, proper stakeholder engagement has a positive impact on how people respond to local project plans.

Research gaps exist for the role of affect (how do emotions play a role?), perceived costs (how do people perceive the costs of a local project?) and contextual factors. Research should investigate de-escalation of conflict and restoring trust to help improve local stakeholder engagement.

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1 INTRODUCTION

1.1 Context of M4ShaleGas

Shale gas source rocks are widely distributed around the world and many countries have now started to investigate their shale gas potential. Some argue that shale gas has already proved to be a game changer in the U.S. energy market (EIA 2015[1]). The European Commission's Energy Roadmap 2050 identifies gas as a critical energy source for the transformation of the energy system to a system with lower CO_2 emissions that combines gas with increasing contributions of renewable energy and increasing energy efficiency. It may be argued that in Europe, natural gas replacing coal and oil will contribute to emissions reduction on the short and medium terms.

There are, however, several concerns related to shale gas exploration and production, many of them being associated with the process of hydraulic fracturing. There is also a debate on the greenhouse gas emissions of shale gas (CO_2 and methane) and its energy return on investment compared to other energy sources. Questions are raised about the specific environmental footprint of shale gas in Europe as a whole as well as in individual Member States. Shale gas basins are unevenly distributed among the European Member States and are not restricted within national borders, which makes close cooperation between the involved Member States essential. There is relatively little knowledge on the footprint in regions with a variety of geological and geopolitical settings as are present in Europe. Concerns and risks are clustered in the following four areas: subsurface, surface, atmosphere and society. As the European continent is densely populated, it is most certainly of vital importance to understand public perceptions of shale gas and for European publics to be fully engaged in the debate about its potential development.

Accordingly, Europe has a strong need for a comprehensive knowledge base on potential environmental, societal and economic consequences of shale gas exploration and exploitation. Knowledge needs to be science-based, needs to be developed by research institutes with a strong track record in shale gas studies, and needs to cover the different attitudes and approaches to shale gas exploration and exploitation in Europe. The M4ShaleGas project is seeking to provide such a scientific knowledge base, integrating the scientific outcome of 18 research institutes across Europe. It addresses the issues raised in the Horizon 2020 call LCE 16 – 2014 on *Understanding, preventing and mitigating the potential environmental risks and impacts of shale gas exploration and exploitation.*

[1] EIA (2015). Annual Energy Outlook 2015 with projections to 2040. U.S. Energy Information Administration (*www.eia.gov*).

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1.2 Study objectives for this report

In the last decades, public acceptance (or the lack thereof) has been a major barrier for the implementation of large-scale energy options (Desbarats et al, 2010). Public opposition has been widespread both geographically and across technologies, often leading to delayed implementation, or even cancellation of energy projects. Research on public perception and stakeholder engagement in large-scale energy projects shows how poor public engagement is handled in some projects (Ashworth et al 2012; Desbarats et al., 2010). The evidence suggests that shale gas in Europe is no different and there is widespread public concern about the potential negative impacts of high volume hydraulic fracturing (HVHF) and associated technologies (Lis, Braendle, & Fleischer, 2015).This is unfortunate and unnecessary as a vast body of research on public perception and engagement exists for technologies such as Carbon Capture and Storage (CCS), nuclear power and wind power.

This body of knowledge on other large-scale technologies can be informative for the development of shale gas because research on public perception of shale gas is limited. Research that does exist seems to indicate that public opposition in some countries is growing (Lis, Braendle, & Fleischer, 2015; Mastop et al., 2014). Fortunately, there is no need to start from scratch with research on shale gas perceptions: the majority of the psychological and sociological processes that have been observed, have been shown to be common to all new, large-scale energy technologies (Desbarats et al 2010; Pidgeon & Demski, 2012). Both empirical knowledge as well as experience from best practices provides invaluable lessons for the development of shale gas. What is lacking is an overview of these lessons and their relevance to the case of shale gas, as not all lessons can be transferred to other technologies, other cultures, or other local (project) situations.

1.3 Aim of this report

The aim this report is to provide an overview of the lessons learned from other large-scale technologies and to consider how they might apply to shale gas development. Both empirical research, as well as experiences from real-life projects, are used to identify the most important psychological factors that influence public perceptions of large scale technologies. We have focused on research about CCS, nuclear energy and wind energy, as these are the most researched large-scale technologies and have technical and spatial similarities with shale gas technologies. The implications for the implementation of shale gas are then discussed.

Research has shown that local responses to facility sites are often not in line with general public opinion. (Eiser, Van der Pligt, & Spears, 1988; Krause et al., 2014). Therefore, in the present deliverable we argue that it is important to distinguish between literature on perceptions and attitudes of the general public (e.g. public perception, knowledge) and literature on attitudes of local communities (e.g. stakeholder engagement, participation and communication styles).

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In Chapter 2 we will discuss awareness, knowledge and attitudes of the general public. In Chapter 3, perceptions of local stakeholders are discussed, as well as best practices for communication strategies. Finally, in Chapter 4 research findings are summarized and implications for the implementation of shale gas are provided.

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2 GENERAL PUBLIC PERCEPTION

2.1 Awareness and knowledge

There are many ways to measure public opinion. The difficulty for new, relatively unknown technologies, such as CCS and shale gas, is that many people do not know or understand what these technologies entail. They are also unfamiliar with potential risks or benefits associated with these technologies (Daamen et al., 2006). Simply asking what people think of a certain technology is not very useful, since it leads to “pseudo-opinions” (Daamen et al., 2006; Malone, Dooley & Bradbury (2010): When asked, people tend to give an opinion even on topics they know nothing about (Bishop et al. 1986). These pseudo-opinions are often highly unstable, easily changed by contextual information and have very small predictive value for actual behavior (e.g. Strack et al., 1991; Daamen et al, 2006; De Best-Waldhober et al., 2009). To be able to obtain informed opinions and avoid pseudo-opinions, it is necessary to also provide information on the technology under investigation. Examples exist in which large scale surveys or public dialogue is combined with supplying information on CCS to respondents (Ashworth et al 2012; De Best-Waldhober et al 2009, 2012; Itaoka et al 2006; Palmgren et al 2004; Reiner et al 2006; Shackley et al 2005; Tokushige et al 2007). A best practice technique for obtaining informed opinions on complex and new technologies is the “Information Choice Questionnaire” (ICQ), developed by Saris and colleagues (1983; see Price and Neijens [1998] for a review). The challenge with obtaining informed opinions is to provide people with unbiased information, which is not easy in the context of an already polarized debate in Europe that has been fueled by the media.

People have different levels of knowledge about different technologies. Public awareness and knowledge of CCS for instance, although somewhat improved over time, remains rather limited (Ashworth et al 2006; De Best-Waldhober et al 2009, 2012; EU, 2002; 2007; 2008; Ha Duong et al 2009; Itaoka et al 2006; Reiner et al 2006). When comparing technologies, people have more knowledge about traditional technologies such as wind and nuclear energy than about newer technologies like CCS and biomass. Informed and uninformed opinions are also more consistent for nuclear and wind energy than for CCS and biomass (Mastop et al, 2014). Shale gas is a relatively new concept in Europe, therefore one might expect that awareness is relatively low. The opposite is true, at least in the Netherlands, where research showed that self-reported awareness of shale gas is relatively high, with only 14% of respondents (138 out of 1000 respondents) indicating to have never heard of shale gas (vs. 35% for CCS and 3% for wind energy and nuclear energy) (Mastop et al, 2014). This relatively high awareness of shale gas is likely to be caused by increased negative media attention while the survey was conducted. It is also the case in the UK that awareness has quickly increased with over 75% of the population now aware of shale gas (Lis, Braendle, & Fleischer, 2015). In a Dutch survey (Mastop et al. 2014) uninformed participants were asked to rate shale gas technology with a grade from 1 to 10. Respondents on average rated shale gas with a

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4.3, this was lower than the grade for CCS (5.1) and nuclear energy (5.3). Respondents who indicated to ‘know a lot about shale gas’ evaluated the technology even more negatively (3.5). Self-reported awareness thus seems to influence opinions on shale gas. No research to date has investigated, however, to what degree self-reported knowledge levels are similar to actual knowledge levels on shale gas.

2.2 Knowledge and attitudes

The relation between knowledge and attitudes is often discussed in the literature. Although it is generally assumed that this relation is strong (see for example Fishbein & Ajzen, 1975), and communication strategies often focus on increasing knowledge, empirical evidence regarding the relation between knowledge and attitudes is mixed. Some studies on nuclear energy show a positive relationship (e.g. Kuklinski, Metlay, & Kay, 1982), some show a negative relationship (e.g. Costa-Fond, Rudisill & Mossialos, 2008) and some show no relationship at all (e.g. Katsuya, 2001). An explanation for why there is no clear-cut relationship found between knowledge and attitudes is that different knowledge domains are investigated. For instance, findings from different Eurobarometer surveys (EC, 2002; 2007; 2008) show that people living in the EU have a moderate amount of knowledge about the proportion of nuclear energy related to other forms of energy generation, but the knowledge about the technology itself (e.g. if people understood the concept of nuclear fission) are not assessed. A study of Brunsting et al. (2013) shows that attitudes towards CCS are mostly indirectly influenced by knowledge, via perceptions. Only the extent to which one correctly recognizes the storage options for CO_2 had a direct effect on attitude of CCS, but also this effect was partially mediated by perceptions of benefits and trust. Misperceptions about CO_2 significantly increased fear of leakage, which in turn leads to more negative attitudes towards CCS. In addition, correcting misperceptions does not seem to have a large impact on people’s opinion of the technology (Mastop et al, 2014). In short, it can be concluded that the role of knowledge in shaping public opinions on energy transition technologies is limited and that perceptions play a much more important role.

Improving the knowledge levels of the general public might not only have a small impact on attitude change, the direction of the change is also unclear: opinions might become more favorable or more negative. For example, correcting misperceptions might lead to more negative attitudes when people incorrectly think that introducing a new technology will lead to a large increase in employment, but to more positive attitudes when they incorrectly think that it will lead to a decrease in property value. Therefore, it is inadvisable to focus communication strategies solely on increasing the public knowledge base when the aim is to change public attitudes.

2.3 Attitude formation

When forming an attitude about an energy technology, people tend to weigh perceived costs (risks) and benefits of the technology (e.g. Otway and Fishbein, 1976). The Netherlands Institute for Social Research (Dekker, de Goede & Van der Pligt, 2010) distinguish five dimensions of attitudes regarding nuclear power: 1) *economical*, which

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addresses economic benefits and technology costs; 2) *energy & climate*, which addresses topics like energy security, CO_2 emission and climate change; 3) *environment issues*, which embody radioactive waste and the effects of uranium delving; 4) *geopolitical*, which addresses topics like dependency of energy supply from abroad and different ideologies and 5) *safety & risk*, which encompasses concern of terroristic attacks and radioactive waste. Perceptions of risks and benefits play a large role in attitude formation of nuclear energy. For CCS, risk perceptions are the most important predictor of the overall evaluation of this technology (Mastop et al, 2014).

Factors that influence risk perceptions were investigated by Dekker, de Goede & Van der Pligt (2010). Knowledge of the technology, control over the technology and exposure to risks, and the impact of negative consequences all influenced risk perceptions. Additionally, their research showed that trust in science and the government, positive intuitive judgment (implicit 'good feeling' on the subject) and moral approval (e.g. next generation issues, fair distribution) also play a significant role in determining risk perception.

For wind energy, perceived risks are less important for attitude formation. Aesthetic aspects seem to be the most important factor in explaining opposition. Local opposition to wind farms is additionally influenced by feelings of equity and fairness (Wolsink, 2013). Research in Sweden (Waldo, 2012) showed that positive attitudes for wind power are mainly based on economic gains (creating jobs and economic growth) and environmental values (sustainable energy source). Negative attitudes are based on aesthetic values (turbines are ugly), material values (unprofitable technology). Negative attitudes are also influenced by a relative comparison with nuclear energy, which is perceived by the Swedish respondents as a more reliable and efficient energy source.

For shale gas, similar factors are likely to play a role in attitude formation. Risk perceptions (e.g. leakage, environmental impact, groundwater contaminations) and aesthetic impact (due to the large number of drill sites) might have a negative influence on attitudes while economic benefits, energy security and decreased dependency on energy supply from abroad may positively influence attitudes towards shale gas.

2.4 How attitudes change over time

How attitudes develop over time is difficult to assess for technologies which are relatively new. Based on experience with attitudes on nuclear energy, it can be concluded that attitudes are rather stable and are mostly influenced by large incidents which receive a lot of media attention. European attitudes towards nuclear energy were fairly positive before the mid-seventies, but due to accidents like the Three Mile Island incident in 1979 and the Chernobyl disaster in 1986, concern about radioactive waste and potentially catastrophic accidents promoted increased public opposition (Van der Pligt, Eiser & Spears, 1984). Around the turn of the century, the general opinion towards nuclear energy became a little more favorable again in the Netherlands, as it was seen as a viable alternative to fossil fuels. Yearly figures from Eurobarometer (EC, 2002; 2007; 2008) show a steep increase in opposition to nuclear power in European

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countries in the eighties, followed by a decrease of opposition in the nineties and finally bouncing back to the same level of acceptance as before 1986 in the first decade of the new century. The Fukushima accident in March 2011 led to a decrease in acceptance comparable to the level of those in the mid-eighties in Europe. However, Visschers and Wallquist (2013) concluded from a poll in Great Britain that more positive opinions had already formed nine months after the accident.

The mechanism behind decreasing and recovering public acceptance right after a nuclear accident can be explained by one of the most general judgmental heuristics: the availability bias. People perceive risk differently from probabilistic assessment(Slovic, Fischoff & Lichtenstein, 1979). This availability heuristic results in people judging an event as more likely if instances of it are easier to recall or imagine. Increased media attention also influences knowledge about the technology and attitudes (Brunsting et al., 2013); although that information may not reflect the actual level of scientific understanding and risk assessment. Shale gas has already received negative media attention (Jaspal & Nerlich, 2013; Upham et al., 2015). Furthermore, relative comparison with alternative (cleaner) large scale energy technologies is unfavorable. Given the findings discussed above, it is therefore unlikely that shale gas perceptions will become more positive in the near future.

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3 PERCEPTIONS OF LOCAL STAKEHOLDERS

3.1 Proximity

The proximity to a facility of a new energy technology influences public opinion. Public attitudes towards new energy technologies in general are different from public attitudes to local sites, such as a nuclear power plant or wind turbines in the vicinity. General public support for a renewable energy technology therefore cannot be easily translated into expected positive response to a specific local site (Wolsink, 2013). For instance, whereas numerous studies have signaled high level of support for wind energy in the UK, real-life projects encountered local opposition, leading to delay and even cancellation (Toke, 2005). Similarly, Krause et al. (2014) showed that a large majority of respondents to a telephone survey support CCS technology. However, when asked about their opinion on the development of a facility near their home, many respondents were opposed to a local facility. This is particularly the case for people who are concerned with safety risks. In addition, Van der Pligt, Eiser and Spears (1986) found that in the UK there were twice as many people strongly opposed to constructing a nuclear plant in their direct vicinity, than people who were opposed to a nuclear plant somewhere else in their country. As there seems to be a discrepancy between what people think of a technology in general and what they think of that technology in their local environment, it is important to not only focus on obtaining insights into general perceptions of the technology on the whole, but also to examine differences in perceptions in local communities regarding specific project plans.

Devine-Wright (2005) was one of the first researchers to advocate abandoning the concept of NIMBYism (Not In My Back Yard), which is often used to explain opposition to large-scale energy technologies, such as wind energy or CCS. Empirical evidence for NIMBYism is, however, limited and also fails to explain *why* people would be opposed to wind power in their direct neighborhood. In a case study about a wind energy project in the UK (Devine-Wright & Howes, 2010), "place attachment" was introduced as an alternative explanation of local opposition to or support for wind energy. Place attachment is a phenomenon where individuals and/or groups develop an emotional bond with the familiar locations they visit (for a detailed description, see Altman & Low, 1992). The authors distinguish between two development locations in terms of place attachment by a free association method: one is seen as "aesthetic beautiful" (Llandudno), the other is seen as "run down" (Colwyn Bay). They conclude that being attached to the place you live, relates to opposition (though mediated by factors like trust), whereas not being attached has no relation to opposition at all. The strength of place attachment was shown to be a better predictor of public support than demographics such as age or gender in a Norwegian study on large-scale hydropower (Vorkinn and Riese, 2001). Rather that assuming that local opposition stems from the resistance to having any development near their backyard, it is important for project developers to be aware of the complexity of factors on which public perceptions are based.

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Experiences from five European CCS cases (Oltra et al, 2012) identified six factors that influence how a local community might respond to a CCS facility: 1) the characteristics of the project, 2) the engagement process, 3) risk perceptions, 4) the actions of stakeholders, 5) the characteristics of the community, and 6) the socio-political context. These factors are interrelated and might be compensatory at times. Gaining insight into the degree to which people are attached to their local environment at an early stage will help in selecting a site where the envisioned facility matches with the environment. In other words, it is important for project developers to take into account that it may be more difficult to develop a project in areas with strong local place attachment.

The risks or (environmental or economic) costs associated with building and operating a new facility –such as nuclear power plant or CCS facility– fall disproportionally on people living near that plant or facility. For that reason, it can be expected that differences between local and national opinions occur. A way to overcome the imbalance in distribution of costs and benefits is host community compensation; compensating the local community for the risks and costs associated with financial or public goods (Dorshimer, 1996; Ter Mors et al. 2010; Toke, 2002). A review of broader compensation literature by Ter Mors and colleagues (2012) showed that host community compensation could potentially contribute to reducing the imbalance in benefit distribution, and thus increase local public acceptance of CCS facilities. Factors that influence the extent to which host community compensation may be effective are: 1) the type of (non)monetary compensation that is provided; 2) the perceived riskiness of the proposed facility; 3) whether it concerns a new or existing facility. Future research should determine why and when compensation is effective. Research is also needed to determine the role of timing, the party offering the compensation, and whether the compensation is given on a voluntarily basis or whether it is obligatory due to legislation.

3.2 Affect

Risks associated with nuclear energy or storage of CO_2 can cause fear. The limited controllability and the seriousness of adverse outcomes may elicits emotions such as concern and anxiety; unfortunately the body of research on emotions is somewhat lacking. Bohm and Pfister (2000) showed that emotions play an important role by mediating the relationship between perceived risk and different action tendencies. They distinguish between progressive (fear, worry), transgressive (anger, outrage, guilt) and retrospective (frustration, sadness) emotions. Another framework for explaining the impact of emotions on acceptance stems from the risk-as-feelings hypothesis (Loewenstein, Weber, Hsee & Welch, 2001), which highlights that emotional responses can override cognitive aspects of opinion forming. Review studies conclude that a knowledge gap exists for research on affect (Devine-Wright, 2007; L'Orange Seigo et al, 2014).

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3.3 Trust and fairness

Trust is another factor that received a lot of attention in the literature (e.g. L'Orange Seigo et al, 2014). It is important that the source of the communication is trusted by the community. Ter Mors et al (2010) showed that information from a dissimilar group of stakeholders (e.g. NGO's and industrial stakeholders) is perceived as more trustworthy than when the same information comes from a single stakeholder. When the communicated message is congruent with the assumed motives of the sender, it is perceived as more honest than when the message and the motives are not aligned. For example, an energy company that says it is interested in the deployment of CCS solely for environmental reasons is perceived as less trustworthy than when it also admits having financial reasons (Terwel et al, 2009). Such one-sided messages also have the risk of being perceived as 'corporate greenwashing': the idea that companies deliberately frame their activities as 'green' in order to look environmentally friendly. Acknowledging economic motives in addition to environmental motives is a strategy to reduce suspicions of corporate greenwashing (de Vries et al, 2013). With regard to stakeholder engagement and communication, researchers and NGOs are trusted most as sources of information, while energy companies and industries face low levels of trust (Ashworth 2012, Oltra, 2012).

Devine-Wright and Howes (2010) investigated the moderating effect of trust on the relationship between place attachment and acceptance of wind farms. They looked into two different kinds of trust: trust in the opposition group and trust in the developer (the company proposing the wind farm). High trust in the opposition group led to a negative correlation between place attachment and acceptance, where low trust led to no correlation at all. The results for trust in the developer were consistent: high trust led to the absence of a correlation between place attachment and acceptance. In addition, results from Upham and Shackley (2006) showed that low levels of trust in key stakeholders influenced public opposition from the local community in a prospective biomass plant. A strong attachment to the place where you live, thus does not necessarily result in opposition, but is shaped by the specific social context, like the level of trust in key organizations.

Terwel and Daamen (2012) have shown that the effect of trust on acceptance is mediated by perceived benefits and risks. Terwel, Ter Mors and Daamen (2012) administered a survey in Barendrecht (a proposed CCS site) shortly before it was decided to cancel the project. Public opinion (which at that time was very negative) was found not only to be influenced by safety perception, but by perceived procedural unfairness (the degree to which people feel they have a fair voice in the decision making process) and issues with trust of the developers and government. Similarly, procedural fairness has been found to be related to actual acceptance of nuclear facility siting (Besley, 2010). Visscher and Siegrist (2012) found that the acceptance of a new nuclear facility in the neighborhood was mainly influenced by *outcome fairness* (the degree to which people perceive the costs and benefits are fairly distributed), rather than by *procedural fairness* (the degree to which people perceive the procedure as fair).

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3.4 Communication and engagement strategies

Proper communication is seen as key for successful stakeholder engagement. In 2001, Van der Pligt & Daamen summarized suggested improvements on the content of communications about nuclear energy in three areas. First, one should conceptually differentiate between the focus on: 1a) providing information, 1b) increasing hazard awareness and 1c) conflict resolution. Second, parties should address the following factors when aligning communication efforts: 2a) complexity of often highly technical subjects, 2b) differences in frame of reference (e.g. laypeople think in frames of catastrophic potential and controllability, where experts think in monetary or loss-of-live frames), 2c) uncertainty when experts do not agree, 2d) trust and credibility (e.g. diminishing trust in governmental agencies or industry) and 2e) involvement & concern (highly charged situations need different communication strategies than less controversial issues). Third, both cognitive and emotional aspects of public reactions should be addressed.

While Van der Pligt and Daamen (2001) focused on the content, Ashworth et al. (2012) focused on factors that determined the success of a communication strategy (in CCS projects). Based on several case studies in the USA, Australia and The Netherlands they identified four factors influencing successful communication and engagement with stakeholders: 1) the extent to which the government and project team were aligned, 2) whether communication experts were involved from the start of the project, 3) the degree to which there was flexibility in the project, and 4) whether communities have expressed interest in a potential site through self-selection.

Creating a shared, common frame will also positively influence communication about new technologies. In large-scale energy projects, spatial planning and policies primarily define the frame within which decisions are taken and communication efforts are laid out. Thereby, options for public consultation are often announced *after* project plans are made and when designs are already at a definite phase (Breukers & Wolsink, 2007). It can be argued that these top-down frames are not conducive to create a balanced discussion with the local community about project plans. This was also the case in Sweden, where semi-structured interviews with developers and local citizens revealed a pronounced mismatch in communication frames between developers and local citizens (Waldo, 2012). Developers felt they had spent a lot of effort in debunking myths about wind power (e.g. the payback time of wind turbines or that no CO_2 is emitted when producing wind energy), but citizens stated that they missed information about technical and financial factors.

Once a facility siting project is concrete, it becomes important not only to inform but to engage actively with local stakeholders about the project. Experience from previous projects (mostly on prospective CCS sites), and research efforts, resulted in a number of practical recommendations. These recommendations take into account relevant psychological factors that may influence decision making. A case study of Barendrecht in the Netherlands (Brunsting et al, 2011) resulted in a number of practical recommendations for future projects. First of all, they conclude it is important to

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involve all local stakeholders early in the project, as this creates trust and commitment. Second, the values, needs, and wishes of stakeholders should be taken into account. This includes having room to change parts of the plan or design when needed to incorporate preferences of the local community. Third, communication with the stakeholders should be regular and both on formal as informal occasions. Fourth, rather than only discussing the local facility siting, project developers should also discuss the technology in general and possible alternatives in order to provide the larger context. Fifth, communication should be tailored to the local public. This includes choosing the preferred medium for communication and adjusting the information to the knowledge level of the community. Finally, the party disseminating the information should be trusted as a source of information and preferably be an independent party.

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4 CONCLUSIONS

The present deliverable aimed to provide an overview of relevant literature on public perceptions of large scale energy technologies, in order to increase the knowledge base for shale gas development.

General public awareness of new, large scale energy technologies is usually low. First indications are that awareness of shale gas may be somewhat higher, likely due to frequent media attention. A difficulty with assessing attitudes towards new energy technologies is that people generally have low levels of knowledge. "Pseudo-opinions" are given when people are none-the-less asked for their attitude without being informed. These pseudo-opinions have limited value, as they are unstable and have low predictive value for actual behavior. To decrease the amount of pseudo-opinions, information should be provided. The difficulty with this strategy is that information should be unbiased. For shale gas, although awareness levels might be relatively high, knowledge levels might not. It might therefore be advisable to provide people with accurate and unbiased information in order to have an informed debate with the public.

The impact of knowledge on attitudes is limited, however, and the direction of change is unclear. Knowledge has low correlations with attitudes. It has been shown that perceptions, for example perceptions of risks (e.g. leakage), play a much larger role in forming attitudes. Knowledge may have an indirect effect on attitudes, as it can influence perceptions, which in turn influence attitudes. For example, providing information on risks of leakage influences perceptions of safety, which will lead to a more negative attitude. Communication should therefore not be focused on increasing knowledge when aiming to change public attitudes.

For technologies such as CCS and nuclear energy, risk perceptions are an important predictor of attitudes of the technology. When people perceive high risks (e.g. radioactive waste or leakage from underground storage) they are less positive about the technology. It is likely that risk perceptions are important for attitudes towards shale gas as well. Aesthetic aspects also seem to be important, mainly for technologies like wind or solar energy. As hydraulic fracking is also associated with having a large number of wells, aesthetic aspects might also negatively impact shale gas perceptions. Factors that have been shown to positively influence attitudes towards technologies and have a positive influence on public perceptions of shale gas are: economic benefits (like jobs and economic growth), energy security, and decreased dependency of energy supply from abroad. Perceptions and attitudes of a technology are not isolated from the societal context. What people think of a technology depends on relative comparisons with other technologies. In literature there is limited attention for such relative comparisons between technologies. For example, people may perceive shale gas as a technology which draws attention and investments away from renewable energy sources.

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Attitudes are commonly seen as rather stable over time. For new technologies, it is difficult to predict how attitudes will develop. Research on nuclear energy has shown that public opinion seems to be negatively influenced by large incidents, such as the Tsjernobyl disaster in 1986 and more recently the Fukushima accident in 2011 which receive a lot of media attention. In the absence of large recent disasters, for example in the early 2000s, opinions were more favorable. In addition, nuclear energy may have benefited from a positive relative comparison with fossil fuels as it was seen as a viable and cleaner alternative. It is uncertain how shale gas perceptions will develop. Given the (negative) media attention shale gas has already received, and given the unfavorable comparison with other energy technologies, it is unlikely that perceptions of shale gas will become more positive over time, although regional differences may exist.

Public perceptions on local projects often differ from general public perceptions. Place-attachment (the emotional bond locals may have with their direct environment) influences attitudes towards specific projects. Having a high attachment to the place one lives relates to opposition to local energy projects. This is mediated by factors such as trust in the project developer. Similar processes might play a role in the case of shale gas. Insight into the level of place attachment in an early stage will therefore help in selecting a good site and developing project plans to match local communities' preferences.

Risks associated with a technology are often disproportionately higher for the local community as compared to the perceived benefits. This disadvantage can be alleviated by host community compensation. Under which circumstances compensation is beneficial depends on several factors, such as the type of compensation, and the perceived riskiness. Care should be taken when using host community compensation, because it can easily be perceived as a bribe when used in the wrong way. Future research should examine when and why host community compensation leads to more positive local attitudes and whether it can be used as compensation for imbalance in cost and benefit distribution in the case of shale gas.

Trust and perceptions of fairness are key factors that influence public perceptions, especially in communication about specific project plans. Companies can be accused of 'corporate greenwashing' when their communication is not perceived as honest, and public opposition is influenced by perceptions of procedural unfairness as well as outcome unfairness. Trust also has a moderating effect on the relation between place attachment and public acceptance; if trust in the opposition is high, people are less likely to accept project plans. It is likely that trust and fairness will influence public debate on shale gas as well.

For successful stakeholder engagement it is key to organize proper communication. A good communication strategy builds on scientific findings as described above as well as on project-experience. A number of success factors were identified in research. Rather than one-directional sending of information to key stakeholders, project communication should be bi-directional and actively engage all stakeholders. This includes the possibility of incorporating stakeholders needs and wishes in project plans and making

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changes to the original plans when necessary. To get insight into needs and wishes of the stakeholders, communication will need to occur on both formal and informal occasion, and information as well as information source should be tailored to the public.

The research discussed in this report provides important insights into factors influencing perceptions of shale gas, but research gaps can also be identified. In a review on CCS literature, L'Orange Seigo and colleagues (2014) conclude that the role of affect, perceived costs, and outcome efficacy (the belief that personal actions can influence the implementation of CCS) have received limited attention. Devine-Wright (2007) concludes his review that there is a need for more research on public engagement which takes a more inter-disciplinary point of view in explaining the dynamics of public engagement, also taking into account affect and beliefs about energy technologies.

In addition, a research gap seems to exist with regard to what type of contextual factors may influence public perception, even though it is often highlighted that it is important to take into account such contextual factors. Future research could also shed light onto the effect of social dilemma's on public perception (e.g. sucker or free-rider effects). Finally, research on de-escalation of conflict and restoring trust is lacking. This would be especially useful for technologies which have already been introduced to the public and were confronted with negative attitudes.

Different technologies have a different impact on the local environment and this also influences social responses. For new technologies it is therefore important to investigate which technological aspects will be relevant for local stakeholders. For example, wind turbines might have a large visual impact, while a biomass plant has issues with smell or transport, and nuclear energy or CO_2 storage will have risks of leakage.. For shale gas people may perceive similar risks of leakage as they do with CCS, but additionally it may also have a larger visual impact due to the number of drill sites.

Other types of ownership or more participatory processes may also influence how the public responds to a facility siting. For shale gas, this might be one of the most important factors explaining the differences in response between de USA and the EU (Kefferputz, 2010). It is, however, not a guaranteed way to secure local acceptance. Rather, it is an effective strategy to have an informed debate with the local community in a structured manner. It is likely that this will positively influence trust and feelings of procedural fairness among stakeholders.

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