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PUBLIC RESPONSES TO CO_2 STORAGE SITES: LESSONS FROM FIVE EUROPEAN CASES

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ABSTRACT

Studies of the factors involved in public perceptions of CO_2 storage projects reveal a level of complexity and diversity that arguably confounds a comprehensive theoretical account. To some extent, a conceptual approach that simply organises the relevant social scientific knowledge thematically, rather than seeking an integrated explanation, is as useful as any single account that fails to do justice to the contingencies involved. This paper reviews and assembles such knowledge in terms of six themes and applies these themes to five European cases of carbon capture and storage (CCS) implementation. We identify the main factors involved in community responses to CCS as relating to: the characteristics of the project; the engagement process; risk perceptions; the actions of the stakeholders; the characteristics of the community, and the socio-political context.

1. INTRODUCTION

Governments and companies in many countries are investing in Carbon Capture and Storage projects (CCS). The separation and compression of CO_2 from power and industrial plants and its disposal in saline aquifers, depleted oil or gas fields has become seen in many quarters as one of the key climate change mitigation options [1]. Pilot, demonstration and industrial projects have been initiated in the last few years around the world [2]. Although some have questioned whether storing carbon emissions should be an option to tackle climate change, given the existence of other options and the potential risks of CCS [3], governments in the European Union and other countries are nonetheless stimulating the commercial deployment of CCS [4].

Public perceptions and acceptance of CCS has been a matter of concern for policy and business communities [5, 6, 7], given their potential effects on the successful deployment of the technology. The topic has been also a matter of research for social scientists interested in how the different publics and social groups perceive the technology (for recent introductory reviews, see e.g. [8, 9]). Understanding social perceptions of a technology is of use both in pragmatic terms (to improve communication efforts and decisions) and in normative terms (governmental and corporate decision making should arguably incorporate, at some level, public concerns and views). But analysis of social reactions to CCS also needs to consider other dimensions. As with other energy technologies, social reactions to CCS will depend not only on perceptions of the technology attributes per se, but also on a wide variety of contextual factors [10]. These, we would suggest, include factors relating to at least two main levels: first the broad, socio-political level and second the community level, at which decisions on CO_2 storage siting will take place.

At the socio-political level, attitudes and actions from policy makers, innovation communities, industry actors, non- governmental associations and the general public may foster or discourage any particular technology development. Competition is the primary motor for technological development and the public often plays a minor role in technology decisions, especially in complex infrastructure, where elites and professional experts are the main institutional actors who make choices among technologies [11]. But, as found in other contexts, many of the barriers for achieving successful projects are sometimes a manifestation of lack of social acceptance [12].

It is at the community level where most of the perceived environmental and public health issues and concerns around CO_2 storage will be concentrated. During the period 2009-11, community reactions to CCS projects have been responsible for the cancellation of, or threat to, several CO_2 storage projects internationally, underlying the importance of taking into account potential local reactions [13]. Controversies around the siting of hazardous facilities have been frequent in the political life of most technologically advanced industrial societies in the last 30 years [14, 15]. The roots of these controversies may be found in deeper socio-economic, cultural and political changes in advanced societies, a combination of policies poorly designed and ham-handedly implemented [14] with a public anxious about health, safety and environmental issues [16] and higher levels of mistrust in risk management authorities modulated by risk amplification process.

To reduce the prospects of local opposition to CO_2 storage project, agencies and research institutes have developed guides on best practices for public communication and involvement around CCS [17, 18]. All these efforts recognize the importance of considering the siting context and the "social fit" in the planning and development of a CO_2 storage project [13]. Accordingly, this paper examines the development of public reactions in relation to five European CO_2 storage projects, in order to shed light on the factors underlying community reactions to such projects and to identify any lessons that may be learned for the future. To this end, we first review the wider literature on public responses to built infrastructure developments, in search of the main variables and processes identified as typically influencing their social acceptability. Second, we analyze five case studies of CO_2 storage projects in the light of the reviewed literature and discuss alternative explanations for the successes and failures of the CO_2 storage siting proposals. Full underpinning reports of our case studies [19, 20, 21] and complementary papers [22, 23] are also available.

2. THE SITING OF ENERGY FACILITIES

Siting controversies have been the focus of social research since at least the 1980's, with studies of risk communication around the siting of hazardous waste facilities and nuclear waste dumps [24, 25, 26]. From this early work, at least two themes emerged. First, the conflicts around siting (the local dimension) have played a key role in the deployment of new technologies in the last decades. Most notably, the history of the nuclear energy in the US and other countries has involved hostile local reactions acting to significantly impede the siting of new facilities [27]. Second, the social acceptance of a proposed infrastructure is not only a function of the characteristics of the technology or the type of facility, nor a reaction driven by egoistic motives. Rather, we would suggest that opposition to new infrastructure is the result of a variety of interacting social and psychological processes that are in turn influenced by a range of wider contextual factors.

The siting literature has provided various explanations for the causes of hostile local reactions to technological facilities. Without intending to provide a comprehensive elaboration of these studies (for fuller reviews see [28] and [29]), explanations can be grouped into three broad categories: i) those studies focused on the characteristics of the technology (e.g. involving waste outputs or contentious inputs, scale and so on) [30]; ii) those focussing psychological processes (e.g. place attachment [31] and familiarity with the technology [32]); and iii) those stressing the importance of wider social and institutional factors (e.g. trust, equity, ownership, planning-related procedures, governance and accountability (e.g. [33, 34, 35]).

One of the main contributions of the siting literature is the rejection of simplistic explanations of local rejection to technological facilities [36, 37, 38]. For the social science community working on these issues, it has become axiomatic that local opposition is not simply a function of the risk characteristics of a technology, or proximity to a development; nor can it simply be resolved through compensation or reward [39]. Social research has shown that local opposition is often based on distrust, negative reactions to the actors (developers, authorities and energy companies) promoting the project and to the way projects are planned and managed, rather than being always a response to the facility itself [40, 36, 38].

In short, the social embedding of a new technology is often contingent on situational, even perhaps randomly assorted combinations of circumstances [41]. Nonetheless, drawing on the broad siting literature, it is possible to identify the following, commonly-active factors with the potential to play a role in social responses to CO_2 storage projects. In the sections below, and based on the reviewed literatures, we cluster factors (see Figure 1) largely by level and agent: that is, by the level at which they are operative and in relation to relevant actors and agents.

2.1. Characteristics of the technology and the project

The characteristics of the facility can play a role in how a local community reacts to a proposed installation. Although studies suggest that the acceptance of a facility is as much a function of the relationship of the facility to the community as it is the type of facility [32], the material characteristics of the technology and the facility can be a factor influencing its acceptance [30]. Some technologies and facilities may be more easily associated with high risks and therefore considered unacceptable and rejected or even stigmatized.

The characteristics of the concrete project may also affect local perceptions and reactions. In the wind energy context, visual impact has been considered a significant factor influencing public attitudes [40], as well as the size of wind farms, the unity with the landscape or the distance to population [37]. The influence of the characteristics of the technological facility (such as size, distance to population, colour or harmony with the environment) on public attitudes may vary depending on the technology and other contextual factors. The particular negative impacts of a technological facility should be taken into account in any planning process [42].

2.2. The planning process and the public engagement strategy

The planning process is often considered one of the key elements in building acceptance for technological projects. The style of engagement between the project, its promoter and the local community often plays a major role in how the local community reacts to a proposed facility, though this will rarely be the only main factor involved. Certainly some of the failures in facility siting in the last years has been attributed to unfair and unproductive processes of making and implementing facility siting decisions [43]. As suggested by Rogers, "facilities are accepted not simply on the basis of the technology and its inherent risks and benefits, but rather on the broad full-cycle bundle of factors that characterize the relationship of the facility to the community" [32: 271]. Conditions such as independent monitoring, enhanced community control of the facility, and the power to shut the facility down tend to increase local acceptance of new facilities [39]. Nonetheless, when thinking about the planning process and the relationship of the facility to the community, we can differentiate between the actions taken by project promoters (compensation, engagement strategy, decision making) and the attitudes towards the community in which the facility is placed.

Compensation (e.g. offering residents a package of benefits) can sometimes help in gaining public acceptance in some contexts through a more fair siting process. An unacceptably high ratio of local costs to local benefits may cause opposition. But other contextual elements may modulate its effects. Incentives are subject to serious limitations when facilities are perceived to be particularly risky or suspect legitimacy [44]. Incentives are likely to increase acceptability if risk potential is also mitigated [39] and safety standards and local community control are enhanced [45]. Finally, some people may view health and safety as rights that should never be traded off for material goods [46].

Having a proactive, carefully planned and flexible engagement strategy is also considered a key issue in producing a positive social reaction to facility siting. Lack of adequate communication and consultation with local residents by developers is commonly cited as one of the main reasons for opposition [47, 34, 48], but again communication extent and style is rarely seen as the only factor. It is widely accepted that the way to build trust in risk management is to listen to public concerns and engage in two-way communication [41]. Public engagement mechanisms are variously claimed to: incorporate public values into decisions; increase the substantive quality of decisions; resolve conflicts among competing interests; build trust in organizations; and inform or educate the public [49]. Of course the level of engagement and the tools applied [50] may differ significantly from one project to another.

Finally, the attitude of the organization towards the local community and towards public engagement may influence social reactions. The studies on public participation mechanisms show that very often the success of a participation strategy (its process and its outcomes) is dependent on contextual issues [51] such as the relationship between promoters and communities, the existence of social and economic ties and trusted relationships [52] or the organizational and decision making characteristics [53, 51]. An organization with a weak culture and custom of external participation will have further to go in successfully engaging than an organisation with a history of this. In sum, stakeholders' and public reactions to a proposed facility may be dependent on the way promoters handle the planning process and respond to community needs.

2.3. Risk perceptions

In opinion-forming processes, public perceptions are both an antecedent and a consequence of the other factors identified here. In general, public perception of risk is an important factor in determining public attitudes towards new facilities and technologies. Research on risk perception [54, 55] has found that the differences in risk perception between experts and non-expert groups do not rest on a different level of technical knowledge, but in a different evaluation of the qualitative dimensions of risk, such as familiarity. Other approaches have also underlined the importance of cultural orientations and lifestyles [56] as well as prior attitudes [57] and emotions in the way individuals react to new technologies and facilities. In general the risk literature indicates that individual positions towards new infrastructures, technologies or organizations may be influenced by unconscious processes such as group and network influences, social identity formation processes, cultural predispositions, emotional responses or automatic associations.

Perceived benefits can play also a role in driving social reactions to proposed facilities. Generally, people accept technology because of the benefits derived [58]. Lober [33], in a study on public attitudes towards waste facility siting, found that the installation needed to provide some form of local benefit before it would be accepted. Perceptions of benefits may in turn be influenced by prior attitudes and cultural orientations as well as group membership. While some groups may value potential global benefits from the facility, other publics may only value the expected local or personal benefits. The idea of public acceptance linked to perceived personal benefits has led to efforts by project developers to deliver personal benefits through financial compensation or community shares [59].

The level of trust individuals have on organizations and authorities managing technological projects is increasingly regarded as a significant element in the social reactions to technological developments and risk management [60]. Although it is empirically difficult to differentiate between trust and other prior attitudes [61], studies suggest that distrust of the developers and disbelief in the planning system have impeded the success of technological projects and risk communication programs [62].

Trust can be created in careful decision making processes, but it can be destroyed in an instant by processes perceived as unfair [60, 61]. Social trust may play an important role in public attitudes to CCS projects, where various organizations, from private energy companies to local, regional and national governments and public research bodies are involved. As stated by Hammond and Shackley [13], CCS projects led by research organizations have tended to benefit from greater perceived credibility.

Public risk perceptions are also influenced by *social amplification* and attenuation processes. Amplification by media coverage and other means of risk signal can significantly affect public views on specific technology projects [63]. Risks interact with psychological, social, institutional and cultural processes that can intensify or attenuate individual and social perception of risks. If an initial risk event which poses a hazard is followed by extensive media coverage, repeated negative imagery relating the place or activity, this can overturn a siting process. Amplification stations such as the media, opinion leaders, activist social organizations, and personal networks, play a significant role in framing and dramatizing the risk and establishing the symbols and metaphors used in characterizing the risks [63]. The battle for the amplification and attenuation of risk may happen also in the CCS context.

Unfortunate events related to the project and the socio-technical context may increase the local concerns for safety and risks and generate an unexpected social reaction. As Slovic et al. [64] state, socially amplified reactions to unfortunate events associated with a facility (major and minor accidents, discoveries of pollutant releases, evidence of mismanagement, attempts to sabotage or disrupt the facility, etc.) may cause significant harm to a proposed project. Unfortunate events associated with other related projects (e.g. rejection of a similar project in another community, major accidents in parallel technologies, etc.) may also generate a negative public attitude towards the new facility.

2.4. Stakeholders' actions

Of course it is not just psychological and social processes that are involved in siting controversy, but an interaction of processes of different types, on different levels. The actions of politicians, influential individuals, the media and representatives from local or national organizations can significantly affect the siting of a proposed facility. The strength of local opposition groups has been considered an important factor in strengthening distrust during the planning and siting stages [65, 66]. Environmental NGOs, the media and policy makers, if actively opposed to a proposed facility, can significantly influence public attitudes to new infrastructures. In the evaluation of the siting strategies of two waste incinerators, Löfstedt [65] found that a strong and organized opposition by environmental NGOs with high credibility in the area put the development organization in a defensive position and contributed to risk amplification, reducing public trust in the organization and eroding its credibility. This is a common pattern and experts and influential actors in the community (e.g. local politicians) who oppose or criticize a project can also significantly influence public reactions. This can be especially true when their voices are amplified by media coverage.

2.5. Characteristics of the community

The characteristics of the community receiving the new facility may determine the social acceptance of the project. In this sense, some projects may have a better "social fit", that is, a better adaptation to the characteristics of a community than others [13]. Communities familiar with the industrial risks may be more receptive to new infrastructures, deprived areas may be more positive about new facilities bringing economic benefits [65]. It is generally agreed that communities having a similar facility may be more positive to new facilities [65, 32]. The local relationships with the fossil fuel and energy industries; the character of a place (e.g. rural or industrial town); reactions to other recent infrastructural developments; and the fit of the project with the needs of the local economy may also determine the social fit of a CCS project [13]. But the contingent and uncertain nature of social reactions makes it very difficult to precisely determine how the characteristics of a community may influence how the local public and stakeholders will react to a proposed facility. In this sense, explanations about the social acceptance of a project based on the features of the community are often more ad-hoc explanations.

2.6. Socio-political context

The socio-political context ranges from the structural and institutional elements that affect policy decisions (policy frameworks, regulations) to the dynamic elements in the context (e.g. political elections, state of the economy, political controversies, shifts in the public opinion) that may affect the social acceptance of a project. Regarding the policy framework, national and local policies may affect the degree to which developers are dependent on community acceptance [67, 68]; the likelihood of establishing alternative siting processes or instituting a broad based participatory process. The broader socio-political context may influence how the public perceives the need for a proposed CO_2 storage project [52]. National public debates may also influence local views. Political controversies in the community may also determine the local reaction to a facility or technology, as the project can be used for political battles. As Hammond and Shackley [13] suggest for CCS projects, particularly sensitive times such as elections can drive a negative reaction to a particular project.

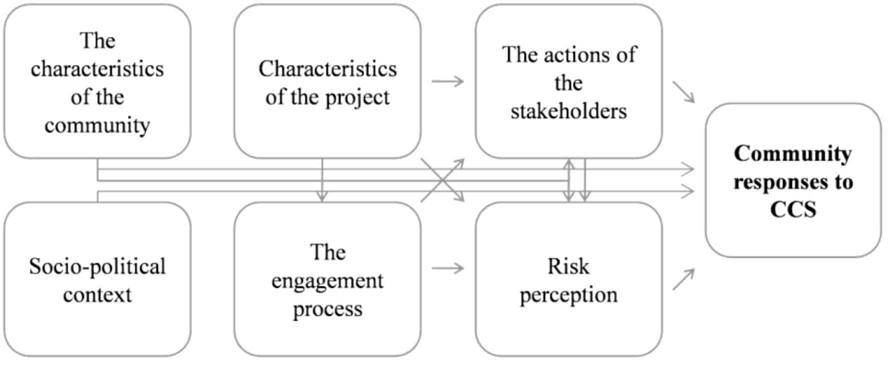

Figure 1. Summary of factors involved in community reactions to CO_2 storage site

3. ANALYSIS OF FIVE EUROPEAN CCS SITING PROCESSES

In this section, we examine the factors underlying the social reactions to the siting of five CCS projects in Europe. The selected cases are those that were analysed by the authors in the context of the European project NEAR CO2 [19, 20, 21]. The cases represented much of the totality of CCS-related activity in Europe, at the time of the study. The selection allowed the existence of variation in the factors studied: public responses, project type, engagement processes, actions of stakeholders, the characteristics of the community, and socio-political context. However, the selection cannot claim to be representative of all cases of public responses to CCS projects around the world: indeed this is part of the thesis suggested here – that the search for a fully-applicable, comprehensive model of CCS siting controversy is something of a chimera due to the sheer contingency and diversity of real-world contexts. Table 1 selectively summarizes the attributes of the five projects.

To understand the community reactions to the CO_2 storage projects, two research methods were used. First, interviews with the main stakeholders: local policy makers, officials, members of the public and environmental non-governmental organization (NGO) representatives. Between nine and fifteen interviews were carried out for each case. Interviewees were selected to be representative of a variety of stakeholders, with selection otherwise on a convenience sample basis – i.e. existing contacts, access routes and snow-balling approaches to stakeholder recruitment were used. Interviews were semi-structured and followed an interview guideline adapted to the project and stakeholder. Topics addressed in the interview included: stakeholder's views on the project; their relations with and views of the other stakeholders involved; efforts undertaken to communicate with the other stakeholders and with the local public in general; and their view on the engagement process.

Second, a complementary documentary analysis of local newspapers, project background information, communication materials and internet sources was undertaken to understand the various stakeholder perspectives on the siting and the dynamics of the controversy. The documents were mainly collected through internet sources, e.g. project web sites, internet sites of opponents, etc. Searches were also conducted in all the local newspapers.

A thematic analysis of the data generated in the interviews was carried out for each case. The process entailed the carefully reading of data, coding generation and integrated analysis [69]. The results have been re-analyzed and summarized for this paper according to the clusters identified in the previous section, and represented in Figure 1: (1) the characteristics of the project; (2) the engagement processes; (3) public perceptions; (4) the actions of stakeholders; (5) the characteristics of the community; (6) the socio-political context.

Table 1. Attributes of the five European CCS projects

Project location, country	Project type and lead developer	Settlement type	Strong opposition experienced	Status
Ketzin, Germany	Experimental, GFZ	Rural	No	Still operational
Hontomín, Spain	Experimental, Ciuden	Rural	No	Injection not yet begun
Barendrecht, Netherlands	Commercial, Shell	Urban	Yes	Cancelled
Beeskow, Germany	Commercial, Vattenfall	Rural	Yes	Cancelled
Belchatów, Poland	Commercial, PGE	Rural	Some	Injection not yet begun

3.1. The characteristics of the project

Although the five cases involve on-shore storage of CO_2, they differ in many aspects. First, while two are mainly research projects led by research organizations, three are demonstration projects led by the industry. The CO_2 Sink project at Ketzin (Germany) and the Compostilla Project at Hontomín (Spain) have been aimed at the observation and analysis of the effects of injecting CO_2 into a reservoir. Both have been coordinated by public research bodies - research institutions and universities. The exploration at Beeskow (Germany) was initiated and led by Vattenfall, supported by the regional government. The CCS project at Barendrecht (the Netherlands) was initiated by the global oil and gas company Shell in response to a tender by the national Government. The CCS project implemented at Be?chatów Power Plant (Poland) is coordinated by PGE Elektrownia Bełchatów S.A., part of PGE, a public company and the largest electricity group in Poland.

Differences in the properties of the project and the type of developer may well have influenced local reactions to the CCS projects. The data from the interviews indicate that the projects at Ketzin and Hontomín were framed as promoting technological innovation and international scientific research by promoters, local stakeholders and the public. Promoters in both projects were highly trusted, as they were perceived as not benefiting economically from the project. Scientists have played a prominent role in both projects. On the contrary, in Beeskow and Barendrecht the projects have been promoted by large energy companies (Shell and Vattenfall) and supported by the national or regional governments. Public trust in Shell and Vattenfall in relation to these cases seems to have been low from the initial stages of the project and both organizations have encountered significant difficulties in building trust among local citizens. In Belchatów, the stakeholders opposed to the project have been successful in framing the CCS project as a plan that is “enforced” by the European Commission and large, capitalist interest groups supported by the Polish government.

3.2. The engagement process

Promoters of the five CCS projects have tried to inform the local public and stakeholders about the projects through various engagement activities, as described below. In Barendrecht, Beeskow and Ketzin, the project developers have tried to comprehensively inform the local public about the projects at an early stage using different channels, e.g. information meetings, web pages, informal contacts. In Barendrecht, the ministers of Economic Affairs and Environment have also regularly visited the community to discuss the project with local citizens. In Belchatów, communication activities by PGE have exceeded formal requirements required by law. PGE launched a series of local meetings to introduce the CCS project to a wider public. The main target group of these meetings was local leaders who were asked to transmit information about the CCS project further to local residents. PGE also organized several conferences and a series of open-air meetings with local residents in the locations of potential carbon storage. In Hontomín, Ciuden initiated various informal engagement activities in the local community such as public meetings and interviews to introduce the project.

There are slight, but possibly important differences among cases regarding the timing of the engagement process. According to our interviews, in Beeskow, the affected communities first learned about the project when the decision had already been taken to go for an exploration permit in the locality, while in Ketzin community representatives had been involved before any geological work began. Engagement with the local community in Barendrecht had started early and has been intensive throughout project development, but nevertheless did not provide any reassurance that local concerns would be taken into account. In Belchatów, the promoter tried to proactively inform the local communities about the state of the project before the storage site was decided. In the Hontomín pilot site, Ciuden adopted a proactive and open attitude towards the local population and stakeholders. Here, public acceptance was recognized as a fundamental issue.

It is difficult to clearly identify promoters' attitudes towards both the engagement process and the views of the local communities. In Barendrecht, the local views raised by the Municipality generated a defensive response from Shell and the National Government. In Ketzin and Hontomín, the social dimensions of the project have been considered as relevant issues in the planning process and the local communities seem to have been relatively satisfied with the engagement processes. In Beeskow and Belchatów, Vattenfall and PGE have actively contacted local groups and stakeholders and offered to provide information. But opponents in both cases have questioned the quality and purpose of the engagement. According to our interviews, in Beeskow, opponents considered the information provided on the project as biased, while opponents in Belchatów considered that engagement with the local public should have taken place at a much earlier stage of project development, when key decisions were being made.

3.3. Risk perceptions

The local public and stakeholder groups at the five sites have been concerned about the potential impacts of CO_2 storage on health, the environment and the local community in general. At all of the project sites, the public have expressed reservations about the technology (e.g. that CO_2 may be toxic; the risks of storing a substance deep underground). Local communities are also aware that the technology is not fully developed and that it still involves unknowns. But the level of perceived risk has differed depending on the project. In Ketzin, it is stated by the interview-partners that the public feels safe due to the minor quantities injected and the expectation that the project would be stopped if there was any leakage. In Hontomín, interviews with key actors and members of the public showed that concerns about water contamination, impacts on private properties and other potential unexpected impacts have not become a generalised public anxiety around CCS in the locality, maybe due to the characteristics of the community and of the project.

However, at Beeskow, the wider public discussion has been strongly related to the potential risks of CO_2 storage. These include concerns that leakage will occur, possibly causing fatal accidents, the problem of controlling or removing the carbon once storage has started and ground water contamination e.g. by salt from the saline aquifer. Furthermore, opponents are afraid of negative impacts on the real estate market and tourism, and also argue that investments in CCS reduce the potential for investment in renewable energy. At Barendrecht, the potential negative impacts on public health as well as monitoring of the CO_2 were the main public concerns. Local stakeholders also doubted the need for selecting their locality for storage rather than others. Regarding the distribution of costs and benefits, the Municipality stated that Barendrecht had already absorbed many infrastructural projects in recent years; that the risks of decreases in real estate value were unclear; and that project developers will hugely benefit from the project in multiple ways by obtaining government funding to pollute, which deviates from the 'the polluter pays' principle and is unfair.

In Belchatów, the media analysis shows that perceived risks also played a role in the debate. These were centred on the potential for CO_2 leakage; earthquakes; underground explosions; suffocation of humans and animals; the risk that the ground surface could be pushed upwards; drinking water contamination; soil contamination and the souring of underground waters. Also, perceived socio-economic risks of the CCS project focused on: potential land de-valuation within the storage area; potential relocation of the population from the area designated for storage; the potential to convert the area designated for storage into a mining area to be regulated by the National Mining Institute; the potential conflict between the CCS project and geothermal projects in the area designated for storage; and the potential increase in electricity prices.

Another contested issue has been the need for the facility and how the community will benefit from it. While in Ketzin and Hontomín the members of the community interviewed seem to feel that they are benefiting from the project, as it is attracting visitors from all over the country and even from foreign countries, in Barendrecht, Beeskow and Belchatów, the local public and stakeholders perceived the project as unnecessary and not beneficial to the local community. In Belchatów, the potential conflict between carbon storage and geothermal development became one of the main issues raised by the CCS opposition.

Lack of public trust in the developers has also been a key feature of the Barendrecht and Beeskow projects. In Barendrecht, Shell and the national government were perceived as not being transparent about the potential costs, risks and benefits of the project; as not taking decisions with the local community; and as not taking public concerns into account. In short, they were not perceived as a trusted source of information and their efforts to provide independent and new information on the project were perceived as partisan. Vattenfall also experienced problems through its dual role of being both the main project beneficiary and the main source of information, for a public who had little prior knowledge of CCS or trust in the company. By contrast, the scientific researchers from GFZ and Ciuden in Ketzin and Hontomín respectively seem to be trusted by the public and by community representatives.

3.4. The actions of the stakeholders

The actions of various stakeholders have significantly influenced the public controversy around the CCS projects in Barendrecht, Beeskow and Belchatów, while in Ketzin and Compostilla stakeholders have adopted a more cooperative position with promoters. In Barendrecht, various stakeholders such as the Municipality of Barendrecht, representatives from the local political parties and citizens active in the local politics have had a role in local reactions to the project. Actions such as organizing public protest activities, creating a local activist group, voicing opinions in the media, letters of complaint about the project and demands for additional, independent research were all means used by stakeholders to influence the planning process. The Municipality of Barendrecht has also been very active in the debate around the planning process. In addition, local political parties have been key actors, organizing protest activities that received regular media attention. One of the political parties mobilized the public by organizing petitions and protest walks.

In Beeskow, politicians from all political parties have declared themselves opposed to the project, several of them in open dissent with the official position of their respective party (e.g. members of the Christian Democratic Union of Germany (CDU) party). Local councils voted against the project and officially registered their opposition at the Landesamt für Bergbau, Geologie und Rohstoffe (LBGR) as the permitting authority; several other societal stakeholders have declared their opposition to the project as well, e.g. farmer associations. The protests of local citizens emerged shortly after the announcement of the project. Local action groups were founded who quickly developed internet sites, put up posters all over the area and organized protest events. These groups have been consistently active and remained so until the cancellation of the project.

In the Belchatów case, stakeholders organized opposition towards the CCS project in different ways. Some reactions came from local authorities – several borough leaders issued formal complaints and letters to the national government. In one particular locality – in Pabianice – politicians from the local government organized the Committee against CO_2 Storage. The Committee was pro-active and organized four meetings with local residents, during which concerns about storage safety and about socio-economic implications of the CCS project were raised.

3.5. The characteristics of the community

Four of the five CCS projects (Ketzin, Beeskow, Hontomín and Belchatów) have been sited in rural areas. But they differ in the level of local familiarity with fossil fuel industries. In the CO_2 Sink project, the community includes the town of Ketzin as well as four villages and has overall about 6,500 inhabitants. Fossil fuel operations are not new to citizens of Ketzin, as the site now used by the research project was formerly used for the storage of natural gas. Regarding the pilot phase of the Compostilla project, the storage is located in Hontomín, a small village (80habs.) in the north of Burgos. The community has a high proportion of elderly residents. The area has very limited industrial activity. But it has had some relationship with the fossil fuel industry, given that small scale oil prospecting activities were developed nearby in the last decades. The area has been affected also by locally unwanted land uses, such as a factory making explosives and a recent incinerator.

Beeskow is also a rural area not densely populated, with roughly 8,000 inhabitants, situated about 80 km south-east of Berlin. Industry does not play a significant role in the local infrastructure and the bigger cities are several kilometres away. The communities are trying to enhance tourism in the region, which has a high-value landscape covered by forests and including several small lakes and rivers. Over the past few years, the local council of Beeskow invested in renovating the historical town centre.

In the Bełchatów project, the three potential storage sites are quite remote from Bełchatów. The Lutomiersk-Tuszyn area is mostly rural but its proximity to Pabianice, Zgierz and the Province capital Łódź gives local authorities and residents fairly good access to the organizations, institutions and media of these cities. This area has also been recently identified as having good geothermal potential. Wojszyce is a village in the Łódź Province, located further from Łódź than Lutomiersk and Tuszyn. Budziszewice is also a village remote from Łódź.

Barendrecht, the only urban area among the cases analyzed, is a town of 44,000 people in west Netherlands, close to one of the largest industrial areas in the Netherlands [70]. Barendrecht is a densely populated area, mainly populated by middle class families and with a high proportion of middle aged citizens and children. In recent years, the municipality of Barendrecht has witnessed a number of major infrastructure projects, including the expansion of the large motorways that surround the town and railway infrastructure, such as a double-track freight line from Rotterdam and the commencement of the High-Speed Line.

3.6. The socio-political context

In the Netherlands, CCS became a seriously considered CO_2 abatement option in Dutch climate and energy policy in 2007, as part of the ‘Clean and Efficient’ policy package. As a result, the Dutch Government provided a budget for several research projects, including the implementation of four capture and two storage projects by 2012. According to the National Government, CCS is needed because other low carbon energy alternatives are not yet ready. This claim has been contested by others who question the effectiveness of CCS as a climate mitigation measure and who argue that there are already better alternatives available. Nevertheless, project development in Barendrecht has not been preceded by an organized discussion about the utility and necessity of CCS.

In Germany, the federal government as well as some of the German Bundesländer have promoted several CCS projects over the past few years. The federal government is financially supporting two projects on carbon storage, CO2Sink at Ketzin and the CLEAN-project (Altmark, Sachsen-Anhalt). Industry (Vattenfall, RWE, EnBW and E.On) has been very active and is running several CCS projects. However, Germany does not yet have legislation on CCS, i.e. Directive 2009/31/EC has not been transposed into national law as of late 2011, a fact that could limit the commercial deployment of the technology. Public awareness and knowledge of CCS are low in Germany and so it is difficult to reliably estimate levels of public acceptance. Similar to other European countries, people in Germany prefer renewable energy sources to fossil sources and nuclear energy.

The Spanish Government has supported research on CCS technologies through Research and Development programs and the creation of Ciuden. Energy companies have invested in CCS technologies, but currently only Endesa is involved in a CCS demonstration project as a part of the Compostilla project. Although some environmental NGOs have opposed CCS technologies, CCS projects have not been subject to controversy in the national or regional contexts. Public awareness is generally low [71]. In a political context dominated by the economic crisis and job losses, the potential economic benefits of CCS projects may be influencing local debate.

In Poland, the policy and political context is arguably not favourable for CCS. While in recent years, strong political signals have been sent in favour of developing nuclear power and exploiting shale gas, a similar positive message is missing for CCS. One of the reasons for the lack of enthusiasm for CCS is its high construction and exploitation cost. The government has not yet committed any state funding to developing CCS in Poland. According to the Eurobarometer survey of 2011 there is poor knowledge on CCS in Polish society. However, more than half of respondents think that fossil fuels will still be used as energy sources in the future, that CCS will help in combating climate change and that it should be compulsory for new coal power plants [71]. Regarding the local socio-political context, in autumn 2010 local elections coincided with the investigation phase of Polish CCS projects. Several local politicians addressed CCS in their election campaigns and tried to gain political capital by amplifying risks of carbon storage, again suggesting an undercurrent of local concern.

3.7. General inferences

Despite cautioning against expectations of any comprehensive theoretical clarity in this context, there are some discernible patterns of success and failure in European CCS siting to date. A project is more likely to generate a positive community reaction if it is at a research-scale; if it is led by a public research organization with wellestablished and trusting community relationships; if the promoters develop a proactive and honest engagement strategy; if trusted experts are involved in the project; if the potential benefits are seen as outweighing the potential risks; and if the storage project is located in an area of low population density with a positive relationship with the fossil fuel industry. Simplifying, three issues can be said to be of particular relevance in terms of local reactions to CO_2 storage projects: trust in the developer, the quality of public engagement activities and public and stakeholder perceptions of the need for the facility.

The cases studied suggest that the existence of trusting relationships among the local community and promoters may facilitate the potential for progress of the project. CCS projects led by research organizations have benefited from greater perceived trust. Public research organizations and scientists usually benefit from higher perceived honesty, competence, empathy and commitment, as seen in Ketzin and Hontomín. On the contrary, industries promoting CCS projects face initial lower levels of trust, as seen in Barendrecht and Beeskow. As Europe slowly moves forward with larger-scale deployment of CCS, all these factors will remain critical to its success.

Trust in developers alone, however, may not be sufficient to generate a positive community reaction to a CCS project. For all successful sites, and as shown in similar studies [52], potential benefits need to be seen as outweighing potential risks. CCS may or may not be considered a good option to tackle climate change by individuals and social groups, but in the siting context, local communities need to perceive the need for the facility in the local community or its potential benefits to the community [33, 26]. In the cases studied, small scale R+D CO_2 storage projects were generally associated with various benefits to the local community (tourism development, higher prestige, future investments in the local community) while commercial projects were fundamentally associated by the local communities with potential costs and risks.

Regarding the role of engagement activities, the cases show that an effective public engagement strategy is a key element in a successful development. An effective engagement meets the needs of the community, is initiated early in the process, is proactive, and is integrated with the technical activities. The local public, local politicians, the media, influential individuals and representatives from local organizations may oppose the project if they are surprised by the project, or feel that they have not been involved in the process and their views have not be taken into account. Early, informal engagement, commitment to take into account stakeholders' and public views as well as a coordinated management strategy among partners are also significant elements in an effective engagement.

However, engagement does not guarantee success as broader policy issues and prior attitudes are likely to affect deployment. As shown in Beeskow, engagement activities do not automatically generate the local acceptance of a project perceived as not needed, or where community relationships have not been built. This has been also found in studies of CCS siting in the American context [52]. Engagement activities can result in many positive outcomes, from integration of a broader knowledge base to community support or social learning [72], but it is difficult to assume that all disputes can be overcome through engagement, or that trust in promoters is automatically enhanced [73].

Regarding the socio-political context, the cases show that the local debate around a CO_2 storage project may be influenced by broader policy issues. The existing policy support to CCS, the debate around the perpetuation of the coal industry, the potential conflicts between CCS and renewables, the general public perception of large energy companies or the economic crisis and job destruction may have somehow played a role in community reactions to the proposed projects. Regarding the actions of the stakeholders, we have seen that environmental NGOs, local policy makers, residents' associations and the media have influenced the public controversy around the CCS projects in Barendrecht, Beeskow and Belchatów. Opposition by local actors may have eroded public trust in these projects.

4. CONCLUSIONS

Understanding the factors involved in community reactions to CO_2 storage projects is an important but difficult endeavour. Explanations that focus on one single factor (e.g. NIMBY explanations) tend to simplify the system of causal relations and overestimate the role of some factors. The case studies considered in this paper underline the need to consider the diversity of factors in relation to CO_2 storage projects. While theoretical perspectives are always useful for their ability to provide new understanding and ways of thinking, typically they are partial in the range of factors considered. In multi-factorial, complex contexts, where diversity between cases is common and conditions are not controllable, it can be as useful - in terms of aiding understanding - to cluster factors by level or agent.

Hence we have classified the main factors involved in community responses to CCS into six broad areas: the characteristics of the project; the engagement process; the public perceptions; the actions of the stakeholders; the characteristics of the community; and the socio-political context. All of these elements can influence the probability of generating a negative local reaction to a siting process. But no factor alone can guarantee success or failure in siting, as the effects are contingent, probabilistic, inter-related (e.g. a pilot research project may increase the perceived benefits of the facility, generate a more open attitude from project promoters that, in turn, may increase trust and decrease the opposition by some stakeholders) and potentially compensatory - for example, an effective engagement strategy may help overcoming an initially wary relationship.

Along with the need to consider technical and geological criteria in site selection, non-technical aspects such as those analysed in this article should be considered and incorporated into the site selection and management of CCS projects. The successful deployment of CO_2 storage projects will be influenced by various technical and non technical factors. Social characterization, used ethically, may allow identifying potentially receptive communities and improve collaboration with communities [52]. The long-term vigilance in managing the CO_2 introduces new technical and management challenges. A socially robust management of CCS storage projects is likely to lead to more acceptable outcomes as well as a more productive and sustainable practices.

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