Understanding Governance and Regulation of CO_2 Storage in Europe

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Abstract

Climate change, continued economic development, and energy security have become increasingly pressing issues over the past two decades or so. One potential solution to this interrelated problem is the idea to capture the carbon dioxide (CO_2) from large stationary emission sources, such as power plants, and permanently store it deep underground. In this way CO_2 emissions can be prevented from reaching the atmosphere, whilst allowing for a continued use of fossil fuels, until other alternatives (i.e. wind, solar, biomass) are developed on a wider scale. This process is also referred to as carbon capture and storage (CCS). The literature review in this thesis identifies the need to present a more in-depth picture of the entire process of governance of CO_2 storage.

The aim of this research is therefore to examine the extent to which the current legal and regulatory frameworks are able to mediate between managing the environmental risks of CO_2 storage and the development/deployment of CCS in Europe. The analysis is underlined by the governance network theory (GNT), borrowing also elements from the theory of bounded rationality. Along with an extensive doctrinal legal scholarship, data analysis is also supported by 15 in-depth interviews with key CCS stakeholders in Europe.

The results show that there is a wide consensus that the current legal and regulatory frameworks are robust enough, albeit the existence of uncertainty in regards to a number of legal provisions. There is also wide agreement between stakeholders in regards to the ability of operators to manage the environmental risks of CO_2 storage.

The discussion of these results show the applicability of the GNT as a framework for studying the management of environmental risks of CO_2 storage, and the development and deployment of CCS technology in conjunction. Implications drawn from these findings also show that the management of environmental risks of CO_2 storage and the future of CCS technology depends heavily on the effective relationship between the government agencies (i.e. competent authority) and project developers. Furthermore, good communication and engagement with other stakeholders, in particular the general public, will also be significant in the future development/deployment of CCS projects in Europe. When these relationships are good, this research argues that efficiency gains of governance are realised.

Acknowledgements

Over the past four years, a number of people were instrumental in helping me get through the PhD journey

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I would also like to thank the University of Sheffield, and the School of Law, for giving me a tremendous opportunity to pursue this PhD, and for all the wonderful moments I experienced playing sports and meeting new people. All had a role to play, in one way or another, in helping me finish this thesis and shaping me into the person and researcher I am today.

Most importantly I want to thank my family. Words cannot express how grateful I am for all the support I have received over the past several years. Without it, the road to finishing the PhD would have been much harder.

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CHAPTER 1: Introduction

1.1 Background information

1.1.1 An interdisciplinary project

This study is part of a critical niche research area in the field of carbon capture and storage (CCS), part of a tri-faculty effort at the University of Sheffield, between the Faculty of Science, led by the Department of Physics and Astronomy, the Faculty of Engineering, led by the Department of Civil and Structural Engineering with the Department of Materials Science, and the Faculty of Social Sciences, led by the School of Law. The overall project is titled **Project Deep Carbon: Verification Engineering and Governance of Environmental Carbon Sequestration.** This thesis, based at the School of Law, aims to support two other studies by identifying and recognising the socio-economic, legal and political issues that do and could have an impact on the science and engineering developments in CO_2 storage.

The other two PhD projects aim to specifically tackle the CO_2 storage issue of how to provide long-term monitoring of the underground CO_2 deposits, how to guarantee the security of the stored CO_2 against potential leakage and release into the atmosphere. Modelling CO_2 containment in rock structures and the improvement of knowledge of the containment challenges, as well as the development of new measurement technologies that would ensure reliable and safe monitoring of this containment are their key objectives.

This collaborative effort falls within the vision of the University of Sheffield's Environment and Energy agenda and within the EU and UK government's environment strategy, where resources are being increasingly targeted. Although significant and growing funding potential for future carbon storage research appears through industrial, EU and international sources, the scholarship to pursue this PhD research came from the University of Sheffield.

While the original intended collaboration between the three PhD researchers was initially working as planned, in that we met frequently to inform each other on the progress made, over the course of the last two years, these meetings in practice did not work as well. As such, the direction of my research was slightly changed, so as to not focus as explicitly on the work being done by the other two researchers. Instead, the focus slightly shifted from examining how the regulatory framework for CO_2 storage supports development of monitoring and verification technologies, to a broader analysis of the coherence and appropriateness of the framework in managing environmental risks of CO_2 storage, whilst supporting the development of the CCS technology as a whole.

Industrial participation

Given the research potential of the project, and its importance to the industry, involvement of three specialist companies that were willing to contribute their expertise was negotiated. These include Alan Auld Engineering Ltd., an international underground design company based in South Yorkshire, CO2DeepStore Ltd., a new carbon sequestration company based in Aberdeen, and Cleveland Potash Ltd., owners of the largest and deepest active mine site in the UK. These companies were brought in to provide technical expertise and strong industrial links.

1.1.2 Personal history and reflection

Before turning to presenting the context and motivation for this study (see 1.2 below), I believe it is important for me to briefly describe my academic, research and professional background. I completed my Bachelors of Science (BSc) in Environmental Science and Policy, with a concentration in Environmental Economics, form the University of Maryland – College Park, in the United States. During my time at the University of Maryland, I also completed an internship at the Embassy of the Republic of Slovenia in Washington DC, and was a research assistant to Prof. Dr. Anna Alberini on a project researching mortality associated with heat waves and the effect of excessive heat advisories and warnings (funded by US EPA via Battelle National Laboratories; project officer: Hugh Pitcher). The research project, for example, evaluated the possible health consequences of climate change and opportunities for adaptation. It sought to address questions like: ‘Are excessive heat warnings issued by the US National Weather Service, and various city initiatives effective at reducing excess mortality?’

I also completed a traineeship at the Directorate for Global Issues and Multilateral Political Relations at the Slovenian Ministry of Foreign Affairs, where I helped organise a major international conference (Bled Strategic Forum). There, my tasks included writing press releases and speeches for various high-level officials, and engaging with other stakeholders, including industry representatives on matters related to the conference. Following the traineeship, I went on to obtain a MA in

Globalisation and Development, at the University of Sheffield, where my focus was on the impact of climate change on development.

My academic, professional, and research background, as briefly described above thus lies in a wider spectrum of interrelated areas: science, economics, and policy. This PhD research, situated at the School of Law, reflects this background and attempts to maintain a sense of these interrelated areas throughout the thesis.

I should also acknowledge at this point, that my academic and research background has over the years in essence led me to today being sympathetic to and supportive of the CCS technology and its role as a climate change mitigation tool. Although other mitigation technologies, such as wind, solar, hydro and nuclear, are required in the overall portfolio of technologies, I firmly believe that CCS is a crucial component as well, given its short- and mid-term potential to deliver large CO_2 emissions reductions. These reductions are necessary not only from an environmental perspective, if global warming of the atmosphere is to be limited to 2 or even 4 degrees Celsius, and as such limit the severity of the impacts, but also from a legal perspective, given the commitments made by the EU, and the UK in particular, to deliver significant emissions reductions.

Lastly, I should note that in regards to the data collected, in particular the views and statements from various industry representatives represent a particular interest and as such could reflect an overwhelming argument that the risks of CO_2 storage are low and that regulation can be burdensome. However, as a researcher I attempt to question their responses and make every effort to present as objective of a picture as possible throughout the thesis.

1.2 The context

Increased frequency of extreme weather events, sea level rise, reduced agricultural yields, and human migration, are only some of the already occurring, and future consequences of global climate change. In 2015, the human influence on the Earth's climate system, primarily via anthropogenic emissions of greenhouse gases, has become clearer, and higher than ever. In the period between 1880 to 2012, for example, the globally averaged combined land and ocean surface temperature data has shown a warming of 0.85 °C, and in 2013, for the first time in history, an average

CO_2 level in the Earth's atmosphere has been set above 400 parts per million (ppm).[1] In this regard, the recent IPCC Fifth Assessment Synthesis Report[2] has concluded that emissions scenarios of GHG concentrations in 2100 of 450pp CO_2eq or lower, are likely to maintain the warming below the 2°C threshold[3], over the 21st century relative to pre-industrial levels. These estimates, however, are based on the notion of 40-70% global anthropogenic GHG emissions reductions by 2050, compared to 2010 levels, and near- or below-zero emissions levels by 2100 (IPCC, 2014: 21). In other words, climate change has taken hold and has the potential to bring devastating consequences by the end of the century. However, as this IPCC report also suggests, there is still time to limit climate change, whilst allowing for continued development.

Capturing CO_2 from large stationary sources and storing it underground has to-date been recognized internationally as one of the key tools for tackling the issue of climate change in the short- and medium- term, in order to decarbonise the economy. Ambitions to limit the impacts of climate change, which include carbon capture and storage (CCS), cannot be achieved without finding solutions that are themselves safe and environmentally acceptable. In the context of CCS, this refers to ensuring the integrity of the stored CO_2 for decades or centuries, and the robustness of a new legal governance structures that support the development process and safeguard against environmental and social damage.

Personally, I acknowledge that given my academic and research background in environmental science, policy and law, I do believe that humans are to a great extent responsible for the dramatic rise in atmospheric CO_2 concentration levels over the last 150 years. At the same time, however, one must also acknowledge that there are still some who deny climate change, or at least the extent of the anthropogenic influence.

Climate change denial

Coastal flooding, drought, heat waves and other extreme weather events are all indicative that climate change is happening, and with all the evidence present today, in the form of temperature measurements, sea level rise, ocean acidification, melting of ice shelves in Greenland and Antarctica, as well as CO_2 concentration levels, it is

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[1] This is primarily a symbolic milestone, illustrating the significant rise in the CO_2 levels of 280ppm before the industrial revolution (Thompson, 2014).

[2] IPCC (2014). Available at: http://www.ipcc.ch/pdf/assessment-report/ar5/syr/SYR_AR5_SPMcorr2.pdf.

[3] This is a generally agreed upon temperature threshold, above which climate change will significantly damage the global environment. See for example World Bank (2012).

becoming increasingly harder to remain a climate change sceptic or denier; denying or dismissing scientific consensus on global warming, its extent and significance as well as its connection to human behaviour. Denial, however, also differs from scepticism, which Peter Christoff (2007) argues is essential for good science. Denial, as Dunlap and McCright (2011) explain, has in recent years been intensified by contrarian scientists, fossil fuels corporations, conservative think tanks, and various front groups, which have assaulted the mainstream climate science, and built their arguments on the manufactured ‘Climategate’ scandal and minor errors in the 2007 IPCC 4th Assessment Report (p. 144). These actors, along with other amateur climate bloggers, self-described experts, public relations firms, conservative media and politicians, have been described as a coordinated ‘denial machine’ (Begley, 2007). In her article, for example, Begley (2007) cites that a conservative think tank, long funded by ExxonMobil, which offered scientists $10,000 USD to write articles, which undercut the above-mentioned IPCC report, and the computer-based climate models it is based on. The motivations behind climate change denials vary considerably, from economic (i.e. fossil fuel industry) to personal (i.e. celebrity status enjoyed by individuals). Furthermore, a recent report by The Guardian[4] identified that over the last three years, around $125 million USD (82 million GBP) was channelled through two organisations (Donors Trust and Donors Capital Fund)[5] to climate change denial groups and organisations in the US. These funds are then used by industry-friendly groups to create and disseminate books, put out briefings and editorials, bring in contrarian scientists, support other public relations efforts and the right wing media which promotes climate change denial, as well as to undermine regulations aimed at curtailing emissions and other environmental standards (Ecowatch, 2015; The Guardian, 2015)[6].

In essence, what holds climate change deniers together, however, is in most cases the opposition to governmental regulatory efforts to ameliorate climate change, such as for example in the case of restricting carbon emissions. In other words, there is a strong commitment to free markets and a disdain of government regulations (Dunlap

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[4] The Guardian (2015). *Secretive donors gave US climate denial groups $125m over three years.* 2015. Available at: http://www.theguardian.com/environment/2015/jun/09/secretive-donors-gave-us-climate-denial-groups-125m-over-three-years.

[5] These are not-for-profit companies that distribute millions in grants each year to groups, organisations and projects, which offers anonymity to donors who do not with to make their donations publicly.

[6] Some of the largest recipients include the Franklin Center, Federalist Society, State Policy Network, and the Hudson Institute. See The Guardian (2015) for a more detailed list.

and McCright, 2011; see also Oreskes and Conway 2010), in large part because of a perceived threat posed by climate change to their interests. Hence, these actors most often strive to undermine the scientific evidence of the reality and seriousness of climate change.

In any description of responses and beliefs to and about anthropogenic climate change, however, the prevalence of views must be allowed (Levett-Olson, 2010). From a critical realist theoretical perspective, this means that while evidence of climate change is prevalent, the possibility of alternative accounts and perceptions is acknowledged. This study takes advantage of this wider debate about climate change and regulation, and advances it by placing it in the context of carbon capture and storage. In this respect, document analysis is supported by data obtained from interviews with those directly involved in CCS project development – the industry – in an attempt to examine the perception of the appropriateness and coherence of the regulatory framework for CO_2 storage in Europe. In other words, the aim of this study is to examine whether and how regulation might stand in the way of developing CCS technology – a climate change mitigation tool.

Dealing with climate change and the role of CCS

There are a number of ways of dealing with the issue of climate change. The approaches include both adaptation[7] as well as mitigation[8]. The latter category is where carbon capture and storage (CCS) is situated.

As impacts and potential future risks of climate change are becoming more apparent, interest in CCS as a climate change mitigation option has also been increasing since the beginning of the 21st century, both in the private and public sectors. By capturing CO_2 from large point sources (i.e. power plants), compressing and transporting it to suitable storage sites where it is injected deep underground, CCS is said to offer the potential to meet the challenges of dealing with increased

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[7] Adaptation refers to the adjustment to the effects of the actual or expected changes to the environment. Depending on its context, refers to approach such as: integrated natural resources management, social and ecological asset development, information systems to support early warning and proactive planning, institutional and educational/behavioural change or reinforcement (IPCC, 2014: 106).

[8] Mitigation refers to efforts to limit the magnitude and rate of climate change, by tackling its causes, such as GHG emissions. Mitigation approaches, among other things, switching to low-carbon energy sources, such as renewable and nuclear energy, as well as things like expanding forests, which serve as carbon sinks, and promoting energy efficiency.

energy demand, the need for energy security, whilst allowing for de-carbonisation and continued economic development.

Essentially, deploying the CCS technology would allow for the continued use of fossil fuels (i.e. coal and natural gas), only without the CO_2 being emitted into the atmosphere. This is considered as a medium-term transition tool in combating[9] climate change, whilst other technologies (i.e. wind, geothermal, solar and hydro) become more widely deployed. On the other hand, one of the arguments against CCS, for example, is that fossil fuels should be eliminated entirely, and that CCS will not be able to achieve what it promises. However, the reality is that in order to meet the increased demand for energy, fossil fuels are still needed, given primarily the intermittent nature of those alternative sources of energy.

The CCS process

The entire process starts with the capturing of the CO_2 at the (stationary) sources. There are essentially three types, or ways, of doing so, including:

- Post-combustion: combustion of fossil fuels (i.e. coal, natural gas, biomass) is done in a traditional manner (i.e. using a boiler or a combined cycle gas turbine), followed by a separation of the CO_2 from the flue gas, most often by a chemical sorbent such as amines or ammonia, which absorb the CO_2 before it enters the atmosphere;

- Pre-combustion: carbon is removed from the fossil fuel prior to combustion in a gas turbine. Coal is combined with oxygen to create a gas ('syngas'), made up of Hydrogen (H) and carbon monoxide (CO). Water (H_2O) is then added to the 'syngas', through a water gas shift reaction, whereby CO is converted to CO_2, which is then removed from the fuel by a separation process. Hydrogen is then burned in a combined cycle gas turbine to generate electricity; process referred to as Integrated Gasification Combined Cycle (IGCC).

- Oxy-fuel combustion: the fuel (i.e. coal, biomass) is burned in pure oxygen, as opposed to air, such as in other two capture methods. Once Nitrogen is

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[9] Intermittent energy sources are essentially those that cannot continuously provide the energy due to some indirect factor. Solar, wind and/or tidal power are such examples. In other words, meeting the demand of a power system cannot always be guaranteed. As such, until the efficiency of some of these energy sources is significantly improved, fossil fuels will continue to be used.

> removed from the air, by an air separation unit, the pure oxygen is combined with the fuel in a boiler, where combustion takes place. This generates steam, which is used to power the turbines and generate electricity, while the flue gas consisting of CO_2 and water vapour is recirculated to control the boiler temperature and to be cooled. The CO_2 is then dehydrated, compressed and made ready for transportation and storage.

Once the CO_2 has been captured and pressurized into a liquid-like state, it is then transported through pipelines to pre-selected and screened storage sites. Possible CO_2 storage locations on-shore include depleted oil and gas reservoirs, un-minable coal seams, and deep saline aquifers. A second option, which is most likely the only option in the UK and for most of the continental Europe countries, is to store the CO_2 under the seabed offshore.

During the storage process, the CO_2 is injected deep underground (i.e. 1000-3000m) into the sandstone layers, where it is to be contained by the natural pressure of the impermeable nonporous cap rock layers above. Although the saline aquifers are thought to hold the largest potential capacity for storage, they are also the least understood – i.e. CO_2 movement and containment – as compared to depleted oil and gas reservoirs, for example. The fraction of the CO_2 retained in appropriately selected and managed geological sites, as the 2005 IPCC Special Report pointed out, is 'very likely' to exceed 99% over 100 years, and 'likely' to exceed 99% over 1000 years (p. 14).

However, despite experiences in capturing and injecting the CO_2 underground, primarily for the purpose of enhanced oil recovery (EOR), the (new) integrated nature of the CCS-system presents a number of uncertainties, and therefore also inherent environmental risks. This is the case in particular with the storage component of the CCS chain.

As such, for the technology to be developed and deployed, and serve its potential as a climate change mitigation tool, a clear and strong legal and regulatory framework is crucial. This brings to the forefront the complex interrelationship between the areas of science, technology and law. This interrelationship comprises one of the underlying themes of this research. In addition, given that permanent CO_2 storage is a relatively novel concept, despite technical and technological experiences and evidence, questions about governance are often raised. In other words, how and to what extent the environmental risks of this process will and can be managed.

To date, the literature on CCS has mainly focused on the capture, and the technical components of the storage parts of the chain. In the case of the storage part of the CCS chain, some amount has also been written about the importance of legal and regulatory frameworks. However, there is still a gap in the literature on CCS that would integrate and present the complex nature as a whole, in particular from a legal and regulatory perspective, and the views from those that would be primarily affected by the regulations – the industry[10]. Here is where this research steps in, by approaching the field of CCS from a governance and regulatory perspective, and offering a critical examination of both the governance process, as well as the legal and regulatory frameworks for CO_2 storage in Europe.

When it comes to new technologies, such as CCS, in particular when these are laden with uncertainty and risk, it becomes crucial to strike a balance between managing those risks, whilst ensuring the technology is being developed in a timely manner. In this research, when discussing the notion of environmental risk, it primarily refers to the risk of CO_2 escaping from a reservoir, in addition to seismic events or contamination of water resources. Given the relatively young literature on CCS, there has not yet been an attempt to approach the issues of governance and technology deployment from such a perspective or in conjunction.

Choosing the focus of study

Arriving at the focus of study started off with a review of the broad literature on governance and regulation of environmental issues, as well as more specifically as they relate to CCS, and how they have been examined thus far in the European and UK contexts.

The reason for choosing the UK as a case study within the European context, was because it has to-date developed one of the most comprehensive legal and regulatory frameworks for CO_2 storage in Europe the world, as well as because a large majority of the overall storage potential for captured CO_2 from Europe lies off its coast – i.e. beneath the North Sea.

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[10] As is explained in Chapter 2, for simplicity and coherence purposes, ‘industry’ and ‘CCS industry’ concepts are used in general terms to encompass those companies that are involved in CCS project developments. Where ‘industry’ is used in the context of other heavy-emissions processes (i.e. steel and cement, chemicals), this is explicitly stated in the text.

One of the major reasons for arriving at the research focus outlined below is that I do not come from a strictly legal background, but rather, as mentioned above (section 1.1.2), from an interdisciplinary background consisting of environmental science, economics and policy. As such, the hope is to try to bring out the interplay of these fields within the context of the regulation and CO_2 storage. In other words, the goal was never to focus strictly on the legal and regulatory aspects of CCS/ CO_2 storage, but rather to give the reader an interdisciplinary understanding of the processes related to CO_2 storage. Thus, I set out to examine not only how environmental risks are substantively accounted for within the legal and regulatory frameworks in Europe and the UK, but also, whether these frameworks in turn in any way inhibit the development and deployment of CCS technology as a whole.

With this in mind, the following key research question was developed: ***to what extent does the current legal and regulatory environment for CCS in Europe mediate between the development and the governance of the technology?***

Based on this question, there are two main objectives set out for this study. The first is to *identify the nature of governance of CCS in Europe*. Doing so involves four steps/aims:

- Identify key debates/characteristics of uncertainties and risks of CO_2 storage.
- Analyse the use of precaution in the current legal and regulatory regimes.
- Undertake an analytical review of the CCS governance process in the EU, and the UK, and their respective regulatory frameworks.
- Identify key legal and regulatory issues.

The second objective is then to find out the effect of the ‘precautionary approach’ (see Chapter 6) in the regulatory regime on the CCS industry. Here, three steps/aims are laid out:

- Examine the perception of the legal and regulatory frameworks among the CCS industry. How does the perception compare to that of other stakeholders? This will be explored by conducting a number of interviews with those directly and indirectly involved with CCS development.
- Discuss the impact of the public factor on the CCS industry and potential for future opposition in the EU/UK.

- Determine whether the legal and regulatory regimes stand as likely barriers to CCS development and deployment.

Based on the set out research question and objectives, as described above, this study essentially represents a critical analysis of the law and regulation surrounding CO_2 storage in Europe. The chapters that follow provide insight into the various aspects of the overall governance process, with the end aim being to determine the coherence and appropriateness of the regulatory framework in terms of mitigating environmental risks of CO_2 storage, whilst ensuring that the development of the CCS technology is not inhibited. As such, this analysis is also situated in a broader context of a debate on climate change, and a theoretical framework on regulation. The key argument of this research is that the current regulatory arrangements for CO_2 storage in Europe and in the UK, as viewed form a governance network framework, are robust enough. Albeit certain potential improvements could be made in regulatory terms, at present the framework does not inhibit the development of the technology. The main reason behind slow development of CCS remains of financial nature – i.e. lack of sufficient short- and long-term financial support and certainty. Although the economics of CCS is not the main concern of this research, various aspects in this area are examined, as they inevitably relate to regulation.

To guide the argument being pursued and answer the main research question, the thesis is set out in the following way. In the second chapter, the theoretical perspective and methodology employed in this study are presented. This is followed by chapter three, in which an extensive review of the literature is presented. This serves the purpose of introducing the underlying theme of the research, which is the interrelationship between the science, technology and law. The fourth chapter then provides a critical examination of the governance of CO_2 storage in Europe, before turning to analysing the UK as a key case study example, in chapter five. Chapter six then presents the data obtained from the interviews with a variety of CCS stakeholders, including government officials, university professors, researchers, and in particular the CCS industry. Lastly, chapter seven is divided to provide first a reflective conclusion on the study and findings, and second to summarise the work and suggest potential areas of research for the future.

CHAPTER 2: Theoretical Framework and Methods

This chapter now presents the chosen research questions, theory, and the methodology and methods employed in this study.

2.1 Research Questions

Carbon capture and storage (CCS), is a technology and process, which today still remains laden with a number of uncertainties, and hence risks. As has been the case in the past with other technologies (i.e. nuclear), the management of environmental risks, whilst ensuring timely development and deployment of the technology becomes crucial; in light of the importance of the issue at hand (i.e. mitigating climate change). Given the relatively young literature on CCS, there has not yet been an attempt to approach the issues of governance and technology deployment from such a perspective. As such, this project seeks to derive answers to the following key question:

To what extent does the current legal and regulatory environment for CCS in Europe mediate between the development and the governance of the technology?

To answer this research question, the study seeks to examine the nature of governance, the legal and regulatory regimes, as well as the perception of the latter by the stakeholders most affected by these regimes. So as to aid in answering the question, the following two sub-questions, and objectives, were also formed:

1) What is the nature of governance of CCS in Europe?

- Identify key debates/characteristics of uncertainties and risks of CO_2 storage.
- Analyse the use of precaution in the current legal and regulatory regimes.
- Undertake an analytical review of the CCS governance process in the EU, and the UK, and their respective regulatory frameworks.
- Identify key legal and regulatory issues.

2) *What is the effect of the precautionary approach in the regulatory regime on the CCS industry?*
    - Examine the perception of the legal and regulatory frameworks among the CCS industry. How does the perception compare to that of other stakeholders?
    - Discuss the impact of the public factor on the CCS industry and potential for future opposition in the EU/UK.
    - Determine whether the legal and regulatory regimes stand as likely barriers to CCS development and deployment.

2.2 Theory

Governance and regulation

Over the past quarter of a century, the literature on governance has been steadily increasing. Chhotray and Stoker (2009) note that in this time, the term 'governance' has moved from the status of a lost word of English language to a fashionable and challenging concept in a range of disciplines and research programmes (p. 1).

The focus of this research is in broad terms the governance of CO_2 storage in Europe. As discussed later on in Chapter 3, the concept of 'governance' often appears in the literature in a number of different ways. This study is underlined by the five propositions developed by Stoker (1998), who notes that governance: i) refers to a set of institutions and actors that are drawn from but also beyond the government; ii) identifies the blurring of boundaries and responsibilities for tackling social and economic issues; iii) identifies the power dependence involved in the relationships between institutions involved in collective action; iv) is about autonomous self-governing networks of actors; v) recognizes the capacity to get things done which does not rest on the power of government to command or use its authority.

The above conceptualisation of 'governance' essentially seeks to understand the way collective decision-making is constructed. The objective of the decision-making process is the effective management of environmental risks associated with CO_2 storage, whilst facilitating the deployment of the CCS technology. Such understanding is deemed most suitable to address the set out research question, and in my analysis plays the role of developing a better understanding of the science, technology and law nexus, in the context of CCS.

At the same time, however, this study does acknowledge the potential critique of Hood et al. (2001), who start their work on government of risk with an observation that this kind of ‘grand theory’ perspective, or a helicopter view of the world of risk management, misses in particular the variety of approaches to regulation of risk, and the messiness of risk. The authors seek to comparatively understand risk regulation regimes and the diversity and commonality between approaches to risk regulation. This study does agree with their views as a fair criticism of risk regulation/risk society kind of literature, and is something it takes into consideration.

Essentially, the Hood et al. (2001) critique is that the risk society framework, as pursued by Beck (1994, 2006) or Giddens (1999), misses the kinds of diversity in risk regulation.[11] However, the central focus of this research is not an explicit examination of the similarities and differences in approaches to risk regulation and management in EU Member States. Rather, the focus falls on a broader regulation and management of risks related to the storage of CO_2 and the development and deployment of CCS technology in Europe. It complements the kind of ‘grand theory’ perspective, which Hood et al. (2001) criticise, by employing elements of bounded rationality theory (see section 2.2.1).

Seeing the nature and problems of regulation from a decentred perspective can also be very stimulating as Black (2002) notes, given that it opens up the cognitive frame of what ‘regulation’ really is. Decentred in this case refers to as it being separated from the state, and other well recognised forums of self-regulation. In this way, ‘decentred’ regulation resonates with the globalisation and governance debate. By looking at regulation as ‘decentred’, it enables commentators to spot regulation in previously unsuspected places, such as different configurations of state, market, community, associations and networks, which deliver public policy goals (Black, 2002: 1-2). As Black (2002) also notes, this throws into question what it is that we want the concept of regulation to do, and its implications. Moreover, it poses the question of what actors other than the state, and to what extent they might be harnessed by the state in the design of hybrid or post-regulatory mechanisms in order to address and further public policy objectives.

In her article, Black (2002) for example, argues that decentred perspective of regulation embraces a wider set of techniques than simply the ‘rules backed by

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[11] See also Hood (2002) for more on risk regulation, and Renn et al. (2011) who provide an interesting examination of the complexity of uncertainty and ambiguity in risk governance/regulation.

sanctions' of command-and-control regulation. In other words, the author suggests that much of the theoretical analysis is rooted in the systems theory or other similar analytical roots and tools, which have at its conceptual core use the following five central notions: i) complexity; ii) fragmentation; iii) un-governability; iv) interdependency; and v) blurring of the distinction between the public and private.

Within a decentred analysis of regulation, *complexity* refers to the dynamic of interactions between the actors and/or systems, which often have different goals, intentions, purposes, powers and norms, as well as the operations of forces, which produce a constant tension between the stability and change within a system. *Fragmentation* on the other hand refers to the fragmentation of knowledge, as well as of power and control. In other words, no one actor has all the information and ability to employ the instruments necessary to solve social problems, and make regulation effective. Not only is knowledge fragmented, but information is also to an extent socially constructed, meaning, that there is no such thing as complete 'objective' truth. Furthermore, no single actor can dominate the regulatory process unilaterally given that all actors can be severely restricted in reaching their own objectives not just by limitations in their own knowledge, but also by the autonomy of others (*ungovernanility*). Also, given that regulation is never a one-way street, each actor is seen as having both problems (needs) and solutions (capacities), and is in turn mutually dependent – *interdependent* - on each other for their resolution and use (Kooiman; in Black, 2002: 7).

As such, regulation is not the product of exercise of formal control, but rather of the interactions between both the public and private actors within a system. Identifying the *blurring of the public-private boundary* involves identifying and analysing so-called 'hybrid' organisations or networks that combine both governmental and non-governmental actors (Black, 2002: 8).

In the five notions mentioned above, is essentially where the connection between governance and regulation, and where this research is situated in. In other words, the theoretical analysis of regulation for CO_2 storage in Europe in this research is rooted in the so-called governance network theory discussed below. The critical stance taken by the analysis employed is essentially to examine whether the current regulatory system is working, and if it is not, why that is the case.

2.2.1 Governance network theory

It should first be noted that governance, as a conceptual framework, is used in this thesis not at the level of a causal analysis, but its value rather lies in providing for an organizing framework. Using such a conceptual framework provides for both a type of language and a lens, or frame of reference, through which a complex reality can be examined. The reality in this research refers to the environmental risk and impacts of CO_2 storage leakage.

In essence, this research employs the wider theory of governance networks, which essentially takes on the rules of collective policy and decision-making, in a setting where there is a *plurality of actors* and organisations, and where *no formal control systems* can exclusively dictate the terms of the relationship between these actors and organisations (Chhotray and Stoker, 2008). While governments are promoting governance networks as an effective and efficient setting in which (CCS) technologies can be developed and risks managed, there inevitably remains a sense of hierarchy and market also playing important roles.

The governance network theory, in this study, essentially focuses on the manner in which environmental risks are dealt with and managed through joint action and interaction. In this respect it examines the management of these risks through the legal and regulatory lens. In terms of the microelement of governance, the research analyses the process of interactions between the various public and private stakeholders that resulted in the development of the respective legal and regulatory frameworks for CO_2 storage in Europe, and in the UK. The macro-element is examined by considering other influences that impact the process of governance, including the role of ‘precaution’ in a wider context of dealing with environmental and energy related issues, as well as the impact of other external factors, such as the global financial crisis and other political issues.

A general theory of governance, and other theories such as reflexive modernisation and risk society are useful to the extent that they provide a kind of ‘helicopter view of the world’. These theories, however, at its core miss out on, some of the sociological elements of governance, which are the focus of theories like rational choice or actor-network theory. As such, the value of employing a governance network theory lies in that it attempts to combine the ‘best of both worlds’, by also drawing insights from the likes of Simon (1982) and Friedman (1953), including strands from behavioural economics and rationality.

In this respect, employing the governance network theory is complemented by borrowing ideas from bounded rationality theory.[12] While bounded rationality theory is today still primarily used in the fields of economics, in this thesis, it is used as a complementary concept, and is not intended to represent a core component of the thesis. Nevertheless, by using some of its elements, an attempt is made to help explain the rationality behind the functioning of the governance network (i.e. interaction between its actors).

The purpose, as well as the value of employing the governance network theory, with elements from bounded rationality, lies primarily at the explanatory level, resting on its ability to provide a framework for a better understanding of the process of governance and regulation. In other words, the theories will be used essentially so as to examine and analyse how the governance and regulatory regimes for CO_2 storage in Europe have come together, and how they interact. As such, this study is primarily an explanatory type of research.

Bounded Rationality

Bounded rationality owes a great deal to notions of rational choice. Rational choice theory, however, uses a very specific and narrow definition of rationality, to refer to an individual, or business, acting *as if* balancing the costs versus benefits in their decision-making process, so as to maximize their personal advantage. However, it ignores some sociological and contextual factors, such as, for example, a history of extractive and fossil fuel industry in an area, or the issue of ethics and trust, all of which can turn out to be a significant factor in shaping public opinion about whether or not to accept or oppose a technology.[13]

Bounded rationality theory, in essence argues that rationality of X is limited by factors such as limited cognitive ability, availability of information and/or time. As such, behaviour is characteristic to utility satisfiers, as opposed to utility maximisers. Bounded rationality theory is in this respect part of a broader sociological group of

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[12] Simon (1982). See also Gigerenzer and Selten (2002: Ch. 2-3), Morecroft (1983), and Jones and Thomas III (2012).

[13] An important component in understanding public perception of the risk of a technology, is the fact that knowledge is conditional, and that whereas experts might exhibit a good deal of trust in the supporting institutions, that same view is not necessarily shared by the public (Wynne, 1992, 1992b; Wynne, 2006).

theories[14], and at its core rejects 'absolute' rationality. Using elements from the theory of bounded rationality therefore helps in providing for a more accurate picture of the governance process.

2.2.2 The approach in this thesis

The main objective of this research is to critically examine the legal and regulatory frameworks necessary for environmentally safe geological storage of CO_2, and the enabling of CCS technologies in Europe. A governance network approach, as used in this research, is a strategy for examining the integrated management of environmental risks of CO_2 storage, and the promotion of the development and deployment of the CCS technology. Such an approach is based on the application of appropriate methodologies and principles, which encompass the essential structure, processes, functions and interactions among the network actors and their environment. Such focus is consistent with the definitions of governance in the literature, as described in Chapter 3.

Furthermore, the governance network approach to the study of risk management must not only deal with the complex and dynamic nature of the policy and decision-making process, given the absence of complete knowledge and scientific uncertainties primarily in the context of CO_2 storage, but also with the legal and regulatory frameworks themselves. By adopting such an approach, this study argues, a near-optimal answer to questions concerning the effectiveness[15] of the legal and regulatory frameworks can be provided, given the relatively young age of the frameworks and lack of any commercial-scale projects to-date in 2015.

It should be pointed out that the contribution of the governance network perspective to theory, as mentioned, does not lie at the level of causal analysis, nor offer a new normative analysis. Rather, its value is as an organizing framework, and rests on its ability to provide a framework for understanding the process of

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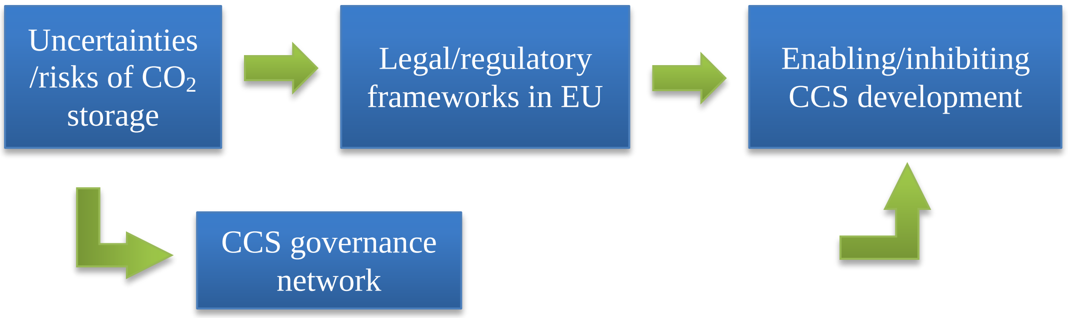
[14] Works of authors like Wynne (1992, 2006) and Douglas and Wildavsky (1982), are also considered influential, in that they highlight the idea that social affiliations and broader life experiences, as well as things like values and interests, play a key part in determining how individuals define problems and issues, aspects of the situation on which they focus, type of evidence they seek, whose opinion they believe, who they trust, and their preferred process for decision-making (Bradbury; in Markusson et al, 2012: 46).

[15] Effectiveness in this respect refers to the extent to which the legal and regulatory frameworks are impeding development and deployment of CCS, as well as their relative perception by the CCS industry.

governance. The following diagram explains the progression of the approach adopted in this study:

Diagram 1: Progression of the study



This study recognizes the limits of using the governance network concept and approach and their power to explain policy outcomes. As such, the study seeks to determine the *nature* of the CCS governance network in Europe, and comment on its role in the development of the legal and regulatory frameworks. In this respect, the driving force of explanation (explananda) is the characteristics of actors[16] and the nature of governance network being the dependent variable (explanans). It is the characteristics of the actors – agency – as well as the institutional structure of the network, and the context in interaction, which determine the nature of the network

The nature of the network is determined based on a variation of the model developed by Rhodes (1998) in his study of policy networks. The so-called 'Rhodes model', and its variants, has been most widely acknowledged in the literature on policy networks, and in particular in relation to the study of EU governance. The 'Rhodes model' is acknowledged by adopting two of its variables: i) the relative stability of the network; and ii) resource interdependency.

2.2.2.1 Stability and Interdependency of a governance network

Stability: core vs. the periphery

The first variable here refers to a *network's structure*. A structure of a network can be defined in a number of ways, however, as Borgatti and Everett (1999) suggest, this is best done by seeing whether it is structured as a *core-periphery model*. In such a

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[16] i.e. control of resources or specialist knowledge, which gives them a kind of over or advantage in shaping the policy shaping and decisions, as well as leads to their inclusion in a 'networkesque' description of the governance process.

model, a network, as argued in this study, has a core-periphery structure if it can be partitioned into: i) a *core*, whose members are closely tied to each other and hold the main policy and decision-making powers; and ii) the *periphery* - members not in the core, but remain valuable to the core. The periphery does not determine, but rather seeks to influence the policy content.

While any node from the core can also be present in the periphery, the periphery nodes cannot be members of a core, unless a cohesive subgroup of a periphery is regarded as a core of a highly localized region of the network[17]. However, the possibility of multiple cores is not considered in this study. The concern is rather with detecting whether the CCS governance network as a whole forms to the core-periphery structure.

While doing so is the first step, it does not reveal much about the nature of the governance infrastructure, and consequently the governance process itself. What is required is also examining the structure of the relations between the core and periphery, by looking at how they interact, be it in formal or informal ways. In a relatively stable network, for example, the interactions would consist of primarily formal ways[18]. However, informal ways would also to a certain extent be considered influential.

In a stable network, the core-periphery structure is relatively prone to withstand influences which would potentially threaten its stability – i.e. external shocks such as the financial crisis, political pressure or public opposition. In regards to the stability of a network, Bomber (1998) for example also argues that influence from other institutional bodies, such as the European Parliament in the EU, or other governmental departments, would indicate a relative unstable nature of the network. It is argued that in cases of a relatively unstable network, the outcome would be an overly stringent legal and regulatory framework. This would be the case as the

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[17] An example of the latter, would be the UK Carbon Capture and Storage Research Centre (UKCCSRC), whose members include representatives of the UK governmental body, the Department of Energy and Climate Change (DECC) and its Office of Carbon Capture and Storage (OCCS), which in the overall network would be considered the periphery, however, in the academic and research localized region of the CCS governance network, could be considered as a core – in that it provides a platform for discussion, as well as research funding to academics and research projects.

[18] This would refer to examples of formal consultations initiated by a government body such as DECC, on new policy proposals, or aspects of existing ones. In addition, a good example of both formal and informal structure of the relationship would be the CCS Development Forum, established in 2010, which brings together DECC and other CCS stakeholders from a broad range of private and public sector organisations together, particularly from the industry, as well as representatives from other international, academic and NGOs communities, in order to facilitate the development of CCS in the UK.

influence of the periphery would be weakened, and the policy and decision-making would be left primarily to the core, which would not receive the input from relevant stakeholders.

As such, the structure and the membership of the network[19] are invariably related to the particular characteristics of actors – i.e. their resources and level of expertise, which essentially determines what they can 'bring to the table'.

Resource (inter) dependency

This assumption relates to the second variable, *resource dependency*, which refers to the extent to which actors within the network depend on one another for resources such as finance, information, expertise and legitimacy. Typically, governance networks are characterized by the interdependence between various politicians, bureaucrats and interest representatives, where administrators (*the core*) need political support, legitimacy and coalition partners in their efforts to implement a policy. On the other hand, interest groups, including companies, environmental NGOs, academic and research communities (*the periphery*) seek access to policy (i.e. legal/regulatory frameworks) formation and implementation, and concessions in their interests. Access and influence is gained by building more stable and permanent relations based on trust, resources and expertise available – i.e. their characteristics. The difference in the needs, between the core and the periphery, in turn motivate and produce exchanges or transactions, which may become institutionalized in network structures (Van Waarden, 1992: 31).

At the level of the EU, the resource dependency is evident in the interactions both horizontally between various EU institutions, as well as vertically, for example between the Commission and the national and sub-national actors, at the various stages of the policy-making process. Given that the EU does not have its own implementation machinery in individual Member States, the Commission often depends on the national and sub-national actors for local expertise, information and the submission of projects, whereas the regional actors and interest groups, for

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[19] Throughout the various stages of this policy-making process, membership in a network varies, and includes representatives from other Directorate Generals (DGs)[19] (at the EU level), national civil servants, scientific experts, industry representatives, academics, environmental and business interest groups, etc. These actors are active within the network depending on the issue under discussion, its stage in the policy-making process and the specific interests involved (Bomberg, 1998: 171-172).

example, in return get information on Structural Fund programs and access to other EU policies from which they are generally excluded (Thielemann, 1998: 8).

Dependency on the exchange of such material and immaterial resources, can be either strong, and thereby signify a close relationship between the core and the periphery, as well as within the periphery itself, or it also be characterized as loose, informal, and/or relatively open, in which case it is more likely that there will be an uneven exchange of resources. In such case, certain groups or actors will possess a much greater amount of resources and thereby potentially more influence in the shaping of the policy outcome. Though this fact is acknowledged, the study is not considered with the emergence of the gap in the distribution of resources nor its influence per se, but rather considers the existence of the dependency in its own right. In this way it examines whether the greater amount of resources has led to that actor dominating in the network and if that dominance is in any way evident in the final outcome – regulations related to CO_2 storage.

The study argues that a greater amount of resources, perhaps contrary to common intuition, at least in the context of CCS, would not lead to dominance in the network, and as such also no favourable sense in the legislative outcome. This argument is premised on the notion of the so-called ‘power paradox’, which states that power, or the capacity to exert influence on others, produces the most constructive results when exercised in a voluntary partnership with others. The more visible power is, the less it works (Van Auken, 1997). This is not to say, for example that large oil and gas companies do not seek to maintain a certain level of ‘power’ in a larger business-oriented context, or that they intentionally seek to disguise their true intentions when they participate in the CCS/ CO_2 storage governance process. At the end of the day, companies are business-oriented and have to see their investments into the technology be worthwhile. In this context then, social science reveals that the ability to get or maintain power, even in smaller network situations, depends on one’s ability to understand and advance the goals of other network members. As such, actions and behaviour of these powerful and/or resourceful actors becomes primarily characterised by cooperation and negotiations. In other words, those with a greater amount of resources, through cooperation and negotiations do not only use their power in just ethical ways or solely serve the interests of a network, but also because they essentially have a vested interest in maintaining the status quo.

This way of thinking about the vested interest and behaviour of large industry players, with significant resources, guides us to question the motivation behind the development of CCS technology in general. Is it simply a way for the industry to maintain their status quo and continue burning fossil fuels, or is it primarily oriented toward climate change mitigation? This research does not attempt to answer such questions directly, although it would venture into saying that it is the combination of the two; continue the business as usual whilst adapting to the changing climate. Nevertheless, this research is mainly concerned with the notion of managing environmental risks of CO_2 storage, how and whether these are adequately covered in the regulatory frameworks in Europe, as well as whether these frameworks stand in the way of development and deployment of the technology.

In this way then, the argument that greater amount of resources controlled by certain actors does not imply dominance within a network and lead to a favourable outcome, can be made. In other words, this argument would prove to be invalid if there is evidence that the regulatory framework itself is in any way biased towards the industry[20], or if other stakeholders, through interviews, would indicate that in the process of development of these frameworks (i.e. during consultations or working groups) the industry in any way exerted any influence on others or if they felt that the industry was a dominant actor. In essence, the lack of dominance and extensive influence on other stakeholders and on the development of the regulatory frameworks is because of its willingness to maintain the status quo. In other words, whereas the industry depends on the government, and other stakeholders, to maintain its status quo, others depend on the industry for its scientific and technical expertise on CO_2 injection and storage, for example.

This research also argues then that an optimal outcome, in terms of a regulatory framework, occurs when the resource dependency relationship between the members of a network is strong. This means that, as mentioned above, each actor is dependent on others for a particular resource – be it material (i.e. financing) or immaterial (i.e. knowledge). What constitutes an optimal outcome is thus considered to be what satisfies the majority of the respondents, all members of the so-called CCS governance network. The chosen methodology is in this way related to the chosen methods.

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[20] i.e. no barriers or unresolved issues on matters pertaining to managing environmental risks, such as the requirement for monitoring or long-term liability and responsibility to manage a storage site.

2.3 Methodology and Methods

2.3.1 Methodology

Understanding governance of CO2 storage: a critical realist perspective

The research philosophy used in this thesis adopts assumptions both about the world and the nature of knowledge. The philosophy, or theory, a researcher adopts in their approach, needs to be compatible with their ontological and epistemological positions, which along with the chosen methodology serve as the basis for the research strategy, as well as influence how the observations made are interpreted. Whereas ontology refers to the status of reality, or the way we look at the world, epistemology on the other hand refers to how we conduct our research, or the style of research chosen, as a response to our views about the nature of knowledge and understanding (Saunders et al., 2009). The view adopted in this thesis is one of an interpretivist epistemology, within the confines of critical realist ontology.

Critical realism

A critical realist perspective in a way developed out of a critique of the positivist approach, and has been associated primarily with a British philosopher Roy Bhaskar. For Bhaskar and other writers on critical realism,[21] the foundations essentially lie in criticizing positivism, its purely objective view of the world and its reduction of reality to the observable. For them, the nature of reality is intrinsically ontological, underlying the nature of reality. As such, a distinction between three ontological domains can be made: i) empirical; ii) actual; and iii) real. It is the observation of the 'real' domain of reality that distinguishes critical realism. In other words, it is such deep dimension of reality that forces us to seek knowledge rather than simply accumulate facts. Since reality is differentiated then, there exist several parallel conceptual frameworks and sometimes competing interpretations (Lessem and Schieffer, 2006: 336). Critical realists also argue that the fact that social phenomena are concept-dependent (i.e. governance networks) should not be seen as if the social world only exists as a mental construction. Social science, for critical realists, brings into question and analyses everyday knowledge, and as such challenges power and dominance relationships, which can be invariably hidden from immediate view. These relationships then need to be conceptualized, from a perspective of hidden depth, as Lessem and Schieffer (2006) describe, given that they cannot be directly perceived

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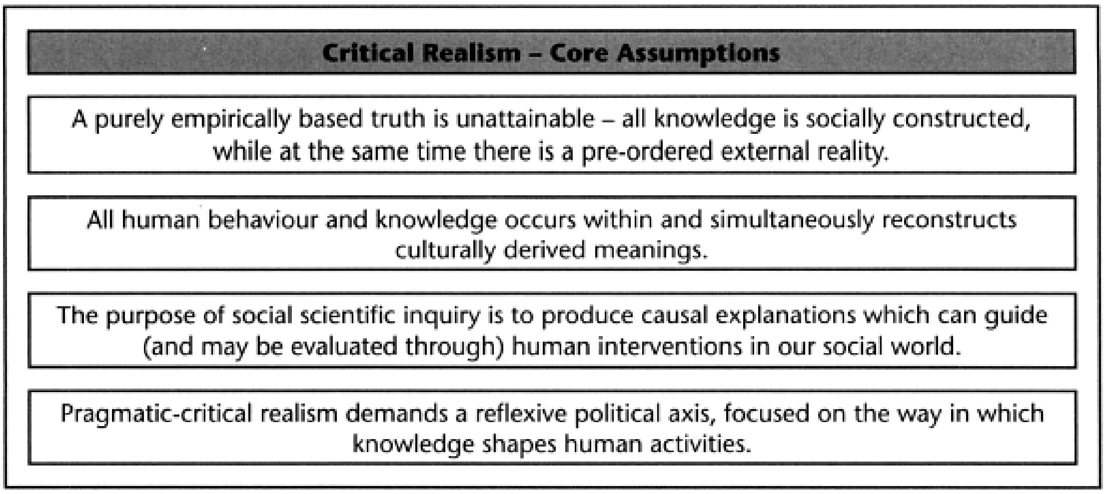
[21] See Bhaskar (1978, 2010) Harre (1970), Archer et al. (1998).

from an empirical surface. As such, conceptualisation becomes a central social scientific activity. If the dynamic dimensions of reality wished to be understood, abstraction is most often the best way to conceptualisation. In sum, the key underlying assumption of critical realism lies in that an objectively based reality is only partially pre-existent, and is also partly socially constructed. The table below encapsulates the core assumptions of critical realism.

Table 1: Critical Realism - Core Assumptions



Critical Realism – Core Assumptions
A purely empirically based truth is unattainable – all knowledge is socially constructed, while at the same time there is a pre-ordered external reality.
All human behaviour and knowledge occurs within and simultaneously reconstructs culturally derived meanings.
The purpose of social scientific inquiry is to produce causal explanations which can guide (and may be evaluated through) human interventions in our social world.
Pragmatic-critical realism demands a reflexive political axis, focused on the way in which knowledge shapes human activities.

Source: Lessem and Schieffer (2006).

A critical realist perspective applies in this research in broad terms in that it identifies the relationship between science and reality. Within this perspective, the starting point is ontological realism, recognizing that essentially environmental risks associated with CO_2 storage are real. However, it differs from realism in that it is critical in the sense that, in light of the existence of scientific uncertainties, the reality (or the extent of these risks) is questioned. In other words, a critical realist perspective argues that although the risk related to CO_2 leakage can to an extent be observed (i.e. subsurface monitoring), there is no way of making objective observations about that risk.

A central issue in critical realism, as Lessem and Schieffer (2006) point out, is the active role of the human agent, in particular in regards to their interaction with an independent external reality, which guides their action. External reality in this research is, as mentioned, the existence of risks related to CO_2 storage. The role of the agent, and their interaction with the external reality (i.e. managing environmental risks) is then examined through the use of the governance network theory (see section 2.2.1).

A critical realist, while denying that there is any entirely 'objective' or certain knowledge of the world/reality, accepts the possibility of alternative valid accounts of any phenomenon. In this study, environmental risks associated with CO_2 storage, such as, for example, leakage from a storage complex, or a seismic event, are seen 'as if' real[22]. In other words, this means that because of unattainability of a 100% certainty when it comes to knowing the location of the CO_2 underground for example, and due to existence of varying interpretations and perceptions[23] of the concept, there cannot be a single correct or objective understanding and representation of the world/reality[24]. There is also no empirical test to determine which view is right.

In epistemological terms, knowledge is considered to come from human experience, and as such, adopting a critical realist perspective means that a researcher has to be in the place of inquiry, listen and talk to the right people, and extract the data primarily through interviews and observation.

Based on this understanding, the study, in essence, combines the philosophies of both the natural and social sciences in order to describe the relationships between the natural and the social worlds. A philosophical stand of worldview, as Sapsford (2007) suggests, underlies and informs a particular style of research, and as such, the chosen methodology also determines ones research design.

2.3.2 Methods

As mentioned, this thesis employs a qualitative research approach, as opposed to a quantitative one. In any case, both approaches have merits in their own right, however, for any researcher, the chosen method must relate to their ontological and epistemological perspective as well as their theoretical framework from which they operate. This research is primarily based on the adoption of qualitative type of methods, involving critical examination of various types of documents, as well as conducting a number of semi-structured interviews.

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[22] Real in a sense that they exist independently of our perceptions, theories and construction, and that such an event is possible.

[23] Risk perception is defined as a subjective judgment people make about the severity and probability of risk. This perception varies between stakeholders, in particular between the industry, policy and decision makers, and the general public.

[24] See Putnam (1999).

Document Analysis and Doctrinal Legal Scholarship

In a qualitative-type research, one of the first and most common components is the analysis of documents, in order to give meaning to a particular assessment topic. Document analysis involves looking at things like primary and secondary legislation, scholarly articles, public records, textbooks, and as Wesley (2010) points out, also other forms of media. The key in the use of any types of documents is that that they are used with rigor.

This research started off with a review of the literature at a general level on climate change, environmental governance and policy-making in the EU and the UK, which included reading a great number of scholarly and peer-reviewed articles. It later on focused more specifically on carbon capture and storage, and even more so on the storage component. Doing a general literature review helped identify the underlying theme of the thesis, which can in a way be seen in the relationship between the science, policy, technology and the law discussed in Chapter 3.

Given that the idea of CCS is relatively young, as mentioned, so is the literature on the topic. In the early 2000s, scholarly documents pertained the focus on the technological viability of CCS, whereas in the mid- and late-2000s, an increasing number of pieces emerged which considered external topics such as public acceptance and the importance of a legislative and regulatory frameworks. Following the 2008 financial crisis, understandably so, the major topic of discussion, in relation to CCS, was its economic viability, which is in sense still prevalent today. More specific articles, research papers and guidance documents on issues such as, for example, monitoring and verification technologies and techniques, injection well-stability, the CO_2 stream composition and movement during transport and once injected underground, were also examined.

The next step was then to tackle the primary and the secondary legislation documents, which in the case of the EU namely involved the 2009 CCS Directive, but also a number of White Papers and Communications. While in the case of the UK, it involved critically examining things such as the Energy Act 2008 and 2011, as well as specific regulations (i.e. for licensing of off-shore CO_2 storage). In this respect, so as to compare the extent of the transposition, texts of UK regulations on CCS was compared with that of the EU CCS Directive.

Qualitative interviews with CCS stakeholders

The approach to knowledge in a qualitative-type research, as mentioned, involves becoming a part of the situation by understanding the views from the participants, who are considered as the experiential experts on the phenomenon being studied – the management of risks of CO_2 storage. As such, in order to obtain a first hand account of the perceptions and experiences with the legal and regulatory frameworks for CCS in Europe, I chose to conduct a number of qualitative interviews with a variety of CCS stakeholders. This included members of the academia, policy- and decision-makers, and people from research institutions and environmental NGOs, in order to obtain a representative sample. Given, however, that the focus of this research is to understand the views of those most affected by the legal and regulatory frameworks, the majority of the respondents were representatives of the CCS industry.[25] Overall, 15 people were interviewed.[26] Although this was a relatively small sample of interviewees, they do represent some of the key people in the industry, making it an elite interviewing method.

Prior to the actual conduct of interviews, extensive preparation was done. First, this involved the identification of the groups of people to interview and arranging appointments. This was done based on what Bryman (2008) refers to as purposive sampling, allowing the researcher to identify the respondents who would be relevant to the research questions in advance. It should be noted that while attention was paid to the representativeness of the interviewee sample, it was difficult to get responses from the industry sector, hence the relatively small number of interviews conducted. However, every effort was made, including follow up with emails and phone calls, to get as many CCS industry representatives as possible. Selected interviewees were contacted primarily via email and phone calls, in some cases several months prior to the actual interviews, depending on their availability. While some were available a week or two after being contacted, others were more time constrained and agreed to contact me when they will find some time. While some interviews were conducted via phone and Skype, I also spoke to a number of people in person.

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[25] For simplicity purposes, the CCS industry here refers to all those involved with project development throughout any aspect of the CCS chain. In this study, however, the main concern is with the storage component.

[26] Of the 15, nine were considered to be from the CCS industry, and the remaining six from other stakeholders group (i.e. academia, policy- and decision-makers, industry lobbyists).

Furthermore, in the end it also turned out to be the case that there was a certain amount of so-called ‘snowball sampling’ present. This means that when someone was interviewed, they were asked if they knew somebody else who might be a good person to interview, they provided names and contact information, or even got me in touch with them. This in fact provided almost half of the overall sample, and it was people from the industry, who turned out to be most helpful in this respect. Ultimately, one has to work with what they can get, however, every effort was made as to be aware of the overall sample, and any potential biased views in the analysis.

Secondly, preparation for the interviews involved a construction of a set of pro-forma questions, which served as tools to draw out the participant to reflect on their experience and involvement with CCS. Pursuant to their responses, questions were then tailored so as to draw up as much as possible.

2.3.3 Analyzing the data

This research, as mentioned, adopts a qualitative technique to achieve the outlined aims and objectives (see section 2.1 above). As Guba and Lincoln (1994) would attest, qualitative approaches are better suited for exploring research questions from an epistemologically subjective perspective. [27] At the same time, however, as Cassell and Symon (1994) correctly argue, a qualitative approach is also more time consuming, with respect to data collection and analysis.

For a researcher adopting a qualitative kind of approach, there are a number of styles and strategies with which one can engage in the analysis of the data. The literature on qualitative research is in fact quite extensive. Many authors[28] have come to conclude that rather than reducing qualitative research to a particular technique or a set of stages, this type of research involves a kind of dynamic process of linking together problems, theories and methods (Bryman and Burgess, 2002: 2). Bechofer (1974) describes it as a “messy interaction between the conceptual and empirical world, deduction and induction occurring at the same time” (p. 73). In other words, analysing the data, for a researcher, means going back and forth between the adopted

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[27] In this study, qualitative methodology is chosen over the quantitative methodology. This is because of the adopted epistemological and ontological stance, which does not see an empirical, or a quantitative approach to uncovering the governance and risk management of CO_2 storage in Europe as being able to reveal all the complexities involved.

[28] See also Bechofer and Paterson (2012), Ritchie and Spencer (2002), Miles and Huberman (2002), Hammersley (2000), Bulmer (1979), Berg et al. (2004), Boeije (2009).

theories, concepts, methodology, and the end goal, or what they are trying to accomplish with their research.

In this thesis, importance is placed particularly on analysing the perspectives of those engaged with CCS projects directly, such as members from the industry and policy-makers, as well as other stakeholders, such as academia, researchers and environmental NGOs, who are involved in a more indirect way, so as to get a complete and a representative picture. Emphasis, however, is placed on the former; namely the CCS industry, given that they are the people whose companies will be most affected by the legal and regulatory frameworks. As mentioned in the methods section (2.3.2) above, those interviewed represented some of the key people in the CCS field.

Conducting in-depth elite interviews, allowed for the information and the phenomenon to be looked at and understood in its context. Due to the complexity of the issue at hand - the nature of governance and management of environmental risks, in general and in the context of CCS - it is important to consider also the underlying themes that run across all categories. These are encompassed by the relationship between the science, policy, technology and the law (see Chapter 3).

As mentioned above, the interviews were semi-structured, which meant that there was a general structure of the ground and main questions that was set up in advance. A detailed structure was then left to be worked out during the interview, giving the person interviewed a fair degree of freedom in what to talk about, how much to say, and how to express it (Drever, 2003).

Using semi-structured interviews also gave me, as a researcher, the opportunity to generate rich contextual data, and identify and explore insights, perceptions and values of those interviewed. In addition, it left space for new issues and themes to be examined/questioned more in-depth, depending on the interviewee’s responses. As Clough and Nutbrown (2007) note, overall, the effectiveness of the interview depends heavily on the communication skills of the interviewer - i.e. their ability to clearly structure questions, listen attentively, and encourage the interviewee to talk freely. For example, to be able to truly understand the other persons’ construction of reality, “we would do well to ask them…and to ask them in such a way that they can tell us in their terms…and in a depth which addresses the rich context that is the substance of the meanings” (Jones; in Punch, 2005: 168).

Equally important, however, is also then the analysis of the qualitative data. As Punch (2005) points out, for the individual researcher, the problem comes alive at the point of sitting down in front of, for example, the interview transcripts, and/or field notes from observations and discussions, and/or documents (p. 195), and deciding where to go from there. A good way to start is intensive and repeated reading of the material (i.e. transcribed interviews). As Schmidt (2004) notes, this reading is similar to study-reading of academic texts, where the aim is to note for each interview, the topics that occur and individual aspects of these, which can be, related to the context of the research question(s) (in Flick et al., 2004: 254).

In order to account for the semi-structured nature of the interviews, it was important to not only focus on the answers from the questions that were asked, but also to consider whether and how the interviewees take up certain terms (i.e. risk and/or governance), as well as which they omit. Although time consuming, attention had to be paid not to relate the responses too hastily to my own theoretical assumptions by reducing the analysis to a search for locations in the text that would be suitable as a proof or illustration of these assumptions (Schmidt; in Flick et al., 2004: 255).

After spending some time reading the texts, the next part was to analyse the data, and code it. Coding here refers to “relating the passages in the text of an interview to one category, in the version that best fits these textual passages” (Schmidt; in Flick et. al, 2004: 255). To interpret the meaning from the content of the text data, a directed approach was chosen, whereby the analysis started with a theory and relevant research findings as guidance for initial codes (Hsieh, 2005).[29] In this respect, during data analysis, as a researcher I immersed myself in the data and allowed the themes to emerge from that data. The purpose of such an approach, as Zhang and Wildemuth (2009) suggest, is to validate or extend a conceptual framework or theory.[30]

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[29] Other approaches that the author analyses are a conventional content analysis, where coding categories are derived directly from the text data, and a summative content analysis, which involves the counting and comparisons of things like keywords or content, followed by the interpretation of the underlying context (Hsieh, 2005). Conventional content analysis approach, for example, is used for grounded theory development, whereas, the goal of a summative content analysis approach, is to explore the use of words/indicators in an inductive manner (Zhang and Wildemuth, 2009).

[30] The analysis sits in contrast to the grounded theory methods, in which data and concepts become the basis for a new theory. Rather, the adopted approach in this research is to critically examine the data to show how the governance network theory applies to the phenomenon under study. The key phenomenon under study in this research is the governance and management of risks of CO_2 storage, in the context of CCS technology development and deployment.

2.4 Research ethics

Any type of research must essentially be underpinned by good research ethics principles, including privacy, informed consent, protection from harm and avoidance of deception.[31] All principles were considered, and were mentioned in the ethical approval application given to the University of Sheffield, School of Law Ethics Committee, which granted the approval. Two issues, privacy and informed consent, are discussed below, as the these were of most relevance to my research, and were also raised by the interviewed participants.

2.4.1 Privacy

The issue of privacy is in particular in social science research one of the central issues of research ethics. A number of interviewees from the industry raised the issue before agreeing to participate in the research, specifically asking about data protection and about confidentiality. Their requests were followed, and those who did not which to be identified by their names, are in this thesis referred to as ‘a representative’ or ‘respondent’. For all the data collected, sufficient protective measures were put in place, which involved deleting the recordings once transcribed, and all the files were protected by encryption on a USB key, which was kept in a locked filing cabinet when not in personal possession.

2.4.2 Informed consent

Even in cases of non-sensitive type of research, all those requested to participate should have the option of either accepting or rejecting to be part of the research. As such, they should be provided with sufficient information on things like the scope, purpose, benefits and risks, timeline and sponsors. When contacting individuals for the purpose of interviewing them, they were each provided with a background and the scope of my research project, as well as on the funder and how their information would be used as part of the research. Those who responded and agreed to the interview were provided with a more detailed information sheet and a consent form prior to the conduct of the interview. Both were kept in a key-secured filing cabinet. Each interviewee was also asked whether they could be recorded. A number of

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[31] See for example Bryman (2008), Ritchie et al. (2013).

interviewees expressed the wish not to be recorded, and in those cases, notes were taken by hand. The audio from all the recordings was destroyed following their transcription.

2.4.3 Limitations of research

One of the weaknesses of adopting a critical realist perspective (see section 2.3.1), and a qualitative type of research methods, is that there was always the possibility of excessive researcher influence. As mentioned in the introduction (see section 1.1.2) my academic and research background has for the most part been situated within environmental sciences, economics and policy, and now law. Such an interdisciplinary background, I believe has in a way given me a generally supportive view of the CCS technology in general. As such, one of the main challenges I had to face during this research and analysis was to always stay ‘a step back’. In addition, coming from an environmental science and policy background, with no prior exposure to the field of law, coming to terms with understanding the concepts, principles, as well as reviewing legislative documents and other legal material, was another challenge on its own.

2.5 Summary

This chapter served the purpose of introducing the key research questions to be addressed in this thesis, as well as justifying the theory, methodology and methods used. In sum, the research adopts a critical realist perspective, whereby the reality (of risks related to CO_2 storage) is seen ‘as if’ real – although risks are considered real, pure objectivity is unattainable. This perspective considers the reality to be in a way socially constructed and recognizes the active role of human agents, in particular in regards to their interaction with an independent external reality. It also considers other external influences to be of importance to some extent in determining the reality[32].

The chosen theoretical framework, which supports such a perspective, is the governance network theory, which focuses on the manner in which environmental risks are dealt with and managed through joint action and interaction. The chosen tool of dealing with the said risks, are the legal and regulatory frameworks in Europe and

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[32] For example, if there was no other political, social and economic issues on the agenda of the industry and policy- and decision-makers, unlimited monitoring and verification could, in theory at least, be done, and as such eliminate (or even further reduce) the risks of storing CO_2 underground.

in the UK. In other words, the governance network theory examines how and to what extent environmental risks related to CO_2 storage are substantively and procedurally encompassed within the legal and regulatory frameworks, and whether/how, if at all, these frameworks serve as either an impediment or facilitator for the development of the CCS technology in general. In this way, legal and regulatory frameworks are considered to be the ‘mediator’ between the management of environmental risks and development of the technology.

The thesis now moves on first to examine the existing literature and the gaps within it, which the remainder of the chapters will then attempt to fill. The review of the literature, however, also serves a larger purpose of setting the underlying basis for the rest of the thesis. These can be best described and examined in the interrelationship between the science, technology, policy and law.

CHAPTER 3: Literature Review

It is not surprising that given the relatively young age of CCS technology, the literature on the subject is still emerging. In many ways, it was the 2005 IPCC Special Report on Carbon Dioxide Capture and Storage (IPCC, 2005) that first presented the carbon capture and storage (CCS) technology to a wider scientific, and broader communities, as a potentially significant climate change mitigation tool. Amongst other insights, this report pointed out the technical feasibility of CCS, but at the same time warned of the uncertainties related to the understanding of the subsurface. More importantly, it deemed the management of storage risks as critical, given geological variability, and the potential risks and environmental impacts.

Since then, the literature on CCS has been growing steadily, with authors covering a wide range of CCS related topics, from the different the different components of the process (i.e. capture, transport and storage), to the various associated scientific and technical, economic, political and legal issues. However, the legal and regulatory coverage of CCS remains in the background to that which focuses on the scientific, financial or policy aspects. Nevertheless, coverage of the legal and regulatory aspects, related to CCS in Europe, has in the recent years increased, following the passage of the 2009 EU CCS Directive (2009/31/EC), and its transposition in a number of Member States. As mentioned in the introduction of this thesis, the United Kingdom has to date developed one of the most comprehensive legal and regulatory frameworks for CCS, not only in Europe but also in the world. As such, this thesis takes the UK as a case study example.

The purpose of this chapter is not only to examine what has already been said within the CCS literature, in particular related to the CO_2 storage component, but also to identify some of the gaps, which the remaining chapters will then attempt to fill. As such, this chapter is structured according to three key themes, which serve as the underlying themes of the thesis. The first part focuses on science, in particular the notions of *uncertainty* and *risk* associated with CO_2 storage. Again, although other types of risks are acknowledged, the main type of risk that this research focuses on is that of CO_2 escaping from a storage reservoir. The second part will then explore some of the dynamics of the policy, technology, law, and their interrelationship with science. As was explained in Chapter 2, the chosen theoretical and methodological approach, and the set out research questions, are based on this interrelationship. Lastly, part three will address the broader role of CCS as a climate change mitigation technology, as well as the importance of uncertainty and risk of CO_2 storage from a social science perspective.

3.1 The science literature

Climate change has undoubtedly become one of the greatest and fundamental threats to the places, people and the environment. Although some effects have already been experienced to date (i.e. increased drought, extreme weather events), the potential future impacts will not only vary by region, but also by the sensitivity of populations, the extent and length of exposure to the impacts, and the society's ability to adapt to change (EPA, 2015). However, since the late 20th and early 21st century, the climate change issue has in a way started to come more to the forefront of global issues of concern, and become integrated more into other policy sectors (i.e. economy, energy). With that also came the growing recognition that innovative and affordable solutions will be required to reduce the emissions of greenhouse gasses (GHG), whilst allowing for continued economic development. One of such potential climate change mitigation solutions that has been gaining attention in the literature on climate change over the past decade, has been the idea to capture and permanently store the CO_2 from large stationary emission sources, such as power plants, thereby preventing it from being emitted into the atmosphere.

Storing CO_2 in deep geological formations, safely and for a long period of time, is the critical aspect of the entire CCS chain. The storage of the CO_2 can occur on- or offshore, primarily in either depleted oil and gas reservoirs or saline aquifers. Other options for storage include un-mineable coal seems, however, the storage capacity of these is far smaller than for other two options. The majority of the technically accessible CO_2 storage potential is said to lie in the saline aquifers (Benson and Cook, 2005; Bradshaw et al., 2007; IEA, 2013, 2014).[33] However, just as geographies differ, in turn so will the storage sites around the world. In other words, no one storage site

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[33] For example, the UK's potential storage capacity is said to be around 70 billion tonnes of CO_2, of which almost 90% would be in saline aquifers, and the rest in depleted oil and gas fields, or hydrocarbon fields, for the most part (DECC, 2012).

will be the same. Furthermore, long lead times[34] (6-10 years) required to make assessments for saline aquifers, uncertainties regarding the overall storage capacities or the location and movement of the CO_2 underground, have been some of the key scientific queries over the past decade or so (DECC, 2012: 5). Because of the novel nature of *permanent* CO_2 storage, the two key terms of *uncertainty* and *risk*, in a way have dominated the scientific CCS literature. The following section first discusses this nexus between the science, uncertainty and risk, in general terms and in relation to CCS. It then puts forth key scientific and technical uncertainties and risks in regards to CO_2 storage, before presenting the role and importance of monitoring and verification as a key component in reducing the uncertainties and associated risks.

3.1.1 The Nexus between the Science, Uncertainty and Risk

Knowledge is the antidote to fear.
— Ralph Waldo Emerson

The basis of science, whether social or natural, is essentially the discovery of something new. This of course means that as long as discovery is possible, there will always be things that we do not know, that we are unsure about, and even the ‘unknown unknowns’. Ambition to reduce such uncertainties, and find out these unknowns, is the driving component of the scientific vehicle. As Lewis Thomas, an American doctor and scientist once said, “science is founded on uncertainty…[and] whenever we discover a new fact it involves the elimination of old ones. We are always, as it turns out, fundamentally in error”[35]. What Thomas implied was that uncertainties, and associated risks, cannot be removed in its entirety, and that our goal is to reduce them as much as possible.

It is more important for scientists and other researchers to ask both *why* we are uncertain, as well as *what* we are uncertain about. Riesch and Reiner (2010) think about it in terms of *sources versus objects of uncertainty*. The authors suggest that there are essentially five levels of uncertainty, which interconnect to form an overall uncertainty of a particular risk: i) about the outcome, ii) about the parameters (i.e.

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[34] Lead times refer to the latency, or the long period of time it takes to properly characterize and assess the suitability of a particular storage site. It has also been voiced as a major argument for the need to expedite early demonstration projects and assessments (Clarke, 2012; Scowcroft, 2012).

[35] Lewis Thomas, “On Science and Uncertainty,” Discover, 1 (Oct. 1980): 59.

local conditions), iii) about the model, iv) about our underlying assumptions (i.e. sound science), and v) complete uncertainty" (p. 2-3).[36] For conventional, or natural science, as McEldowney and McEldowney (2011) also suggest, the largest uncertainty-challenge can be seen in the risks linked to new technologies, such as CCS, which produce considerable uncertainty as to how to anticipate and prevent harm (p.3).

In the scientific literature in general, the notions of uncertainty and risk quite often appear in conjunction. As mentioned, uncertainties, and efforts to reduce risks, drive scientific progress thereby increasing the knowledge, which as an American poet Ralph Waldo Emerson would say, serves as an antidote to fear (i.e. of CO_2 escaping from a storage complex). Uncertainty in itself is not necessarily a risk, however, it does impact the way in which risk is understood, determined and evaluated. As such, in the presence of uncertainty, risks should be graded and ranked conservatively.

In relation to conditions of uncertainty and risk, Stirling (2007) for example, also argues that trying to assert a single aggregated picture of risk is neither rational nor science-based. He is right, in that uncertainty in itself creates an ambiguous interpretation of a problem. In other words, interpretation of uncertainties can have both subjective and objective elements, which will ultimately determine the outcome of a particular decision and solution to a problem. Interpretation of uncertainties can become a problem, when statements about causation or correlation are made, which depend on certain assumptions. When these are incorrect, any associated measures, however accurate numerically, may provide misleading information (Agius, 2009). In this respect then, enhancing repeatability and consistency of risk assessments should be seen as a key challenge in making the associated processes and results verifiable and auditable (DNV, 2009: 68). This points to the fact that monitoring and verification, the process as a whole and specific technologies are crucial in reducing the uncertainties and provide for better-informed decisions. In addition, it provides for a greater degree of investor and general public certainty[37].

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[36] i) final uncertainty predicted by a model, which is then used by politicians; ii) lack of knowledge over precise nature of local conditions; iii) which (statistical) model is best for a particular reality of a situation; iv) in absence of detailed knowledge people are left to trust experts involved that the underlying science is sound (Riesch and Reiner, 2010: 2).

[37] See Macdicken (1997) and Groenenberg and de Coninck (2008).

3.1.2 Uncertainty and Risk of CO_2 Storage

Carbon capture and storage is for the most part a response to the relative uncertainty, not about whether, but *the extent* to which the Earth's climate will change, and the risks of continued CO_2 emissions and the use of fossil fuels. At the same time, however, CCS has also been addressed in the literature as a technical and a geo-hazard issue[38].

Friedmann (2007) for example paints a fairly optimistic picture for the idea of permanent CO_2 storage, by suggesting that the risks of this activity appear to be very small and manageable. He argues that the operational risks are no greater than those of oil and gas equivalents. Essentially, he makes this connection based on the assumption that experience with various tools and methodologies, and because mitigation techniques exist in order to limit leakage risks. Although Friedman does draw a parallel with oil-gas equivalents, he does not incorporate into his analysis risks and hazards such as contamination of marine life (when drilling is done off-shore), oil spills form platforms, underwater pipelines and/or tankers. One simply needs to mention the Exxon Valdez[39] and BP[40] oil spills, and his arguments can become less convincing.

These events, however, were one-off events, whereas one of the major uncertainties about CO_2 storage relates to the effects of leakage over a longer period of time. Geological storage of CO_2 is a hazard to both the environment and human health. Interestingly, other anthropocentric geological, or geo-technical, threats (i.e. coal, oil and tar sands mining, injection of waste water in aquifer systems, shale gas 'fracking', liquefied natural gas storage) are often not seen as hazardous, or at least not to the same extent. The main reasons for that is that our experience with CO_2 geological storage is still rather limited, apart from only a few commercial and small-scale pilot projects. This means that there are still uncertainties about threats and risks, some of which have perhaps yet to be discovered – fear of the unknown, or

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[38] Geo-hazards are both natural processes (i.e. flooding, ground cracking, tsunamis, et.) as well as human-induced ones (i.e. seismic activity resulting from 'fracking').

[39] One of the largest oil spills which occurred on March 24, 1989 when an oil tanker hit the Bligh Reef of the coast of Alaska, spilling an estimated 11million gallons of crude oil (EPA, 2014).

[40] Occurred in April, 2010 when the Deepwater Horizon oil rig exploded, allowing for crude oil to continuously, for a period of 3 months, escape into the Gulf of Mexico. It was estimated that overall, up to 4.9 million barrels, or 205.8 million gallons, of crude oil were released (Smithsonian Ocean Portal 2013).

"…the oldest and strongest kind of fear"[41], as an American novelist, H.P. Lovecraft would say.

3.1.2.1 Migration and Leakage of the CO2

CO_2 Migration

For CCS to deliver on its potential and promises, the CO_2 injected into underground formations must essentially remain there permanently. Once underground, the CO_2 could in theory migrate both horizontally and vertically, however, much depends on the topography of a particular storage site. Lindberg et al. (2002) for example, suggest that a smooth topography of the top seal (i.e. depth variation is less than 80m over a 120km^2 area) would allow for the injected CO_2 to spread over a very large area, and conclude that the long-term fate of the injected CO_2 in a saline aquifer will strongly depend on the topography of the cap rock. Zweigel et al. (2000) came to a similar conclusion, identifying that even subtle topography differences (i.e. 0.3 degrees, or 4 meters, over a distance of 1km) can affect migration patterns. While they point out that such simulations require geological input data, rather ironically, they openly admit that their simulations neglected input data like CO_2 solution into water, leakage into the cap rock, changing pressure and temperature, and potential porosity or permeability changes (p.3), all of which have the potential to play a significant part in CO_2 underground behaviour. Nonetheless they do in the end also point out that development of appropriate tools is consequently a major challenge to ensure safety and manageability of, and public confidence in underground CO_2 storage projects (p.6).

Understanding underground CO_2 migration is still mired by uncertainties. If reservoir capacities and leakage risks are to be assessed, as Macminn et al. (2010) point out "it is essential to understand the subsurface spreading and migration of the plume of mobile CO_2" (p.1). Because of the potential of significant damage occurring, it is necessary to deploy technologies that measure, monitor and verify that injected CO_2 remains in the subsurface (Wilson and Gerard, 2007).

The general sense in the literature on CO_2 storage is that horizontal migration of the CO_2 plume is expected and not a major issue per se, as opposed to CO_2 migrating

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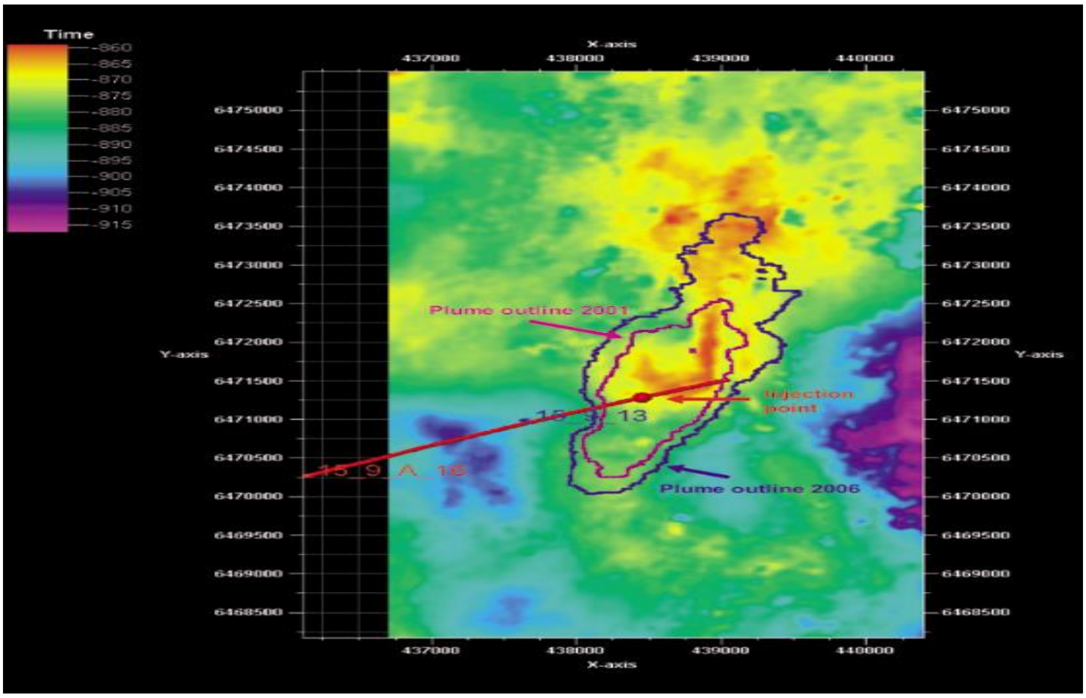
[41] H. P. Lovecraft. (n.d.). BrainyQuote.com. Retrieved January 16, 2014, from BrainyQuote.com Web site: http://www.brainyquote.com/quotes/quotes/h/hplovecr676245.html.

into the overburden. As shown by Arts et al. (2008) in their study on the monitoring of the injected CO_2 in the Utsira Sand at Sleipner, Norway, while the CO_2 has migrated laterally, there has been no indication of any migration into the reservoir overburden.[42] See Figure 1 below.

Figure 1: Outlines of the extent of the CO2 plume in 2001 and 2006 over the top structure map of the top Ultsira Sand



Source: Arts et al. (2008).

Although, even horizontal migration, when this goes beyond the outlined storage complex, can be problematic. This, however, then becomes a CO_2 leakage, and fundamentally a legal issue, and not necessarily entirely an environmental or health one.

CO_2 Leakage

As mentioned, one of the underlying concerns behind most of potential CCS hazards[43] is the issue of leakage from a storage reservoir. For the most part, it has been

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[42] To track the behaviour of the CO_2 plume in the reservoir a combination of seismic monitoring and seabed gravimetry was used.

[43] Some of the main potential hazards of CCS, which include: i) exposure due to pipeline leaks; ii) exposure due to leakage from geological storage; iii) leakage from geological storage to groundwater; iv) leakage from geological storage to fossil fuel assets; v) leakage eliminates benefits of geological storage; and vi) induced fracturing or seismicity (Benson and Cook, 2005: 246-250).

acknowledged that it is likely that some of the stored CO_2 will leak. Thus, if geologic sequestration is to be proven effective, one of the main concerns, and goals, is to keep the level of leakage at a minimum, as trying to eliminate the risk of leakage would be both futile and impossible. Although, for legal and regulatory purposes, 'leakage' is defined as *escape of the* CO_2 *from a storage complex*, and does not necessarily include leakage to the atmosphere for example, nor does it presuppose any environmental or health impacts. Unless otherwise stated, for simplification purposes, the same general definition is used when referring to the issue of CO_2 leakage.

In any case, a number of studies[44] have suggested ranges for 'acceptable' levels of leakage and the levels of associated uncertainties.[45] Risks, including leakage, can always be reduced with the implementation of additional safeguards, however, at the price of a higher cost. Thus, defining acceptable levels of risk often comes down to the question of cost of implementation of these safeguards relative to the potential negative impacts and cost of possible corrective measures (DNV, 2009).[46]

From a scientific point of view, estimated potential leakage rates range from 0.01% to 1% per annum (Chow et al., 2003: 1175). While the percentages might seem small and insignificant to some, in actuality, the implications are quite significant, not only in terms of its direct effects on human health and the environment, but also on the policies and legislation that are developed as a result of these estimates.

Hepple and Benson (2004) for example also offer an examination of the implications of CO_2 leakage to the atmosphere on the effectiveness of geologic storage of CO_2 as a climate change mitigation strategy. In the study they come to the conclusion that geologic sequestration can be an effective method even if some small amounts of CO_2 escape from storage reservoirs back into the atmosphere. Their conclusions are based on the finding that the required sequestered CO_2 quantities are

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[44] See for example IPCC, 2005; Tao et al., 2010; White et al., 2003; Trabucchi et al., 2012.

[45] The question that is often not address in such studies, however, is, whether acceptability differs between stakeholders, and/or whose matters the most. Is it for the businesses and companies making the investments, the governments, or the people (near and far from storage sites)? Acceptability essentially also ties in with the notion of perception of risk, which in the case of the general public, is often far more subjective than objective.

[46] DNV's CO2QUALSTORE report: Guidelines for Selection and Qualification of Sites and Projects for Geological Storage of CO_2 (2009-1425) identified an approach for risk reduction, known as As Low As Reasonably Practicable (ALARP), which allows project developers and regulators more flexibility, in terms of the project design and influence on risk management respectively, by giving them an inventive to reduce risks beyond minimal thresholds (DNV, 2009: 72)

in the range of the estimated global geological capacity,[47] and that seepage rates[48] of less than 0.01% per year may be 'universally' acceptable and a reasonable performance requirement for surface seepage. While their study is valuable in that their observation and analysis of the effectiveness of CCS as a climate change mitigation tool is based on several scenarios of desired atmospheric CO_2 concentration levels (at 350, 450, 550, 650, 750ppmv), their models do not account for any uncertainties in their estimations.

In any case, there is a fairly wide consensus in the natural sciences literature that there is the possibility and risk of leakage occurring, albeit some degree of variation in regards to the likelihood and the rate of leakage. A simple scholarly search on risk of CO_2 leakage, however, can reveal that the largest potential pathways for leakage are represented by wellbores.[49]

3.1.2.2 Well integrity

One of the main potential concerns that has been associated with leakage from geologic sequestration sites, both on- and offshore, revolves around the integrity of wellbores that have not been appropriately sealed, or poorly constructed. As Duguid and Tombari (2007) suggest, the integrity of injection wells is crucial in that the wells and the annuli and pathways that may exist within them can serve as leakage pathways for the CO_2 back to the surface, or act as a conduits for leakage between formations (p.1).

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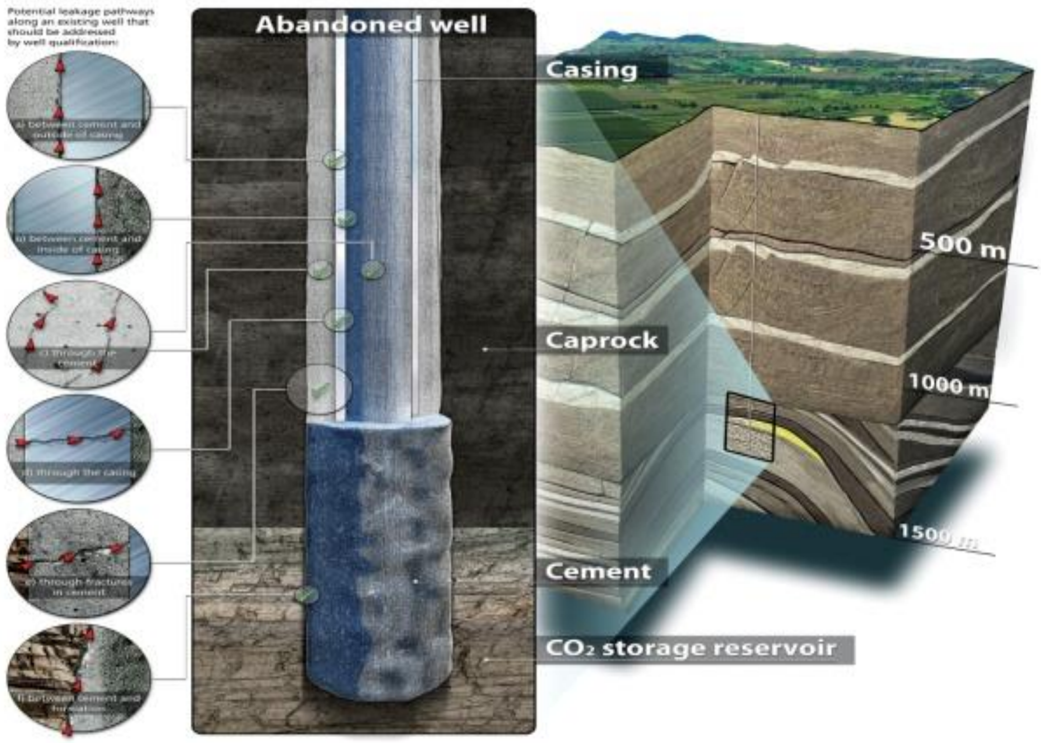
[47] This means that no more CO_2 is being stored that in theory could be dealt with by the environment. It should also be noted that there essentially could be a significant difference between the total geological capacity, and the total 'technical capacity', which does not take economics or security of storage into account.

[48] See also Macminn et al. (2010), Farcas and Woods (2009) for more on CO_2 leakage.

[49] See Barlet-Gouedard et al. (2006), Loizzo et al. (2011), Le Guen et al. (2008).

Figure 2: An abandoned well used for CO_2 storage and possible leakage routes



Source: DNV, 2009.

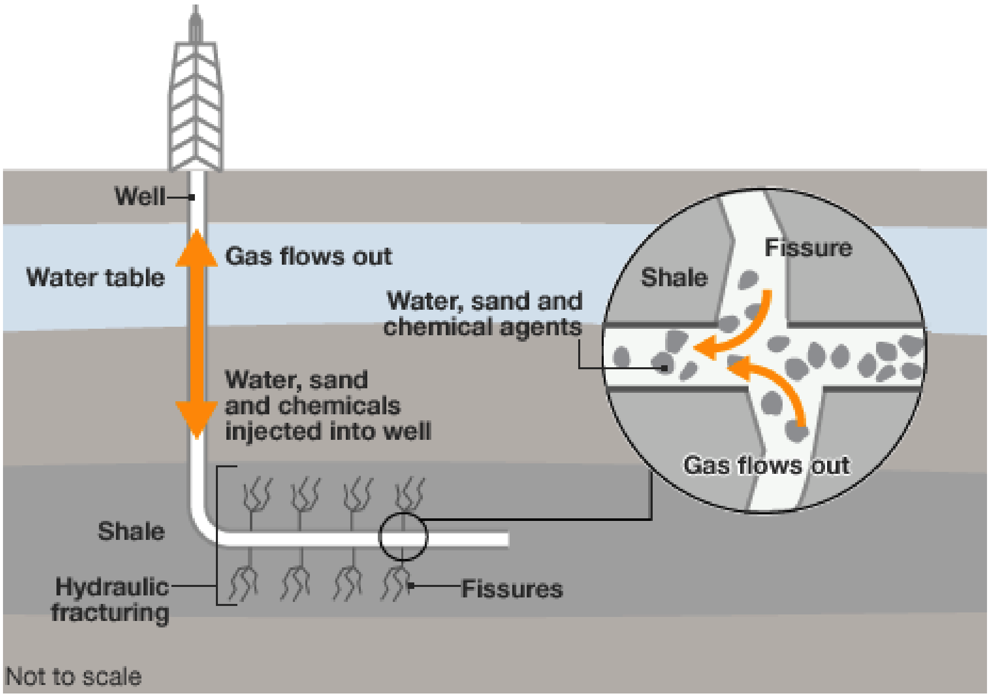
A study by Barlet-Gouédard et al. (2007), in which the authors look at the chemistry between the cement used in wells and the injected CO_2, along with the potential for cement failure, also suggests that wellbore integrity is an important component in preventing CO_2 migration/leakage. One of the greatest risks of CO_2 leakage for any geological storage project, as mentioned, is that associated with old abandoned wells. In other words, the integrity of wells may become compromised as a result of poor completion or abandonment, and/or poor well operation (Zhang and Bachu, 2011). In this respect, it is particularly important that abandoned boreholes are located, plugged and then monitored for leakage, that selected sites are not near any large population concentrations, and that injection of CO_2 is limited or ceased, if leakage or other significant irregularity is detected (Mathieston et al., 2010).

Le Guen et al. (2009) argue that performance assessments for the long-term well integrity is a crucial step that needs to be addressed if CCS deployment is to be an acceptable safe solution for CO_2 emissions reductions. Similarly, Imbus et al. (2006) also suggest that a key vulnerability of CO_2 storage is well integrity.

3.1.2.3 ‘Fracking’ and shale gas

Extraction of natural/shale gas could potentially also pose a risk to the integrity of CO_2 storage. In brief, shale gas is a natural gas located in tightly compressed shale rocks deep below the surface. The only way that that gas can be extracted is via a process called hydraulic fracturing, or ‘fracking’. The drilling is done thousands of meters below the surface, normally at depths of 1500m to 5000m. In contrast to conventional gas extraction techniques, however, the drilling is done horizontally (see image below), so as to maximize its economic feasibility[50]. Once the boreholes are lined with steel and concrete casing, a mixture of water, chemicals and sand is injected at very high pressure in order to fracture the shale, after which the shale gas flows back to the surface where it is captured.

Figure 3: Shale gas extraction and hydraulic fracturing



Source: BBC, 2013.

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[50] By horizontally fracturing the shale, the rate of production increases, as opposed to simply drilling a vertical well. Estimates show that the production ratio for horizontal vs. vertical wells is 3.2 to 1, whereas the costs are only 2:1. In some carbonate formations, the productivity of horizontal vs. vertical drilling can be up to 400% higher, while only 80% more expensive (NaturalGas, 2013).

Shale gas is important primarily because it has the potential to radically transform the energy future of many countries reliant on coal and other fossil fuels, such as the United States in particular, as well as other developing countries like China, India and countries in Latin America, where largest shale reserves are said to exist. It should be noted that while shale gas is still a fossil fuel, however, it contains more energy per pound than coal, and is considered a cleaner source of energy as it produces none of the other particulates that burning of coal does (Mares, 2012). In other words, in light of the commitments to reduce carbon emissions, many countries have began exploring, and/or heavily switching from coal to shale gas as their choice of energy fuel.

In relation to CO_2 storage, the issue of hydraulic fracturing – 'fracking' – and shale gas exploration and production, has not yet been extensively explored, however, given the potential implications, it is an issue not to be ignored. It should be pointed out that 'fracking' is not a CCS process issue per se, but its implications relate to potential impacts on the integrity of storage sites, which in some cases, in particular in the US, are situated above the shale formations, where the CO_2 is being stored. Furthermore, it is an interesting comparator to CCS in terms of a number of uncertainties and risks (i.e. leakage, well integrity), and the differences in views of those between the various stakeholders (i.e. government, industry, public). Nevertheless, as many authors[51] have come to point out, shale gas extraction still carries a number of risks, including increased seismic activity, water contamination, and CO_2 and CH_4[52] emissions during drilling (BGS, 2011).

The debates on fracking continue between the industry claiming that the risks are small, and that shale gas is good news for the climate as it would limit coal consumption, and the opposition, in most cases environmental NGOs and the public,[53] which point to the still prevalent uncertainties about the safety and risks of significant damage to the health of people and the environment.

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[51] See for example Rozell and Reaven (2012), Vidic et al. (2013), Rahm and Riha (2012), McKenzie et al. (2012).

[52] CH_4 = methane. As far as emissions of this gas is concerned, as a result of fracking, a recent MIT study showed that extraction of shale gas through hydraulic fracturing in fact emits only a fraction more methane into the air than conventional gas drilling (O'Sullivan and Paltsev, 2012).

[53] In spring of 2011 two small earthquakes in Blackpool were blamed to be the result of hydraulic fracturing activity done by Cuadrilla Resources – the UK company licensed to explore Lancashire's shale gas resources. Immediately after those events, the UK government placed a moratorium on all shale gas exploration. This, however, only lasted until December, 2012, when the government lifted the ban (BBC, 2011).

3.1.3 Measurement, Monitoring and Verification

As far as any new technology is concerned, for it to receive approval and investment, reassurance from both the government (e.g. competent authorities[54]), as well as the companies looking to invest in the project, reassurance as to the safety is pertinent. Though in case of the latter, as Chapter 6 of this thesis shows, in which data from stakeholder interviews is presented, the largest issue remains the lack of sufficient policy support in terms of short-term capital investment support and long-term policy incentives. Nevertheless, as far as reassurance as to the safety of geological storage is concerned, this is provided through the various monitoring and verification efforts. This includes both deployments of various monitoring and verification technologies and techniques, such as field surveying, 3D imaging, or muon tomography,[55] as well as various legal and regulatory requirements. For example, Article 13 of the CCS Directive stipulates that project operators must, based on a monitoring plan, carry out monitoring of the injection facility, storage complex, and where appropriate also the surrounding environment.

As far as monitoring and verification is concerned, an interesting example is the In Salah project in Algeria, an industrial-scale CO_2 storage project, whose main objective is to provide reassurance, through monitoring and verification, that geological storage of CO_2 is safe in the long-term. In their analysis of the In Salah project, Mathieson et al. (2010) come to a number of important conclusions, including that: i) each storage site is unique, and the monitoring and verification program is specific to the risks at each site; ii) cost-effective technologies such as wellhead and annulus monitoring have proven to be very useful in the verification of long-term storage; iii) CO_2 plume development requires high-resolution data for reservoir characterization and modelling (p.221).[56]

Essentially, monitoring technologies play a vital role in helping to define vertical and lateral migration of injected CO_2 (Arts et al., 2002), and help to reassure that the

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[54] A competent authority is essentially the main governmental body that is entrusted with the permitting and licensing of CCS activities. It is also the governmental body that takes over the responsibilities and liabilities once storage sites are closed. Under the EU CCS Directive, stemming from the provisions of the UK Energy Act 2008, the competent authorities in the UK are the Secretary of State and the Scottish Ministers, depending on where the activity takes place.

[55] See NETL, 2009; Mathieson et al., 2010 for a useful account of specific monitoring technologies.

[56] Other examples of projects focusing specifically on measurement, monitoring and verification of CO_2 storage include the Heartland Area Redwater Project (HARP) CO_2 pilot injection site in Alberta, Canada, the monitoring program at Slepiner field in the North Sea and Snøhvit CO_2 injection program in the Barents Sea, of the coast of Norway (GCCSI, 2012; Chadwick et al. 2006: 2).

injected CO_2 remains underground. As several studies[57] have also pointed out, there is no ‘cookie cutter approach’ to the selection of monitoring technologies, as every site will be different based on its geology and/or capacity. As will be explained in greater detail in Chapter 4, the legal and regulatory frameworks in Europe take this notion into account in their provisions.

3.1.4 Summary of Observations

The three concepts of science, uncertainty and risk are interrelated in the sense that science is founded on uncertainty, and risk comes out of the uncertainties. While CCS is certainly a climate change issue, it is perhaps even more so a technical geo-hazard issue as well. Here again, the issue of uncertainties in relation to CO_2 subsurface migration, and the risks of leakage appear. The scientific literature is for the most part in agreement that one of the main threats of carbon storage is that of the failure of wellbores, which would even further increase the risks of leakage. To attempt to reduce these risks, studies have shown that robust measurement, monitoring and verification technologies will be required to offer reassurance that the CO_2 will stay underground for the long-term.

Essentially, the goal, and more importantly the *duty*, has become to limit these uncertainties and risks associated with carbon sequestration, thereby preventing human and environmental harm. The following section translates the above discussion of science, uncertainty and risk, and incorporates it into the debates on governance of CO_2 storage.

3.2 Mediating between the science, policy and law

3.2.1 A complex and reflexive relationship

When scientific findings are made, in particular in relation to potential significant threats to humans and the environment, bodies of environmental law (national, regional, and international) respond in a way to address that issue. When uncertainties exist, however, it makes things more complex, in particular for the policy and decision makers who have to incorporate the scientific findings into the developing policies and legislation. Production of sound science and a higher the degree of objectivity, or “usable knowledge” (Haas, 2004), the better the basis for policy

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[57] See Madsen et al. (2009), Davies et al. (2004), Wells et al. (2010), Mathieson et al. (2010).

making and in turn the basis for good laws. In other words, setting the framework for environmental law requires policy and decision makers to interpret the science and adequately grasp underlining scientific assumptions and uncertainties. A crucial role in this process is often played by various advisory bodies and agencies, which provide an important platform for the cooperation between the scientists, policy and decision makers. One such example is the Royal Commission on Environmental Pollution (RCEP), which advised the government on environmental pollution and had a substantial influence on environmental policy making. Yet another is the British Geological Survey (BGS), which has contributed substantially, both at the UK, European and international levels, in regards to the understanding of the character and capacity of potential underground storage reservoirs, chemical interactions underground, as well as monitoring and assessment technologies and strategies.

In light of the existence of scientific uncertainty, governments have for the most part used the principle of precaution[58] to address and deal with[59] many of today's pressing environmental issues. Essentially, this means that even though the existence of uncertainties is acknowledged, and that of the 'unknown uncertainties' (i.e. the unknown unknowns), action is taken in order to protect the environment. It was the 1992 Rio Declaration on Environment and Development first conceptualized this action in the precautionary principle, which essentially states, that "where there are threats of serious or irreversible damage, lack of full scientific certainty shall not be used as a reason for postponing cost-effective measures to prevent environmental degradation" (UN, 1992). An excellent example of the application of acting with precaution can be seen in the 1987 Montreal Protocol on Substances that Deplete the Ozone. In this case, all the signatory countries essentially came to an agreement that despite an incomplete certainty on the extent of the influence of the use of certain substances, such as chlorofluorocarbons (CFCs), on the thinning of the Earth's ozone layer, action must be taken.

All scientific approaches to dealing with environmental issues, in particular when uncertainties exist, involve scientifically rigorous techniques, such as risk assessments,[60] which quantify and aggregate the different outcomes and multiplying

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[58] See also Whiteside (2006), Weiss (2003, 2006), Bodansky (1991), Herremoes (2013).

[59] For example, through the implementation of environmental policies and legislation.

[60] This involves a range of quantitative and/or expert-based techniques in form of experimentation and modelling, probability and statistical theory, cost-benefit analysis, and Bayesian and Monte Carlo methods (Byrd and Cothern, 2000).

them by their respective probabilities, in order to yield a single picture of ‘risk’. It should be pointed out, however, that in light of uncertainties, ambiguity and ignorance, such techniques might not, or as Sterling (2007) suggests, should not be persistently adhered to.

Lastly, the relationship between the science, technology, policy and law can be said to resemble one of reflexivity. In the literature, definitions of reflexivity vary, depending on the context the term is used in. However, it is most often connected to the writings on reflexive modernisation by Beck (1992, 1994)[61], who essentially noted that the processes that were designed to yield progress, also at the same time produced side effects and risks. This research considers reflexivity in broad terms, in that the scientific progress is achieved through re-examination of that which is already used by society. In the context of CO_2 storage, this is evident in applying the existing technology for capturing, transporting and injecting CO_2, that has been around for decades, to advance the idea of permanently storing the CO_2, essentially for the purpose of mitigating climate change and continued use of fossil fuels.

Reflexivity is in this context also related to the concept of governance, in that knowledge production is integrated and based on cooperation, strategies and anticipation of long-term effects are based on adaptation (i.e. monitoring and corrective measure plans). Principles such as sustainability and precaution are examples of principles that reflect the possibility of unintended consequences, whilst reflecting the complex interactions within the governance system (i.e. between the scientific, industry and government communities). By creating and guiding interaction between various rationalities (i.e. of different actors), they take account of the complexity of interlinked social, technological and ecological development, the fundamental uncertainty with respect to system dynamics and the contingency of the effects of human action. Reflexivity is therefore geared towards continued learning in the course of on-going developments, rather than towards complete knowledge and maximisation of control (Voss and Kemp, 2006: 7).

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[61] See also Giddens (1991, 1999); Beck, Bonss & Lau (2003), Christoff (1996).

3.2.1.1 Translating science into policy

Translating the science, and its findings into policy is often complicated by the existence of the scientific and/or technical uncertainties. While the scientists, who produce findings acknowledge and understand the associated uncertainties, the policy makers most often do not; at least not to the same extent. This makes it necessary for the findings to be translated and communicated to them in an effective, efficient, and simple manner. The importance of the latter is often underestimated. This interpretation, or communication, is most often done by the so-called agents, also referred to as 'knowledge brokers' (Litfin, 1995), or by the 'epistemic communities' (Haas 1992; Williams, 2005). These agents play an essential role, as their ability to frame and interpret information is a substantial source of power, in particular under conditions of scientific uncertainty (Liftin, 1995: 254). Uncertainty, as Bryner (1997) argues, is a central feature of environmental crises. Essentially, policy and regulations are all formed in the context of uncertainty. The mere existence of uncertainty, as Williams (2005) would add, highlights the importance of science, and the important role of knowledge, as the basis for effective environmental policy-making.

The existence of scientific uncertainty, however, does not presuppose that effective environmental policies, agreements and legislation cannot be developed. One excellent example is the banning of man-made chlorines, such as chlorofluorocarbons (CFCs) and halons, the principal chemical agents said to be causing ozone depletion. While concerns around the effects of CFCs and halons on the ozone layer started to grow among the scientific community in the 1970s, it was not until the 1985 Vienna Convention that international cooperation on the issue was formalized[62]. Moreover, the Montreal Protocol, with its application of the precautionary principle, also serves as a prime example of what McEldowney, McEldowney (2011) refer to as the emerging paradigm shift in environmental policy- and law-making.

The key message here is that in order to produce sound policies, effective communication between the scientific and policy communities is essential and that even when a certain degree of uncertainty exists, effective agreements can be reached. In this case, Cash and Clark (2001) see effective communication in forms of distributive assessment systems, for which the effectiveness, saliency, credibility and

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[62] On the basis of this convention, the Montreal Protocol on Substances that Deplete the Ozone Layer was negotiated and opened for signature in 1987, entering into force two years later in 1989. To date it has been amended several times, signed by 197 countries and still serves as one of the most successful international environmental agreements.

legitimacy is influenced by factors such as the historical context, characteristics of the assessment user or audience and of the assessment process itself. This plays into the main conclusion of their study, which is that the science-policy interface is not a sharp line or demarcation but rather a fuzzy, dynamically shifting boundary, constantly influenced by the communication process itself.[63] The fact that this boundary is blurry, Jasanoff (1990) argues, can also increase the productivity of the decision making process itself. In this sense, productivity can be increased by a greater degree of cooperation and coordination, in terms of information sharing in particular, between the public and private stakeholders.

When examining the science-policy boundary in general, the context is an important component. This relates to the fact that there are different norms and values in institutions, which results in what Ruscio (1994) calls a policy culture. In his study of the science-policy culture in the US, the author also concludes that the policy culture in the end shapes the policy agenda, the debates and their eventual outcomes. The study of policy culture, in Ruscio's view, helps us understand the ways in which values shape the science-policy boundary. As can be seen in the case of CCS in the EU, not all Member States appear to have the same aspirations to deploy the technology, which is evident in the extent that CCS is included in their environment and energy policies, for example.

The structure of the science-policy boundary is also an essential element for the description of variation in regulatory regimes, as Halffman (2005) points out. His study provides a useful in-depth systematic description of the national patterns in regulatory regimes in the United States, England, and the Netherlands, and concludes that the regulatory regimes are an important locus for the articulation of the science-policy boundaries[64]. This research situates itself in such a context, in that the main research question sets out to explore the extent to which regulation mediates between managing the risks of CO_2 storage, and the deployment of the CCS technology.

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[63] See also Jasanoff (1987), Gieryn (1995), Guston (1999).

[64] Halffman (2005) also brings up an interesting idea, of *mimetic isomorphism,* which essentially means that institutional patterns of regulatory regimes can be mimicked by other regulatory regimes. He gives a useful example, when a regulatory agency is under pressure to devise a program to regulate a new environmental hazard, it copies successful approaches developed for other environmental hazards onto a new program (p. 464). In the case of carbon sequestration, this could essentially be applied by copying a regulatory approach that has been used to regulate hazards associated with oil and tar sands mining, injection of waste water in aquifer systems, liquefied natural gas storage, etc.

3.2.1.2 Science and law interface

Similar to the interface between science and policy, the relationship between science and law can also be seen as complex and multi-dimensional. In the words of Oliver Houck (2003), the historical relationship between science and law is one of a "tale from a troubled marriage." Gibbons (1981) also describes it as reflexive and complex, as both science and law to some extent exert an influence on each other (p. 44).

As mentioned earlier, science, uncertainty and risk are three interconnected terms. The idea of risk, and using risk assessments, then, has become increasingly important in environmental law, in particular in the light of the growing amount of environmental legislation and regulation aimed at reducing or managing the risks associated with a particular activity or process. In this field, the relationship between environmental law and science can often be seen best[65].

One of the more in-depth pieces in the literature on the relationship between science and environmental law, by McEldowney and McEldowney (2011), puts the intersection between the two fields under scrutiny. The authors essentially argue for a more interdisciplinary, reflexive learning processes that should engage with the changing and diverse regulatory styles of governance and the complex nature of environmental problems. A reflexive learning process, in this context, refers to the science essentially being regarded not as an autonomous and external input into law and environmental policy making, but rather as an intrinsic part to the regulatory process. In practice, this means that for the governance network theory, as used in this research, it is important to examine, for example, how government officials considered the input of scientists and the industry. In other words, this means answering questions such as were consultations with the scientists and the industry throughout the policy development process meaningful, and to what extent were any expressed concerns by the scientific communities ultimately incorporated into the regulatory frameworks in the end. Such, and similar questions are examined both through document analysis and interviews with various key stakeholders.[66]

The McEldowney and McEldowney (2011) article also suggests, among other things, that developments in environmental law and policy, can push science and

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[65] The actual, calculated or perceived risks, and impacts, of geological storage, and the liabilities that come as a result, will also be central to the legal framework for the entire CCS process, to the business decisions about the projects, as well as to the design, operation and closure of those projects (CSLF, 2011).

[66] See Chapter 6 in particular where data obtain from interviews is examined in-depth.

technology development forward. It also puts forth the notion that science is not an *external* influence on policy making and law, but should rather be seen as intrinsic to the regulatory process, evidence of which can be seen in modern techniques such as the precautionary principle, polluter pays principle, eco-labelling, and environmental impact assessments (p.14). This notion, that the science is an intrinsic part of the regulatory process, is important for the underlying theory and direction of this thesis. In turn, the research then examines whether the law pushes the science and CCS technology development/deployment further, or whether it impedes it.

Can the law capture science and technology development?

It is often argued that law is unable to adequately capture the science and technology and its principles. In this respect, Marsden (2008) points out that there is a general consensus that "the [law's] tendency to assume that science can provide clear, objective goals…[which then] provide a foundation for law and policy is a false assumption" (p. 52-53).[67]

Ellis (2006) also notes, for example, that while the law attempts to bring clarity and certainty to ambiguous situations, precaution on the other hand seems destined to defeat these attempts with its fluidity and flexibility, and the injunction to keep changing the rules of the game in light of new knowledge and understandings (p. 462). Similarly, Hutter (1999) points to the difficulties of legislating in situations of scientific uncertainty, the status of scientific evidence, and the issue of risk and its relationship with the law. She goes on to suggest three important implications of examining the interface between law and science, including that: i) science and technological issues are related to political values; ii) there is no simple division between facts, values, and opinions; and iii) science and technology are related to broader societal changes (p. 7). In other words, the science, technology and law come into conflict most often in light of scientific uncertainty and the required use of precaution. It is the role of the policy and decision-makers then to aim to bridge that gap when developing legal and regulatory regimes.

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[67] See also Raffensperger and Tickner (1999) who discuss this relationship in the context of the precautionary principle (Ch. 5-6).

3.2.2 Governing under conditions of uncertainty

In the presence of scientific uncertainties, questions regarding governance are often raised, such as, for example, how uncertainties and risks (i.e. CO_2 leakage) associated with the deployment of a particular technology (i.e. CCS) will be managed, or who is involved in the process of information gathering and the development of policy and legal frameworks. This, in essence, encapsulates the term ‘governance’, as understood and employed in this study.

3.2.2.1 Principles in environmental law

When placing science, uncertainty, and environment in the legal context, it is important to also recognize the importance and role of some of the main guiding principles. According to the Oxford English Dictionary, a *principle* is defined as ‘a source of action or a general law or rule adopted or professed as a guide to action’. *Rules* on the other hand, in contrast with a principle: i) operate in an all or nothing fashion (whereas principles have the quality of ‘weight’ or importance); ii) specify a course of action to be followed or avoided (whereas principles are about values and cannot, therefore, indicate particular actions); iii) can be justified by principles, but the reverse is not true (Perry 1997; Wilkinson, 2002: 100). What then is the importance of principles in (environmental) law in the first places?

The great advantage of legal principles, as Wilkinson (2002) suggests, is that “given their general or non-particularised nature, they have the flexibility to deal with novel and complex situations, and to act as general guides to action” (p. 101). However, the flexible nature of legal principles in turn also implies a certain extent of unpredictability, and uncertainty, which can make them seen as possessing unquantifiable legal obligations. For this reason many developed countries have not always supported the inclusion of environmental principles in treaties and other legislation (Wilkinson, 2002: 101). Alder and Wilkinson (1999) also point out that principles can be divided into three categories: i) legally substantiated principles; ii) legally binding principles; and iii) guiding principles[68]. Despite a large number of principles, international environmental law essentially relies extensively on several of the key principles: i) the preventative principle, or the no-harm principle; ii) the

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[68] i) a principle that originates external to law (i.e. a principle of environmental policy), but which is manifest and concretised through specific legal examples; ii) a principle that must, by law, be followed by certain actors (i.e. states; regional bodies; government ministries); iii) a principle that must be taken into account in the formulating or subsequent interpretation of legislation.

precautionary principle; iii) the polluter pays principle; and iv) the principle of sustainable development. Each of these will now be addressed in turn along with their relationship to the issues at hand in this thesis.

The precautionary principle

As mentioned earlier, science is characterized by uncertainty. In this respect, Rayfuse (2005) adds that "developing on the awareness of the uncertainty of scientific information and prediction, and the possible catastrophic effects of this uncertainty and inaccuracy for humankind…has led to the development of the precautionary principle" (p. 360). This means that as people have become more aware of scientific uncertainties, a call on 'the facts' as the only rational basis for decisions has become weakened, which in a way places scientific uncertainty and the precautionary principle, at the centre of environmental decision-making.

The precautionary principle has today developed into one of the more influential modern techniques of environmental legislation. The use of the precautionary principle in developing environmental legislation encourages, and essentially requires, the interdisciplinary collaboration between the science, law and policy in response to ecological and health risks in particular. Furthermore, the precautionary principle is also considered as a risk management and a decision-making tool (Marr, 2003: 22).

The precautionary principle, as mentioned in section 3.2.1 above, is a guiding principle for action being taken by governments to address the issue of climate change and other environmental matters, despite the existence of scientific uncertainty. It states that, "where there are threats of serious or irreversible damage, lack of full scientific certainty shall not be used as a reason for postponing cost-effective measures to prevent environmental degradation" (UN, 1992).

In any case, the precautionary principle also faces a number of criticisms[69]. As Stirling (2007) points out, these are often founded on an unfavourable comparison with 'sound scientific' methods of risk assessment. In this case the author suggests that the principle essentially fails as a decision rule. However, he does acknowledge

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[69] Other prominent critics of the principle also include Bodansky (1991) who suggests that the principle is also too vague to serve as a regulatory standard, Peterson (2006) who argues that it fails as a basis for any similar operational type of decision, and Adler (2011) who presents the idea that the precautionary principle could become a Trojan horse for other ideological crusades, and can, when selectively applied to politically disfavoured technologies and conduct, act as a barrier to technological development and economic growth.

that the principle cannot be compared to specific methodologies, as it is rather meant to be more of a normative guide than anything else. To this effect, policy-making should give the benefit of the doubt to the protection of human health and the environment, rather than to competing organizational or economic interests (p. 312). Wilkinson (2002) would agree with Stirling (2007), as he also notes that the precautionary principle is only meant to be a guiding principle which is taken into account when formulating or interpreting legislation.

3.2.2.2 Governance

For any political science scholar, *governance* might at first appear as a fairly straightforward and self-explanatory term. It is often considered in relation, or as a synonym for other similar terms such as law, government, politics, policy, etc. In any case, the literature has over the past two decades or so been flooded with the writings on governance, to the extent that in fact the term has become in a way a ‘catchphrase’ in both the social and policy worlds (Haas, 2002). The literature on governance is anything but scarce, with the term being used by authors in a variety of ways[70], making it, as Pierre and Peters (2000) describe, ‘notoriously slippery’. Even so, governance has become *the* concept with which to make sense of, or grasp modern policy making and implementation. In the words of a number of authors, governance has come to refer to a new process of governing, or the new method by which society is governed (Stoker, 2006; Rhodes, 1996).

Governance networks

When talking about governance, in any form or sense, the common thread in the literature has become that of a *network*. While both, governance and network are now often in the literature used in conjunction, it is important to make the distinction between these two similar but different terms, ‘network governance’ and ‘a governance network’. This distinction is important and can sometimes be neglected, or even used interchangeably to represent the same thing. While the former signifies a way of governing, the latter only encompasses the concept of a network, for the lack of a better word, as a ‘thing’ or a structure. Furthermore, whereas ‘network governance’ represents an explicit claim that the network is proliferating as a form of

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[70] See for example authors like Rhodes (1996), Pierre and Peters (2000), van Asselt and Renn (2011), Jordan et al. (2005), Chhotray and Stoker (2011), Davies (2011).

governing and heralds a break with the past, using the term ‘governance network’ instead emphasizes and focuses on the recurring or institutionalized formal and informal resource exchanges between governmental and non-governmental actors (Davies, 2011: 3), and thus avoids any definitive or predictive claims about outcomes of such governing, which ‘network governance’ theories and studies essentially attempt to make.

In today’s complex, dynamic and differentiated modern societies, looking at the act of governing by focusing and relying solely on government arrangements is not sufficient.[71] In other words, governance and the act of governing has become a matter for both public and private actors, “neither of which have the capacity to address public policy problems alone but find themselves participating in governing schemes characterized by resource dependencies” (Damgaard, 2005: 2). Ansell and Gash (2008) refer to the bringing of public and private stakeholders together in collective forums with public agencies to engage in consensus-oriented decision making as ‘collaborative governance’. As such, governance as a concept encompasses not only the formal and informal interactions between stakeholders, but as Blanco et al. (2011) point out, also the procedures, processes and the rules developed as a result of those interactions. Stoker (1998) describes governance as ultimately being concerned with creating the conditions for ordered rule and collective action (p.17).

In the literature, governance networks are often referred to or used interchangeably with the term policy networks. While the governance network concept has not achieved any agreed upon definition within the literature, it most commonly refers to a set of “relatively stable clusters of operationally autonomous actors connected to each other by mutual resource (inter) dependencies that interact, frequently in institutionalized settings, in order to address a public policy problem” (Damgaard, 2005: 3). Where governance network, as far as this research is concerned, differs from the concept of policy network, is in that, contrary to the arguments of the latter, actors within a governance network are not seeking to exert influence on a particular policy or legal outcome. Actors within a governance network, in other words, seek to primarily coordinate and pool together resources.

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[71] See Damgaard (2006), Kooiman (1993, 2003), Hirst (2000).

3.2.2.3 Application and implications

In broad terms, whereas the governance refers to a process, governance network is understood as a structure. Briefly mentioned above was what governance and governance networks are. The main objective of governance (networks) is that of managing the uncertainties and risks, whilst ensuring the deployment of a technology. In this research, this refers to the management of main environmental risks associated with CO_2 storage component of the CCS chain, and the deployment of the CCS technology as a whole. The medium for doing so is seen in the legal and regulatory frameworks, with the licensing and permitting regimes as their central features.

Licensing and Permitting

Since the late 19th century, the role of the planning systems in environmental protection has broadened, from seeking to prevent and control pollution, to encompassing sustainable development as an objective (Holder and Lee, 2007: 503). An important, and core part of any planning system is the licensing of activities. Licensing or permitting, essentially serves the purpose of prevention, control and management of risks, and should be viewed as an important tool in regulation of activities that may cause harmful pollution or environmental damage. This mainly refers to the issuing of an administrative document provided by a responsible, or competent authority, which gives the project operator the permission to carry out the activity for which the license is demanded given that a number of conditions are fulfilled, certain use limitations are respected, and measures are implemented for containment, minimization and avoidance of those environmental impacts the activity or work may cause. It also, however, refers to a system of periodic control of the activity, by which compliance with the stated requirements in the permit itself is assessed (Martin, 2011: 14, 22).

Essentially, it is a way for a licensing authority to screen the applicants, and thus help to control the particular activity. In providing material consideration in such a decision, McEldowney (2011) also points out that collection of information and analysis are particularly important. As far as it relates to the storage of CO_2, the main licensing authority bases their decision on whether or not to issue a permit on its satisfaction with the information it receives from the permit applicant, in particular storage site assessment and characterization.[72]

Licensing and permitting is thus clearly a regulation mechanism, and its objectives are, as mentioned, mainly to control and manage environmental risks. In doing so, the licensor (i.e. the government authority), as well as the general public, can be assured that the activity is being conducted with respect to the law, and most importantly in a safe manner. However, licenses and permits are only effective to the extent that they are complied with. This makes, as mentioned above, the periodic control of a particular activity and its compliance with the requirements of the license and/or permit, a crucial component in the management of potential environmental impacts. In other words, it is not only sufficient to issue a license or a permit, but for the government, and other third and independent parties, to check up on the compliance with those permits. In that way then, the management of environmental risks and the controlling of the activity are done most effectively. As is the case in many jurisdictions around the world, however, verifying permit and license compliance is often restricted by the availability of resources (i.e. finance, regulators/inspectors), which in turn can raise questions about the effectiveness of the licensing and permitting as a regulation mechanism itself. The extent of the effectiveness, however, is dependent on a number of other factors, and varies between jurisdictions.

3.3 Risk and Society

As mentioned earlier in this chapter, science is based on the concept of uncertainty, which undoubtedly plays a part in the policy and legal contexts. Essentially, the overarching concept bringing the science, technology and governance into the same realms is ‘risk’. This section first discusses the notion of risk society and the relationship of the general public with science and new technologies, before concluding with a discussion on the importance of communication and public engagement. The aim is to bring the social science perspective into play, and present the general public as an important contributor, albeit at arms-length, in the governance process.

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[72] See chapter 3 for more detailed discussion on the permitting regime for CO_2 storage in the EU.

3.3.1 The 'Risk Society'

Only those who risk going too far can possibly find out how far they can go.

— T.S. Elliot[73]

Risk is like fire: If controlled it will help you; if uncontrolled it will rise up and destroy you.

— Theodore Roosevelt[74]

Many environmental matters are often not predictable, or at least not with certainty. In much of the adverse criticisms to which science is often subjected to today, it is a common misconception that it claims certainty, and is/can be completely objective. However, uncertainty involves more than the presence or absence of objective scientific knowledge. It is to a large extent both socially and politically constructed. As a result, uncertainty can lead the policy and decision-makers, the industry, the lay-public and other stakeholders to acknowledge that there is a certain amount of risk when dealing with environmental issues. The term 'risk' essentially implies that there is a potential of failure or an undesirable outcome.

Our society in general could more or less, as far as it relates to environmental matters, be seen as risk-averse, meaning uncertainty causes reluctance in accepting and/or making decisions. For example, people might be more inclined to accept a technology, which has a lower payoff (i.e. lower emissions reductions) but has been around for a while and has been proven safe, than they would be to accept an emerging technology, which has a higher predicted payoff (i.e. higher emissions reductions), but is surrounded with a number of uncertainties. A good example of the former is nuclear power, though at its early stages of development it was also plagued with uncertainties, while a good example of the latter is CCS (Fleishman et al., 2010; Upham and Roberts, 2011; Corner et al., 2011; Roberts and Mander, 2011; Poumadère et al., 2011).

The idea of risk, and understanding risk, is really one of the fundamental aspects of human nature, our logic and our instinct. Within environmental law, it tends to become defined as the probability of a loss or probability of damage (i.e. to the environment or human health), which is often expressed in both quantitative and qualitative terms. Particularly over the past 30 years or so, the field of quantitative

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[73] Obtained by searching quotes on 'Risk' on brainyquote.com. Available at: http://www.brainyquote.com/quotes/quotes/t/tseliot161678.html.

[74] Obtained by searching quotes on 'Risk' on riskczar.com. Available at: http://riskczar.com/risk-quotes/.

risk assessments has grown in importance. Scientists and policy makers have come to use terms like acceptable levels of risk of some undesirable outcome. However, how far can we actually go with such estimates before it is too late? In this case, the two quotes above, by Elliot and Roosevelt, seem appropriate, in that taking and regulating/controlling risks has become nearly synonymous.

In other words, today's modern society has become characterized and driven by (technological) development, moving forward despite uncertainties and associated risks, yet at the same time, acknowledging and acting cautious, by trying to control these as much as possible. As such, it would not be false to classify the modern society today as a *risk society* - a term coined by a German sociologist Ulrich Beck in his writings in the early 1990s.

Beck, for example, primarily wrote on the state of modernity, and the modern society's problems, arguing that society's advancements have as a side effect produced risks with potentially catastrophic consequences, on a scale never seen before[75]. Essentially, the modern society has turned into a risk society in the sense that it has become preoccupied with debating, preventing and managing risks brought upon itself. For Beck (1992, 1996, 2006) and Giddens (1999), another of the most prominent writers on the risk society, society has become preoccupied with the future, and safety, which in itself generates the notion of risk. For both Beck and Giddens, the primary interest lies not in the quantifiable part, but rather in the effects that risk awareness has on the functioning and self-awareness of late modern society (Riesch, Reiner, 2010: 2). One of the main contributors to the development of a risk society, as both Beck and Giddens would suggest, can be seen in the role of the mass media. Risk consciousness, exacerbated by the mass media, indicates that the concept of risk has become the signature of the contemporary society (Strydom, 2002: 4).

Many of the debates on risk society, however, miss the most important point about risk, in that the term does not itself imply a catastrophe, but rather its anticipation. In this way then, risk can be seen as a virtual construct, and becomes 'topical' only when it is anticipated. In other words, they are not 'real', but better said; they are 'becoming real' (van Loon; in Beck, 2006: 332).

Interestingly, Jarvis (2007) also points out to the paradox in the contemporary risk debate, stating that, "risk might in fact be increasing due to technology, science and

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[75] See Beck (1992, 1994, 1996, 2006). See also Cottle (1998) for a good critique of Beck and the 'risk society' concept.

industrialism rather than being abated by scientific and technological progress." The risk society debate and the paradoxes within it, also in the end lead to exposing the political and legal nature of many risk decisions. This relates to the idea that we also live in, what Majone (1994) calls a regulatory state, defined by the notion of risk regulation. In the process of risk regulation, the legislators, judges, regulators, as well as public opinion all have important, but distinct roles to play. In particular in the case of the latter, Majone also argues that people often tend to overestimate events associated with lower-probability of harm, while ignoring potential benefits (p. 294-96).

3.3.2 The relationship between the risk society and science

In 2000, the UK House of Lords Select Committee on Science and Technology issued a report on the relationship between science and society, which pointed out that the society's relationship with science is in a critical phase, defined by public unease, mistrust and occasional outright hostility (in Sturgis and Allum, 2004: 56). What the report also found was that even though people value science and technology on a daily basis, because of such a rapid scientific and technological progress, they become increasingly uneasy. This then further exacerbates the society's problems with science in general, in particular if such progress is associated with questions of uncertainty and risk.

In the literature, the lack of or declining status of public trust in science and technology, and their role in identifying and solving society's challenges, is often referred to as science's 'legitimacy problem'. According to Beck, Giddens and Habermas, some of the most prominent social theorists, this could be explained as "a symptom of a general disenchantment with the late modernity, mainly, the limitations associated with codified expertise, rational bureaucracy, and institutional authority" (Beck, 1992; Giddens, 1991; Habermas, 1997; in Gauchat, 2011: 752). Some would suggest that the legitimacy problem of science comes as a result of the lack of people's scientific and technological knowledge, which is sometimes depicted as the so-called 'deficit model'. Many scientists also believe that the public's "scientific illiteracy [is] at the root of opposition to new technologies**,** environmental action and adequate science funding (Besley and Nisbet, 2011: 4).

Not surprisingly, given its rather simplified assumptions and the implications this can potentially carry, the 'deficit model' has been criticized by a number of authors.

For example, Douglas and Wildavsky (1983) have argued that what people perceive as risks is more in response to their cultural associations as opposed to being related to an ‘objective’ hazard. Slovic and Peters (1998) also suggest that one’s perception of risk is never primarily dependent on their level of scientific understanding. In her case study on the perception of science by the public and social elites in Croatia, Katarina Prpic (2011) for example finds that the general value systems and social role and position of individual groups, plays the most important part in the perception of science; as opposed to the level of scientific understanding.

Essentially, it is quite clear that culture, economic factors, social and political values, trust, risk perception, and worldviews are all important in influencing the public’s attitude towards science, and new and emerging technologies (Sturgis and Allum, 2004: 58).

3.3.3 Public attitude and reaction

Understanding the public’s attitude (i.e. opposition or support) towards science and technology is important, as it helps formulate appropriate responses in cases of objection (Upham and Roberts, 2010: 6339), as well as build upon in cases of support. This recognition becomes even more evident when it comes to new and emerging technologies, such as nuclear energy in the 1950s, or CCS today.

Attitude, as a concept, however, can be understood in a number of ways, including as an affect (i.e. emotion or arousal), or a distinct measure of favourability. Furthermore, attitudes can be explicit and implicit, both however, having a varying effect on people’s behaviour. Wood (2000) for example, in this respect also implies that people can become conflicted or ambivalent towards an object or a situation at different times, potentially holding multiple attitudes. This has to be acknowledged by the policy and decision makers in particular, as well as the industry, when it comes to communication and engagement efforts.

As the UK Department of Energy and Climate Change (DECC) pointed out in their 2003 Energy White paper[76], it has become widely recognized that assessing public attitudes and perceptions of new technologies is vital for their future successful implementations. When assessing public perception, however, authors such as Scheufele (2011) would be eager to point out that there is a clear distinction between

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[76] DTI (2003). *Energy White Paper: Our energy future – Creating a low carbon economy*. Available at: http://www.uea.ac.uk/~e680/energy/pdf_files/Energy_Papers/Energy_white_paper_2003.pdf

the self-reported perception (i.e. what people think they know) and the objective assessments of knowledge (i.e. what people actually know). A study by Upham and Roberts (2010) on public perceptions of CCS, for example, found that perceived risks of new technologies often have far greater potential to undermine deployment, than do scientifically determined risk. Their findings essentially indicate and highlight the fact that risk perception has become highly culturally and socially significant, which is consistent with the popular discourse on risk society.

3.3.3.1 Public opposition and participation

When risks and other concerns associated with new and emerging technologies, such as CCS today and/or nuclear in the 1950s, are not adequately addressed, the public can become sceptical about the intentions of the main actors involved and the reliability of the technology itself. A number of CCS projects for example have already been cancelled[77] or been delayed, in large part due to local public opposition (Hammond and Shackley, 2010: 11).

Public Participation

It would be true to claim that an informed public can participate better in the decision-making process, and can more effectively call authorities and project developers to account. In this respect, the 1998 *Aarhus Convention on Access to Information, Public Participation in Decision Making and Access to Justice in Environmental Matters*[78], has established a first set of rights of the public with regard to the environment. It requires the signatory Parties to implement the necessary provisions in respect to the right to access to environmental information, the right to participate in environmental decision-making, and the right to challenge public decisions made (access to justice). The Convention, has often been regarded a driving force for environmental democracy (Watts, 2005; Palerm, 1999; Hartley and Wood, 2005; Toth, 2010), as its aim is to essentially mediate between the public and the public authorities in regards to environmental matters.

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[77] CCS project in Barendrecht, Netherlands cancelled after a delay for more than 3 years and complete lack of local support (CCJ, 2010).

[78] Convention on Access to Information, Public Participation in Decision Making and Access to Justice in Environmental Matters (Aarhus, 25 June 1998). Available at: http://www.unece.org/env/pp/documents/cep43e.pdf.

As a number of studies have shown, a significant amount of people, in the context of their everyday lives, are still not thinking about climate change, and even less so about CCS[79]. Furthermore, a 2011 Eurobarometer Survey on Public Awareness and Acceptance of CO_2 capture and storage, for example, has shown that only about 10% of Europeans have heard of CCS. This also indicated that awareness of CCS were highest in EU countries that host demonstration projects, such as Germany and in particular the Netherlands (52%). Another important finding was that people were often confused about characteristics of CO_2, such as the fact that it is not toxic or flammable. This goes to show that with insufficient, or false knowledge, people cannot correctly appraise the safety of long-term CO_2 storage.[80]

As Wolf and Stanley (2010) point out, what the public values and what it fears are two related issues capable of forming important inputs into environmental policy and environmental decision making (p. 557). Thus, the significance and extent of the public's participation should be of particular interest to all. Essentially, public participation encompasses everything from the traditional forms of participation such as voting, lobbying, demonstrating, and forming interest groups, to any organized processes adopted by officials, government agencies, or other public/private organizations to engage the public in environmental assessment, planning, decision making, management, and/or monitoring.

The public's participation can most commonly be seen at the development stages of particular projects, such as with licensing and permitting decisions (Wolf and Stanley, 2011: 558). Since many project developments require some formal planning agreement by the public authorities, as Wynne (in Redclift and Benton, 1994: 17) suggests, there is a great opportunity for public participation in the formal planning procedures. A good example of such opportunity is in the environmental impact assessment (EIA) processes. Where the public is formally engaged in a particular project, the quality and local relevance of an EIA can be improved, which in turn also leads to the project itself carrying more legitimacy (Hunsberger et al., in Noble and Birk, 2011: 18). As Dietz and Stern (2008) add, by directly involving the public, it can also lead to a build up of trust and understanding among parties (p. 1-2).

On the other hand however, there is also the argument that the disadvantages of

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[79] See also Shackley et al. (2004), Reiner et al. (2007); de Best-Waldhober et al. (2009).

[80] Eurobarometer (2011). Available at: http://ec.europa.eu/public_opinion/archives/ebs/ebs_364_en.pdf.

public participation in decision-making need to be considered. In this respect, Irvin and Stansbury (2004) provide an interesting comparative account of the advantages as well as disadvantages of public participation. They point out that disadvantages can be seen in the process itself, both to the public (i.e. time consuming, pointless if decision is ignored) and the government (i.e. time consuming, costly), and in the outcomes. In this respect, for the public this involves worse policy decision if heavily influenced by opposing interest groups, and for the government when there is a loss of decision-making control, or a lower budget for implementation of actual projects (p. 59).

Environmental Pressure Groups and Lobbying

Environmental pressure groups, such as Greenpeace, Friends of the Earth, WWF, etc., can to an extent also influence public opinion. In some cases, such pressure groups can have significant financial and technical resources that allow them to better influence and challenge, as well as monitor compliance in environmental law. Recently, for example, two environmental NGOs - Focus, and Environmental Law Service - issued a complaint to the European Commission, that officials in Slovenia have breached the Article 33 of the EU Directive on Carbon Capture and Storage, when issuing a building permit for the construction of the 6th unit of the thermal power plant Šostanj (TEŠ). Along with the complaint, the two NGOs also enclosed an assessment made by Bellona Foundation on the feasibility of CCS at TEŠ. In the assessment, numerous abnormalities in the feasibility studies for CCS were found, which included a lack of transparency of data, cost estimates and poor analysis. If it is found that the officials were in breach of the EU law, the funding, which comes from the EIB and EBRD, will be in jeopardy.

To an extent, the work of NGO’s can be considered a type of lobbying. Undoubtedly, some NGO’s have come to acquire significant influence in global environmental governance (Corell and Betsill, 2001). In many respects, Brussels is sometimes also referred to as the centre for European lobbying, with the EU institutions being a target for various professional and voluntary lobby groups. These groups also differ in the type of lobbying - commercial and social. The latter consists of pressure groups, trade unions and concerned individuals based on non-commercial motives that are most often either ideological or political. Environmental NGOs fall within this category of lobbying, seeking to promote the intrinsic and priceless value of the environment (Biliouri, 1999), and their role in EU environmental governance system is best seen as policy 'teachers' or 'exporters' of policy lessons (Bomberg, 2007). Some have also come to point out that EU institutions will often have low interest in the activities of environmental NGO's given that they cannot provide specialized information due to their broad orientation (Michaelowa, 1998)[81].

On the other hand, the industry lobbying groups fall under the commercial type of lobbying, and with their extensive resources, both material and immaterial, one could think that they can easily influence policy-making in Europe. Although industry lobbying groups, cannot prevent adoption of certain emissions targets, for example, they have in the past lobbied effectively (in their favour), and managed to stall the adoption of various measures and mechanisms, and shift the balance in favour of voluntary agreements, as Michaelowa (1998) points out.

In any case, successful lobbying groups will normally exhibit usual professional characteristics, such as resources, advance intelligence, good contacts with bureaucrats and politicians, and most importantly the ability to provide policy-makers with sound information and advice. Just as is the case elsewhere in the world, in Brussels, reputation for expertise, reliability and trust are also key resources in lobbying. In addition, the perceived responsibility of the lobbyists, or the willingness to be involved in the policy-making process without publicity, goes to show that the *style* of lobbying is perhaps even more important than the content and the objectives of the lobbying itself (Mazey and Richardson; in Jordan, 2005).

Key industry lobby groups for CCS, such as the Zero Emissions Platform (ZEP)[82] and the Carbon Capture and Storage Association (CCSA) have been relatively successful[83] in promoting CCS technology development and deployment in Europe, thus far. Their primary role within the wider EU governance system continues to be as provider of advice on technical, policy and commercial issues related to CCS. The

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[81] I have also asked this question, of the influence of environmental NGOs in Brussels, to some of my friend currently working at various EU institutions, and majority of them agreed with Michaelowa's (1998) comment, in that their influence is rather limited.

[82] Whereas ZEP is an industry-led body set up in 2005 and partially funded by the EU Commission's DG Research & Innovation, representing 28 companies, CCSA was established in 2006, and is based in London. Both ZEP and the CCSA also include members drawn from across the industry and other areas such as academia and finance.

[83] A report by the Corporate Europe Observatory and Spinwatch, for example, states that the industry lobby has been very successful thus far, securing funding for CCS from the third phase of the EU's emissions trading scheme, which will come in the form of 300 million allowances from the scheme with a value of between 4–7 billion euro, depending on the price of carbon. Report is available at: http://corporateeurope.org/sites/default/files/sites/default/files/files/article/ccs.lobbying.pdf.

question remains, however, whether, or to what extent the CCS industry lobby has had an influence in shaping EU policy and guidance on CCS. To some extent it certainly has, given the specific expertise of its members in oil and gas extraction and monitoring and verification for example, which was relied upon when developing the CCS policy and legal frameworks.

It would not be difficult to claim that maximizing self-interest or the interests of its members motivates the industry lobby. After all, companies are in the business of making a profit. Rather than making such a claim, however, this research would instead argue, that rather than utility maximisers, the industry, and the industry lobby, are better described as utility satisfiers. Their participation in the overall governance system hinges not only on a cost-benefit analysis of (non) participation, but also on a broader realisation of the importance of CCS. In other words, although to an extent profit oriented, the industry (lobby) recognizes the importance of developing CCS,[84] and as such will seek to obtain an outcome (i.e. funding and content of the policy and legal frameworks) that would satisfy them, and other stakeholders as well.

This premise is in line with the arguments of the governance network theory, in that no single actor holds ultimate authority or receives an ultimately favourable outcome by participating in the network. This is tested in the chapters that follow, by examining the legal and regulatory frameworks as well as speaking to the CCS industry representatives, as well as other stakeholders, in order to attempt to determine the remaining barriers for the industry, and as such come to a conclusion as to whether the industry did in fact receive a favourable outcome within the legal and regulatory frameworks.

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[84] Determining whether the importance of CCS for the industry lies in the legal requirements in their respective jurisdictions that are likely to ultimately mandate the implementation of CCS technology, or whether such realisation comes from understanding of a broader societal importance, is beyond the scope of this research. Although it would be an interesting direction to go in for future research work on CCS and the industry.

3.4 Summary and ways forward

"Although our intellect always longs for clarity and certainty, our nature often finds uncertainty fascinating."
— Carl von Clausewitz[85]

The purpose of this chapter was essentially two-fold: to introduce the underlying themes of this thesis, as well as to provide a critical overview of the general and specific CCS literature. This section now draws together the material discussed above into an overall picture, and offers some ideas for further research, some of which are to be taken up in the proceeding study.

3.4.1 Summary

Science, uncertainty and risk, are three extremely interrelated concepts that have come to characterize the development and deployment of CCS thus far. Most of the literature, as discussed above, whether scientific, technical, policy or social, have in some form or another focused on uncertainty and risk. Acknowledging the notions of uncertainty and risk revolves primarily around the potential for leakage of CO_2 from a storage reservoir, and other consequences such as induced fracturing and seismicity, and harm to the environment and humans. These issues place CO_2 storage, along with other already present geo-technologies (i.e. coal, oil and sands mining, shale gas, liquefied natural gas storage), making it not only a climate change mitigation technology, but also as a geological hazard.

As already mentioned, uncertainty as acknowledged and accepted by science, and applied by the policy and decision makers (i.e. via precautionary principle), implies that a certain amount of risk is taken. This makes the society of today, as far as it relates to dealing with environmental matters, risk-averse. Science plays an important part in the construction of such a society, along with other influencing factors such as the economy in particular. An argument could be made that to a good extent, the lack of commercial-scale projects in the EU, and elsewhere around the world for that matter, is a result of the recent financial crisis. Unfortunately, environmental issues in general, and projects often tend to be de-prioritized first.

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[85] Quote obtained from BrainyQuote (2012). Available at: http://www.brainyquote.com/quotes/quotes/c/carlvoncla138186.html.

In any case, although not involved in the formal process of the development of policy, legal and regulatory frameworks, and the general public remains an important factor in the overall process of governance. This is evident from the power of public opposition and the cancelation/delay of a number of projects in the previous decade. Although this research acknowledges the role and impact of the public factor on the development and deployment of CCS technology, its primary focus is the governance process for CO_2 storage in Europe, from a legal and regulatory perspective. This area of the literature on CCS remains underdeveloped, and this research hopes to contribute to its growth.

3.4.2 Ways Forward

As mentioned, although the literature on CCS has been increasing over the past several years, some issues remain to be uncovered, or explored in greater detail. As pointed out in section 3.3 in this chapter on risk and society, there have been a great number of studies done on the role and importance of the public, for example on (factors influencing) public awareness, perception, and acceptability, as well as on communication efforts. There is, however, a lack of those, for example, focusing specifically on monitoring and verification activities, and how they can provide reassurance. One study was found on this matter, by Seigo et al. (2010) who suggested that contrary to popular belief, communication and additional information about CCS monitoring activities may in fact not have a reassuring effect after all, and can even be alarming by causing greater risk, and lower benefit, perceptions.[86] Nonetheless, no study has yet to investigate, in regards to monitoring and verification, on what would reassure the public of the safety of CO_2 storage.

A gap in the literature that this research is most concerned with is that related to the governance of CO_2 storage. In this respect, although a number of journal articles and reports have been found which examine the legal and regulatory frameworks for CCS, there is no comprehensive account for the governance process as a whole. By examining the so-called CCS governance network(s) (i.e. their structure and interactions), as well as the legal and regulatory frameworks more in depth, and by speaking to those directly involved in project development, as well as other key

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[86] See also studies by Wiedemann & Schütz, (2005) and Wallquist et. al. (2012)., which find that information about precautionary measures, such as monitoring and verification for example, in fact lead to a heightened risk perception, as opposed to reassurance.

stakeholders, a more comprehensive, and up-to-date picture of the governance of CO_2 storage in Europe will be presented. The main aim is to determine the extent to which the current legal and regulatory frameworks in Europe mediate between the management of CO_2 storage risks, and the development and deployment of CCS technology. In this way, the research hopes to contribute not only to the general literature on CCS and governance, but also be available for reference use in light of the upcoming review of the EU CCS Directive this year.

CHAPTER 4: Governance and Regulation of CCS in the EU

Over the past several decades, the environment has undoubtedly acquired a more prominent role as an issue of public concern and established itself on the policy agendas of many countries around the world. Conditions of scientific uncertainty and environmental risks, brought up by the increase in scientific knowledge and emergence of new technologies, along with the political, economic, and social pressures to deal with climate change and energy security issues, has raised numerous governance-related questions

As explained in Chapters 2 and 3, the concept of governance has in the literature acquired a number of differing definitions and been used in various contexts. As a general consensus, it has come to refer to a two-way street, involving both those being governed and those governing (Kooiman, 2003), including both formal and informal interactions, as well as procedures, processes and rules (Blanco et al., 2011).[87] [88] The concept of governance has, in essence, turned to represent a continuous and an interactive process of decision-making, cooperation and facilitation, whose effectiveness often in the end lies in, but is not determined by, appropriate and robust policy, legal and regulatory frameworks. The main objective of governance, in the context of climate change and emerging mitigation technologies, such as CCS, as understood in this research, however, remains the *effective management of environmental risks* associated with the technology, *whilst enabling its development and deployment*.

This chapter sets out to examine this objective of governance in the context of CCS in the EU. As mentioned in earlier chapters, given that environmental risks are primarily concentrated in the storage component of the CCS chain, this remains the main focus of the chapter, and the thesis as a whole. To do so, this chapter is structured as follows. First, the evolution of environmental governance in the EU is

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[87] Moser (2009) also suggests that governance extends also to the institutional structures and mechanisms, as well as the division of authority and the underlying norms involved in determining a course of action.

[88] As Falkner (2003) points out, a more recent phenomenon is so-called ‘private environmental governance’, which sits outside of the traditional realm of state-centric international politics. Here, businesses, NGOs and other organizations work together to create norms, rules and mechanisms such as certification schemes for environmentally friendly corporate behaviour.

discussed, followed by the analysis of the CCS governance regime, including the policy and legal context for CCS, and the overview of the EU CCS Directive. Lastly, a summary of the chapter is provided.

4.1 The EU environmental governance regime

This section first briefly examines the evolution of the EU environmental governance regime. Understanding the process of integrating environmental issues into the policy and legal spheres, as well as the role of various institutions and instruments within the EU governance system provides an important basis for understanding and analysis of the CCS governance regime (see section 4.2).

4.1.1 Establishing the environment's legal character

Pre-Single European Act

Following World War II, with the establishment of the European Coal and Steel Community (ECSC) in 1952, and several years later, in 1957 also the European Economic Community (EEC) and the European Atomic Energy Community (Euratom)[89], there was no sense of any specific mention of a common European policy on the environment, let alone any provisions on environmental regulation.[90] This was because, at that time, Europe was still evolving into primarily an economic community. It was not until the late 1960s and early 1970s, as environmental awareness in Europe began to grow[91], in light of the growing scientific understanding of impacts of human behaviour on the environment that policy makers began to consider the incorporation of such issues into the official agenda of the EEC. It was not long after the 1972 United Nations (UN) Conference on the Human Environment in Stockholm, which signified a turning point in international environmental politics

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[89] The EEC and Euratom were established by the 1957 Treaty of Rome, also known as the Treaty Establishing the European Community (TEEC; or TEC), or the Treaty of the European Community (TEC), respectively, in order to establish a common market, a customs union, common policies and liberalization of trade (Art. 2 and 3 of the TEC), and to form and develop a European nuclear industry, and provide for energy security. Later on in 1967, the Merger ('Brussels') Treaty was signed in order to streamline the European institutions by creating a single Commission and a single Council to serve then three European Communities (EEC, Euratom, ECSC). The founding six member countries included Belgium, France, Germany, Italy, Luxembourg and the Netherlands.

[90] The Art. 37 of the Euratom Treaty is by some argued to represent one of the first environmental legislations, in relation to protecting the environment and human health (Heul-Fablanek et al, 2008). It relates to the plans for disposal of radioactive waste and potential liabilities to result in the radioactive contamination of the water, soil or airspace of another Member State.

[91] In 1970 for example there was the first observance of Earth Day, by some to be considered the birth of the modern environmental movement (Ausubel et al., 1995).

(Baylis and Smith, 2005), that the Heads of State or Government of the six EEC Member States met at the Paris Summit in July of 1972, recognizing that in the context of economic expansion and improving the quality of life, particular attention should be paid to the environment (Europa, 2012). As Grande and Peschke (1999) also explain, the link between [environmental] science and the industrial competitiveness began to be seen as indispensable. Finding compromise solutions between industry, government, and civil society from this point on starts to become increasingly difficult. As will be argued later on, CCS is essentially one of such solutions.

Following the development of the first official EEC Environmental Action Programme (EAP), at the 1972 Paris Summit, the foundations were set, and European environmental policy began to take shape.[92] This essentially established the main policy framework for developing future EEC strategies in the environmental field suggesting priority themes and the development of a wider range of strategies (Stallworthy, 2008).

Yet another result of the 1972 Paris Summit was the setting up of an administrative unit called the Environment and Consumer Protection Service (ECPS), the predecessor of the present day Directorate-General (DG), at the beginning of 1973. As Jordan (2005) points out however, at that time the Commission's bureaucratic capacity to effect great change in the environmental field was still small, and with some notable exceptions, many of the early environmental policies in the 1970s related primarily to less politically important areas such as bathing water and wild bird protection, areas where it found it could operate relatively unsupervised by pressure groups, national politicians and government officials (p. 6). In some respect, much of the focus for these actors at the time was, as far as environmental policies were concerned, still concentrated at the national level. Essentially, having been given a formal role in the EEC, the environment still took the backseat to other issues, especially the economy. Arguably, to some extent, the economy versus environment remains one of the key debates to-date.

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[92] Since then, there have been six EAPs implemented, and the 7th EAP is soon to be finalized, as the 6th is set to expire in mid-2012: 1st Environmental Action Programme 1973-1976 (OJ C 112, 20.12.73); 2nd Environmental Action Programme1977-1981 (OJ C 139, 13.6.77); 3rd Environmental Action Programme1982-1986 (OJ C 46, 17.2.83); 4th Environmental Action Programme1987-1992 (OJ C 328, 7.12.87); 5th Environmental Action Programme1993-2000 (OJ C 138, 17.5.93); 6th Environmental Action Programme 2002-2012.

This being the case, it is unsurprising that the form and manner of EEC environmental policy up to the mid-1980s was in large part dictated by the use of economic means to achieve political ends, meaning it had to deal both with cross-boundary pollution flows as well as the consequences of environmental regulation for the functioning of the single market (Weale et al., 2005: 29). Nevertheless, in the years between 1973 and 1983[93], over 70 environmental Directives were adopted, and well in excess of 150 pieces of environmental legislation had been put in place (Stallworthy, 2008: 95).

As economic integration remained the primary focus for the EEC, many environmental measures were 'cloaked' as being for the harmonization of trade. As a result, the expansion of the European environmental acquis in the period before the SEA has in large part occurred through a pragmatic and an incremental approach via networks of expertise building.[94]

Post-Single European Act

In light of the expansion of the European Community (EC) in the mid-1980s,[95] the 1986 Single European Act (SEA) aimed to remove some of the barriers to economic integration, increase harmonization and competitiveness among the Member States, and to streamline the decision-making within the EU. The SEA is seen as instrumental in many respects, including, perhaps most importantly, that for the first time the EU became committed to include environmental protection in all of its sectorial policies[96]. Over the past 25 years, environmental protection has become entrenched even further into the functioning of the EU, essentially giving it a firmer legal basis and a legally binding character.

The 1992 Treaty of the European Union (TEU), also referred to as the Maastricht Treaty, for example, expanded the requirement to include environment as a

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[93] In this period pressures from some of the greener Member States such as Germany, Netherlands and Denmark, as well as national and transnational environmental pressure groups, also increased, which lead to quickening of the stream of environmental legislation, in particular in the early 1980s on issues such as natural habitats, sewage treatment, genetically modified organisms and climate change.

[94] Early years of EU environmental policy-making have also often been characterized as 'integration by stealth' (Weale et al., 2000), or away from the spotlight of political attention (Weiler, 1991).

[95] By that time, the members of the European Community included France, West Germany, Italy, the Netherlands, Belgium, Luxembourg, Great Britain, Ireland, Denmark, Greece, Spain and Portugal.

[96] Art. 130r(2.2) TEC for example states that 'environmental protection requirements *shall be* [emphasis added] a component of the Community's other policies".

component of the Community's other policies[97], by placing it along the economic and social objectives of the EU. This was to be based on the principle of sustainable development[98] [99], which in turn also made the principle one of specific policy goals in EU's external relations[100].

The overall profile of EU environmental policy and legislation was further heightened by the 1997 Treaty of Amsterdam, as well as the more recent 2009 Lisbon Treaty, both of which emphasized the principle of environmental policy integration (EPI) [101]. Whereas the former also moved environmental consideration to the forefront of the treaty,[102] the latter on the other hand, is instrumental in that it included specific reference to climate change as a policy objective of the EU,[103] which could have positive implications for further integration of environment and climate change considerations into other EU policy sectors, such as energy in particular.

Given that the Lisbon Treaty includes a separate chapter (Title XX) on energy, essentially giving the EU energy policy for the first time its own legal basis, it can be seen as a progressive piece of legislation. Whereas before, energy policy[104] was primarily incorporated under various provisions throughout the TEC but without explicit recognition of the EU competence on energy related issues, the new chapter on energy essentially made it possible for the EU as a whole to develop a more

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[97] Art. 130r(2) of the TEC. Whereas in the SEA it is stated that the environmental protection *shall* be integrated, the TEC rephrased it, noting that it *must be* integrated into the definition and implementation of other Community policies.

[98] Article 3 of the TEU states the objectives of the EU and defines the sustainable development principle in terms of its economic, social and environmental elements. The term was initially coined by the UN Brundtland Commission in its 1987 Brundtland Report on *Our Common Future*. It argued for the "development that meets the needs of the present without compromising the ability of future generations to meet their own needs" (UN, 1987).

[99] The TEU also included in the principle of preventive action, the principle of rectification at source, and the polluter-pays principle in its wording. Ex-Art. 174 of TEC now Art. 191(2) of TFEU. These principles were, however, already present in Article 130r(2) of the TEC.

[100] See paragraph 5 of Art. 3 of the TEC, which states that the EU "shall contribute to peace, security, the sustainable development of the Earth, ... as well as to the strict observance and the development of international law, including respect for the principles of the United Nations Charter."

[101] For more on EPI see Lenschow (2002), Lafferty and Hovden (2003), Jordan and Lenschow (2010). In terms of the EPI, Art. 11 of the TFEU keeps the meaning as under Art. 6 TEC and states that: *Environmental protection requirements must be integrated into the definition and implementation of the Union policies and activities, in particular with a view to promoting sustainable development.*

[102] This was achieved by changing the preamble and Article 2 (ex.Article B) of the TEU in order to strengthen the principle of sustainable development and underlie the EU's commitment to the principle's objective.

[103] (Art. 191 of TFEU).

[104] See Art. 81-88 TEC concerning competition; Art. 95 of the TEC concerning the internal market; Art. 154-156 of the TEC on trans-European networks; Art. 175 of the TEC concerning adoption of energy measures adopted for the purposes of environmental protection (Ballesteros, 2010).

strategic and harmonized energy policy.[105]

Choosing the legal basis

A legal base essentially entitles the EU to legislate in a particular field, setting out the scope for legislation in that area. The legal base also determines the legislative procedures and the type of laws that can be adopted, which consequently determine the powers and influences of the various EU institutions and national governments in the law-making process. As Chalmers et al. (2008) also note, in choosing the legal basis for the adoption of a legal provision, different institutions will often seek to use the legal basis that provides the procedure that is most advantageous to them. Given that different procedures privilege different actors, the EU institutions and Member States will often actively litigate over the choice of the legal base (p. 140).

The 2009 Lisbon Treaty allows for a choice of legal basis for specific legislative measures to be based on either the environmental or the energy titles of the TFEU. The choice of the legal basis, depending on the area of the stated objective and the content of a measure, influences not only the legislative competence of institutions to take action, but, as mentioned above, also the procedures by which legislation is adopted, and as such also the scope and the content of the policy. As de Sadeleer (2014) explains, the choice between legal basis which requires unanimity or only qualified majority voting (QMV)[106], or the choice between a base which implies an ordinary, as opposed to a special legislative procedure, is fundamental, and also exemplary of the inter-institutional power struggles,[107] as well as has significant repercussions for the institutional equilibrium within the EU governance system, and on the leeway enjoyed by the Member States in employing secondary law (p. 172).

The choice of the legal basis is important, yet at the same time contentious, when it comes to issues and measures pursuing objectives that concern more than one policy area at the same time, such as environment and energy for example. Such measures (i.e. harmonized energy efficiency targets or percentage of energy created via renewable sources) have in particular been slow to develop. This comes largely as a

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[105] The four main objectives of the EU energy policy include: i) ensuring the functioning of the energy market; ii) security of energy supply in the Union; iii) promoting energy efficiency and energy saving and the development of new and renewable forms of energy; and iv) promoting the interconnection of energy networks (Art. 194(1) of the TFEU).

[106] See Appendix A on the (changes in) EU voting procedures.

[107] The institutions will often seek to chose the legal base, which provides the procedure most advantageous to them (de Sadeleer, 2012: 5). See also Chalmers et al, 2010: 95.

result of such choice, between legal bases, given to the EU institutions, which often choose the base that provides the procedures most advantageous to them (de Sadeleer, 2014: 149).

Moreover, for example, while such measures could be adopted under the environmental legal base if their aim is to ensure environmental objectives, they would not be justified under the energy provisions under Article 194 (2) of the TFEU, as they could (significantly) affect a member states' right to exploit its energy resources. Furthermore, under the energy chapter of the TFEU, some EU measures based on environmental principles (i.e. precaution, rectification at source, preventive action, polluter pays), could not be justified, and would have to be based on the provisions of the environmental chapter (Ballesteros, 2010: 10). In any case, it is not to say that energy related measures cannot or should not take environmental principles into consideration[108], however, this study does suggest that such a dual, or multiple legal base, creates many grey areas, thereby precluding the implementation of many of such measures, or at least delays the process.[109]

The principle of precaution

To date, versions of the precautionary principle have been adopted in over 50 multilateral instruments, and been signed and ratified by a majority of the world's countries, including the US, the EU, Australia, and Japan. The fact that the principle has been signed and ratified, however, does not presuppose that these countries will abide by the principle. Instead, it raises questions as to how, and to what extent, these countries will abide by it (Montague, 1999).

Whereas the EU has endorsed the principle as a rule of customary international law (Sirinskiene, 2009; Trouwborst, 2009; Kazhdan, 2011), the US, for example, has in contrast sought to downplay its legal nature, by referring to the term precautionary 'approach' as opposed to a 'principle' (Bodansky et al., 2007: 601). The reason for the US being in favour of a precautionary 'approach' rather than a 'principle', as explained by Recuerda (2008), is because of the stronger connotations that a 'principle' carries in the legal language, than an 'approach' does for example.

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[108] Art. 194(1) of the TFEU.

[109] The SEA has also had an important symbolic effect on the EU policy process on matters related to the environment, and recently on energy as well, by making it also about the notion of ethics. This can be seen in the shift in the debate away from whether the EU *should* act, to a more technical question of *how* it should act, which as Jordan (2005) explains, has accelerated the development of the EU environmental acquis as well as facilitated the adoption of more stringent environmental rules (p. 63).

The principle itself, however, is just that: guiding as opposed to binding. Some authors may suggest that as usage appears and develops through treaty making or other legal procedure, countries may come to consider the practice to be required by law, or that the implementation of the precautionary principle through national legislation and national judicial decisions can also be evidence of customary international law (Deloso 2005: 37).[110] As a study by Sirinskiene (2010) found, in the case of the European Communities, there is sufficient state practice and *opinio juris* that would suggest that the precautionary principle has already crystalized into a general customary rule (p. 360).[111] Nevertheless, given that there are 14 different interpretations of the precautionary principle in various treaties and declarations, as Foster et al. (2000) finds out, an argument could also be made that the principle remains pre-eminently an illustration of 'soft law', and cannot as yet be elevated to the harder status of customary international law. Ultimately, its impact depends upon how far it becomes effective in legislative, administrative and judicial law making within jurisdictions of the Member States.

What is certain, however, is that, as discussed earlier in Chapter 3, the link between the science and law has become embedded in the principles/approach of precaution, which has to a good extent become characteristic of the legal and regulatory frameworks for CO_2 storage in Europe. See section 5.1.2 on how the precautionary principle has been implemented in practice within the legal and regulatory frameworks in the EU and the UK.

4.1.2 (CCS) Governance Network

Governance in this study is in broad terms understood as the interaction of various stakeholders, through negotiations and cooperation, all of which are to some extent interdependent on one another on formal and informal resources, and have a common goal. In this case, the goal is the development and deployment of CCS technology, and the management of environmental risks related to CO_2 storage. As such, the role

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[110] Whether it is part of customary international law is essentially an argument between those who see its incorporation into international conventions and judgments as the proof of its customary status (Cameron and Aboucher 1991; Hey 1992; McIntyre and Mosedale 1997) and those who oppose its existence in customary law and cite the uncertainties and its lack of consistent state practice and o*pinio juris* (Gundling 1990).

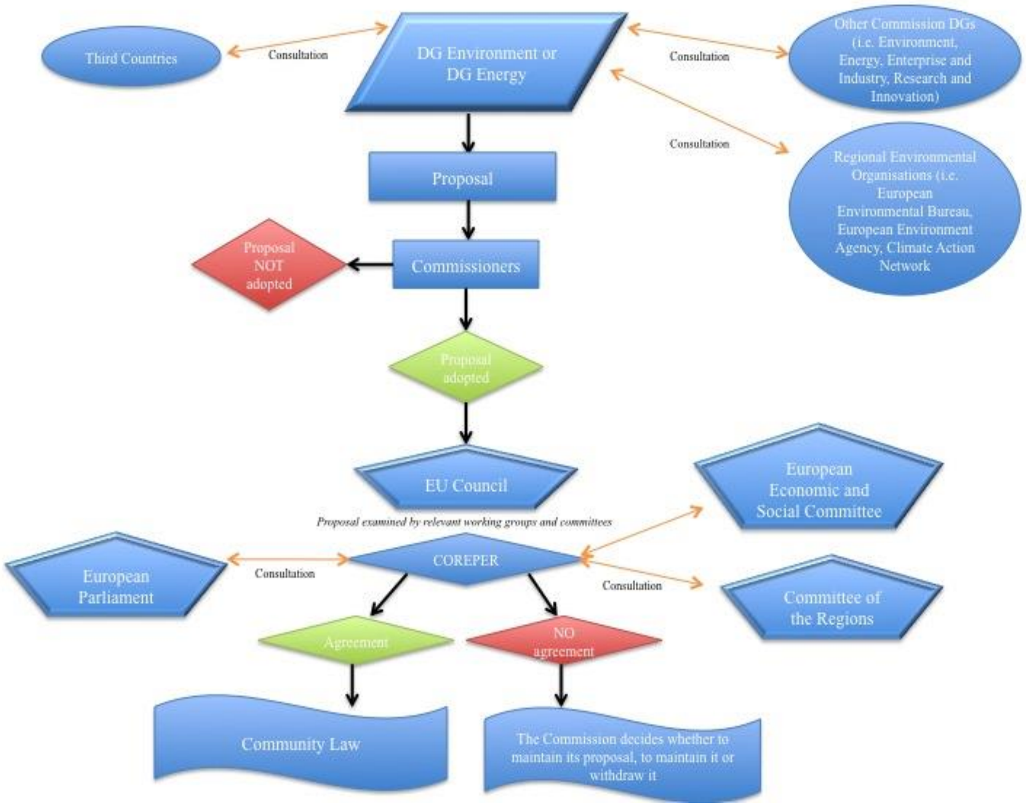
[111] Others, such as Basili et al. (2008) would add also that its 'soft nature', or the fact that the lack of a unique and clear formulation leads to different notions that can be labelled as either a strong or a weak version of the principle (p. 487).

and purpose of main institutional actors and their available instruments are examined in this section, so as to provide the framework that constitutes the so-called CCS governance network.

4.1.2.1 Institutions

Within an environmental governance system, technology deployment and risk management, it can be said, is as much an intellectual activity as it is an institutional process. Institutions, for example, help determine not only the scope of issues that are dealt with, but also, to some extent, dictate who is involved. European institutions and institutional actors, as Weale (2000) points out, therefore occupy a pivotal position in the EU environmental narrative. As such, it is important to look at the character of various institutional actors and the range of their capabilities and responsibilities. Important to keep in mind is the complexity of the process of developing environmental law, as each institution contributes to the process at one stage or another. The diagram below serves to demonstrate this complexity in a simplified format.

Diagram 2: Major pathways leading to European Community environmental law



The European Commission

The European Commission (hereinafter the Commission) is essentially the executive body of the European Union, primarily responsible for proposing legislation, implementing decisions, and the general day-to-day running of the Union. Its functions are both political as well as administrative, making its presence in the European environmental governance network as the primary "agenda-setter, consensus-builder, manager, and the formal initiator of legislation" (Weale et al., 2000: 87). It is also responsible for the monitoring and controlling of the formal and practical transposition of EU law by the Member States.[112] It should also be pointed out that for each of the Directorates-General (DG)[113], their image within the Commission is important, making it necessary to build coalitions of support for any legislative proposals among other DGs and EU institutions.[114]

To date, the Commission has done a great deal in relation to the environment. Apart from initiating a great amount of environment-related policy and legislation, the Commission has also enforced its legislation, and continues to do so, by initiating infringement cases and pursuing legal action against Member States not in compliance.[115] After all, legislation is only as effective as it is implemented and complied with. Otherwise, the law is essentially only words on paper. By the end of 2014, there were 334 open environmental infringements, for the most part in the waste, water and air sectors. These came primarily as a result of bad application (189 out of 334) and non-communication (86 out of 334).[116]

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[112] Ex-Art. 211 TEC, now Art. 17 TFEU.

[113] Within the more than 40 Directorates-General (DG), the primary responsibility of which is policy leadership and agenda-setting of the EU, it is the DG Environment and DG Energy respectively, that are responsible for proposing main EU policies that ensure a high level of environmental protection and creation of a competitive internal energy market, development of renewable energy sources, and energy security and independence. While a Commissioner is the central figure of each respective DG, Weale et al. (2000) suggest that they are only as good as their supporting cabinet staff, who together are also responsible for the specific sectoral and horizontal policies, reflecting the policy competences of the Union (p. 88-89). Furthermore, the Commission makes sure that the member states apply environmental law correctly, and can, in cases of non-compliance with EU regulations or directives, take infringement actions against a member state if it determines a case of non-compliance. It also represents the EU at international environmental negotiations and finances environmental protection projects (EC, 2012).

[114] Interview with Elena Visnar-Malinovská, Member of the Cabinet of Commissioner for the Environment Janez Potočnik. July 10, 2012. In addition, a number of in-formal conversations with people working in the Commission and the European Parliament were conducted around the same time in July, 2012.

[115] See EC (2015)a for an up-to-date list of infringement cases brought up by the Commission: http://ec.europa.eu/environment/legal/law/press_en.htm.

[116] EC (2015)b. Statistics on environmental infringements. Available at: http://ec.europa.eu/environment/legal/law/statistics.htm

Moreover, the Commission (DG Environment and DG Climate Action) also manages the LIFE Programme, EU's funding instrument for environmental and climate-related action. Since 1992, when it was first started, the programme has co-financed some 4,171 projects, and contributed over €3.4 billion euros to the protection of the environment and climate.[117]

The Commission also hosts a number of specialized ad-hoc committees, which in the DG Environment and DG Energy are composed of experts and scientists from each of the member states, and play an important role in environmental policy-making by acting as "policy entrepreneurs, or policy spoilers, for which they often quickly get an EU-wide reputation" (Wurzel, 2002: 73). This goes to show that policy development process, for example, involves both inter-institutional, as well as intra-institutional dynamics. As this study argues, this makes the Commission the key institutional actor within the CCS governance network, in respect to the development/deployment of CCS technology in Europe, and the management of associated risks related to CO_2 storage.

Although it can be said for the Commission that it is a key institutional actor, one should also consider whether its inputs are to any extent either facilitating or restricting the development and deployment of the technology. Upon doing extensive literary research, as well as speaking to various people within the various EU institutions,[118] one aspect that came up often was that the Commission was a kind of 'bureaucratic monster where thousands of bureaucrats work' (Arató: in Marchetti and Vidović, 2010). A former classmate[119] at the University of Sheffield, who is now working for the European Commission, also noted that the Commission remains very understaffed, and often relies on external experts for advice (see also Diagram 2 above). She also noted that with a significant number of other Directives, and Regulations, which need to be controlled, it should come to no surprise if things sometimes 'do not run as smoothly'.

In any case, it would not be entirely true to make a claim that simply because of the bureaucratic reputation that the Commission sometimes seems to hold, the development and deployment of CCS is being inhibited. However, in the context of

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[117] EC (2015)c. Welcome to LIFE. Available at: http://ec.europa.eu/environment/life/

[118] These conversations were primarily of informal nature, and occurred during a number of conferences that I attended, or were my former classmates at the University and are now working in various EU institutions, including the Commission and the European Parliament.

[119] Interviewed by: Maver, M. (July, 2012).

this research, the most important aspect is that the Commission, and in particular the Environment and Energy DG's, are dependent upon external organisations and other actors to aid them in advancing its goals – of developing and deploying CCS in Europe. Dependency is particularly important at the input stage of the policy making process in order for it to obtain a level of legitimacy (Bache et al. 2011).

This notion of dependence on other external expertise, whether at the policy development process, or later on in the management of risk (i.e. through review of permits), supports the claims of the governance network theory, which state that even though a level of hierarchy remains, managing environmental risks whilst providing for a facilitating environment for technology development and deployment, requires cooperation. This notion is particularly sounded by the industry community (see Chapter 6), which believes that rather than the legal and regulatory frameworks themselves, open and effective negotiations, both with the respective Member States and the Commission itself, will be key in moving the technology forward.

The European Parliament

Together with the Commission and the Council, the European Parliament (EP) makes up the legislature of the EU, and thus plays an important role in the CCS governance network. Unlike the Commission, however, it does not possess the power of legislative initiative, meaning, it only holds the power to amend or reject legislation. Thereby, it plays an important part in the legislative process, somewhat indirectly, through non-binding resolutions and committee hearings, as well as the power of a second reading of legislation for example, under the ordinary legislative procedure. The EP also holds supervisory powers, in terms of checks and balances, essentially giving it the option to call under questioning other EU institutions and if necessary take them to the European Court of Justice, if they are found to be in breach of EU law or treaty provisions.[120] [121]

When it comes to environment and energy related issues, the EP has to a good extent proven its democratic legitimacy, by not only sending strong signals to the Commission requesting for tougher measures to be taken.[122] For example, in light of

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[120] Art. 263 TFEU.

[121] The EP's powers in the EU policy and decision-making process, as mentioned, have taken some time to develop, and were greatly expanded by the Single European Act (SEA) in 1987 and with each subsequent treaty.

[122] In regards to the EP's members (MEPs), it is important to point out that they are directly elected by their respective countries' citizens every five years, and as their voting on legislative issues/proposals

the recent delays in the development of CCS, in particular in the EU CCS Programme, the EP called on the Commission for the need to deliver and publish a direct CCS Communication[123] as well as to work more closely with the member states and the industry on building public support for CCS (Bellona, 2013).

However, the EP is not simply a kind of ‘controller’, in a sense that it checks up on the Commission and other institutions. It also plays a part in bringing together key stakeholders, in an effort to identify how to ensure that the heavy industry sector, for example, achieves decarbonisation in the most cost-effective manner. One such example was a hearing held in November 2014[124], initiated by the EP through ZEP’s General Assembly,[125] which brought together both EU officials and representatives from the industry and NGO sectors. The goal of this hearing, and others that occurred in the past, and will continue in the future, is essentially to provide for an interactive debate through which a common understanding of key issues, sharing and exchanging of ideas, can be achieved. In other words, the role of the EP extends beyond simply supervisory powers, but also to facilitate this interaction between stakeholders, thereby contributing to the achieving a common goal – wide deployment of CCS.

The European Council

Although the European Council has no formal legislative power, its role is best seen as the political organ of the EU, defining the general political direction and priorities and also providing the momentum to guide legislative policy.[126] It also works closely

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directly affects the citizens of all Member States, it makes the EP is an institution with a strong democratic legitimacy. However, as Menon and Peet (2010) point out, “*there is more to democratic legitimacy than just being elected. Any institution aspiring to such a status must also be considered by voters to represent their interests*” (p.2.) While the authors argue that it is in this respect that the EP has failed to deliver, and to some extent they are correct, I would be more inclined to suggest, that whether the claim towards democratic legitimacy is justified is better, or more appropriate, to be looked at from an individual policy or issue perspective, as opposed to a generalized view as a whole. With the latter, it is only too easy to come to such a negative conclusion, and thereby ignore the positives that occur at the micro, or specific policy/issue level. However, it is also important to acknowledge the macro-level conclusions, such as the ones developed by Menon and Peet (2010), as they help increase the overall understanding of the institution itself, or a particular research area.

[123] EC (2013). *Communication from the Commissions to the European Parliament, the Council, the European Economic and Social Committee and the Committee of the Regions on the Future of Carbon Capture and Storage in Europe.* Available at: http://eur-lex.europa.eu/legal-content/EN/ALL/?uri=CELEX:52013DC0180.

[124] The event took play on 10 November 2014 in the European Parliament in Brussels, under the title: *European Parliament Hearing on Carbon Capture & Storage (CCS) – An essential part of Europe’s industrial growth equation*.

[125] ZEP (Zero Emissions Platform), established in 2005, serves as a key advisor to the European Commission on research, demonstration and deployment of CCS in Europe.

[126] Its functions are defined in Art. 4 of the TEU. Following the Treaty of Lisbon in 2009, it also became an official EU institution (Art. 235-236 of the TFEU).

with the Commission and the EP as well, through the various working groups, where, for example, the Commission explains and defends its proposals (Krämer, 2006). Perhaps a more important, or better said, a more prominent role, as far as substantive development of environment policy and legislation in the EU is concerned, is played by the Council of Ministers, whose identity depends on the policy sector in question[127]. In this case, it is the Council of Environment Ministers (hereinafter the Council)[128].

In general, the Council is seen as pivotal to the overall environmental governance system of the EU, as it is often the 'last port of call' for European environment legislation, and represents a forum where differences of national preferences can be expressed. Here, the decision-making process is influenced by the preferences that each of the Member States brings to the discussions. It is also where the leader vs. laggard dynamic[129] plays out, as Weale et al. (2000) describe it, which in turn can either slow down or expedite the pace of environmental legislation development.

Essentially, what the Council has done, and continues to do, in relation to the environment, is to provide for an institutional framework, where national differences and other issues can be ironed out. In other words, it has provided a platform where political agreements on legislation (i.e. Directives and Regulations) can be reached, and further legislative policy is guided from. In relation to CCS, the Council, along with the EP, for example, reviewed and adopted in February 2014 the report from the Commission on the state of the implementation of the 2009 CCS Directive.[130] This

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[127] Policy sectors, or areas of focus of the Council, as defined by the recent Decision 2009/878/EU, include: [127] i) General Affairs; ii) Foreign Affairs; iii) Economic and Financial Affairs; iv) Justice and Home Affairs; v) Employment, Social Policy, Health and Consumer Affairs; vi) Competitiveness (Internal Market, Industry, Research and Space); vii) Transport, Telecommunications and Energy; viii) Agriculture and Fisheries; ix) Environment; x) Education, Youth, Culture and Sport (EU, 2013).

[128] Ex.-Art 202-210 TEC, now Art. 235-243 TFEU. See also Art. 202 of the TEU for the Councils explicit tasks and powers.

[129] According to this view, member states can either be 'leaders', in pressing for example for higher environmental standards, or they can be seen as 'laggards', who either oppose the raising of standards, or simply do not show any significant environmental initiative. In the 1970s and 1980s, the division between these two was perhaps more evident, with countries such as Germany, Denmark and the Netherlands were seen as the main 'leaders' in pushing for higher emission standards in air pollution and favouring more stringent controls, and countries such as Spain, Italy, France and the UK seen as the 'laggards', who were more keen on pushing the case for conventional economic growth against the demand for stricter environmental standard (Weale, 2000: 94-97). In the 1990s and the 2000s, however, the leader vs. laggard boundary was beginning to blur, leaning towards more leadership. Nevertheless, today, in some respects, this debate is still present.

[130] Available at: http://eur-lex.europa.eu/legal-content/EN/TXT/HTML/?uri=CELEX:52014DC0099&from=EN.

means that the general legal framework for the environmentally safe geological storage of CO_2 in Europe was confirmed.

Nevertheless, a further review, by the EP and the Council, of the CCS Directive is scheduled for the end of 2015, with the objective of assessing the effectiveness, efficiency, and ease of application and legal practicality of several CCS Directive provisions. Moreover, the review will also provide an assessment on how the enabling policy of CCS in Europe has thus far worked in practice (Ricardo-AEA, 2015). In this way then, the Council, through the review of the Directive, and consequently with any changes to it, can impact the development and deployment of CCS in Europe.

Although no major changes are expected to occur in the 2015 review, the main issue remains clarification on practicality of certain legal provisions. As was discussed in a number of interviews (see Chapter 6), on the legal and regulatory frameworks for CCS in Europe, this review is unlikely to cause any significant delay in the development of CCS projects. It could, however, result in better clarity on those provisions, and other issues, and hence expedite the technology’s development and deployment.

Other Institutions

Apart from the three main bodies of the EU, as mentioned above, a number of other institutional actors are worth mentioning, given their influence on the future of CCS in Europe. The European Court of Justice (ECJ), for example, acting as an institutional court, aims to determine how European law is interpreted across the EU. National courts, when facing problems in applying and interpreting EU environmental law, can also look to ECJ. For example, in an event of a dispute over whether an environmental impact assessment (EIA) is required at a particular stage of the CCS chain (capture, transport, storage), although it rests first with the national courts, they could also ask the ECJ for help in interpreting the CCS Directive and respective national legal frameworks. In addition, the ECJ also acts as an international court, in cases in which it sanctions EU Member States for violating European law, and can in cases of non-compliance with a Directive or Regulation, also, at the request of the Commission, impose significant financial penalties, for example, if Member States failed to transpose the CCS Directive.[131]

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[131] Ex-Art. 228 TEC, now Art. 260 of the TFEU.

Also worth mentioning, although lacking the institutional powers of others mentioned above, is undoubtedly the European Environment Agency (EEA). With a specifically environmental objective, its role and value to addressing environmental protection, has, and continues to be the collection, analysis and dissemination of environmental information. It is important in that it supports the Commission and other institutions in the formulation and implementation of EU environmental policy and legislation. It does so, in large part through consultations with the Commission, and via publication of various technical reports,[132] which make it an essential information tool for all stakeholders, including policy and decision-makers as well as academic, research, and industry as well.[133]

4.1.2.2 The Instruments

Just as it is important to understand the main institutional actors, their roles and objectives, as well as the institutional dynamics between them, so is it to be familiar with the instruments, or tools, with which they build the overall environmental governance system in the EU. Bähr (2010) offers the following classification of instruments: i) governance instruments; and ii) legal instruments. Whereas the former is divided into command and control, economic, and persuasive instruments, the latter refers to either hard (i.e. directives, regulations) or soft law (i.e. recommendations, resolutions, opinions)[134].

The majority of EU environmental legislation comes in the form of Directives[135], primarily as a result of geographical, as well as institutional and political variety of Member States (MS). The intention of Directives is to give the MS sufficient flexibility in achieving the objectives, as opposed to issuing Regulations, which some MS might see as intrusive and unfair. Although, this same flexibility can become a hindrance, as there is no clear guidance on how a directive should be interpreted,

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[132] EEA (2011). Air pollution impacts from carbon capture and storage (CCS). Available at: http://www.eea.europa.eu/publications/carbon-capture-and-storage.

[133] It also contributes to the dynamics of the environmental governance system both within and outside of the EU, working closely with many other important organisations such as the UN 's Environment Programme and the OECD.

[134] Whereas hard law refers to legally binding commitments, soft law primarily refers to non-binding provisions. Within hard law, while regulations are directly applicable and binding on all member states, directives state the objectives to be achieved, but leave it up to the member states to themselves decide how best to achieve those objectives (Ex-Art. 249 TEC, now Art. 228 of the TFEU).

[135] It is important to also note that there are essentially two types of directives. While a *framework directive*, as the name would suggest, is more general in scope, a *daughter directive*, which often follows and is related to a framework directive, tends to be more prescriptive, and specific in detail and clarity.

transposed and practically implemented, which can lead to significant delays in achieving a particular result. Also important to note is that while directives are intended to generally standardize environmental requirements across the EU, variations are possible under EU law, following the principle of subsidiarity[136] and the sharing of competences[137] between the EU and member states.

In general, the use of legal instruments of hard law (i.e. directives) and command and control type of governance instruments, have been associated with the traditional environmental paradigm and represent the dominant form of coordination and control of EU environmental policy (Carter, 2007; Diedrichs et al. (2011). In recent years, as Holzinger et al., (2006) point out, the Commission has been increasingly advocating the use of persuasive (i.e. voluntary agreements) and economic instruments (i.e. EU ETS) in its Environmental Action Programmes as well. These could be classified under the ‘soft law’ category. From a legal perspective, ‘soft law’ in general, according to Boyle (2006), is only a convenient description of a non-legally binding instrument, making it, similar to multilateral treaties, a vehicle for focusing consensus on particular rules and standards. Nevertheless, as Boyle (2006) warns, the legal significance of soft law, should not be dismissed, as it does contribute to the corpus of international law (p. 118). A number of authors have also argued that even though, given that they imply almost no real obligations, it remains difficult to evaluate their effectiveness, soft law can still represent an important instrument for climate change mitigation (Rezessy and Bertoldi, 2011; Borck and Coglianese, 2009).

Economic instruments

Economic instruments, such as the Emissions Trading Directive (2003/87/EC) and the Environmental Liability Directive (2004/35/EC), make use of market mechanisms and can provide for increased efficiency, by allowing flexibility in deciding on how to meet targets while at the same time encouraging technological innovation; in theory at least. Economic instruments, such as the ETS, can be prone to failure, as a result of being subject to the uncertainties of the financial markets. At the Member State level, government expenditure, most often in a form of a subsidy, intended to encourage development and adoption of cleaner technologies, is another form of

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[136] The principle is included in ex-Art. 5(2) TEC (now Art. 5 of the TFEU), and in Art.2(2) of the TEU.

[137] See Art. 4 and Art. 191-193 of the TFEU. Under the shared competence rule, which includes environmental, and after the passing of the Lisbon Treaty also energy related issues, the ability to legislate can come form both the EU and the member state government.

economic/financial instrument. These, along with long-term economic policies, as will again be mentioned later on in Chapter 5, remain at this stage the key factor in the (slow) development of CCS, in Europe, and in the UK.

In any case, it is important to acknowledge and point out a number of things. Since the passing of the SEA in 1986, along with the increased institutionalisation of the environment, the diversity of instrument portfolios dealing with such matters has certainly also increased. Furthermore, whatever the choice of a policy instruments, it is both a technical matter of selecting the instrument that can offer an efficient and effective means of delivering a policy objective, as well as a political process, shaped by decisions between competing interests (Carter, 2007: 322). In both the EU environmental, and energy policy spheres, the policy instruments are adopted by actors who have to interact with other actors with potentially diverging interests, beliefs and preferences for a certain type of policy instruments[138]. Lastly, there is essentially no silver-bullet or one-size-fits-all tool in the broad spectrum of instruments in the EU environmental governance system. This allows for the use of different policy instruments for different purposes, or in conjunction, in order to achieve a particular policy goal, which can in the end also lead to the creation of tensions between actors and other stakeholders within a particular policy area.

Standards and voluntary agreements

The purpose of setting environmental standards is, generally speaking, to regulate human activities impacting the environment. When standards can be enforced, the process can be seen as one of the best ways of applying law to environmental problems (Wilkinson, 2002). However, many environmental standards are not legally binding, though they can still “give legislators valuable information about best practice in the field and thereby offer a viable model for the regulatory process” (Decarboni.se, 2015). Therefore, standards may in fact serve as to reinforce the regulatory frameworks, and can make compliance and enforcement of regulation easier, for all stakeholders involved (i.e. the operator, regulator, third parties). A word of caution is necessary, however, as giving standards too much credit can also lead to

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[138] For example, whereas, within the Commission, “the DG Environment pursues more environment-friendly policy, the DG Enterprise and Industry proposes policies that are more favourable to the industry. Within the EP, the greens are close to the environmental NGOs while the conservatives and Christian democrats tent to the position of the employers’ associations. The social democrats and socialists as well as the liberals take up a middle position between environmental protection and economic competitiveness” (McElroy and Benoit, 2007: 11-14)

a reverse effect of weakening the regulatory frameworks (see Clapp, 2001). Equally significant, standard setting can also serve as an assurance, when compliance is achieved, and can lead to increased trust[139] on the side of the public and the society at large.[140]

Standards and CCS

Vahjjala et al. (2007) describe in their report on the regulatory framework for CCS risk governance, that as a result of leakage-related climate risks for example, "a certain quality level in terms of minimum retention time for the stored CO_2…[would give] important guidance for governance, site selection, and operation and for repair activities as necessary". At present (March 2015), however, despite there being a number of research and demonstration projects underway, there are yet no recognized national or international standards for long-term CO_2 storage. This comes primarily as a result of the differences in national environmental regulation, as well as the fear that specific standards would stifle improvement and innovation (Morrison, 2006). In the EU for example, there are no specific standards for CO_2 transportation for storage, as things such as the CO_2 purity is left to Member States' discretion. Nevertheless, there are several existing standards applying oil and gas pipelines, which could potentially be applied for pipelines transporting CO_2 for the purpose of storage.

While to some extent that might be true, it could be more likely that, unified, recognized and publicly available guidelines can provide the standards that can in fact speed up innovation. Furthermore, through collaboration with the industry, for example via so-called Joint Industry Projects (JIPs), which serve a number of purposes, including: i) develop methodologies suited to characterize, select and qualify sites for storage of CO_2; ii) help assure regulatory compliance (i.e. with conventions, regulations, directives); and iii) manage risks and uncertainties. Essentially, such guidelines are for use by operators, authorities, verifiers, and other stakeholders, and help bridge the gap in need of moving CCS forward (DNV, 2009).

Examples of such guidelines already issued, include a set of criteria for the selection of potential storage sites and descriptions of the related geological parameters by the EU GeoCapacity project, whose aim was to adapt and define common standards in order to produce uniform assessments of geological storage

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[139] Trust between the public, the government and the industry. Without a certain level of trust, between all stakeholders and the public, opposition and delays in achieving goals/outcomes can arise.

[140] See Appendix A for more on standard-setting.

capacity (Vangkilds-Pedersen et al. (2008). Yet another example includes the DNV's guidelines for the qualification procedures for CO_2 capture technology, design and operation of CO_2 pipelines[141]. More recently, the DNV also published a new industry guidance document - CO2RISKMAN – to provide a comprehensive reference source to assist the emerging CCS industry appreciate, understand, communicate and manage the issues, challenges and potential hazards associated with handling CCS CO_2 streams (DNV, 2013).

In any case, international standards can have a number of benefits for CCS, such as promoting a common understanding of rules, reducing conflicting regulations, and facilitating the transfer of expertise and technology, and in this way facilitate and not impede innovation.[142] While international standards on CCS might not be available just yet, there are a number of guidelines and best practices, which for creating requirements will help ensure consistency and fairness – crucial for a safe and sustainable deployment of CCS.

Despite the non-existence of any specific international standards on CCS, they are likely to become significant in the future, given their potential for increase in safety and perception, amongst other benefits. For various political, technical, and economic reasons, the industry will not always want to adopt standards it considers a burden rather than an advantage. Adoption of such standards is therefore often easier said than done. That being said, there are however number of existing sets of standards for the safe management of processing and capture of CO_2, which have been in place in many of the EU countries, including the UK[143]. Nevertheless, since permanent storage of CO_2 is the novel aspect in the CCS process, more standards in this respect will have to be developed. The CCS industry, however, has shown to be willing to cooperate with other stakeholders, including the regulators, government and academia

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[141] DNV (2010). Available at: https://exchange.dnv.com/publishing/codes/download.asp?url=2010-04/rp-j201.pdf.

[142] Currently, a new CCS ISO TC 265 standard is being proposed by Canada, which would include: standardization of materials, equipment, environmental planning and management, risk management, quantification and verification, and related activities in the field of carbon dioxide capture and storage (CCS), but exclude equipment and materials used in drilling, production, transport by pipelines already covered by ISO/TC67 (ISO, 2014).

[143] In the UK, it is up to the Health and Safety Executive (HSE), the lead regulator for health and safety, to closely monitor the development of CCS projects and the industry that it ensures that various risks are safely controlled.

in the guidance and development of standards, not only for the purpose of storage, but also across the entire CCS chain.[144]

4.1.2.3 Non-governmental actors, drivers and platforms for interaction

As mentioned earlier, governance network actors are the various EU institutions and agencies, as well as other stakeholders such as academic and research institutions, the civil society (i.e. eNGOs), and the industry. According to the governance network theory, as explained in Chapter 2, each actor has, to a certain extent, something to contribute to the functioning of the network itself, albeit with a varying degree.

One of the largest issues for CCS to-date has undoubtedly been that of cost. In other words, the lack of capital investment and long-term policy certainty, essentially that the investment into the technology will be worthwhile for the company deciding whether or not to develop the technology/process. The issue of cost, however, is most often discussed in the context of the capture component of the CCS chain, given this part constitutes up to 80% of the total cost of a typical CCS project.[145] This issue of cost, as was mentioned by a number of industry and academic interviewees (see Chapter 6), has been the main driving force of the interactions between the governments and the CCS industry.

A good example of a non-governmental CCS governance network actor is certainly UK's Carbon Capture and Storage Research Centre (UKCCSRC), established by the EPSRC and the UK Department of Energy and Climate Change (DECC) in April 2012, as part of the Research Councils UK (RCUK) Energy Programme. Within the UKCCSRC, hundreds of academics, industry, regulators and others in the sector form a network where collaboration on analysing problems and undertaking world-leading research is possible (EPSRC, 2012). A number of state-of-the-art capture research facilities will allow UK scientists and engineers to deal with the uncertainties and complexities of carbon capture, working with industrial partners in improving the technologies, and ultimately bringing down the costs.[146] While the

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[144] This finding, that the CCS industry has shown intent to cooperate with other stakeholders, as well as government institutions, on the development of standards, was obtained from the number of interviews, with both the industry, academic, and government representatives.

[145] Capture costs include both capital and operating costs, and varies depending on the specifics of the facility and the chosen capture technology.

[146] These new facilities include: i) a pilot scale advanced testing facilities in Yorkshire, with a 1 tonne CO_2 per day amine capture facility; ii) a mobile testing unit to allow a range of tests to be conducted on real power station flue gases; iii) an advanced oxyfuel fluidised bed and chemical looping pilot facilities (UKCCSRC, 2012).

UKCCSRC is primarily set to catalyse CCS research in the UK, it also serves as a platform for international collaboration and cooperation between researchers, the industry, governments and other stakeholders, by providing a platform for knowledge exchange and exploitation of intellectual property.

Yet another example of an interface, or platform where industry, government and academic stakeholders come together is in a good number of conferences that occur each year. These can be small, focusing on a specific component or issue of CCS, or large, encompassing a number of issues at once. In the case of the latter, a particularly important one for the development and successful deployment of CCS in Europe has for the past eight years been the Platts' Annual European Carbon Capture & Storage Conference. Bringing together representatives from the political sphere, such as the DG Energy and DG Environment from the EU Commission, as well as leading CCS industry experts from major companies, and other leading utilities, academics, project developers, NGOs and regulators, it is here, and other conferences or meetings such as this one, that provide the mechanism for exchange of information, knowledge and ideas. These are then translated to and employed by individual actors in their respective environments.

Perhaps more influential, then individual conferences for example, when it comes to actual policy and CCS technology development, is the European Technology Platform for Zero Emission Fossil Fuel Power Plants (ZEP), which serves as a direct advisor to the European Commission on the research, demonstration and deployment of CCS. It also provides a diverse group of stakeholders, including European utilities, petroleum companies, equipment suppliers, scientists, academics and environmental NGOs, a unique platform for knowledge and information exchange, and promotion of CCS technology, both at the European and international level as well.[147]

4.1.2.4 Pooled Interdependence

The above discussion demonstrates that the EU CCS governance network constitutes a wide range of actors and stakeholders connected to each other through an interdependent relationship. This relationship is evident in, for example, research institutions and/or companies looking towards some form of government funding, or

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[147] For a list of members/CCS stakeholder in ZEP, see: http://www.zeroemissionsplatform.eu/our-members.html.

the government or EU institutions looking for outside expertise on a particular issue, also in order to in a way legitimise its policy goals.

In broad terms, the theory of governance networks applies in this case in that all actors in one way or another are driven by a common goal, to contribute to or facilitate the development of the CCS technology, either in scientific, technological or legal contexts. Interdependence can be measured either by the costs of severing the relationship between the actors of the network, or by measuring the benefits of developing/promoting the relationship. The higher the cost of severing the relationship, the higher the dependence would be.

This study finds that the CCS governance network is relatively stable and open. In other words, given that the actors can come and go as they please, the dependence of the network relationships can be considered to be relatively low. As mentioned above, when actors start to benefit from the relationship, it is considered to be interdependent. To measure the extent of the dependence between actors[148] would involve extensive quantitative analysis, which is beyond the scope of this research.

However, as the sections above on the organizational structure of the CCS governance network in Europe have shown, the relationships within can be characterized as pooled interdependence, reflecting a lowest form of interdependence resulting in a relatively low amount of conflict. Thompson (2003) defines three different types of interdependence to describe the intensity of interactions and behaviours within an organizational structure.

Adopting Thompson’s classification,[149] the character of interactions within the EU CCS governance network would fall under the so-called ‘pooled interdependence’. In broad terms, each part of an organization makes a contribution to the whole, and each is in some form or another supported by the whole. While the various EU institutions and other actors, are not directly dependent on one another, however they do interact with one another, and contribute to an overall goal. Outputs of each actor are essentially pooled together at an organizational level (i.e. the EU Commission).

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[148] For example, measuring the monetary benefits of the relationship, and costs of severing it, for a particular company, institution, etc.

[149] The other two types include *sequential* and *reciprocal* interdependence. The former occurs when output of one unit in the overall process is necessary for the operation/performance of the next unit (i.e. like an assembly line). The latter, is similar to sequential interdependence, in that the outcome of one unit becomes the input of another, in addition to it being cyclical. In other words, reciprocal interdependence reflects the highest degree of intensity of interaction and are often most complex (Murray, 2013).

Pooled interdependence refers to a situation where individual actors do not directly affect one another, but rather indirectly, given that their actions/functioning affects the overall success of the network as a whole. Such interdependence then requires standardization in the rules and operating procedures. This is clearly evident for example in the employment of the precautionary principle, and the qualified majority voting procedure.

In other words, the functioning of various EU institutions, including the EP, the Commission, the ECJ, and sub-units such as the various DGs and/or COREPER, rather than impacting one another directly, in respect to developing policy and legislation on CCS/ CO_2 storage, the success or failure of each essentially affects the organisation (i.e. the EU) overall. As such, people and departments must rely on each other for information sharing, which makes communication and cooperation valuable to all parties in coming to a successful outcome. In this case, constructing a firm legal and regulatory environment, and developing and deploying CCS in Europe.

As mentioned, the main question of this research is concerned with the legal and regulatory framework for CO_2 storage in Europe, and the extent to which they mediate between the safe storage of the CO_2 and the facilitation of the development of the CCS technology. As such, the following section now turns to examining the legal and regulatory context within which CCS technology is governed. This will also provide the basis for answering the question of whether, or how CCS is being enabled or inhibited by the legal and regulatory frameworks (the focus of Chapter 6).

4.2 Governing CCS and CO_2 storage

Although the focus of this research is the legal and regulatory frameworks in Europe, and respectively in the UK, it is important to be aware of such frameworks at the international level as well, as they too form a part of the overall governance network.

CCS became an eligible activity under the Clean Development Mechanism (CDM)[150] of the Kyoto Protocol at the 17th Conference of the Parties (COP17) of the UN Framework Convention on Climate Change (UNFCCC) in December 2011 in Durban, South Africa. This inclusion is significant as it reflects a formalized

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[150] A project classified as a CDM essentially allows developed countries to offset credits for emission reductions generated from their investment in projects in other, primarily developing, countries. These credits, also referred to as certified emission reduction units (CER), can then be sold on a number of existing and emerging carbon markets, and help meet industrialized countries their emission reduction targets. Each CER, for example, is equivalent to one tonne of emitted CO_2.

international acceptance of CCS as a legitimate low carbon technology, and is intended to facilitate its deployment on a large scale. As of January 2015, however, there are no projects classified as CDMs. Although development and deployment of CCS in Europe is not impacted by the CDM framework, given that it is more of a policy as opposed to a legal/regulatory framework, a number of pieces of international marine legislation are significant in that respect.

4.2.1 International Marine Legislation

Onshore storage is, of course primarily governed by national law, whereas offshore CCS activities fall under international law, with its legality depending on a number of global and regional marine agreements. This includes the 1982 UN Convention on the Law of the Sea (UNCLOS), the 1972 London Convention on the Prevention of Marine Pollution by Dumping of Wastes and Other Matter, as well as its superseding 1996 London Protocol, and the 1992 ‘OSPAR’ Convention for the Protection of the Marine Environment of the North-East Atlantic[151].

Under the OSPAR Convention, CO_2 injection and storage is now allowed in the North East Atlantic waters.[152] Furthermore, the 2006 amendment[153] of Annex I of the London Protocol was significant in that it added the captured CO_2 to the list of wastes allowed to be dumped in the subsea geologic formations. Another amendment to the Protocol in 2009 set out to distinguish the movement of CO_2 across international borders for the purpose of injection and subsurface storage from the movement for the purpose of enhanced oil recovery (EOR), which under existing laws is allowed. This amendment, however, has thus far only been ratified by two contracting parties, Norway and the United Kingdom, and has not yet received the required two-thirds majority. This effectively means that trans-border movement of CO_2 for the purpose of injection and subsurface storage, under the London Protocol, is prohibited. The following outlines some of the main points of each of the international marine legislation relevant to CCS in Europe.

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[151] While the 1982 UNCLOS is considered to be more general in terms of providing protection to all marine areas, the London Convention and the Protocol are intended to regulate waste disposal at sea. The OSPAR Convention concerns the protection, and prohibition of pollution, in the North-East Atlantic Ocean, and is thus an example of a regional marine treaty (Haszeldine et al., 2007: 5).

[152] Pursuant to the 2007 amendment to the Convention, and its ratification in 2011.

[153] Since this was an amendment to the Annex of the Protocol, it was not subject to the ratification requirements.

UNCLOS

The recognition, in the late 1970s, that the world's oceans and seas needed an overarching international agreement that would regulate issues such as the use of resources, shipping, exploitation and pollution, led to the signing of the UNCLOS Convention in 1982, which entered into force in 1994.[154] As the UNCLOS Convention was agreed upon without having CCS in mind, and does not mention it in its texts, some of its provisions have been considered to be a barrier, in particular whether CCS activities would be classified as dumping of waste or causing pollution (Art. 1(4)), under the Convention[155]. As Armeni (2011) points out however, while reference to CCS among permitted activities would create a stronger framework for CCS off-shore operations, UNCLOS is unlikely to be amended to clarify the issue of pollution and dumping, as it only constitutes a framework agreement, leaving details to be settled by other prescriptive instruments such as the London Protocol or the OSPAR Convention, as well as national legislation.

London Convention

The 1972 London Convention, was first to establish a legal regime for the 'deliberate' dumping, or disposal,[156] of wastes and other matter at sea where as such it creates 'hazards to human health, [harms] living resources and marine life, [damages] amenities or [interferes] with other legitimate uses of the sea' (Art. 1). Under the Convention, CO_2 storage is 'technically' permitted. First, even though the Convention's Scientific Committee classified CO_2 from fossil fuels as industrial waste, consensus between the Contracting Parties on that has yet to be reached. Thus, it is not yet clear whether it falls under the prohibited (Annex I) substances, or even those (Annex II and III) requiring a permit prior to dumping. In any case, the

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[154] One of its more important aspects includes the division of the various parts of the oceans into zones: i) the Territorial Sea; ii) the Contiguous Zone; iii) the Exclusive Economic Zone (EEZ); iv) the Continental Shelf; and v) the High Seas. For each of these zones, differing rights and duties apply. For example, under Article 33, the State retains rights to prevent or punish infringements of its customs, immigration or sanitary laws and regulations up to 24nm from its coast. Within the EEZ, coastal States also have the rights of exploration, exploitation and management of the natural resources as well as the seabed. Interesting to note is also that the UK for example has abstained from declaring its EEZ, but rather relies upon the Continental Shelf rights. Within the Continental Shelf, Art. 77(4) gives a State the right to exploit the natural resources of the seabed and subsoil, as well as to lay pipelines (Art. 79) to exploit those resources. No state however, can exercise any sovereignty in the High Seas zone, which is considered to be the 'common heritage of mankind' (Türk, 2012: 182).

[155] Part V of the Convention, for example, also prohibits building infrastructure where it could interfere with recognized sea lanes.

[156] For matter under Annex I, absolute prohibition is in effect, while for those in Annex II a special permit is required, and for those in Annex III, a general permit needs to be issues prior to the dumping taking place.

Convention's definition of 'dumping' gives exemption to CO_2 injection for the purpose of enhanced oil or gas recovery, or if it is considered as a purpose to mitigate climate change, suggesting the CO_2 is being injected beyond mere disposal of waste.

The provisions of the Convention also exclude from its text the disposal, or discharge, from pipelines, and only refer to discharge from aircraft, ships or platforms, which is less likely to occur in the context of CO_2 storage.

London Protocol

Nonetheless, CCS off-shore activities and operations are currently to a greater extent governed by the 1996 London Protocol, which entered into force in 2006, with an aim to modernize and provide for a restrictive[157] and comprehensive oceans and sea waste management. Under the Protocol's regime, the legal basis for regulating off-shore CCS activities was established by the amendment to Annex I in 2006 (entered into force in 2007), which adds CO_2 on the approved list of materials to be considered for dumping, as well as explicitly states (Art. 1(4)) that CO_2 may be considered for disposal, under the condition that it be disposed of into a sub-seabed geological formation, that it consists overwhelmingly of CO_2 (though it may contain small traces of other substances), and that no other waste or matter be added during the disposal process.

Following the amendment, a number of specific guidelines for risk assessment and management, evaluation and monitoring of the CO_2 storage in sub-seabed formation have emerged. Combined with other provisions of the Protocol, such as the licensing process under Article 4[158] or Article 9, which set reporting obligations, these guidelines provide for a permitting framework for offshore CCS activities. Essentially, governments of each contracting party undertaking offshore CO_2 storage activities must adopt administrative/legislative measures to provide for permits to be issued. The permitting requirements, and the general emphasis placed on impact evaluation and monitoring requirements, the latter seen as essential to ensure compliance, points to the coherency and inclusiveness of the Protocol. In particular as

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[157] The dumping of materials listed in Annex 1 requires a permit, which must be issued in accordance with the provisions of Annex 2. Contracting Parties, when undertaking an assessment of wastes or other matters must, amongst other things: carry out a waste prevention audit to ascertain whether the waste can be reduced at source; consider the chemical, physical and biological properties of the material to be dumped and the site identified for the deposit; and make an assessment of any potential effects. (UCL-CCLP, 2012)

[158] Requires Contracting Parties to adopt administrative and legislative measures for the permitting process to comply with the Annex II of the Protocol (Armeni, 2011).

far as impact evaluation and monitoring is concerned, such emphasis also points to the important role of the sciences in providing an essential input to the entire governance framework. A strengthened science-policy-legal interface then also leads to a more informed and effective decision making.

Also, in 2009, amendment of Article 6 of the Protocol, which prohibits export of wastes or other matter for dumping in other countries, was adopted in order to allow for CO_2 export for the purpose of CCS related activities. The amendment, opposed to by China on the basis of concern over hastiness of such an amendment and that it might result in export of other waste, essentially requires prior agreement between the countries concerned, including (IEA, 2011:11):

i) Confirmation and allocation of permitting responsibilities between the exporting and receiving countries, consistent with the provisions of the Protocol and other applicable international law; and

ii) In the case of export to non-Contracting Parties, provisions at a minimum equivalent to those contained in the Protocol, including those relating to the issuance of permits and permit conditions for complying with the provisions of Annex II, to ensure that the agreement or arrangement does not derogate from the obligation of Contracting Parties under the Protocol to protect and preserve the marine environment.

This amendment, however, given the required two thirds of the Contracting Countries to ratify, the low number of ratifications to date (aside from Norway, who initiated the amendment, UK is the only other party to have ratified it), the difficulty of the ratification process itself, as well as the contracting party interest in CCS in general, is unlikely for the amendment to be ratified in the near term (IEA, 2011). This essentially means, that at this point trans-boundary CO_2 transport with the purpose of CO_2 disposal/storage is under the London Protocol still prohibited.

OSPAR Convention

Last, but not least, the OSPAR Convention, primarily focuses on pollution from land-based sources (Art 3; Annex I), dumping and incineration (Art. 4, Annex II), and offshore sources (Art. 5; Annex III). While, unlike the London Convention and Protocol, OSPAR is an example of a regional maritime agreement, it is similar in the extent of requiring an amending process to remove some of the legal obstacles to CCS deployment. In 2007 the Contracting Parties also adopted amendments to the Convention's Annex II[159] and III,[160] which added to the legitimacy for off-shore CCS activities and operation in the North-East Atlantic, as well a Decision 1/2007, which entered into force in 2008, and explicitly reinforces the requirement for sub-seabed storage by prohibiting storage in water columns. Furthermore, the number of guidelines and decisions[161] on CO_2 storage in geological formations similar to those under the London Protocol additionally enhance the CCS legal framework.

However, given that, as is the case with the Protocol, the OSPAR Convention has been ratified only by a number of countries to date and has yet to come into force, it means that CCS offshore activities under the OSPAR regime are, for the time being still prohibited (Armeni, 2011).

4.2.2 Setting the legal and regulatory framework for CCS

The EU has to-date established itself as one of the leaders in the international fight against climate change, playing important roles in the negotiations of the Kyoto Protocol, and in the post-Kyoto period pushing for more stringent and inclusive climate agreements (Claes and Frisvold; in Meadowcroft and Langhelle, 2010: 217). One of the key climate change policy tools in the EU has undoubtedly been the EU Emissions Trading Scheme (ETS)[162], established to facilitate emission reductions and encourage investments into low-emission technologies, in particular for large emitters in the power generation and other heavily energy-intensive sectors.

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[159] i) Article 3(2) of Annex II added CO_2 streams from CO_2 processes for storage to the list of substances allowed for dumping, following several conditions are met. See requirements of Art. 1(4) of London Protocol; OSPAR also adds that permanence of storage and guarantee of no significant adverse effects.

[160] While the newly inserted Paragraph 3 adds that CO_2 streams from CO_2 capture processes are not prohibited, subject to conditions listed in Annex I, the new Paragraph 4 requires guarantee that CO_2 storage will not occur without authorization or regulation from the Parties' competent authority. (Armeni; in Havercroft et al., 2011: 154).

[161] i.e. the OSPAR Guidelines for Risk Assessment and Management of Storage of CO_2 Streams in Geological Formations, or the Decision on the Storage of Carbon Dioxide Streams in Geological Formations

[162] Within this scheme, every member state is allocated an annual quantity of allowances on the basis of their emission reduction targets. These allowances are then auctioned off, and the revenues must be used to combat climate change, including for CCS. In addition to the revenues raised through the ETS scheme, an additional 300 million allowances, each equalling to one tonne of CO_2, were allocated under the New Entrants Reserve 300 (NER300) for the financing of renewable, as well as CCS demonstration projects. (GCCSI, 2012: 192).

In any case, CCS in the EU first emerged on the political scene in Brussels in the mid-2000s following the introduction of a number of 'Communications'[163] which outlined EU's way of combating climate change and achieving energy security, and along with measures to increase energy efficiency and production of renewables, considered CCS as one of the key technological options and solutions. One of the key policy developments in that time was the Commission's comprehensive 2020 Climate and Energy Package[164], the goal of which was set to ensure greenhouse gas (GHG) reductions as well as signal a strong commitment to a low-carbon economy in Europe. Among the four proposed legislative texts included in the package[165] was also the Directive creating a legal framework for the safe and environmentally sound use of carbon capture and storage technologies[166], which only two years after its mention in the 2007 climate and energy package, was adopted in April 2009.

In a short span of time, the EU has asserted itself as not only a leader in the fight against climate change but as the first to develop a comprehensive policy, legal and regulatory framework for CCS as well, which has since served as a model for such framework developments throughout the world. Good examples of countries that have "borrowed" from the EU in this respect include Australia and Canada[167].

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[163] Most relevant of these Communications, among nearly 20 of them in the years 2005-2007, include the Commission's 2005 White Paper on *Winning the battle against climate change*, and the Green Paper on Energy in 2006.

[164] Also referred to as the '20-20-20 in 2020' or the Merkel Miracle', which in March of 2007, following the unanimous backing by all 27 heads of state, saw the EU establish itself as a world leader in the fight against climate change (Claes and Frisvold; in Meadowcroft and Langhelle, 2009: 219). It set out three specific targets to be achieved by 2020: i) a 20% reduction in EU GHG emissions from 1990 levels; ii) raising the share of EU energy consumption produced from renewable resources to 20%; and iii) a 20% improvement in the EU's energy efficiency. On 23 October 2014, EU leaders also agreed on 40% reduction in domestic 2030 GHG emissions, compared to 1990 levels. The 2030 policy frameworks intends to make the EU's economy and energy system more competitive, secure and sustainable. In addition, target of at least 27% for renewable energy and energy savings by 2030 were set (EC, 2015).

[165] It also included, a directive revising the EU Emissions Trading System (EU ETS), which covers some 40% of EU greenhouse gas emissions; an "effort-sharing" Decision setting binding national targets for emissions from sectors not covered by the EU ETS; and a Directive setting binding national targets for increasing the share of renewable energy sources in the energy mix (EC, 2014).

[166] The package also engages with CCS by calling for the creation of a policy that would stimulate construction and operation of up to 12 CCS demonstration plants by 2015, create a Strategic Energy Technology Plan (SET-Plan) for Europe and prepare a road map for developing European Industrial Initiatives for key low-carbon emitting technologies, which would include CCS (Claes and Frisvold; in Meadowcroft and Langhelle, 2009: 219).

[167] See the Global Status of CCS 2012 report from the Global CCS Institute (ch.4) for detailed information on the policy, legal and regulatory developments around the world. Available at: http://www.globalccsinstitute.com/publications/global-status-ccs-2012

Key elements

This research considers the legal and regulatory frameworks to be a critical factor for the future of CCS technology. The purpose of such frameworks is not only to ensure that all environmental, social, and economic risks are taken into account and properly managed. It goes also without saying, that without favourable legal and regulatory frameworks, CCS will essentially be condemned to a small-scale market. As such, a key pre-condition for the development of this technology is the reduction of technical, legal and administrative barriers. For example, clear and simple regulations on the permitting process, or smooth application of other procedural requirements in general are particularly important. Good understanding of these frameworks, from the industry's perspective in particular, is crucial, as they are the ones who will be facing the majority of the environmental, social, and of course financial risks. This research, as mentioned in the introduction, is primarily concerned about the environmental risks. Nevertheless, all types of risks should, at least to some extent, always be addressed in conjunction, given that they are invariably related. The European legal and regulatory framework for CO_2 storage reflects this notion well.

In Europe, the key framework, as mentioned, is the 2009 CCS Directive, which introduces elements such as the monitoring plan, provisions for financial security and mechanism, and for the transfer of responsibility.[168]

Given that no CCS project is allowed to operate without an approved storage permit, the outcome of the permitting process is crucial to the project proponents. Often, this process takes a long time, as was the case in the ROAD's CCS project experience, which took almost two years from the time of the application to the point where the permit was awarded, with full support from the Dutch competent authority. Through document research, and speaking with members of the CCS industry community, as well as with other government and academic stakeholders, the following key issues were identified in relation to permitting: i) storage complex and storage site; ii) financial security; iii) financial mechanism; iv) transfer of responsibility.[169]

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[168] It is up to the Member States to interpret these elements into their respective national legislation. This flexibility is purposely given in light of the specific characteristics of each CCS project.

[169] In respect to storage complex and site, although the definition is made in the CCS Directive, these are not as easily applied to a reservoir or aquifer. The *financial security* requirement makes the operator present a proof that sufficient FS will be available at the time of CO_2 injection; not necessary at time of permit application. Lack of clarity on calculating amount of FS and acceptability of instruments are seen as key issues in this respect. Lack of clarity on the *financial mechanism*, in

In addition to the permitting process, equally important are the legal liabilities that may arise in the CO_2 storage process, and could become reasons for which a project developer would either stop or become hesitant to continue their involvement with a project. There are essentially four different legal regimes under which liability may arise. These include the: i) EU-ETS – where the operator is liable for damage to the climate in case of CO_2 release; ii) Environmental Liability Directive – where the operator is liable for the damage to the environment; iii) civil liability – where operator is liable for damage to third parties (persons or goods); iv) CCS Directive – where operator is liable to the competent authority in case of insufficient monitoring or corrective measures.[170]

While Chapter 6 presents the views of the key stakeholders, in particular the CCS industry, on some of the above-mentioned legal and regulatory issues, so as to aid in understanding of those views, the following section turns to providing a brief overview of the CCS Directive and its provisions. A more in-depth analysis of the key provisions is provided in Chapter 5, where the UK legal and regulatory framework is also examined. Although the focus of this research is the storage of the CO_2, provisions on the capture and transport components of the CCS chain are also provided below.

4.2.3 Overview of the EU CCS Directive

The CCS Directive was published in the EU Official Journal on June 25, 2009, with the EU Member States required to fully transpose its provisions by the deadline, on June 25, 2011. By that date however, only Spain was able to have fully transposed the Directive, which resulted in the Commission initiating infringement proceedings against 26 of the 27 EU member states, which have either failed to comply, or failed to communicate their compliance with the text and any other administrative measures of the Directive to the Commission[171].

As the name suggests, the CCS Directive provides for a regulatory framework ensuring permanent containment of CO_2 underground, and where this is not possible,

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particular the amount and though which mechanism it should be made available before transfer of responsibility occurs, is also a key issue. Lastly, a key issue is also the lack of clarity on the *transfer of responsibility*, and what evidence is to be taken into account, and who is to assess the evidence (Havercroft and Macrory, 2014: 5-7).

[170] Ibid. 5.

[171] By end of 2013 all MS have notified the Commission of their transposing measures. The Commission is now performing transposition checks.

eliminate any possible negative effects and risks to the environment and human health (Art. 1(2)). It applies to the territory, the exclusive economic zone and the continental shelves of the 27 Member States (Art. 2(1)). It also explicitly prohibits (Art. 2(3-4)) any storage to take place in the water columns offshore, or between a EU and a non-EU member states' territories. For capture and transportation components of CCS, however, in order to avoid double-regulation and to remove an existing legal barrier, the CCS Directive amends several existing Directives, under which the two components will be primarily regulated.

4.2.3.1 Capture

As far as it relates to the capture component, Article 37 of the CCS Directive for example, amends the Annex I of the 2008/1/EC IPPC Directive to include CO_2 capture on the list of permitted industrial installation activities, which essentially means that all operators of power plants equipped with CCS are required to obtain a permit, as determined by the member state's regulation. In the UK for example, this is an environmental permit, as the environmental permitting regime implements the IPPC Directive. As such, it also requires the establishment and application of best available techniques (BATs), and improvement of the composition of the CO_2 stream. Furthermore, while Article 31 requires operators to comply with provisions of the EIA Directive (85/337/EEC) and conduct assessments of any likely significant environmental impacts form any capture facilities, Article 33 of the CCS Directive amends the Large Combustion Plant Directive (2001/80/EC) on the limitation of emissions of certain pollutants into the air from large combustion plants, to require operators of new coal-fired power plants with an output greater than 300MW to assess suitability of storage sites and available transport facilities, as well as technical and economical feasibility of retrofitting the power station for CO_2 capture (Oberthur et al., 2010: 167).

4.2.3.2 Transportation

In terms of transportation of CO_2, relevant provisions include Article 21, which requires Member States to ensure a fair and open access to the transportation network for all potential eligible operators, criteria for which is left to be determined by the Member States themselves. To account for any potential disputes related to access of the transportation network that might arise, Article 22 requires Member States to also establish a dispute settlement mechanism.[172] Furthermore, the CCS Directive amends the Annex I of the Environmental Impact Assessment Directive (85/337/EC) by including pipelines with a diameter of more than 800mm or of length greater than 40km to be subject to mandatory environmental impact assessments (EIAs)[173].

Transportation of CO_2 for the purpose of geological storage is also excluded from application and scope of the EU Waste Framework Directive (2006/12/EC), which is essential in that it excludes CO_2, for the purpose of storage, from the definition of ‘waste’. Important to note is also that for both capture and transport components of CCS, other relevant legal issues such as standards for health and safety, standards for design, construction, monitoring and maintenance, remain outside the EU framework, and are to a large extent left to the Member States’ discretion.

4.2.3.3 Storage

Pre-injection

As mentioned, the CCS Directive allows for injection and storage of the CO_2 to occur only in suitable storage sites that are carefully assessed and characterized (Art. 4). The goal is to minimize financial, environmental and human health risks, resulting from possible leakage, which the Directive refers to as “any release of CO_2 from the storage complex.”[174] The site selection and exploration is also conditional on obtaining an exploration[175] permit, procedures for which are determined by the Member States, but must be based on objective and non-discriminatory criteria (Art. 5).

Once the site is properly characterized and proved suitable for storage, an operator may apply for a storage permit, from their respective national competent authority. In addition, all permit applications must also be reviewed by the European Commission (Art. 10), which provides a non-binding opinion. Member States can essentially

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[172] In this respect, Art. 24 also requires cooperation on trans-boundary transport of CO_2 between Member States.

[173] Annex II of the EIA Directive is also amended by adding on the list other pipelines transporting CO_2 for the purpose of storage, meaning Member States have the primary discretion of deciding whether an EIA is required. Also, other relevant environmental concerns will largely be covered by the EIA Directive and other national laws.

[174] In the EC Guidance Document 2, a storage site is defined as a “defined volume within a geological formation used for CO_2 storage and associated injection wells and pumps”. A storage complex definition includes both the surface and sub-surface facilities at the storage site, as well as the secondary containment formations/reservoirs, which may contain the CO_2 in case it migrates beyond the primary seal (p. 26). Available at: http://ec.europa.eu/clima/policies/lowcarbon/ccs/implementation/docs/gd2_en.pdf.

[175] Refers to intruding into the subsurface (i.e. drilling) in order to obtain information.

ignore the Commission's opinion, only if it provides sufficient justification for doing so. While it is up to the Member States to issue such permits, Articles 7-9 of the CCS Directive provide for the minimum criteria for the conditions and contents of a permit application and a permit itself. Failure to meet the said criteria, as well as failure to communicate any matters of concern as to the operation and integrity of a site gives the competent authority, as well as the Commission, the right to deny, change, update or withdraw a storage permit (Art. 11).

Operation

Once injection of the CO_2 starts, the most important provisions in the Directive include Articles 13-15, which relate to the monitoring, reporting and inspection, respectively. Monitoring of irregularities, migration of CO_2 underground, leakage or significant adverse effects for the surrounding environment (Art. 13(1)) is essential. A monitoring plan is submitted for approval together with an application for a storage permit, and must be updated every five years. Annex II of the CCS Directive also sets out specific parameters to be monitored/measured, for which it suggests the use of 'best available technology'. Based on the monitoring required by Article 13, operators are then required to submit a report, at a frequency determined by the competent authority and in any event at least once a year, on the status of the storage site, the condition of the CO_2 stream, as well as any other relevant issues, such as financial security.

In order to check for compliance with any of the Directive's provisions, a competent authority must also set up a routine inspection system of storage complexes, which should occur at least once a year for the first three years after closure, and once every five years until the transfer of responsibility to the competent authority occurs. Non-routine inspections are suggested, however, the frequency of which is to be determined by the relevant competent authority.

In the event of any leakage or other irregularities, Article 16 sets out the measures to be taken by the operator as set out in the corrective measures plan submitted at the time of the permit application. If, however, the operator is incapable to take the necessary measures, the responsibility of doing so falls on the relevant competent authority, which is then allowed to acquire the incurred costs from the operator (Art. 16(4-5)).

Post-closure

Post-closure obligations (Art. 17) apply once a storage site has been closed, which can occur either if conditions stated in the permit have been met, a permit is withdrawn (based on Art. 11(3)), or a competent authority approves the request of the operator to close the site. Unless a storage permit is explicitly withdrawn, the operator remains responsible for any monitoring, reporting and corrective measures, based on the post-closure plan submitted in the original permit application (Art. 17(2-3)), until the transfer of responsibility occurs (Art. 18). Such transfer can occur upon request from the operator, if: i) all available evidence indicates that the stored CO_2 will be completely and permanently contained; ii) a minimum period, no shorter than 20 years, determined by the competent authority has passed, unless the authority determines that criteria under (i) have been met; iii) financial obligations under Art. 20 have been fulfilled; and iv) the site has been sealed and the injection facilities have been removed. Here again, the operator must prepare a report of the fulfilled conditions and that the CO_2 is 'completely and permanently contained'. As such, if conditions are met, and the competent authority approves the report, it has one month to submit the approval for review to the European Commission, which then has additional four months to make a non-binding opinion the European Commission (Art. 18(4).[176]

Following the transfer of responsibility, any routine inspections and monitoring efforts may be reduced, unless significant leakage or irregularities are found, in which case they can be intensified, and costs incurred can be recovered from the operator, only if it is found that the fault has been on the side of the operator (Art. 18(7)). This relates then to the provisions under Article 19, which requires the operator who is applying for a storage permit, to present proof that sufficient financial security (FS) will be valid and effective before CO_2 injection starts. The FS should cover the: i) operational period (monitoring, corrective measures & post-closure plans; surrender of allowances for any emissions; maintaining injection; and ii) closure and post-closure period (sealing the storage site and removing injection facilities). In case of significant irregularity or incident, the competent authority can then use these funds to cover the incurred costs in case of corrective measures or premature closure of the storage site. However, the CCS Directive does not require the permit applicant to

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.[176] If however the Commission decides not to issue a opinion, it must inform the competent authority of such decision within one month after receiving the draft approval.

have the FS available at the time of the storage permit application, but only before the injection starts.

Lastly, according to Article 20 of the CCS Directive, an operator must make a financial contribution to the competent authority, before the transfer of responsibility, in order to cover the cost of monitoring for a period of at least 30 years, as well as to cover the costs incurred by the competent authority after the transfer to ensure that the CO_2 is completely and permanently contained (Art. 20(1)).

4.3 Discussion

While the foundation for environment as an important EU policy paradigm has emerged in the early 1970s with the development of the first Environmental Action Programme (1973), it did not take long for it to also acquire a solid legal basis, following the passage of the 1986 Single European Act (SEA), ending its previous rather informal legal status. Over the next 25 years, environmental, as well as energy related matters have become more prominent, and an integrated part of other policies of the EU. In the years following the SEA, other important institutional changes emerged, such as the expansions in the use of qualified majority voting (QMV) in all sectors related to the internal EU market, including much of the environmental policy. In addition, procedural changes, such as the introduction of the co-operation and co-decision procedures, increased the role of the European Parliament over the policy setting decisions by giving it the right to veto legislation. These changes have to a good extent shaped the dynamics of the policy and decision-making process in the EU It is important to note, however, that in environmental and energy policy, the institutional balance of power is constantly shifting, and decisions rules are manipulated in the struggle (Peterson and Bomberg, 1999: 185-99).

The environmental governance system, however, is not only composed of institutions. A wide array of non-institutional members and interests, including scientific experts, business interest groups and environmental NGOs, also come to form an important, but a messier than most, component of the overall governance network (Peterson and Bomberg, 1999). As discussed earlier in Chapter 2 (Section 2.2.1) on the governance network theory, as employed in this research, what gives the governance network its character, or nature, are the characteristics of particular actors within the network, and their (material or immaterial) resources which the actors exchange in one form or another for the purpose of achieving a common goal - in this case, environmentally safe CO_2 storage and deployment of CCS technology. As such, the resulting nature of the legal and regulatory framework in Europe is reflective of both the interdependency between the actors, and the institutional structure in place.

The CCS Directive is clearly evident of an outcome of extensive collaboration across a wide range of stakeholders, and is a model framework for the regulation of CO_2 storage. This study argues that its provisions offer sufficient flexibility to the Member States to implement the Directive into their respective national legislation, yet at the same time provide sufficient rigor so as to ensure environmentally safe geological CO_2 storage, whilst not impeding the development/deployment of the CCS technology. As also argued in this study, a strong regulatory framework, hopes to not only provide for certainty, to all stakeholders, including the public, as to its safety and importance, but also to encourage the increasingly necessary investments into the technology, and inspire confidence in the international arena, which would then hopefully translated into development of the technology across the developing countries as well.

CHAPTER 5: Governing and regulating CO_2 storage in the UK

The CCS Directive represents the common denominator for the regulatory frameworks for CCS across the EU Member States, which were required to transpose the Directive into their national legislation. Essentially, there have been two methods by which MS have gone about doing so, either via: i) a literal transposition, such as in the case of the Netherlands; or ii) in greater details and specific regulation of aspects left by the Directive for MS to regulate[177], such as is the case in the UK.

As of February 2015, the UK has no fully operational CCS projects, whereas in Europe, Norway[178] for example already has two – at Snohvit and Sleipner – and elsewhere around the world, primarily in North America, six additional projects are currently capturing and storing CO_2. None of these projects, however, are capturing CO_2 from power stations, but rather from various industrial sources, primarily gas processing and fertilizer plants. Given that CO_2 emissions from power generation represents the single largest source of global emissions, the UK could be praised for its efforts at CCS development in this area, despite having no operational commercial projects yet. This is because what the UK does have is one of the most comprehensive sets of legislation and regulations in place, and is considered as a leader in this respect, as well as in the case of developing a funding mechanism at the national level.[179] This is an interesting state of affairs, in that the UK is in a sense the most developed in legal and regulatory aspects, but has yet no fully operational projects to date.

Development of the law is in essence the foundation for effective environmental protection. As such, when it comes to new technologies such as CCS, legislation and regulations will be developed before the technology itself is widely implemented.

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[177] Given the principle of subsidiarity, which the EU is governed by, the Member States are left with some degree of flexibility in regards to regulating certain aspects of CCS.

[178] Even though Norway is technically not an EU Member State, its membership with the EU is formed via its membership in the European Economic Area (EEA), and with the CCS Directive qualifying as being 'EEA relevant' it means that it must be implemented by all EEA members, including Norway (Decarboni.se, 2012). CCS development in Norway is largely driven by the oil and gas experience, and regulations. Although, the Norwegian Government announced its intention to transpose the EU CCS Directive in the near term, as of April 2014, it has not yet implemented any CCS specific legislation or regulations.

[179] As will be explained later on the funding mechanisms at the national level involves both the direct funding for projects in the short-term, but more importantly for the long-term via the Electricity Market Reform.

This is done so as to account for all elements that would lead to a safe geological CO_2 storage. Effective regulations aim to provide the highest level of assurance, to the investors, operators and the general public that the long-term benefits of CCS will be achieved, whilst safeguarding against any potential risks or disasters. In respect to the latter, a clear allocation of risk and responsibilities over the short, medium and long-term, is a crucial aspect in determining how liabilities are attributed, and for providing the confidence among investors.

As such, an effective regulatory framework should facilitate CCS development whilst protecting the environment. However, as the DECC's 2012 CCS Roadmap openly acknowledges, although the UK has one of the most comprehensive regulatory frameworks for CCS in place, "this has yet to be tested in practice…[and] is inevitably an area where policy and practice will develop with experience" (p.4).[180] In other words, the governance network can only get so far without actual practical experience (i.e. operational CCS projects).

Albeit relevant and interrelated, the chapter itself is less concerned with the funding mechanisms per se. The main objective of this chapter is to critically evaluate the legal and regulatory framework in which CCS is being debated in the UK. First, the context for CCS in the UK is set out, including the role of environment in policy and legal spheres, and the legal position of CCS. The second part then examines how CO_2 storage is governed in the UK. This includes analysing the UK's governance network, and identifying outstanding regulatory issues. Here the study also starts to draw on the interviews occasionally, however, the majority of data comes later in Chapter 6. Lastly, a discussion is provided.

5.1 The context for CCS in the UK

In light of the epistemological stance[181] adopted in this research (see section 2.3.1), this section first turns to briefly presenting the historical development of environment in the policy and legal spheres, as well as the reasons behind developing CCS in the

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[180] DECC (2012). Available at: https://www.gov.uk/government/uploads/system/uploads/attachment_data/file/48320/4904-ccs-roadmap--storage-strategy.pdf.

[181] According to epistemological relativism (see Chapter 2), our *understanding* of this world is inevitably a construction from our own perspectives and standpoint. As such, governance network, its construction and operation, is understood as being under the influence of both horizontal and vertical developments; i.e. historical context and the spread of the influence from the EU, respectively.

UK. This will set the context for later on examining the governance of CO_2 storage, and identifying the outstanding legal and regulatory issues.

5.1.1 Environment as an emerging theme in the policy and legal spheres

In the wake of the development of industrial towns in the early 19th century in the UK, much of the early legislation that considered environmental measures was concerned primarily with public health issues, such as water pollution. It was in 1863 that the first centralized regulatory authority, the Alkali Inspectorate, was established, at the time the first of its kind in the world. Much of the early history of environmental policy and law in the UK can be characterized by a somewhat limited focus on the local pollution problems and a reliance on common law, or the law of torts. However, it was not long before more comprehensive legislation would address the gross and widespread pollution problems caused by the industrial revolution. Such legislation was also directed towards addressing more specific problems such as atmospheric pollution from the chemical industry and water pollution controls. For the 19th century, such developments were seen as quite innovative and placed the UK as one of the leaders in addressing environmental and climate related issues (Wolf and Stanley, 2010).

While it has been said that the late 1960s and early 1970s were the beginning of a modern form of environmental policy and law-making in the UK (Weale et al., 2000), there is a long history of environmental measures pre-dating this period, which have to an extent characterized and shaped them. For example, the Great London Smog of 1952, a December-event in which the city of London was engulfed by smog for several days[182] was significant in that it led to the passing of several legislative acts, such as the City of London (Various Powers) Act 1954 and the Clean Air Acts of 1956 and 1968, marking significant development not only for the regulation of air pollution, but for environmental protection policy and legislation in general[183].

Up until the mid-1980s, dealing with environmental issues in the UK can be primarily understood as based on informal, reactive and voluntary types of regulation, underlined by negotiations between industry and government. Research has shown, as

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[182] This occurred as a result of windless conditions, cold weather and an anticyclone, which collected airborne pollutants to form a smog cover over the city, lasting from December 5-9, 1952.

[183] Other events, such as the sinking of the Torrey Canyon oil tanker in 1966, or bad publicity received by the industry from the press in regards to poor waste management, led to a number of other legislations in the early 1970s, as well as significant organizational restructuring, with the creation of the Department of the Environment (Weale et al., 2000: 154).

will be presented in-depth in the sections to follow, and later on in Chapter 6, that this relationship is still highly evident today.

In any case, the environmental governance at that time has been characterized by authors in a number of ways, including devolved fragmentation, disjointed incrementalism, (over)reliance on scientific and technical expertise, informal regulation, and close consultation with affected interests (Richardson and Watts, 1985; Lowe and Flynn, 1989). With the signing of the Single European Act (SEA) in 1986 then, a more integrated approach to environmental protection, not only at the EU level, but at the national level as well, was adopted. In other words, environmental concerns began to be incorporated into other policy sectors. In addition, the EU's influence over national environmental legislation also began to expand.

On a global stage, the then UK Prime Minister Margaret Thatcher, at the UN General Assembly in 1989 and the 2nd World Climate Conference in 1990, became one of the first world leaders to explicitly warn of the dangers of climate change and global warming, and the need for working together to deal with these issues. This was significant in that it further entrenched the already strong position of the UK as one of the leaders in the area[184] of addressing and dealing with the issue of climate change. While these were significant moves in a normative sense, the introduction of the principle of integration pollution control (IPC), codified in the UK Environmental Protection Act of 1990[185], serves as an example of a way with which the UK sought to influence pollution control beyond its borders, within the EU (Weale et al., 2000).

In any case, over the past quarter of a century or so, the development of UK environmental legislation has served as a good example of the evolutionary nature of regulation. Today, the approaches to environmental policy and regulations in the UK

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[184] It was Mrs. Thatcher who also signed the UK up to the Montreal Protocol, a treaty on banning the use of chlorofluorocarbons (CFCs), in 1985, and established the Met Office Hadley Centre for Climate Change, one of UK's foremost climate change research centres, in 1990. While Mrs. Thatcher was in some aspects a controversial figure politically, when it came to climate change, she was largely seen as a political pioneer, with her stance based on the principle of precaution and encompassing conservative arguments – i.e. taking action now as being more cost-effective than wait and pay later on.

[185] The principle is meant to bring about a way of proper management of substances in all media, applying to the most seriously damaging industrial processes, including the cement, chemicals, refineries, and iron and steel industries. Pollution from large industrial installations is further regulated under the Pollution Prevention and Control Regime, which implements the EU Directive on Integrated Pollution Prevention and Control (IPPC) (2008/1/EC), and applies to approximately 4000 industrial installations in the UK, including refineries, cement works, chemicals, and iron and steel. It requires each installation to have a permit containing emission limit values and other conditions based on the application of Best Available Techniques (BAT) and set to minimise emissions of pollutants likely to be emitted in significant quantities to air, water or land. Permit conditions also have to address energy efficiency, waste minimisation, prevention of accidental emissions and site restoration (DEFRA, 2012).

owe a great deal not only to the historical legacy derived from the 19th century developments onwards, but also to some extent by the developments at the EU level[186].

5.1.2 Guiding principles

In terms of enabling legislation in the UK, wide power is vested in statutory bodies, which enjoy a broad discretion affecting their exercise. These bodies, such as the Department of Energy and Climate Change (DECC), are also supported by substantial legal powers that affect the regulatory control and enforcement through devolved regulatory agencies, such as the Environment Agency (EA). Overall, in terms of environmental regulation in the UK, there is a characteristic reliance on the licensing regimes, conditional consenting and setting requirements for information and data submission, inspection, and monitoring. In addition, as Smith (1996) describes, environmental regulation in the UK can be characterized as placing to an extent more emphasis on the science and policy, rather than the law. In the context of carbon capture and storage (CCS) regulation, the UK has adopted a risk- and evidence-based approach, supplemented by a reliance on a number of guiding principles, such as the principle of precaution in particular.

The guiding principles of the UK's environmental policy, legislation and regulation, as mentioned, owe a great deal to the historical legacy since the 19th century. At first, this was based on the 'best practicable means' (BPM) applied to dealing with air pollution, taking into account local conditions, current state of technical knowledge, and financial implications. The traditional BPM approach developed into an approach based on best available technology not entailing excessive costs (BATNEEC) and best practicable environmental option (BPEO) principles. While the former identified 'best' in terms of new technological developments coming into light, the latter took into account the effects on the environment as a

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[186] Up to 80% of the national environmental legislation essentially originates at the EU level (Scheuer, 2005: 3). As mentioned in earlier sections, this comes due to the fact that the UK Government is obliged to implement EU directives and regulations through its primary (i.e. Acts of Parliament) and secondary legislation. Generally, EU environmental legislation, however, comes into national law via the latter. Furthermore, as mentioned earlier, environmental legislation in the UK is also influenced by the judgments and principles of the ECJ and various international treaties and agreements, which the EU is a party of. As far as the latter is concerned, the UK can also sign treaties and agreements with other states on a bilateral or multi-lateral basis (Wolf and Stanley, 2010: 14), which goes to show that the sources of UK environmental law derived from international law, are not solely limited to that of the EU.

whole (Weale et al. 2000: 180). More recently, over the past decade or so, there has been an increased focus on an approach that would apply policy more efficiently and effectively. Today, this approach is best known under the term New Environmental Policy Instruments (NEPIs)[187], which intends to provide a more flexible approach, stimulate both technical and organizational[188] innovation, and reduce the costs of monitoring and enforcement. In an effort for environmental policy to be most effective, a combination of both the traditional command-and-control and the NEPIs has been increasingly used in the UK over the past decade.

The precautionary principle

As examined in the previous chapter, in the context of CO_2 storage, the principle of precaution[189] is of most relevance, and has been the main guiding principle at both the EU level and in the UK. Essentially, the key purpose of the precautionary principle is to guide policy and decision-making in light of/despite the existence of scientific uncertainty concerning the nature and the extent of the risks involved. The principle should, in theory at least, also bring together all the relevant social, political, industrial and economic factors and stakeholders, and thus offer the best, or the most appropriate risk management option. Applying it essentially becomes a matter of making assumptions about the consequences and likelihoods of establishing credible scenarios and then, most importantly, using standard procedures of risk assessment and risk management to guide administrators and regulators to make decisions or develop policy in situations where scientific uncertainty is present and the likely impact of a hazardous activity is uncertain. However, there is in fact “no definitive statement of ‘the’ precautionary principle, nor any agreement on when it applies or what it requires. [It] is an overarching principle that will always require contextual elaboration” (Fitzmaurice, 2009: 64; Harremoes and Gee, 2005).

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[187] Examples of NEPIs include: i) market based instruments – (i.e. the Landfill Tax, the Climate Change Levy); ii) UK emission trading scheme; iii) voluntary agreements; iv) information and awareness schemes

[188] Technical innovation develops new technologies, whereas institutional innovation refers to the changes in organizational behaviour.

[189] The precautionary principle states that “*where there are significant risks of damage to the environment, the Government will be prepared to take precautionary action to limit the use of potentially dangerous materials or the spread of potentially dangerous pollutants, even where scientific knowledge is not conclusive, if the balance of likely costs and benefits justifies it*” (HM. Govt, 1990, 11).

Given that environmental and safety risks related to carbon capture and storage concern primarily the releases of CO_2 during transport and geological storage part of the process, application of the precautionary principle essentially entails a risk assessment and management framework in which the scientific uncertainties associated with long-term storage and possible negative impacts are addressed. In other words, the precautionary principle is the characteristic and guiding element of the legal and regulatory frameworks, and for the overall governance of CO_2 storage.

In practice, the application of the precautionary principle can be seen within the contents of the regulatory frameworks for CO_2 storage – the EU CCS Directive and the UK's Storage of Carbon Dioxide Regulations, which transpose the CCS Directive. As mentioned in chapters above, and emphasised in a number of interviews with key stakeholders (see Chapter 6), it is extremely difficult, if not impossible, to prove that no leakage of CO_2 from a storage reservoir is occurring. Apart from uncertainties in regards to CO_2 leakage, there is also lack of certainty as to exact position of the CO_2 once underground, in particular when storage occurs in saline aquifers, which are much more difficult to characterise than depleted oil and gas reservoirs, for example. As such, the sense of the precautionary principles in these frameworks will be evident within the number of requirements for careful examinations, additional information and consistent monitoring.

For example, Article 4 of CCS Directive states that storage of CO_2 is only allowed to occur in suitable storage sites that have been carefully assessed and characterized. The process of careful selection and characterisation[190] is a critical component, as it is here where future risks are essentially reduced the most. Furthermore, throughout the operational phase of CO_2 injection as well, it is critical to act with precaution, in large part due to uncertainties as to the exact movement of CO_2 underground, in particular when injected into saline aquifers, as well as uncertainties related to other geotechnical, chemical and/or physical changes that might jeopardize the integrity of the storage site. Provisions within the regulatory framework, such as in particular Articles 13-15 of the CCS Directive on monitoring,[191] reporting and inspection[192].

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[190] Provisions specify various parameters that have to be included in site characterization.

[191] For example, monitoring of any irregularities, migration of CO_2 underground, leakage or significant adverse effects for the surrounding environment (Art. 13(1) CCS Directive).

[192] These provisions are transposed in the UK by the *Storage of Carbon Dioxide (Licensing etc.) Regulations 2010*. Available at: http://www.legislation.gov.uk/uksi/2010/2221/pdfs/uksi_20102221_en.pdf.

5.2 Why CCS in the UK?

CCS technology has the potential to significantly curb CO_2 emissions from large stationary sources, and thereby can help countries like the UK to achieve its climate change targets, whilst maintaining a competitive economy. As described by the Climate Change and Energy Committee (13 May 2014, HC 742, p. 13) in its report on Deploying CCS in the UK, successful CCS deployment could cut UK's annual costs of meeting carbon targets by up to 1% of GDP, or by £30-40 billion per year by 2050,[193] as well as result in £2-4 billion per year by 2030 in gross value added (GVA) benefits per year by 2030.[194]

In the UK, the debates surrounding CCS have now slowly started to move away from the 'how-it-works' and the extent of its potential, and more towards the policy requirements, and the legal position and obligations where CCS actually needs to be developed, making this study a timely piece of research. In other words, the context for CCS does remain protection of the environment and ensuring a secure energy future. Nevertheless, the UK Government has also at the same time acknowledged that fossil fuels - coal and gas - will continue to play a vital role in providing reliable electricity supplies and a secure and diverse energy mix in the transition to a low carbon economy. In 2010, for example, fossil fuels still accounted for 72% of UK's electricity generation (DECC, 2012: 15). As such, the reality is that in order to meet the emission reduction obligations, while maintaining the fossil fuels within the generation mix, the UK's legal position is one in which it could be argued that the development and deployment of CCS is necessary. This contention will be explored in more detail in the next section.

5.2.1 The legal position of CCS

The 2006 Climate Change Programme, and the 2007 Energy White Paper[195], set out the UK's policies to move towards a long-term target of 60% cut in CO_2 emissions by 2050, from the 1990 base (Scrase and Watson; in Meadowcroft and Langhelle, 2006: 162). The UK Government's commitment to reducing CO_2 emissions has gone further in the Climate Change Act 2008, by which 'it is the duty of the Secretary of State to

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[193] By avoiding spending on other more expensive alternatives for cutting emissions.

[194] HC (2014). Deploying CCS in the UK. Available at: http://www.publications.parliament.uk/pa/cm201314/cmselect/cmenergy/742/742.pdf

[195] DTI (2007). *Meeting the Energy Challenge: A White Paper on Energy*. Available at: http://webarchive.nationalarchives.gov.uk/20121205174605/http:/www.decc.gov.uk/assets/decc/publications/white_paper_07/file39387.pdf.

ensure that the net UK carbon account for the year 2050 is at least 80% lower than the 1990 baseline' with an intermediate target of 26%-32% by 2020 (compared to 1990 levels) (DECC, 2012: 13). This essentially created a legally binding framework and set UK's long-term CO_2 emissions reduction targets into law. In addition, given the EU Commission's recent ambitions to raise the EU's long-term target of GHG emissions reduction to 40% by 2030 (compared to 1990 levels), only adds to the external pressure for the UK to implement emissions reductions measures in order to achieve these low carbon aspirations. The 2012 CCS Roadmap[196], issued by DECC, pointed out that by 2050, emissions from the power sector will have to be close to zero if the UK is to meet its legally binding targets, mentioned above. This means that in the 2020s, deep cuts in emissions from the power sector will have to be achieved, if the targets are to be reached at the lowest-cost scenario. The potential role for CCS in regards to meeting climate change and emissions reductions targets is fairly evident, given that fossil fuels will remain a part of the future energy mix.

In this respect, as part of the UK's decarbonisation efforts, the 2009 CCS strategy policy stated that there would be 'no new coal without CCS' and any proposed new combustion plant over 300MW would need to be deemed 'carbon capture ready' (CCR)[197].

More recently, the Energy Act 2013 focused on establishing binding decarbonisation targets for the UK and establishing an electricity market reform and has been seen by CCS proponents as a significant piece of legislation for the future of CCS in the UK. Aims of the Energy Act 2013 include the phasing out and closing of coal-fired power stations over the next two decades, reduce dependence on fossil fuels, produce 30% of electricity from renewable sources by 2020, as well as cut GHG emissions by 50% by 2025 and by 80% by 2050, based on 1990 levels. [198]

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[196] DECC, 2012. *CCS Roadmap: Supporting Deployment of Carbon Capture and Storage in the UK.* Available at: https://www.gov.uk/government/uploads/system/uploads/attachment_data/file/48317/4899-the-ccs-roadmap.pdf.

[197] The CCR requirement was again reiterated in the July 2011 Overarching National Policy Statement (NPS) for Energy (EN-1), and in a more specific NPS for Fossil Fuel Electricity Generating Infrastructure (EN-2) which stated the all new coal-fired stations would need to be built with "a full CCS chain fitted on at least 300MW net of their proposed generating capacity" (Richards, 2013: 3).

[198] DECC (2013). *Energy Act 2013.* Available at: http://www.legislation.gov.uk/ukpga/2013/32/pdfs/ukpga_20130032_en.pdf.

Energy security

Much of the debate revolving around energy security[199], as Scrase and Watson (in Meadowcroft and Langhelle, 2006) point out, revolves around the perceived ‘energy gap’, which is expected to arise in light of the planned closure of a number of power stations across the UK by 2020, and if new power generation capacity is not developed in the near future. This capacity, however, cannot be fulfilled by any single energy source, essentially requiring the UK to use a portfolio of energy sources to generate the electricity, balance the needs of low-carbon emissions, ensure the security of supply and its affordability (Grubb et al., 2006). In addition, as Haszeldine (2007) points out, the sense of an energy and electricity ‘crisis’ is exacerbated by the imposed phase-out of coal generation as a result of the EU SO_2 directive. For the UK, this means that it will have to retire 40% of its coal-fuelled electricity capacity by 2015. Furthermore, the potential future role of CCS in the UK has increased also given the fact that without a clear mandated re-build programme for the decommissioning of a nuclear generation capacity, and the rising natural gas prices, as well as fear of increased reliance on foreign supplies[200]. In other words, development and deployment of CCS is warranted not only ‘on the basis of the science and technology and evidence base’, as former Minister of Energy Malcolm Wicks pointed out in 2008 during the Environmental Audit Select Committee hearing

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[199] Interestingly, the definition of energy security slightly differs between countries, for the most part depending on the context in which it is debated in. For example, the usual definition of energy security, refers to simply the ‘availability of sufficient supplies at affordable prices. As Yergin (2006) points out, energy exporting countries use the term ‘energy security’ to refer to focusing on the maintaining ‘security of demand’ for their exports, which generate a large share of their government revenues. As an example, Russia’s aim in maintaining energy security, is to reassert the state control over strategic sources and gain the primacy over the main pipelines and market channels. On the other hand, for many developing countries, ‘energy security’ means how changes in the energy prices affect their balance of payments. In other words, energy security lies in their ability to adjust to their new dependence on global markets, in a way representing a major shift away from their former commitments to self-sufficiency. In Europe, however, the major debate centres around how best to manage the dependence on imported natural gas (excluding France and Finland), and whether to build nuclear power plants and possible return to clean coal (Yergin, 2006: 71). It is Europe’s definition of ‘energy security’ that this thesis takes up.

[200] The UK has been a net importer of natural gas and oil since 2004 and 2005 respectively, having previously been a net oil exporter since 1980 and net gas exporter since 1997 (Scrase and Watson; in Meadowcroft and Langhelle, 2006: 159). Similarly, the UK’s coal imports have been growing steadily since 1970, with, in 2012, 40% (18 million tonnes) of imports coming from Russia, and another 56% (25 million tonnes) from Columbia, the USA and Australia combined (DECC, 2013: 45). Along with Germany, the UK has consistently remained as one of the top coal importing countries in the EU, in 2012, accounting for 22 and 14% of the total EU imports respectively. Nevertheless, it should be noted that in general, the UK’s coal consumption has been in decline over the last 30 years or so, primarily as a result of the UK’s energy mix becoming more diverse, and a number of relevant environmental regulations.

on carbon capture and storage (HC 654),[201] but also given the geopolitics of energy (in) security in the future, and UK's legal position in relation to its climate change goals and obligations (p. 19).

5.3 CCS Governance Network in the UK

The context for CCS in the UK is situated in the long-standing nature and importance of environmental protection, including its main guiding principles, as well as UK's legal position for emissions reductions, and maintaining energy security. In essence, these are the main drivers of the CCS governance network in the UK.

Given the nature of the problem at hand (i.e. risks of CO_2 storage), this research argues that governance networks[202] offer an effective mechanism and manner, in which 'risk' is dealt with and managed; through joint action and collaboration.

5.3.1 UK's CCS governance network

As discussed in Chapter 2, the nature of a governance network can be examined by referring to its relative *stability* and the *interdependency* of the actors within the network. A governance network, as mentioned, consists of a network of public, semi-public and private actors, who are to varying degrees interdependent on one another, either for material or immaterial resources. For this reason, and the fact that all actors are not equal in terms of expertise, authority, and available resources,[203] the relations between the actors are horizontally, rather than vertically, structured. Such a structure essentially implies a level of autonomy within the network. In addition, given that participation is voluntary, in that actors are not 'required' to participate and can 'leave' at any given time, no single actor can exercise complete control over the others. When talking about actors within a given governance network, this refers to governmental bodies, various research and academic institutions, as well as the

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[201] Yeo (2009).

[202] See chapter 2 for more on governance networks. In brief, a *governance network* refers to: i) relatively stable horizontal articulation of interdependent yet autonomous actors; ii) interactions between actors occur through negotiations; iii) negotiations occur within a regulative, cognitive and imaginary framework; and iv) the framework contributes to the production of public purpose. Based on these features and characteristics, the essence, or character, of a governance network can be assessed. See for example Rhodes (1996), Jessop (2002), Klijn and Koppenjan (2000), Torfing (2005), who use these features to ascribe governance networks.

[203] The skills are said to be to an extent innate, but are also a product of the actors' learning from experience (Marsh and Smith, 2000). For the oil and gas industry, for example, this refers to their experiences with drilling and extraction, while for the policy makers it refers to the historical developments of environmental and energy policy on a broader level, and their employment history at an individual level.

industry. Industry actors in this context encompass a wide range of CCS-related sectors, mainly the oil and gas (i.e. BP, Shell), manufacturing and contracting (i.e. Alstom, BOC), power generation (i.e. Drax Power, E.ON, Progressive Energy), transportation and storage (i.e. National Grid, CO2DeepStore Ltd.). In addition, actors such as various independent organisations or 'watch dogs', including environmental NGOs and regulatory agencies, could be considered members of the network, however, these in a way rather sit on its perimeter[204].

Within the UK, the lead responsibility for carbon capture and storage (CCS), was in 2008 taken up by the Department of Energy and Climate Change (DECC).[205] Amongst its responsibilities, DECC serves as the primary authority for petroleum licensing, the licensing for gas storage and unloading, and carbon storage licensing. In terms of the latter, the Secretary of State for the DECC remains the primary (competent) authority (CA) for offshore CO_2 storage in the UK, except within the territorial sea adjacent to Scotland (0-12nm), for which the Scottish Ministers retain the legislative, licensing and enforcement authority (i.e. the CA). Both the Secretary of State of the DECC and the Scottish Minister are given wide discretion to make regulations and determine the terms and conditions for the license for storage activities (Oladotun, 2010)[206]. In addition to the regulatory permission required from the government, any CO_2 storage project developer must first also obtain a storage lease, which provides the rights to install, commission, operate and maintain the storage infrastructure, from the Crown Estate[207].

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[204] These actors, such as various environmental NGOs, in a way act by putting pressure on the government to demonstrate results, and ask for accountability and legitimacy in Governments' actions. Given that in some aspects these ENGOs can have a strong influence on the level of public perception, the Government is in a way required to keep them at least at an arms-length, or the perimeter of the network. In other words, it tries to keep them relatively informed by providing information on what is going on, etc., but at the same time then in turn also seeks some level of approval from them, and in turn from the public as well.

[205] Previously, the main department in the UK responsible for CCS policy was BERR, with the help also from Defra – the industry and environmental ministries respectively. The Department for Business, Enterprise and Regulatory Reform was created in June 2007, and disbanded two years later in June, 2009, upon the creation of the Department for Business, Innovation and Skills.

[206] As Oladotun (2010) also notes, this wide discretion applies especially to the "persons or class of persons who can apply for a license, the manner in which an application must be made, the information which an application must contain, accompanying documents and application fee and the requirement of an applicant to provide financial security in respect of any future obligation arising from or connected with the licensed activities" (p. 9).

[207] The Crown Estate essentially manages a portfolio of asses, including the entire seabed around the UK, as well as other urban and rural areas, with profits going to HM Treasury. In relation to CCS, the Crown Estate manages the UK seabed up to 12 nautical miles and holds the rights for CO_2 storage within the Gas Importation and Storage Zone (GISZ), which extends out to the continental shelf (200nm). The Crown Estate awards rights for CO_2 storage through three documents: an Agreement for

Within DECC, the crucial role for development of CCS in the UK is played by the Office of Carbon Capture and Storage (OCCS), whose main objective has been to create the policy, legal and regulatory frameworks and support the various arrangements in order to stimulate the private sector, as well as to work with the variety of stakeholders, including other foreign governments, the industry, and the general public.

Governmental bodies are essentially in charge of writing the policy, the legislation and the regulations, and in fact do have their own internal experts, depending on the specific area in question. However, as one interviewee within the CCS industry sector pointed out when interviewed for this project:

> "what is often written down is written down by people who are not practitioners…[and] in my experience, ministers, civil servants, and regulators, are very risk averse, which is understandable. But what this has often led to in the past, in particular in relation to environmental issues and introduction of new technologies, is that they have tried to take account of absolutely everything written down. So the more that is written down, the more constrained [project developers] are…and the harder it is for them to try things out, as [they] have to overcome something that someone has written down"[208].

Essentially, depending on the issue at hand, the more constrained project developers are, or better said, the more they perceive to be constrained with what is written down in the legislation and regulations, it can also in a way serve to impede scientific development; and deployment of a particular technology for example.

Since the UK government is interested in facilitating scientific development and introduction of new technologies, it will aim to work closely with other stakeholders, from an early stage. Perhaps better said, given its legal position, when it comes to GHG emissions reductions for example, scientific and technological development and deployment, close collaboration and coordination between the government and other stakeholders is required. In other words, the government will seek and increasingly rely on outside expertise, in an attempt to facilitate the deployment of a technology,

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Lease (AfL), a lease and a pipeline lease (if necessary). The AfL grants to the holder a time limited exclusive option to proceed through to a pre-agreed lease once a number of conditions have been met, including obtaining a storage permit from DECC (Crown Estate, 2012).

[208] Interviewed by: Maver, M. (October 12, 2013).

such as CCS for example. At least that is its goal, and in essence represents the notion of governance in a nutshell.

So, for DECC, and the OCCS, the goal is to act in a facilitative way, creating a market and offer financial support in which CCS will then be able to grow. As such, they have worked closely with other stakeholders, by way of formal consultations on new policy proposals, participating in meetings and events, and via the CCS Development Forum.[209] Within these consultations, the government officially recognizes the importance of working closely with the CCS industry in order to achieve their mutual objective of a strong and successful CCS industry in the UK (DECC, 2013). The government's dependency on the outside expertise, however, is not related to exchange of any material resources per se. Rather, it seeks to obtain the immaterial resources, or the information, the findings, the perceptions and views, on various aspects of CCS, which it then incorporates in the formulation of policies and regulations.

As an example, the British Geological Survey (BGS), a public sector research institute, is relied upon by the UK government on all aspects of geoscience[210], in particular the mapping of the geology and conducting dynamic modelling of CO_2 injection. While the BGS has advised DECC at various times, given that they are a national survey, it does not have a permanent, kind of government approved role in CCS. As Dr. Andy Chadwick, team leader for CO_2 capture and storage at BGS, pointed out in an interview[211], "most of the consultations that BGS has done with the UK government has in fact been rather informal, apart from when it served on the DECC's Advisory Panel during the first CCS Competition."[212] Generally speaking,

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[209] Within the CCS Development Forum for example, approximately 40 members largely drawn from the industry directly involved in delivering CCS in the UK, but also other international, academic and NGO community representatives. While this forum initially ran from 2010-2012, the new format for 2014 onwards, is designed with a particular focus on the industry and prospective projects so that it can provide an environment for common issues to be identified and resolved – with the aim of accelerating commercial deployment (DECC, 2014).

[210] The BGS has been involved in coordination of the first EU (Geo2) project, which was the first sort of CO_2 storage project back in 1993, thus, establishing its mark as a research institute interested in CCS. Since then BGS has had a contributive role in a number of projects across Europe, in particular in regards to surveying and monitoring. In addition, BGS undertakes its own research, surveying and monitoring, and institutional strengthening programmes in the developing world (BGS, 2014).

[211] The personal interview was conducted at the BGS offices in Nottingham, UK, in October, 2013.

[212] Even then, this came about only as a result of BGS approaching DECC and saying 'we think you need some geologists on this'. When asked why that was the case, the interviewee noted that it was because "perhaps DECC was not very organised, having a lot of legal, financial and engineering people, with jobs for very short periods of time. And we went up to them and said, well you also need storage people, otherwise you won't know what you're getting". The interview was conducted with a

informal consultations with preselected stakeholders can often occur aside from the more formal official consultations, are based on relationships that can date back many years, and can come so late in the policy development process that it can be perceived simply as an attempt to legitimise or communicate decisions (Russel and Turnpenny, 2009).

In a number of interviews conducted as part of this research, the point of consultations being simply a legitimisation tool was in fact brought up. In one case, an interviewee also pointed out that it was his institution that approached the UK Government, and not the other way around. The reference to the notion of legitimacy is used here in order to raise a question about the overall integration of various stakeholders into the policy-making process, and whether, or what deficiencies there exist in this consultation process. In other words, it questions the governance network theory in a sense that it questions the true nature of the cooperative and coordinating approaches to solving a common problem, which essentially sits at the core of the theory itself. So, is the CCS governance network then truly a governance network, if the government for example fails to include all relevant actors in the policy development process? Based on the literary research and interviews conducted as part of this research, I would come to conclude that it is not so much a question of whether the so-called CCS governance network is a governance network per se, but rather whether or not it is effective.

In any case, government bodies for the most continue to rely on actors such as the BGS, or private companies such as Shell or British Petroleum (BP), which have extensive experience in oil and gas exploration and injection, for their knowledge of the subsurface and the expertise relevant to the permanent storage of CO_2. Whereas companies with large capital, might not require government funding, but instead interact with the government with an objective to reduce their investment risks, the UK Carbon Capture Research Centre (UKCCSRC) on the other hand, for example, does rely on government funding[213] and in turn then provides for a platform for carrying out research and share delivery, thereby maximizing the overall impact for learning and common understanding on issues related to CCS in the UK.[214]

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representative from the British Geological Survey, in 2013. Pursuant to confidentiality agreement, the name of the interviewee remains hidden.

[213] For example, in the recent Chancellor's Budget for 2014, an additional £60M is to supplement the existing £125M R&D CCS programme.

[214] UKCCSRC (2014). *Centre Mission*. Available at: https://ukccsrc.ac.uk/about/centre-mission.

When it involves emerging technologies such as CCS which are for the most part unfamiliar to the general public, a key ambition of the government has been to govern at a distance, involving a plethora of intermediary actors, as well as other citizen groups and environmental NGOs for example, in order to obtain a certain level of approval or credibility – critical when billions of pounds of public money are spent on research and development of the technology.[215]

5.3.2 (In)effective governance networks

As is evident from the experience over the past seven years or so, since the first UK CCS tender competition, poor or ineffective negotiations between project developers and the UK government, can lead to projects being first delayed, and ultimately even canceled.

In 2007, for example, BP abandoned their efforts to build the world’s first CCS powerplant in Peterhead, Scotland, primarily because of the failure of negotiations with the government. The project would transform the natural gas from the off-shore Miller oilfield into CO_2 and hydrogen, the latter which would be burned as fuel, and the former captured and piped back to the oilfield for storage. In hopes of receiving government funding, BP postponed the closure of the oilfield twice, despite the fact that there was a limited window of opportunity to keep the oilfield alive, before it became too technical and economically challenging.

For that year the UK government also announced the first UK CCS competition, with a goal of getting the first UK full-scale demonstration project off the ground and create an environment which would allow for further seedy deployment of CCS in the

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[215] The UK Research Councils, a group of non-departmental government bodies, responsible for funding and coordinating research, play an integral part in the CCS governance network. One of these councils, the EPSRC, provides government funding for research and postgraduate degrees in engineering and physical sciences, which in turn then provide their ideas and findings and thus help shape the government’s capacity to meet a number of challenges – including dealing with various aspects of uncertainty and risk of CO_2 storage. Supported by the EPSRC, with additional funding from DECC, and other private actors, the UK Carbon Capture and Storage Research Centre (UKCCSRC), made up of over 200 academics working in 36 universities, the industry, regulators and other stakeholders, provides a national focal point for CCS research and development with the goal of maximizing the impact of CCS to the low-carbon energy system for the UK (UKCCSRC, 2014). Lastly, the Carbon Capture and Storage Association, a non-technical trade association, which focuses on the facilitating the business side of CCS and the commercialisation of the technology, has thus far worked extensively with the UK Government, as well as with the EU Commission, in particular in the development of an appropriate regulatory framework for CCS. The CCSA, serves as a model for sectoral cooperation in business development, by representing over 70 different organisation across a number of sectors, including engineering, electrical utilities, law and insurance, and aims to bring together other specialist companies in the manufacturing and processing, power generation, engineering and contracting, oil, gas and minerals, etc. (CCSA, 2014).

UK. At that point, having had a good contractual agreement with Scottish and Southern Energy (SSE), a partner in the project, and having taken the project right up to the finishing front of the engineering and design, BP had to shelve the project, essentially because it could not afford to wait any longer for the government to guarantee a part of the funds needed for the project.[216] However, the first CCS competition had criteria in place which limited it to only coal-fired post-combustion, consequently leaving out the BP's Miller oilfield project, given that it was on pre-combustion and based on gas. For a company like BP this was not a good signal.

The abandonment of the BP's Miller field project for example, can today be seen as somewhat ironic, given that in the current CCS Commercialisation Competition,[217] one of the two preferred bidders announced by the government, the Peterhead CCS Project, is based on a gas power station, which would transport and store the captured CO_2 to a depleted gas field in the North Sea[218]. Failure to reach an agreement with project operators also lead to the cancelation of the plans for the first UK CCS project at the Longannet coal-fired power station in 2011, four years after launching its funding competition, with the main reason being overall costs of the project exceeding the original estimates.

However, with the recent signing of the contracts for the Front End Engineering and Design (FEED) studies[219] for the Peterhead CCS Project, in March 2014, and the White Rose Project, in December 2013, between the project developers and the UK government, there has been a renewal in the momentum for CCS, and the transition to a low-carbon future in the UK. For this momentum to be sustained, UK government will have to continue working closely with the project developers, not just in the above-mentioned projects, but also with others, in particular with the Teeside Low Carbon (TLC) consortium in order to develop the industrial CCS cluster in Teeside and the wider North East of England. As has been pointed out numerous times in the interviews, with both representatives from industry, academia and government, as

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[216] Chipman (2007).

[217] This competition makes available £1 billion in capital funding, together with additional operational funding through the UK Electricity Market Reforms, to support the design, construction and operation of the UK's first commercial-scale CCS projects.

[218] The other project, White Rose in North Yorkshire, involves capturing of CO_2 from a new super-efficient coal-fired power station at the Drax site, before transporting it in a saline rock formation in the North Sea.

[219] The FEED study is a two year programme of detailed engineering, planning and financial work to finalise and de-risk all aspects of the proposal ahead of taking the final investment decision, and proceeding to financial close and the commencement of construction (CCJ, 2013).

well as during various CCS-conferences, one of the key areas of focus, as it pertains to negotiations between the government and project developers, is during the permitting process, and trying to get the projects permitted as quickly as possible. As such, careful cooperation and coordination between the stakeholders, in particular between the industry and the government, is key for getting the projects permitted and CCS technology deployed.

Essentially, governance networks are effective when the full potential of the interdependency is used. In other words, when the government listens to the concerns of the industry, environmental groups and other stakeholders, whilst in turn supporting them, most often financially. As soon as relationships between actors become unproductive, such as was the case of the BP's Miller Oil Field example mentioned above, then governance networks become ineffective. When governance networks become ineffective, the development of CCS technology can be jeopardized. This has already been seen in light of the sigificant delays in the development of a commercial scale CCS projects.[220] Environental risks, for example, could be jeopardized if Such a claim, however, ventures into the extremes

5.3.3 A facilitating or impeding environment for CCS?

From practical experience thus far, governance of CCS, from the government's perspective can be seen as an on-going effort to improve the effectiveness of co-ordination and cooperation. By doing so, consensus building on the various aspects of CCS, such as uncertainties and risks related to CO_2 storage, is sought. In addition, it seeks to provide instruments for the aggregation of information and knowledge, which when pooled together helps in the qualifying of political decisions (Torfing, 2005) and for making informed, inclusive and evidence-based choices.

One could also make an argument for it being an example of proactive governance, in that the variety of actors seek to identify potential policy problems and opportunities at an early stage, and in this way also try to reduce the risk of implementation resistance later on. Governance in this respect can to an extent then also be characterised by separate, but loosely coupled links between government and individual actors or companies, and broader forums such as the UKCCSRC for example. These arenas are in a way linked primarily by communication, and perhaps

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[220] Examples of when CCS governance network proved to be ineffective include the abandonment of the Miller Field and Longannet projects in Scotland.

less so by resource dependencies, and/or control, and are also rather cognitive rather than strictly political (Balme and Jouve, 1996; in Benz and Eberlein, 1999). According to the governance network theory, the structure and the interactions can be characterized as being embedded in a wider framework which is based on trust building, learning and common understanding (Torfing, 2005: 307). While such a framework is characteristic of the CCS governance network in the UK, it does not necessarily lead to a facilitating environment for development and deployment of CCS[221].

Essentially, this means that given that these interactions between actors occur in a relatively institutionalized framework, or in an amalgam of contingent ideas, conceptions and rules as Torfing (2005) would describe it, the framework itself is shaped and reshaped in the course of action.[222] However, more importantly, in doing so, it also conditions future interaction among the network actors. In other words, if actors, in particular the industry or the project developers, perceive the framework to be conducive, it will facilitate the development and deployment of technologies, such as CCS. This perception, however, develops over time, and is conditioned by the

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[221] It is the physical, chemical and geological characteristics of a potential storage site that essentially determine its efficacy in trapping and retaining the injected CO_2 for long periods of time. This thesis sets out to examine whether or not the CCS governance network facilitates the development of CCS in the UK. So, what can the nature of the network and the policy-making process tell us about its ability to do so? Going briefly back to what was said in chapter two on methodology and theory, the driving force of explanation, or the independent variables (explananda) are not the network characteristics per se, but rather the characteristics of *components* in networks, as Dowding (1995) would agree. In other words, it is argued that the available resources, or their control, and/or specialist knowledge of certain actors, gives them a kind of ‘power’ over policy decisions, as well as lead to their inclusion in a ‘networkesque’ description of the policy-making process. In this case then, it is the components of the network - the actors and their interactions – as well as external forces and events (i.e. socio-economic conditions) – that explain both the nature of the network and the nature of the policy-making process (explanans). Based on the nature of the network and the policy-making process, assumptions can then be made about whether the network and the process produces a facilitating, or impeding environment for CCS.

[222] Negotiations, or the deliberations and bargaining, between the government and project developers in particular, as Torfing (2005) would argue, do not occur in an institutional vacuum. Rather, they occur in a wider framework, which is a product of contingent ideas, conceptions and rules (p. 308-310). This framework, in the context of CCS, has a regulative aspect, in that it provides the rules, specifies the roles and procedures, for example, to obtain a CO_2 storage lease or a permit, to undertake environmental impact assessments (EIA), conduct measurement and monitoring activities of the subsurface, etc. In addition, such a framework also has a cognitive element to it, in that it allows for the creation of concepts and specialized knowledge, such as for example in the increased understanding of the movement of CO_2 in the subsurface, and an imaginary aspect, in that it produces, or reaffirms, the ideologies and common hopes. In other words, the imaginary aspect refers to the reaffirmation of the belief that the speedy development and deployment of CCS is crucial if UK is to meet its decarbonisation targets, and ensure a secure supply of energy in the future. As can be said to be evident from the lessons learned from the failures of the first UK CCS competition, and progress made in the more recent Commercialisation Programme, this framework is also in a way shaped and reshaped in the course of action, and to an extent conditions the future interaction among network actors.

interactions. So, if through experience project developers, for example, come to believe that their interactions – deliberations and negotiations - with the government are fruitless, this will then condition whether the developers will either continue to commit to a particular project, delay it, or abandon it completely. A good example of such a case is the abandoment of the BP's Miller Field CCS project in 2007.

It appears as though the UK authorities are making an honest effort in trying to find the right solutions, and getting involved in the process of deliberation and negotiation (i.e. the FEED contracts with White Rose and Peterhead projects). While it is true that this has not always been an easy process, partially since the 2008 financial crisis, but also because of other points or issues on the Government's political agenda, some interviewees did in fact point out that not enough is being done.[223]

According to the governance network theory, the efficiency gains of governance networks are only fully realised in a well-functioning governance network. Things such as frequent change in the composition of network actors, the presence of unresolved tensions and/or conflicts, (perception of) weak and ineffective leadership, lack of clear and visible results, and external events that disturb the policy process, can destabilize the governance network, and venture it ineffective. For the most part, as discussed in sections above, the CCS governance network in the UK has thus far been functioning well, in that it involved a plethora of actors via a variety of mechanisms (i.e. formal and informal consultations) and relatively quickly produced a comprehensive legal and regulatory framework for CCS. However, it has also been 'destabilized' to a certain extent, evident by the slow negotiations between project developers and the government, as well as lack of a clear and visible long-term policy framework that would incentivise investment into CCS, and perhaps most heavily by the financial crisis, which severely put the brakes on the technology development. To this extent then, efficiency gains of the CCS governance network in the UK have not been realized.

Nevertheless, as mentioned, the network did succeed in other ways, in particular in regards to developing a robust legal and regulatory framework that will, in theory at least, ensure a safe geological storage of CO_2 and a long-term future for CCS.

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[223] The information about the views and perceptions on the functioning of UK authorities, as mentioned, was obtained by interviewing various stakeholders, from the academia, industry, and the Government as well. These were conducted in the period between June – December 2013.

Regulation, as mentioned, is one way in which the government can influence the development and deployment of technologies such as CCS. When the regulatory framework is introduced in a timely manner, it gives a clear sign to the investors and project developers, effectively reducing their investment risk. In this way, *regulation serves as a way to promote and enable development and deployment of CCS.*

While some aspects of the regulatory framework will be fairly familiar to the project developers, given that they have been to an extent developed based on the existing oil and gas regulatory regime, other aspects that are specific to CCS, will create uncertainty amongst project developers thus serving as a break on technology development and deployment. It is still too soon to make any assumptions or assessments about the effectiveness of the legal and regulatory framework in the UK, given that, as mentioned, as of February 2015, there are still no operational CCS projects. Without having operational projects in place, it is difficult to understand how various aspects of CCS projects can be better regulated, in order to make sure these projects are safe and all the health and environmental concerns are effectively addressed.

The purpose of the next section is not to look at the entire legal and regulatory framework for CCS, and CO_2 storage, in the UK. Rather, it is to identify and examine where the main regulatory uncertainties lie for project developers, and thereby, based on these uncertainties make an assumptions as to whether they serve as significant barriers, and as such whether the legal and regulatory framework impedes or promotes the development of CCS.

5.4 Outstanding regulatory issues

As mentioned, a clear regulatory framework is pertinent to facilitating the deployment of CCS technologies, in the UK and elsewhere, primarily because it allows the developers and investors to essentially quantify their exposure to investment risk. To date, evidence shows that for projects in Europe, the lack of clarity on certain regulatory provisions is inhibiting a faster deployment.

For high cost CCS projects to be developed, finance must somehow be sourced, and currently, funding is difficult to obtain – without direct government assistance. This is primarily because risks, their probability and consequences of occurrence, to a particular project must be identified and quantified in order to secure the necessary funding. In addition to the capital costs of construction, contingency sums and insurance costs to cover the various risks must be added to the overall budget, which will only become more conservative as the indeterminacy of risks will increase. Therefore, only when project developers are able to accurately quantify the risks and their exposure to them, will the CCS projects essentially start to emerge.

Based on such reasoning, this section thus aims to examine the current regulatory framework and identify which regulatory uncertainties, or provisions in particular, are still not providing the necessary confidence for the investors, and thus serve as potential barriers preventing a successful development and deployment of CCS in the UK. Three main challenges were chosen, following an extensive desk-based research exercise of documents as well as after consultations with a number of stakeholders from the academia, science community, the relevant authorities, and the industry, which identified these as key challenges that still need to be addressed. These three challenges relate to the transfer of responsibility, financial security and financial contribution, to be made during the permitting process and before the transfer of responsibility, respectively.

Transfer of responsibility, financial security and financial contribution, essentially fall right in the centre of the overall structure of the process of regulation in the area of CO_2 storage, and the concerns of this thesis. The environmental risks and uncertainties related to CO_2 essentially have to be eliminated or reduced as much as possible, so as to ensure the safety and the integrity of the storage site. If the competent authority believes this is not the case, no transfer of responsibility can occur between the project developer and the competent authority. Furthermore, if project developers cannot accurately quantify the risks and their exposure to them, it is very unlikely that they will proceed with plans to make the significant investments into the development of the project in the first place. As such, the three challenges of transfer of responsibility, financial security and contribution best encapsulate the underlying theme of this research, of managing environmental risks and development and deployment of the technology as a whole.

5.4.1 Transfer of responsibility

In the EU CCS Directive, Article 18 sets out the requirements that have to be met before key obligations (i.e. residual monitoring, corrective measures, and surrender of allowances in event of leakage) in regards to a storage site can be transferred from a storage operator to the competent authority. As mentioned, in the UK this is either the

Secretary of State or the Scottish Ministers, depending on the location of the storage site.

Before such a transfer can occur a number of conditions must be met, including that: i) all available evidence indicates that the stored CO_2 will be completely and permanently contained; ii) a minimum period of 20 years after closure of a site has elapsed, iii) financial obligation for contribution towards post-transfer costs has been fulfilled; and iv) the site has been sealed and all injection facilities removed. This provision of the CCS Directive is transposed into UK law by the Storage of Carbon Dioxide (Termination of Licenses) Regulations 2011. [224]

The key uncertainty in respect to this provision for the transfer of responsibility (section 8)[225] is the requirement to prove that CO_2 is permanently stored (section 8(a))[226] and that a minimum period of no less than 20 years has elapsed (section 7(2)) [227] unless the competent authority – the Secretary of State or the Scottish Ministers - is convinced that conditions about permanent containment have been met (section 7(3))[228], upon which transfer of can occur earlier.

A number of interviewees, for example, pointed out the unclear nature as to how the 20 years rule was determined. From my interviews with the relevant authorities in the UK[229] as well as with several project developers[230], it was found that most of them believe it to be *nothing more than a political compromise*. As such, uncertainty in regards to the situations when transfer of responsibility should occur before the 20-year period was expressed. In this respect, it was noted that the competent authorities are to an extent given too much authority or discretion in determining whether and when the transfer can occur, which then creates a level of uncertainty about the objectivity of the decision of either approving or denying a transfer. The implications of this 20-year rule then primarily extend to its impact on the monitoring and insuring costs for the project operators.

Essentially, the 20-year rule provided a timeframe throughout which the project operator remains responsible for any problems that might occur after the injection of

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[224] DECC (20110). *Storage of Carbon Dioxide (Termination of Licenses) Regulations 2011*. Available at: http://www.legislation.gov.uk/uksi/2011/1483/pdfs/uksi_20111483_en.pdf.

[225] Ibid.

[226] Ibid.

[227] Ibid.

[228] Ibid.

[229] Billson, M. Interviewed by: Maver, M. (October 17, 2013).

[230] Interviews with representatives from BP, National Grid, and Shell. All were conducted in the months between June to December 2013.

the CO_2 ceases. In other words, it is also at the same time about managing the risks of liability exposure for the relevant competent authority in a particular Member State where the storage site is located. Given that in the majority of the interviews in this research, it was pointed out that the 20-year provision, as mentioned above, was for the most part a political compromise, between the EU Commission and Member States, it could be said that this provision is an example of governance network theory in practice. At the same time, it points to the network's capacity to deal with situations of intrinsic uncertainty and decision-making under bounded rationality (Haas, 2004). Bounded rationality refers to the idea that when it comes to decision-making, rationality of individuals is limited by the available information, cognitive limitations and time. In this case, the policy makers who included the 20-year rule as a provision within the CCS Directive, acted as 'satisficers' who sought to arrive at a satisfactory solution, lacking the ability and resources to arrive at the optimal one. As shown by the responses from the industry, and other stakeholders including the academia, who largely believe that the 20-year rule is not necessary, the outcome was indeed not an optimal one.

In any case, given the principle of subsidiarity which the EU is governed by[231], as mentioned in the introduction of this chapter, which gives Member States the ability to regulate certain aspects of the CCS directive in greater detail, the, UK regulations have a somewhat wider scope of the permitted transfer of responsibility, as compared to what is stated in the EU CCS Directive. For example, they specifically include actual or contingent liability, as well as liabilities for personal injury, damage to property and economic loss (section 15(3)(b)),[232] which are not referred to in the CCS Directive.

Nevertheless, as of March 2015, the UK still lacks any clear criteria for when such a transfer of responsibility can occur. In other words, there are no conditions such as which evidence, or to what extent or detail, should be produced showing that CO_2 storage is permanently contained. This issue was also often brought up in a number of CCS-related conferences.

However, it is at the same time also widely acknowledged that, as demonstration and commercial-scale projects are deployed, and more information in regards to

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[231] Article 4 of the TEU.

[232] DECC (20110). *Storage of Carbon Dioxide (Termination of Licenses) Regulations 2011*. Available at: http://www.legislation.gov.uk/uksi/2011/1483/pdfs/uksi_20111483_en.pdf.

safety of storage is readily available, it is likely to lead to greater reassurance for the competent authority and their decisions to approve the transfer of responsibility. In other words, as more information becomes available, the extent to which the rationality of the decision makers (i.e. competent authority) is bounded will also be reduced, and as such, their decision as to whether to approve or deny the transfer of responsibility to occur would be more optimal.

5.4.2 Open-ended liability

The second identified issue that has the potential to serve as a barrier to development and deployment of CCS in the UK is the long-term and open-ended nature of financial liability. As mentioned, it is when project developers and investors are able to accurately quantify the risks and their exposure to them that CCS projects will start to develop; absent any substantial government subsidies. According to the CCS Directive there are essentially two types of financial requirements storage site operators. The first, relates to the financial security to be made during the permitting process, and second, to financial contribution to be made before the transfer of responsibility.

Financial security

It is stipulated in Article 19 of the CCS Directive, and transposed into law by way of the Storage of Carbon Dioxide (Licensing etc.) Regulations 2010, that project developers are required to have in place before injection (section 6(3)(i))[233], a financial security, which should cover all obligations related to the permitting of storage activities. Such financial security requirements include a charge over a bank account or any other asset, to deposit of money, performance bond or guarantee, an insurance policy, or a letter of credit.[234] The key identified concern is related to the uncertainty and the volatility of prices of EU emission unit allowances (EUAs) in the long run. Essentially, storage site operators have to surrender EUAs in case of any CO_2 leakage to the atmosphere. Given the unknown future price of EUAs, it means that the size of this liability is essentially open-ended. Also, because storage sites will be in operation anywhere from several years up to 20 or 30 years, compounded by the long post-closure period before the transfer of responsibility can occur, it is again

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[233] DECC (2010). *Storage of Carbon Dioxide (Licensing etc.) Regulations 2010*. Available at: http://www.legislation.gov.uk/uksi/2010/2221/pdfs/uksi_20102221_en.pdf.

[234] Ibid. - 1(3)(a-e)).

difficult for project developers to come up with the costs and model variation in prices of European emission allowances (EUAs)[235] and thereby quantify their investment risks.

In addition, another issue, related to the financial security provision, is the method with which the amount of financial security is to be calculated, as well as which activities it should cover. The UK regulations in this respect simply provide for the amount to be 'sufficient' to ensure that the obligations[236] of the operators are met[237]. In essence the way this provision was transposed into UK law is very similar to what has been written in the CCS Directive already. In the UK, there are currently no projects operational yet, and as such no practical experience exists with the above-mentioned issue. On the other hand, as can be seen in the case of the ROAD project in the Netherlands, which also has no specific regulations for calculating the amount of financial security, it is has been agreed between the project developers and the competent authority that the amount should cover the cost of monitoring, contingency monitoring, financial contribution and the cost of EUAs (in case of leakage). Though, in relation to the latter, the uncertainty in EUA prices was reported to remain an open issue.

Financial contribution

The second issue related to the financial obligations, as provisioned by the CCS Directive and subsequent UK Storage of Carbon Dioxide (Termination of Licenses) Regulations 2011, is the financial contribution under the financial mechanism. Article 20 of the CCS Directive essentially requires project proponents to set up a financial contribution (FC) to the competent authority, before transfer of responsibility, to cover at least the anticipated cost of monitoring for a period of 30 years. This contribution can also be used to cover any costs borne by the competent authority *after* the transfer of responsibility, so as to ensure that the stored CO_2 is permanently contained.

The challenge in this case, however, is in determining the degree of financial contribution to be made in order for the transfer of responsibility to occur. Otherwise,

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[235] An EUA is essentially a permit to emit one tonne of carbon under the EU Emissions Trading System.

[236] Ibid. Schedule 2 - 7(5). These include obligation arising under the storage permit, the obligation to pay the competent authority's costs, and any obligations of the operator arising under legislation implementing the EU ETS Directive.

[237] Ibid. - 7(1)(a).

if costs are not reasonably determined, an operator could potentially be liable for additional costs even after the transfer of responsibility occurs, given the discretion, or duty, awarded to the competent authority to recover costs borne as a result of cases where there has been fault on the part of the operator.[238] Examples of what would constitute fault on the side of the operator includes cases of deficient data, concealment of relevant information, negligence, or wilful deceit.[239] Questions can be raised, however, as to the objectivity of the competent authority's interpretation and use of these provisions to bring about recovery of any additional costs. Essentially, this means that under this approach, it makes it again difficult for the project developers to quantify their financial exposure, which could lead to further delay in the investment decision process.

Pursuant to these provisions then, financial contribution in the UK should cover any post-transfer costs and the costs for which authority would be liable for as a result of the transfer of responsibility. Here again, however, given the lack of any practical experience with actual CCS project, this issue remains to be evaluated and discussed in the future. Interestingly, as was pointed out by Diana Poputoaia from the Global CCS Institute,[240] in the case of the ROAD project in the Netherlands, for example, the project proponents and the competent authority that the financial contribution should cover only the cost of monitoring agreed it. While in Norway, in the case of Sleipner and Snohvit projects, the financial contribution depends on the specific conditions for storage site facility, and how much CO_2 is actually stored, thereby enabling potential calculation of costs. However, as Ms. Poputoaia pointed out, no financial contribution has thus far been asked for either of the two projects.

5.4 Discussion

The purpose of this chapter was to examine and evaluate the governance framework for CCS in the UK. Examining the historical and legal contexts, as well as the general (CCS) governance network, allows us to see that not only is CCS needed in order to deal with the issues of climate change and energy security, but in fact, the legal

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[238] Art. 18(7) of the EU CCS Directive.

[239] Storage of Carbon Dioxide (Termination of Licenses) Regulations 2011 – 16(1-3).

[240] In the Junior Professional Legal and Regulatory Tutorial Group (Session 3). Webinar held by the GCCSI on 25 March 2014. Slides available at: http://www.slideshare.net/globalccs/junior-professional-legal-and-regulatory-group-session-3-lecture-and-tutorial.

position of the UK in the climate change context, essentially requires CCS development.

Within the so-called CCS governance network, each of the actors possesses their own particular characteristics, such as relevant expertise or resources, with which they contribution to overall functioning and the nature of the network. The research argues, that the stability and interdependency between actors has allowed for the development of a strong legal and regulatory framework in place in the UK today.

As mentioned, when the governance network is considered to be well functioning, it will facilitate the development of CCS. However, in addition to providing the necessary incentives and funding for research and FEED studies for example, the role of the government in influencing the development and deployment of CCS is also seen through the regulatory framework. A well-judged, timely, and most importantly a clear regulatory framework can serve as an important enabler of the development of the technology; just as an incoherent, over-restrictive or too-broad of a framework, can serve as an impediment. As will be shown in greater detail in the next chapter, whilst the legal and regulatory framework in the UK is for the most part considered to be in place, it has not yet been road tested, and a number of uncertainties or issues remain. These included the issue of transfer of responsibility and the open-ended nature of liability.

It should also be noted here again, as research has shown, in relation to the legal and regulatory framework for CCS, the UK remains to a good extent influenced by developments at the EU level. Whereas some countries, such as the Netherlands for example, chose a path of literal transposition of the CCS Directive, the UK on the other hand went deeper on certain provisions, in particular as it relates to the permitting process. However, in this respect, permitting itself is not a major regulatory issue per se, albeit it can be argued that the process could be streamlined in some ways. The major challenges or concerns, relate to the mentioned transfer of responsibility issue and the 20-year rule, as well as the uncertainty about the amount of financial contribution to be made to the competent authority by the storage site operator, as well as the necessity, and again the lack of clarity in the amount of financial security to be in place before the injection commences.

Essentially applying to the entire EU, a potential solution in respect to the financial security issue could be for the EU Member States to agree on a ceiling and a floor price for the emissions unit allowances (EUAs), so as to provide a greater certainty for potential investors and storage site operators, giving them a better ability to quantify their financial risk exposure. This would lead to a better ability to secure financing and thus to the investment and development of CCS projects. Such a solution, however, may be interpreted also as a deviation from the polluter-pays-principle, whereby Member States would essentially agree to take on the risk of price per EUA, meaning polluters (i.e. CCS storage projects) would not be covering the entirety of the liabilities.

It appears then that the main identified challenges for CCS, from a legal and regulatory perspective are of financial, and not environmental nature. However, that is not to say that human and environmental risks of CO_2 storage are not taken seriously enough. This is what the following Chapter 6 attempts to address – how the industry perceives the environmental risks, along with the key uncertainties of the legal and regulatory frameworks.

Earlier, in Chapter 2 of this thesis, it was noted that this research has adopted a critical realist ontological perspective in that although risks of, for example, CO_2 escaping to the surface or leaking into the groundwater, are real, we cannot have a truly objective, or completely certain, knowledge of the world/risk. Rather, risk is seen 'as if' real, in that the meaning and the concept of risk are to an extent socially constructed. As Easton (2010) also describes it, "we behave as if it was true, as if the world was real." Given the lack of complete certainty then, dealing with the said risks becomes about how best to manage them, and the confidence, ability and effectiveness of those creating those risks (i.e. project developers).

Based on the literary research, and speaking with those involved in actual CCS project development, as well as other stakeholders from academia, the industry and the UK government, however, human and environmental risks related to CO_2 storage appear to be well understood, and can be effectively managed. As mentioned, Chapter 6 explores this notion further, by speaking to those directly involved in project development, as well as other stakeholders from the academia, research institutions and the UK government

In any case, what the above discussion has demonstrated is that, based on the analysis of the context for CCS, the governance network – its structure and functioning - regulations remain a key way by which development and deployment of CCS will be conditioned. Without clarification on certain provisions of the framework, development and deployment will be significantly delayed. However, perhaps even more importantly so than regulations themselves, is the need for support and involvement of the relevant public authorities. Only with close collaboration, can solutions be worked on, experience gained, and thus projects developed and deployed on time.

Lastly, it also demonstrates to the notion that the law essentially needs the operation of projects in order to work. Essentially, this is the nature of the policy and governance networks and the law. It is not simply about putting the laws in place. As data obtained from the interviews (see Chapter 6 below), and doctrinal analysis of legal scholarship, a perfect law cannot be put in place, before taking the risk. In other words, a law can never deal with the entire risk, essentially, because the risk is needed to generate the law in the first place. However, if there is too much risk, even the strictest legislation and regulations will not be sufficient to ensure environmentally safe operation, let alone not serve as an inhibitor to technology development and deployment.

CHAPTER 6: Regulatory perspective of the CCS Industry

"Living at risk is jumping off the cliff and building your wings on the way down."

– Ray Bradbury[241]

The only thing certain about capturing, transporting and storing CO_2 underground, is that there is an element of risk involved. By taking up a critical realist ontological perspective, this thesis argues, however, that we cannot have a truly 'objective' or certain knowledge of the world (i.e. of risk of CO_2 leakage). In other words, while there is indeed a probability of a CO_2 leak for example, or a seismic event, however small or large, it is impossible to know anything with complete certainty. Understanding and interpretation of risk, whether environmental, health and safety, property or financially related, is ultimately a subjective construction from ones own perspectives and experiences. As such, different constructs and interpretations are bound to exist.

Nevertheless, in the storage component of the CCS chain in particular we are not just 'building the wings on the way down'. The technological concepts behind this idea have been around for decades, so it could be said that the design for the 'wings' has already been built. However, today perhaps more so than ever, a sturdier 'framework' is required, to safeguard against any 'gusts of wind'. The legal and regulatory frameworks, whose primary objective is to minimize and manage the risks and liabilities of geological CO_2 storage, provide this safeguard. However, one will only 'jump off a cliff', if they have the confidence in the design of the wings, and the sturdiness of the framework.

As such, the purpose of this chapter is to examine the supporting legal and regulatory framework from the CCS industry's perspective. The objective is to find whether, or to what extent these in any way impede or enhance the development/deployment of CCS, in the European and UK contexts. It should be noted that the majority of the respondents, upon request, have agreed to have their

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[241] Obtained by searching quotes on 'Risk' on brainyquote.com. Available at: http://www.brainyquote.com/quotes/quotes/r/raybradbur102288.html.

names included in this thesis. This is done so as to give the reader a sense of the background of the responses and possible prejudices of each respondent. In some cases, however, respondents' names and companies were asked not to be included in the thesis.

The results and analysis that underpin this chapter are based on a qualitative study of documents and semi-structured interviews.[242] The responses have been coded into three main themes, based on which the chapter is constructed. First, the familiarity and perception of the legal and regulatory frameworks for CO_2 storage are examined, followed by the relevance and importance of monitoring and verification. Lastly, the impact of public perception and acceptance factor for the CCS industry is considered, before providing a concluding summary of the chapter.

6.1 Familiarity and perception of the legal and regulatory framework

> *"If you have ten thousand regulations you destroy all respect for the law."*
> - Winston Churchill[243]

Managing the risks and liability, as well as other issues related to climate change commitments, commercialization policy, financial responsibility, intellectual property, etc. in essence all serve as the drivers shaping the CCS legal and regulatory framework. On the one hand, while too little or loose regulation does not adequately manage the risks of a particular activity, in this case CO_2 storage, on the other hand, too much regulation, or one that is too stringent, does not necessarily lead to destroying all respect for the law, but can impede the industry's competitiveness, and development/deployment of CCS, by imposing costly and unnecessary regulatory burdens.

A central element of legal framework in the EU, and the UK, as examined in chapters 4 and 5, is the permitting regime. In addition, various closure and post-

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[242] While the majority of the interviews were conducted in the months from July to November 2013, some were also conducted later on up until August 2014. The respondents ranged across the wider stakeholder spectrum, however, majority of them were considered to be representatives of the CCS Industry in the UK. The nature of the CCS technology is such that the term CCS Industry, as mentioned in the chapter on methodology and theory (Chapter 2), is a fluid construct, encompassing a collection of companies directly involved in the development of specific CCS projects (i.e. National Grid, Shell, ScottishPower, etc). Questions asked were the same each time, but altered and probed for more information when necessary, so as to provoke a narrative and reflective considerations about the issues involved.

[243] Obtained by searching quotes on 'regulations' on brainyquote.com. Available at: http://www.brainyquote.com/quotes/quotes/w/winstonchu122577.html.

closure obligations, financial security, and transfer of responsibility criteria come to characterize the legal and regulatory system as a whole. When there is a lack of familiarity with any of these aspects of the regime, or when perception of them is negative, it can in turn impede the development of a particular project.

6.1.1 Managing environmental risks

In order to improve the conduct of risk management, which begins at the point of identifying a risk issue (i.e. CO_2 leakage), and goes through the cycle of debate, quantification, legislation and regulation, and finally monitoring, understanding the complexity of the task is essential (de Marchi and Ravetz, 1999: 744). As such, all interviewees were initially asked, what they believed the risks of CO_2 leakage to be and how best we can manage them.

Perhaps somewhat unsurprisingly, the respondents were nearly unanimous in the view that the *risks of a CO_2 leak from a storage reservoir were minimal*, with responses ranging from ‘very small’, ‘extremely small’, to ‘almost impossible’. It is important, as I have come to learn during a number of interviews, to be specific when discussing a risk of leakage. In this respect, it was pointed out that the CO_2 is more likely to come through an old injection or monitoring well, than through naturally occurring faults or pathways. However, as Mr. Cawley[244], CO_2 Project Resource Manager at BP Alternative Energy, was quick to point out in this regard as well:

> “The risk of well leakage is very small…it is a very small risk, but[245] it is a manageable risk. For example, we had a small leakage at one of the wells at a demonstration project, and that is only because it was an old appraisal well that was not completed/abandoned properly by the operator, and also the local people were stealing things off of the wellhead. During one of the routine surveillance passes, an operator could hear a ‘hissing’ noise, and they went to test it and found it was CO_2. What we did was, we suspended injection, worked the well over, at a cost of $3 million USD to cement the thing up from the reservoir right up. It is fine now! I believe, we estimated, that we lost only a

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[244] Cawley, S. Interviewed by: Maver, M. (August 5, 2013).

[245] Emphasis added to reflect the tone of the respondent, reflecting the acknowledgement of the notion of risk, but then continuing on to emphasize its manageability.

> couple of tonnes of CO_2. So all the kind of stuff is doable and manageable. At the end of the day it is just engineering, it is just money."[246]

Mr. Phillips[247], Technical Sage and Business Development Director at Pale Blue Dot Energy Limited, was also fairly optimistic when it came to discussing the risks of CO_2 storage, saying that they are "very manageable and leakage probably will not occur…but these need to be managed properly." When asked if this holds true for both an oil and gas reservoir as well as for the saline aquifers, the latter of which is less certain when it comes to monitoring and verifying the CO_2 plume, Phillips (2014) responded that:

> "it is much less easy to demonstrate that if your proposed target is purely an aquifer. There is nothing driving fluid through the barrier. You simply don't know, for example, where the shale over your formation will contain the CO_2 or not. As a result of that it is very difficult to prove that it won't leak. So, I think there is an issue around how you handle that uncertainty."

As the literature review (see Chapter 3) in this thesis has pointed out, the uncertainty of knowing where the CO_2 is underground is further exacerbated by issues arising in the capture and transport components of the CCS chain. These relate for example to CO_2 streams coming from multiple sources, which could in the end put in danger the integrity of the storage reservoir. To the question of whether CO_2 streams can be combined and if this creates any additional risks in terms of jeopardizing the integrity of a storage site, Mr. Reimink[248], Director of Safety, Technology and Environment at the World Steel Association, appeared confident enough, noting that:

> "Of course [streams can be combined]. Even though the composition of the CO_2 stream may be different given the different sources the type of capture technology or the emission producing industry, there is little difference in the gas composition between a 98% pure CO_2 stream or a slightly lower level of

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[246] I should note here that BP currently does not operate anything in Europe or in the UK in terms of CCS, but are involved with an aquifer test well recently drilled by the National Grid, at 'kind of arms length' through the Energy and Technology Insitute, and feed into various platforms such as the ZEP and the CCSA (Cawley, 2013). Having said that, BP had a major role to play in giving consultative advice to the European Commission about what regulations (at the EU level) should look like.

[247] Phillips, I. Interviewed by: Maver, M. (January 31, 2014).

[248] Reiminik, H. Interviewed by: Maver, M. (September 30, 2013).

> purity. The key item to remove is dust and chemicals; this should be taken as part of the capture process. The transportation pipelines can be made resilient to handle minor impurities, as are most intended storage sites. Depending on the chemical reactions of the gas it influences the inner surface of the pipeline or affect the storage site medium or rock formation. The technical capability to prevent this having a detrimental effect is minimal and can be mitigated in most situation as is the case now with many sour gasses. A check on the gas composition or potential compositions will enable the system to be designed, installed and used to deal with the situation."

In a follow-up question, Mr. Hill[249], Director of Carbon Solutions at British Petroleum, commented that as far as transportation is concerned, the industry is fairly comfortable that it knows enough about the technology to ensure safe CO_2 transport. Even when it comes to the storage of the CO_2, Mr. Hill (2013) notes that:

> "It is about location, location, location – it's all about site selection. If you pick the wrong sites, you might get risks that you will have to deal with and manage later. It's all about site selection and picking the right site and then monitoring that the way you expect that site to behave during CO_2 storage process is indeed how you predicted that."

So, from the responses noted above, and the general sense from other interviewees, the industry appears to be very confident in what it is doing, whilst acknowledging the existence of risk of a particular event, such as leakage from a storage reservoir. The apparent confidence expressed by the industry representatives was also to some extent echoed by academic experts. One of the most prominent academics in the field of CCS, Prof. Haszeldine,[250] professor of Sedimentary Geology and CCS at the University of Edinburgh in Scotland, for example, noted that "the risk of leakage with a well chosen site, that has gone past the regulatory process, is very limited".

However, despite the confidence expressed by both academics and the industry, on being presented with the view that there is almost nothing to worry about when it comes to CCS, and CO_2 storage, as one respondent from an environmental NGO

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[249] Hill, G. Interviewed by: Maver, M. (June 3, 2013).

[250] Haszeldine, S. Interviewed by: Maver, M. (August 7, 2013).

pointed out[251], “there is a lot of people who work on CCS, and it’s really easy to be biased about something if you care about it.” This research has tried to stay as un-biased as possible, however, it does on the other hand argue that legislation and regulations play a key role in mediating between the claims made on the side of the industry, academia, and the perceptions of the general public. In other words, the legal and regulatory frameworks serve to provide a neutral platform through which issues related to risk of geological CO_2 storage, and management of those risks, can be assessed, and managed.

Managing all the associated risks, however, is anything but easy. The need for an understanding of the essential complexity of the task at hand is thus crucial. Here, this research refers to the understanding and the perception of the legal and regulatory frameworks for managing the risk of CO_2 storage.

6.1.2 Managing legal and regulatory risks

It appears as though there is a general consensus amongst the CCS industry that the EU CCS Directive, as well as the regulations in the UK, for the most part does not serve as significant legal barriers to the development and deployment of the technology.

Perceptions and views on the legal and regulatory frameworks

When asked about their view of the legislation and regulation for CO_2 storage in Europe and in the UK, Mr. Phillips (2013) for example stated that while “there is nothing fundamental missing…the regulatory framework is absolutely there…what is not there is anybody that has road-tested that framework.” Similarly, it is the opinion of a representative from Shell,[252] that “overall, the regulatory framework as developed by the CCS Directive is robust enough, and provides the clarity to investors to build projects in Europe.”

A respondent[253] previously involved with a CCS project, yet still active in the CCS field ‘at arms length’, as they described it, on the other hand, was slightly more critical and noted that:

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[251] Interviewed by: Maver, M. (June 16, 2013).
[252] Bolscher et al. (2014).
[253] Interviewed by: Maver, M. (July 19, 2013).

> "There is considerable irritation that when the UK government implemented the EU CCS Directive, it created both a lease and a license requirement…and from an industry's perspective this simply creates a whole lot of extra bureaucracy which is just from our point of view a waste of time."

A similarly critical response was offered by a representative[254] that is currently involved with a CCS project in the UK, who admitted that the CCS Directive reads 'quite well', and that the issues is "in the interpretation…and the Guidance that has been written [being] frankly terrible." When asked why that is the case, they went on to explain:

> "[The CCS Guidance Documents] are too detailed. If you're a Minister in a country that has to transpose the Directive, and you go against the Guidance, then people will say 'well, why have you done that?' In my experience, Ministers and civil servants, and regulators, are very risk-averse, and that's understandable. But what it means then, is that if someone has written something down, they take account of absolutely everything written down. So, the more that is written down, the more constrained they are, and the less they are willing to allow people to try things out. And the harder it is to allow people to try new things, as you have to overcome something that someone has written down."

Given that the Guidance Documents are technically not legally binding, the above-mentioned industry representative was also asked whether they would still claim that the documents are too prescriptive, to which they responded: "I think so. I think it is overprescribed. Now, I know it's not official, and that it's just guidance, but the reality is that it has more power than just guidance."

In essence, the *power* that the interviewee is referring to is the power of legitimacy, from which no project developer would want to stray away from. Legitimacy, in this respect, is a powerful determinant for assurance to the regulators and the general public. However, when guidance is over-prescriptive, it can deter investors from making the final decision in a project.

The general feeling from the CCS industry, in regards to the perception of the

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[254] Interviewed by: Maver, M. (July 4, 2013).

current legal and regulatory frameworks, is that 'the framework is workable', as one respondent described it. However, despite some uncertainties, given that the UK has for the most part gone for a relatively literal transposition of the EU CCS Directive, the "industry is fairly comfortable with that…the key question mark is how some of these measures will be implemented in practice", as Mr. Warren, Chief Executive at the Carbon Capture and Storage Association (CCSA) pointed out.[255] In other words, it appears as though the industry is for the most part comfortable with the current frameworks in place, albeit some uncertainties (i.e. financial securities and CCR), and is waiting on more, or perhaps better said, clearer guidance, both from the UK government, and the European Commission.

Understanding the views and perceptions of those that the legal and regulatory frameworks are essentially written for – the industry - is important, as the identified issues and concerns can help in improving the frameworks in the future. This is particularly the case in light of the upcoming review of the CCS Directive at the end of 2015, and what makes this research current and valuable.

Perceived remaining barriers for CCS

While the industry seems to want greater clarity on some of the issues mentioned above, in particular in relation to financial securities, the EU CCS Directive, and subsequent UK regulations, do not seem to pose any fundamental barriers for CCS. When asked, for example, whether they believed that the EU legal framework, with the CCS Directive, and UK regulations have ensured that legal barriers for CCS deployment have been removed, and what issues remain Prof. Haszeldine (2013) noted that:

> "The main remaining issue, in particular for the industry, is that liability is still too open ended. Also, outstanding issues are still the London Convention main text, which does not permit the routine transfer of CO_2 across member state boundaries. This severely limits the deployment of CCS. States with high CO_2 emissions but no consented storage such as Germany are not able to use validated storage beneath the UK or Norwegian North Sea. Bi-lateral contracts can be made, but that is complex."

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[255] Warren, L. Interviewed by: Maver, M. (August 29, 2014).

Warren (2014) also suggests that the biggest concern is still the financial securities requirements, in the context of the UK legal and regulatory framework. Miligan (2014) on the other hand adds that another issue is also the potential overlap of the licensing regimes, between a CO_2 storage and petroleum development activities. On this note, the author suggests that this overlap could only become contentious when the activities are undertaken by different commercial entities that are unable or unwilling to establish a contractual relationship (p. 169).

When asked whether the current CCS permitting regime, which requires both a lease from the Crown Estate and a license from DECC, is perceived as a barrier, one respondent from the industry[256] sector noted that the current regime has certainly complicated matters. However, as they pointed out, it is not a barrier per se:

> "But something that adds an element of cost to the complexity. It is not a showstopper in any way. Both UK projects [Peterhead and White Rose] have gone through this process…but there is still the sense that they would have preferred to only have one entity to have to interact with. But, due to some quirky issues, set up 200 odd years ago, the framework is what it is."

It would be true to say that not all barriers have been removed, given that only one project in Europe (the ROAD CCS project in the Netherlands) has thus far received a permit for CO_2 storage. As Bolscher et al. (2014) point out in their report to the European Commission,[257] it appears that during the phase before a final investment decisions (FID) for moving ahead with the project is made, the requirements for technical specifications may be too high. It is thus particularly important to have the 'learning by doing' essence reflected in the storage regulations (p. 16). This, to a good extent is in fact reflective of the current state of regulations in the UK, and what is written in the EU CCS Directive.

Although several CCS industry respondents also noted that while the CCS Directive, and subsequent UK regulations are effective in regulating and allowing CCS, it could be argued that the challenge is not so much the European and UK legal frameworks, but rather the current economic conditions, and a lack of a sufficient

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[256] Interviewed by: Maver, M. (October 9, 2013).

[257] Bolscher et al. (2014). Available at: http://www.ccs-directive-evaluation.eu/assets/Uploads/CCS-Directive-evaluation-Interim-report.pdf.

policy framework and demonstration funding for early deployment. This means that the industry for the most part cannot see it economically justifiable to make an investment in a project, which requires significant upfront capital expenditures, and has uncertain operational costs in the future.

6.1.3 Removing the legal and regulatory barriers

Another question that was asked of all industry interviewees, was what, if any provisions in the CCS Directive, or UK regulations, need to, or should be, revised. The majority of the respondents suggested that it should be the Guidance Documents (GD), written in order to assist Member States with the transposition of the CCS Directive that should be given more attention to.

By revising Guidance Document 4, for example, which can be done by the EU Commission, the need to go through the European Parliament and be subject to the co-decision process, a requirement in the case of Directive revision, could be avoided. Any revision of the CCS Directive, or UK regulations for that matter, would also not necessarily help to provide confidence to investors and project developers, and thus not be advantageous for CCS. Warren (2014) proposes that instead, "the Directive is not revised at this point in time. It should be perhaps revised in 5,10, 20 years time if we make any progress in projects and we have real experience."

An industry representative[258] currently involved with a CCS project, notes that what is written in the guidance documents essentially means that:

> "One has to prove basically 100% that nothing has happened, or will happen...I think this is actually impractical. The industry view is that – providing Guidance Document 4 is not applied literally but that Member State Competent Authorities are given the latitude to apply the Directive according to their local circumstances - it is best to 'let sleeping dogs lie' and work with the current wording. Progress will be achieved through a pragmatic discussion between projects and regulators; however, making changes that could be misinterpreted by uninformed observers as being less than fully committed to permanent storage could lead to unfounded opposition."

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[258] Interviewed by: Maver, M. (October 9, 2013).

This relates back to what a number and variety of respondents, said about the issue of risk, and its management, in that a sense of risk, and uncertainty, will always exist. In other words, it is extremely difficult to prove a negative (i.e. no leakage).

A big issue for the industry, in this respect, is the contingent liability created by the inclusion of storage sites under the EU Emissions Trading Scheme (ETS). The CCS Directive stipulates that storage site operators will be required to surrender EUAs in a case of any seepage from a storage site to the atmosphere. The extent of this liability is essentially unquantifiable, which creates a major barrier for investors. A potential solution, as suggested by Warren (2014), is that the Commission should be clearer in the GD-4 that risks can be shared between the storage site operator and the relevant competent authority.

However, in essence, what the industry seems to have echoed was that the CCS Directive is relatively clear enough to offer sufficient confidence to the investors, and serve as a satisfactory framework for ensuring safe and secure geological storage of CO_2. The majority of the respondents, as mentioned, believe that there is no need to re-write the Directive itself, but rather review the Guidance Documents. The reason behind a lack of support for the revision of the Directive stems from the belief that at this point in time, with no commercial CCS projects in operation, doing so would only increase the regulatory risk and thus lead to potential additional delays – in a technology where investor confidence is still not well-developed.[259]

6.2 Importance of Monitoring and Verification

"There are known knowns. These are things we know that we know. There are known unknowns. That is to say, there are things that we know we don't know. But there are also unknown unknowns. There are things we don't know we don't know."
- Donald Rumsfeld[260]

Given the associated uncertainties and risks of permanent underground storage of CO_2, as mentioned, a robust regulatory framework is important. As this research argues, this framework is essential for mediating between the management of risks and the deployment of CCS technology.

In order to verify the amount and composition of CO_2 being injected, to understand how the CO_2 behaves once underground, to give early warnings if something goes

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[259] Bolscher et al. (2014). p. 77.

[260] Obtained from brainyquote.com. Available at: http://www.brainyquote.com/quotes/quotes/d/donaldrums148142.html.

wrong, to measure any leakage, and to provide assurance of long-term integrity of a storage site, the monitoring and verification process is also a key component. In other words, monitoring and verification is both about providing reassurance, and managing the risk.

The regulatory frameworks in the EU, and in the UK, are particularly emphatic on monitoring and verification, throughout the life cycle of a storage site, from characterization, operation, and closure and post-closure, to the period of handover of responsibilities to the relevant competent authority. The rationale for monitoring and verification are baseline studies, detection of any leakage, and flux emission quantification. In any case, monitoring and verification emerged as a major issue and extensive topic of discussion during the interviews. The next part presents some of the main views on the matter.

Proving the negative?

Relating Mr. Rumsfeld's quote above to the context of CO_2 storage, there are things that are known about the subsurface, largely from the experiences gained from the oil and gas exploration and extraction. For example, how to measure the CO_2 that is injected, and whether integrity of the storage reservoir is affected. However, the extent of CO_2 movement in a saline aquifer, or the possibility of a leakage event, can still be considered to be the so-called 'known unknowns'. Precisely because there will always be uncertainties and residual risks related to CO_2 storage, monitoring and verification is important for managing them.

Cawley (2013) for example, notes "there is always uncertainty in the subsurface which is why it is an expensive thing to do. You will never be 100% certain. Anything to do with subsurface is expensive, and anything with subsurface has risk attached to it. But it is a risk that you can manage." As a number of other respondents have also pointed out, saying that something can be measured with 100% accuracy would simply not be valid. It is also not a pragmatic point of view, as it is quite difficult to prove a negative - guaranteeing with 100% certainty that the CO_2 for example is exactly where it is supposed to be, or that there is no leakage happening anywhere. So why monitor and measure then, or, to what extent?

Essentially, the reasoning for and the extent of monitoring for a project, also comes down to the financial and business case of that project. For a project to receive financial benefits or incentives, such as under the UK £1 billion CCS Competition or the Electricity Market Reform (EMR), as an indirect benefit under the EU Emissions Trading Scheme (ETS) whereby EUAs are not required to be purchased[261], or for it is to be considered as a clean development mechanism (CDM) activity, the CO_2 has to be permanently stored, and accounted for. As such, the cost of measurement, and monitoring and verification, is always factored into the business case of a project.

One can essentially measure to the n^{th} degree, but that would most likely not be financially viable for a project. Rather than indefinite monitoring, what is needed is better and more efficient monitoring technologies that are effective, yet not expensive to the degree that would make a project unlikely to go ahead. Given also that the risk profile of every storage project will be different, the extent of monitoring and verification, and the use of particular techniques and technologies will also differ.

That being the case, if project operators are required to prove with 100% certainty that CO_2 is where they predicted it to be, that it is not leaking, or if they are required to use an extensive set of monitoring and verification methods and technologies, it could make it not practical for them to even get started with the project. As one interviewee[262] from National Grid answered to the question of what uncertainties lie in respect to monitoring and verification:

> "We can't monitor absolutely everything because it just won't be practical, and cost vs. benefits will not give us that much in return. I think the biggest uncertainty is not with the technologies, but rather with the regulations or what is required of the developers to prove that the regulator will be satisfied."

However, an interviewee[263] from the British Geological Survey (BGS) did point out for example that the development of monitoring and verification technologies was still:

> "Pretty basic at the moment. In some cases seismic monitoring could work but certainly the two projects [White Rose and Peterhead – only two currently in process of development in the UK] I've looked at, it wouldn't. You can do modelling in advance, but you're just not going to see it. So you are left with looking for esoteric new technologies."

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[261] EUAs are not required to be purchased since the CO_2 that is permanently stored is not considered emitted.

[262] Interviewed by: Maver, M. (October 24, 2013).

[263] Interviewed by: Maver, M. (September 12, 2013).

One of such new technologies for example is muon tomography, a technique/process currently being developed also at the University of Sheffield, which measures cosmic ray muons to generate three-dimensional images of volumes of CO_2 beneath the surface. As the respondent from the BGS pointed out in reference to this method, however, while "the idea is good…it is the practicality of it that is problematic." Practicality, in many ways then is inherently related to the financial commitments of the project developer, who are unlikely to use a particular technology if the costs are determined to be too high, and other technologies could be deployed instead and still meet the legal and regulatory requirements.

From the interviews with CCS industry representatives, as well as other stakeholders, it seems as though there is some difference in respect to the belief of the extent of development of sufficient monitoring and verification techniques and technologies, with the industry representatives appearing more certain in being able to accurately account for the injected CO_2. However, on that same issue, the interviewee from BGS did point out "while in terms of detection the development of [M&V] technologies is good, [he thinks that] when it comes to quantification [of the CO_2 from storage] it is still insufficient." Whereas detection refers to the means to detect any irregularity with the injected CO_2, quantification refers to the measurement of that irregularity. In this respect, monitoring and verification is linked to the legal and regulatory frameworks, and where the science, technology and law interact in many ways.

Legal and regulatory uncertainties

The detection vs. quantification debate, in relation to monitoring and verification, is evident in the legal and regulatory requirements. Whereas the EU CCS Directive (2009/31/EC) covers detection of CO_2 underground fairly extensively, as do the associated Guidance Documents, the EU ETS Directive covers quantification, or the accounting of the CO_2 in case of a seepage event. Seepage is referred to as any release of CO_2 to the atmosphere.

According to Article 13 of the CCS Directive, which focuses on the monitoring requirements, a particularly important part is the requirement that monitoring has to be based on a monitoring plan (Art. 13(2)) designed by the operator pursuant to the requirements laid down in Annex II of the Directive. This monitoring plan is then essentially also the basis on which the competent authority determines whether requirements for the transfer of responsibility have been met, following a certain period of time after the closure of the storage site. At present, the EU Directive and UK regulations require that after a storage site is closed, a minimum of 20 years must pass before the transfer of responsibility can occur. However, the regulations also state that this transfer can occur sooner, *if* the competent authority is satisfied that all available evidence indicates that the stored CO_2 will be completely and permanently contained. An interviewee[264] from BP summarizes the issue well:

> "You can imagine a site operator doing a certain amount of monitoring and then saying 'look we've done all these monitoring activities, but nothing has changed. We're not seeing any movement; all the CO_2 is staying there and is safe. Do we really have to go on and do all the remaining years? Even then in the regulations it says that the CO_2 has to be 'proven' permanently secured. But then, how do you interpret the word proven? How do you prove it?"

In this case, for the relevant competent authority, it will essentially come down to the conformity by the project operator with their monitoring plan, in addition to their meeting the financial security requirements, as stipulated in the CCS Directive and the UK regulations.

In the UK, the Department of Energy and Climate Change (DECC) has taken a practical view when it comes to monitoring and verification requirements, essentially by allowing developers to come up with a proposal that is consistent with the CCS Directive. However, as Warren (2014) pointed out, "it will be interesting to see how flexible DECC are on some of the elements and whether or not they are willing to shift somewhat on what the guidance documents say".

As mentioned, regulations for monitoring and verification also apply under the EU ETS Directive, which applies in the case that any leakage results in emissions or release to the atmosphere, or water column. In June 2010, the EU Commission agreed upon a set of monitoring and reporting guidelines for CCS[265], to which the BP interviewee went on to say:

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[264] Interviewed by: Maver, M. (June 3, 2013).

[265] EU, 2010. Commission Decision of 8 June 2010 amending Decision 2007/589/EC as regards the inclusion of Monitoring and Reporting Guidelines for greenhouse gas emissions from capture, transport and geological storage of carbon dioxide.

> "It is a lot of complicated stuff. The kind and level of calculations and measurements that one needs to do is extremely complex. In particular for meeting the uncertainty thresholds…the technologies today would find it difficult to meet those uncertainty calculations. Especially when done with EOR and how that percentage might be achieved are still unclear."

What these comments essentially come to suggest is that not only is there still uncertainty as to how certain provisions of the legal and regulatory requirements will be met, but perhaps more importantly, that there is the widespread belief among CCS industry that it will come down to the interpretation from the relevant competent authority as to whether those requirements have been met. In relation to the requirements for establishing and updating the monitoring plans,[266] a number of industry stakeholders believed that the criteria as stated are 'reasonably ok', however that the guidance, in particular GD-4, are too prescriptive on this issue.

However, as prof. Haszeldine (2013)[267] noted in this respect, "guidance can be interpreted and can be changed and adapted over time." Yet, a number of other industry stakeholders still believed that the monitoring and verification requirements placed on the project developers are 'very onerous'.

An interviewee[268], currently involved with the Peterhead CCS project in Scotland, also stated that "while regulations are well understood, and we know what the requirements are for site characterisation and development - so we know who to go to for permitting and such, and what various other provisions require - a key uncertainty for project developers is still with what happens during handover time."

Will DECC be enforcing the 20-year minimum period requirement, or will it take an approach that is based more on the performance of the storage site? Essentially, it will come down to negotiation between the project operator and the competent authority, as to determining whether all the criteria for transfer have been met.

6.3 The public factor and its influence on industry behaviour

In addition to the understanding and perception of the legal and regulatory requirements, and the importance and role of monitoring and verification, a third

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[266] Art. 13(2) of CCS Directive.

[267] Haszeldine, S. Interviewed by: Maver, M. (August 7, 2013).

[268] Interviewed by: Maver, M. (March 20, 2014).

identified major theme during the interviews was the influence of the public factor on project development, and as such has been included in this thesis. Questions in this regard revolved around the risk of public perception and opposition to a particular project, as well as of the risks not directly related to the project itself but rather to a broader ‘image’ of the company.

Indirect risks

For companies involved with a project anywhere along the CCS chain, from capture, to transport and in particular storage, the purpose conducting public consultations and in doing extensive monitoring and verification, is to also manage the risks that are indirect to the project itself. As one industry respondent[269] pointed out, this relates to mainly the impact on the brand and on share prices. As he describes:

> “Lets stay for example if 25% of your large scale investors are these ethical investors, they may question investment in your company because you’re not being transparent. So there are other risks that are not directly related to the project, but are risks nonetheless. Something quite small might cause a ripple effect and become quite significant. And the ripples can be whipped up by NGOs if they caught on to something…they are skilful in making something seem more alarming.”

In other words, there is a lot of extrinsic brand value at stake for the company involved with a particular project. As an example, another respondent also pointed out, that such extrinsic values:

> “Are a big deal for [the companies]. So consequently, for example, when they injected out of zone at Snøhvit[270] and NGOs found about it, they stayed quiet and got burned really badly. They’ve sorted it out now, and there’s no problem, but they are very conscious of the fact that stuff was discovered and they didn’t come clean about it quick enough, so now they are very keen on transparency.”

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[269] Interviewed by: Maver, M. (May 5, 2014).

[270] Snøhvit is a liquefied natural gas (LNG) development in the Barents Sea, off the coast of Norway, which employs a monitoring and verification programme in order to investigate the behaviour of CO_2 underground. For more on the project see: http://www.globalccsinstitute.com/project/snøhvit-co2-injection.

Transparency, trust, and engagement were the three main concepts that continuously emerged throughout the interviews, when talking about risk and public perception. A number of events such as what happened in the case of Snøhvit, or in Barendrecht in particular, have essentially brought CCS more into the public domain.

Public perception risk

When asked about any remaining risks for CCS deployment apart from lack of commercial incentives, Mr. Reimink[271] for example responded that:

> "One of the big risks of acceptance is lack of public and political awareness and acceptability. You see similar issues for example with fracking. It is more about ensuring that anyone has the ability to access accurate and correct information rather than short media announcements which do not provide the full story or provide adequate information for the public to judge they need all the information to be able to understand that the tests and many projects have been safely and professionally implemented."

Whilst Reimink (2013) brings up an interesting point in that the perception of the public, or perhaps better said, the trust of the public in a company, is a determining factor as to whether a CCS project will be accepted or not, a majority of the respondents, including within the CCS industry, agreed that the major driver for public acceptance or opposition of CCS, is primarily still based on the cost-benefit analysis of a particular individual or a community as a whole. In other words, whether the public will believe that the project would lead to more benefits as opposed to costs, or vice-versa.

Looking at the current situation in regards to public opposition and acceptance of CCS in general, and of CO_2 storage, across Europe, the picture is different between each of the EU Member States. In the Netherlands and Germany for example, public opposition is believed to be a much greater of an issue as compared to in the UK, where CO_2 storage has not, and is unlikely to become a major issue. In this respect, Prof. Haszeldine (2013) notes "the UK took a wise decision to not go for on-shore storage, which has resulted in very little mobilized public concern over this [in that country]." Although, even in the UK, issues around on-shore pipelines or construction

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[271] Reiminik, H. Interviewed by: Maver, M. (September 30, 2013).

of large facilities could become concerns for local communities and thus lead to some amount of public opposition. As Warren (2014) points out during the interview, however, "there does not seem to be any concerted opposition…but one can never take things for granted."

Things can never be taken for granted, as evidenced in the cancelation of the Barendrecht CCS project for example, where poor or lack of communication from the side of the project developer mobilized the general public which in turn proved to be a powerful determinant in the project being delayed, and ultimately cancelled. For fear of public opposition, CO_2 storage is thus very likely to only occur offshore (Cawley, 2013). As an interesting comparison, another person interviewed was Ms. Forbes[272], a senior associate at the World Resources Institute in the United States. She notes that:

> "In the US, there is concern about the off-shore in a way that it is for all off-shore activities – off-shore wind, off-shore gas, etc. It is different than the European perspective. I think in the US you will see public opposition for offshore, just because it is offshore. I think it is a fascinating difference."

Ms. Forbes (2013) indeed brings up an interesting point, in that in terms of public opposition, a lot of it depends also on the previous experiences of a community near a particular project. For example, whether the community is used to the infrastructure in place in their area, would certainly play a role as to the likelihood of acceptance of a new project developing there. However, if an area does not have a history of other projects going on such as natural gas exploration or mining for example, one industry representative[273] noted that:

> "It is not so much about what people themselves think, but more about what others think. So of course I would object, because it might lower the price of my house by 30,000 or whatever. That's what people are worried about."

So, when asked how to prevent significant public opposition, both for the people living around a particular project, and for the wider public, the responses from the industry and other stakeholders were nearly unanimous. The majority of them related to the importance of public engagement and communication, and early efforts of

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[272] Forbes, S. Interviewed by: Maver M. (August 15, 2013).

[273] Interviewed by: Maver, M. (June 7, 2014).

doing so as being a critical factor in determining whether opposition will arise, or to what extent. As was evident in the Barendrecht project in the Netherlands, the project was ultimately abandoned precisely because of the lack of effective public engagement.

Framing CCS projects

It is important for CCS project to also be framed appropriately. In contextualising CCS, consideration has to be given to all perceptual positions, and not simply focus on CCS as a climate change mitigation tool. Given that perceptions on climate change differ from belief to scepticism and denialism, project developers must provide rationality for the local community where the project fits in, as well as where it fits in the national context.

However, the local context is particularly important to project developers, who need to take careful account of all potentially impacted communities, both in terms of the social, cultural, economic and political characteristics. This involves making sure there is sufficient background knowledge and awareness of the needs of the communities, and to minimise any false expectations or misunderstandings. Related to comments made above on the importance of monitoring and verification, Gardiner Hill (2013) adds that such information (on M&V) needs to be shared not only with other companies, but be communicated to the public as well.

Engaging with the public

The key goal of the legal and regulatory frameworks, and the efforts behind extensive monitoring and verification, is essentially to provide reassurance to the investors, regulators and the general public as well. As identified by all the respondents, the effort to emphasize the benefits that a project will bring to the community, as well as to the wider country-level scale, is crucial. One industry respondent,[274] for example, on this note pointed out that “most importantly, it is for a project developer to keep in mind not only what information is being communicated, but also how this is done, and by whom. The public is very susceptible and can quickly mobilize around a particular issue.”

The Peterhead CCS Project for example, as part of their public consultation efforts, recently included a series of exhibitions[275] in the communities closest to the proposed

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[274] Interviewed by: Maver, M. (June 7, 2014).

[275] These were held in Boddam, Peterhead and Cruden Bay, Fraserburgh and Aberdeen, and according to Shell, over 500 were in attendance.

project, as well as a number of other public events, including offering tours of the Peterhead Power Station. The purpose behind these consultation efforts is to "provide local communities with an update on how [their] design work is progressing, to respond to feedback received during Phase 1 and to listen to further feedback on [their] plans as they currently stand" (Shell, 2015).

There are a number of ways in which project developers can engage and communicate with a community, however, as research has shown, and as Dr. Esposito from Southern Company[276] suggested, "most successful ways are often the ones that embrace a meaningful dialogue and offer a two-way street of communication. Openness, transparency, and trust are key here." Trust, in particular, is a key theme that emerged during my conversations across the stakeholder spectrum. When organisations, or companies, identify themselves with the 'affected' communities, and that their messages and information are seen as trusted and reliable, it goes a long way in building up the level of approval necessary to develop a project. It also serves to deal with issues related to perceptions of risks related to CCS.

Recognizing individual risk perceptions and tailoring the responses are an essential component. In other words, if risk perceptions are high, some flexibility in project planning, which allows the general public to influence the outcome in some capacity, can actually be helpful in minimizing those risk perceptions. This holds true not only for CCS projects, but has been the case with other analogues such as nuclear or hydraulic fracturing.

Lastly, in relation to governance and the public factor, clearly defined processes for all stakeholders to get involved, or provide some input into project decisions, will ensure a wider acceptance, thereby reducing the risk of any opposition arising and thus allow the project to move forward. Following the CCS Directive's approach, the UK CCS regulations are silent on public participation in the decision-making concerning CCS projects, as this aspect will be addressed in the context of the Environmental Impact Assessment (EIA) and Integrated Pollution Prevention and Control (IPPC) regulations. At the EU level, the only requirement is that MS should make available to the public environmental information relating to the geological storage of CO_2[277], prescribing the information to be included in the public register

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[276] Esposito, R. Interviewed by: Maver, M. (June 2014).

[277] Article 26 of the EU CCS Directive, transposed in UK's Storage of CO_2 (Licensing etc) Regulations 2010, by section 9.

(i.e. about storage licenses and permits, about storage sites both before and after site closure, etc.).

While there is no specific requirements stating that project developers should engage with the public, it is noted in the EU Directive that it is important in CCS demonstration that public awareness measures are also done, so as to enhance public confidence and deter opposition, which could set back development and deployment. As such, even though the general public might not have had any ‘voice’ in the development of the legal and regulatory frameworks, the public factor still plays an important role in the overall governance process, and in potentially determining the outcome of a particular project.

6.4 Discussion

“*Any goal worth achieving involves an element of risk.*”
-Dean Karnazes[278]

When talking about CCS, and in particular when it comes to the storage component, one of the central emerging themes is most often the management of risk. However, depending on who is being spoken to, the definition, or the context of risk, is inherently different – i.e. financial, regulatory, health & safety, environment. While this research is mainly concerned on regulatory and environmental risks, this chapter was primarily focused on the element of risk form the perspective of the CCS industry and what that represents. It would be hard to argue which type of risk is prevalent amongst the CCS industry, as all risks are invariably related. However, to some extent financial risks appeared to have been a recurring topic in the interviews, thus, it could be said that these remain prevalent to the industry representatives. Nevertheless, that is not to detract form the fact that environmental and health and safety risks are taken extremely serious and are being dealt with by project developers.

From the conducted interviews, three subjects of discussion were particularly prevalent, thus they formed the structure of this chapter as well. These included: i) the familiarity with the legal and regulatory frameworks for CO_2 storage; ii) the importance of monitoring and verification; and iii) the influence of the public factor.

In relation to the familiarity with the legal and regulatory frameworks for CO_2 storage, both in the European and UK contexts, the respondents seemed fairly

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[278] Obtained on brainyquote.com. Available at: http://www.brainyquote.com/quotes/quotes/d/deankarnaz523683.html.

confident that they understand the content of the relevant Directives, and subsequent UK regulations. For the most part, the frameworks were considered to be sufficiently robust, however, some pointed to a number of provisions, in particular Articles 18-20 of the CCS Directive, relating to transfer of responsibility and financial security and mechanism requirements, that should be made clearer, when the Directive comes under review in 2015. In addition, the CCS industry respondents were particularly confident when it came to questions relating to the management of storage risks, whilst at the same time, unanimously acknowledging that there are still various uncertainties, however, that these can be managed.

The second theme concerned the importance of monitoring and verification. Questions in this respect related to its importance to managing risks, its inclusion in the regulatory frameworks, and the extent of the development of various technologies and techniques. As mentioned earlier, all conversations revolved essentially around the management of risk, and the unanimous acknowledgement from the CCS industry of the existence of uncertainty when it comes to CO_2 storage. Respondents emphasized that no amount of monitoring and verification will be sufficient to prove anything with a 100% certainty, and therefore much will depend on the interpretation on the side of the regulators as to whether legal and regulatory provisions are being complied with. As such, regulations, and the regulators themselves will need to take the best-available-technologies approach when doing so.

As far as the current status of the development of monitoring technologies and various techniques is concerned, there was a general consensus that current technologies are sufficient for detection and monitoring of the CO_2 underground to a ‘reasonable degree of certainty’. Two respondents also said that the biggest uncertainty remains the ability to effectively quantify/account for any fugitive emissions from the storage reservoirs, and suggested that this will be particular important in regulatory terms under the EU ETS Directive, which applies in the case that any leakage results in emissions or release to the atmosphere, or the water column. How to meet the uncertainty thresholds, as stated in the Guidance Documents, was identified as needing more clarification in the upcoming Directive review. Nevertheless, while respondents believed that monitoring and verification has gotten a lot better over the years, and that new technologies and techniques are being developed, the key issue/challenge remains the need to develop and demonstrate low-cost and sensitive CO_2 monitoring technologies, and to be practical and pragmatic in their application.

Lastly, the influence of the public factor on the behaviour of the CCS industry was discussed. Questions in this respect related to how the respondents perceive the issue, and how they believed it has affected their practice. Not surprisingly, there is near unanimity again in respect to the importance of public perception and acceptance/opposition, when considering the development of CCS projects, in particular when talking about underground storage components. A number of respondents pointed out that the UK was smart in this respect in going for only off-shore storage, and that is why there has been little to no public opposition thus far. When asked how the public factor (i.e. perception, acceptance/opposition) affects the practice of the CCS industry, majority of the respondents noted that previous events, such as cancelation of the Barendrecht CCS project in the Netherlands, have increased the extent to which the project developers have engaged with the general public. Early engagement, effective communication, transparency, and trust, were identified as key issues to building reassurance, and in that way managing the risk of public factor significantly impacting the development of a particular project.

In sum, based on the conducted interviews, a number of important conclusions about governance and management of risks of CO_2 storage can be reached. First, the perception of the appropriateness and the good understanding of the legal and regulatory frameworks – in the EU and the UK respectively – show to the relatively effective cooperation and coordination, not only between the government/EU and the industry, but across the wider spectrum of other stakeholders as well. [279] Second, as the data has also shown, it is impossible to have a perfect law in place before taking some level of risk. Therefore, development and deployment of the technology and the management of environmental risks requires a continuous process of information gathering, monitoring and verification, and cooperation between a wide range of stakeholders. As such, this notion also addresses the research questions of this study, in that the regulation has to-date managed to mediate between the management of environmental risks related to CO_2 storage and the deployment of CCS technology in Europe. A more in-depth discussion and analysis of these implications are provided in the concluding chapter below.

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[279] Conclusion arrived from document analysis and doctrinal legal scholarship, and by speaking with the variety of key stakeholders considered the leaders in the CCS field in their respective disciplines.

CHAPTER 7: CONCLUSION AND DISCUSSION

This chapter sets out to offer the main conclusions and findings of this study, through which the main research question, have been answered. First, a brief reflection is offered on the choices made about the theory and analytic categories used in this research. This is followed by a summary and discussion of the key findings. As a reminder to the reader, these were the main research question, and two sub-questions, with associated objectives, which guided this study:

To what extent does the current legal and regulatory regime for CO_2 storage in Europe mediate between the governance and development of CCS technology?

Sub-question #1: **what is the nature of the CCS governance regime in Europe?**

- Identify key characteristics and debates surrounding risks and uncertainties related to CO_2 storage, with focus on the need for and role of monitoring and verification.
- Analyse the use of precaution in the legal and regulatory regimes; and its role in seeking to mediate between technological development and governance
- Undertake an analytical review of the governance process, and the relevant legal and regulatory frameworks for CCS (in Europe and the UK).
- Discuss whether the current legal and regulatory frameworks effectively manage the environmental risks of CO_2 storage.

Sub-question #2: **(how) do the regulatory framework and the public factor impact the CCS industry?**

- Identify key remaining legal and regulatory challenges and barriers for CCS: as perceived by the CCS industry.
- Discuss how the public factor has impacted the CCS industry.

"*All courses of action are risky, so prudence is not in avoiding danger (it's impossible), but calculating risk and acting decisively.*"
– Niccolo Machiavelli[280]

Science is a continuous process of changes and advances in knowledge, and to some degree holds a level of authority in our culture. However, as has been the case in the past with emerging technologies, such as nuclear, and more recently with CCS, science can be laden with a degree of uncertainty, and inherently also risk. Environmental and scientific risks, with them in turn then also carry and create other types of risk, such as political and/or financial. The primary concern of this thesis has been the environmental risks, and their management.

Based on the epistemological and ontological ideals employed, the environmental risks associated with CO_2 storage, such as leakage or a seismic event for example, are seen 'as if' real[281]. In other words, this means that because of unattainability of a 100% certainty when it comes to knowing the location of the CO_2 underground for example, and due to the existence of varying interpretations and perceptions[282] of the concept, there cannot be a single correct or objective understanding and representation of the world/reality. There is also no empirical test to determine which view is right.

While Chapter 3 in this thesis examined the literature on CCS, and its gaps, Chapters 4 and 5 analysed the governance of CO_2 storage in the EU and UK jurisdictions, respectively. From these observations, chapter 6 then examined the perception, understanding and impacts on the CCS industry in the UK. In this chapter then, the discussions from Chapters 4, 5 and 6 are brought together, and the implications of the observations and findings and their effect on the future of CCS are discussed.

7.1 Reflection on the theory and the analytical choices made

While the adopted philosophical approach was that of critical realism, the key underpinning theory of this research was the governance network theory, supported

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[280] Obtained on goodreads.com. Available at: http://www.goodreads.com/quotes/148562-all-courses-of-action-are-risky-so-prudence-is-not.

[281] Real in a sense that they exist independently of our perceptions, theories and construction, and that such an event is possible.

[282] Risk perception is defined as a subjective judgment people make about the severity and probability of risk. This perception varies between stakeholders, in particular between the industry, policy and decision makers, and the general public.

by the theory of bounded rationality. The first part of this chapter, as mentioned, is intended to provide some personal reflection on the theory and the analytical choices made throughout this research and the thesis.

7.1.1 Governance network theory and bounded rationality

The intention behind using the governance network theory was essentially to provide for an organizing framework through which the complex reality of collective policy and decision making in regards to carbon capture and storage (CCS) can be examined. This process of policy and decision-making occurs in a setting where there is a variety of actors and organisations are to an extent mutually interdependent, on material/immaterial resources, and guided by a common goal – to develop and deploy CCS. A key predisposition in using this theory and argument within this research, is that governance networks are an effective and efficient setting in which environmental risks of CO_2 storage can be managed, and the CCS technology itself can be managed. In other words, the goal of this research is to examine the extent to which environmental risks are dealt with and managed through joint action and interaction. The value of using the governance network theory lies in that it considers both the macro- and micro-elements of governance, or the external influences (i.e. economic crisis, politics, etc.) and the interactions between the individual actors within a network.

In hoping to add to the analysis of the micro-elements of governance, the thesis sought to add elements of the bounded rationality theory, which is in the literature still primarily used in the field of economics to interpret consumer and business behaviour, and sits in contrast to the rational choice theory. Bounded rationality is essentially the study of how individuals and businesses make decisions in an uncertain world, when optimisation is out of reach. The key premise of the bounded rationality theory then, is that actors are limited by things such as their cognitive ability, contextual factors, availability of information, resources and/or time, and as such what they would constitute an optimal outcome is out of reach, making them utility satisfier as opposed to maximisers. This means that the guiding force of behaviour is that which will lead to a satisfying outcome of a particular actor. For the CCS industry, for example, this would mean a policy framework, which would incentivise investments into CCS. It would also mean, not necessarily a non-restrictive legal and regulatory framework, but one, which does not leave many barriers to overcome. As this research found, apart from uncertainty on several provisions, which as the industry has echoed are likely to be ironed out as technology development moves forward, the legal and regulatory frameworks can be described as a satisfying outcome – for the industry, and other stakeholders as well.

Overall, I believe that the governance network theory served the goals of this research well. First, it helped identify the key actors and pathways of interactions between them, which led to the development of the legal and regulatory framework for CCS in Europe. Second, it emphasised the importance of resource and capacity sharing between these actors in managing the environmental risks and uncertainties, and in getting CCS technology developed and deployed. Third, on a broader level, it allowed for the examination of the intersection between environment, law and technology in the context of CCS. The overall aim of using the governance network theory was not a causal analysis of governance of CCS and CO_2 storage, but rather, as mentioned, to provide for an organising framework through which a complex reality can be presented. To this extent, I believe the thesis has managed to achieve its goal.

On the other hand, although bounded rationality theory was never intended to serve as a ‘core’ component of the thesis, its utilisation did not work to the extent that I had hoped for at the commencement of this project. In a way, rather than a theory per se, it would have been better to refer to bounded rationality as a concept, which served to complement the governance network theory, as opposed to a theory in itself. To that end, the utilisation of the concept of bounded rationality as a theory was not successful. Nevertheless, bounded rationality theory leaves open an interesting area of further research in regards to CCS.

7.1.2 Critical realism

A critical realist perspective was adopted as an overarching, or ontological stance, in this research. The key underlying assumption of critical realism lies in that an objectively based reality is impossible. It is only partially pre-existent, in that the risks associated with CO_2 storage are real, and also partly socially constructed. In other words, within the scope of this thesis, the belief is that a purely empirically based truth about the risks of CO_2 storage is unattainable, and that risks of CO_2 storage have different meanings to different actors. For some, the predominant concern is the environmental risks, such as leakage out of a storage reservoir, earthquakes, contamination of groundwater, etc. For others, it is the financial and liability risks. This was the premise from which this research set out.

However, as the research progressed, and after speaking to a variety of stakeholders, including the industry, government and academia, there was almost an attempt at appeasement coming both from the literature and the stakeholders themselves in regards to environmental concerns. In other words, despite the recognized existence of uncertainties and risks associated with CO_2 storage, key 'risk' and 'uncertainty' discussions in the end always turned about policy and financing. This was perhaps one of the main surprises, that the ability to manage the environmental risks and uncertainties associated with CO_2 storage received such a large consensus among stakeholders. In a way, critical realism therefore combines the philosophy both about the natural and the social worlds.

In epistemological terms, knowledge is considered to come from human experience, and as such, adopting a critical realist perspective meant that as a researcher, I had to be in the place of inquiry, and listen and talk to the right people, and extract data through interviews and observation. In other words, the philosophical stance adopted also dictated my research design and methods used.

Overall, I believe the critical realism perspective is, as mentioned, well placed to examine and analyse the key underlying concern of this research, the management of environmental risks of CO_2 storage in Europe. In particular, it argues that the legal and regulatory frameworks for CO2 storage (i.e. the CCS Directive and UK Regulations) are the medium through which the complex realities are encompassed. It then examines, whether this medium is effective in managing environmental risks, whilst allowing for the development and deployment of CCS technology in Europe.

7.2 Summary and discussion of key findings

7.2.1 Dealing with the Uncertainty Challenge

Ralph Waldo Emerson, an American writer, once noted that "knowledge is the antidote to fear."[283] Placing this quote in the context of CCS is not too difficult. The main concerns, or fears, for example, relate to the stored CO_2 escaping to the atmosphere, or seismic events, to the extent that the resulting impacts are devastating.

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[283] Obtained from inspirationalquotes.com. Available at: http://www.inspirationalstories.com/quotes/ralph-waldo-emerson-knowledge-is-an-antidote-to-fear/.

These fears and concerns are essentially grounded in the existence of scientific/environmental uncertainties associated with the process itself. Although CO_2 injection has been used in the United States for decades for the purpose of enhanced oil recovery (EOR), the idea of permanently storing the CO_2 is relatively new; despite significant progress made in the past decade or so. By progress, I refer to proving, or perhaps better said, demonstrating, that there is great confidence in CO_2 storage. Development of various monitoring and verification techniques and technologies for measuring and tracking the CO_2 plume underground has played a key role in this respect.

As has been discovered through interviews with various stakeholders, discussed in Chapter 6, in particular those from the CCS industry, even though knowledge of what happens once CO_2 is stored underground has greatly increased, it is still impossible to predict with a 100% accuracy for example, where the CO_2 plume is, when, if ever, it will leak to the surface, or at least migrate outside the predicted boundaries.

The largest scientific challenge, linked to technologies such as CCS, has turned out to be how to best reduce these scientific uncertainties, and anticipate and prevent harm from unexpected events. Effects of leakage over a longer period of time remain one of the key uncertainties. In general words, the existence of scientific uncertainty predisposes any development and deployment of technologies such as CCS to a certain level of risk. Management of those risks then becomes a central concern for the policy and decision-makers as well.

How much uncertainty and risk is acceptable?

From a scientific point of view, estimating the likely and acceptable CO_2 leakage rates has in the literature primarily been quantitatively focused, with estimates ranging from 0.01% to 1% per annum[284] of total injected CO_2 into a particular storage reservoir or aquifer. Most studies would agree that even if small percentages of CO_2 does in fact escape from the storage reservoir back into the atmosphere, or move laterally past its boundaries, this would not jeopardize the effectiveness of CCS/geologic CO_2 storage as an effective climate change mitigation strategy (IEA, 2013). It is also important to note that there is significantly better understanding of depleted oil and gas reservoirs, due to past experience with oil exploration and

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[284] See for example Chow et al. (2003), Hepple and Benson (2004), Farcas and Woods (2009).

extraction, as compared to the other option for CO_2 storage, the saline aquifers, which offer greater overall storage capacity.

On the other hand, from an industrial perspective, economic challenges and uncertainty are primarily related to investment into capture technologies, which constitute up to 80% of the total CCS-chain (capture, transport, storage) cost.[285] In some industrial sectors, such as cement production, chemical industry, or the power sector as well, achieving for example a composition of 90% CO_2 could offer a significant cost saving when compared to 99% CO_2 purity.[286] As has been pointed out by some interviewees (see Chapter 6), more guidance on the stream criteria would reduce some of the uncertainties related to the CO_2 stream.

In addition, for the up-stream part of the CCS process (capture), a great deal of uncertainty is also related to the price of carbon credits in the long run. For the down-stream portion of the chain (storage), there is essentially no cap on the amount of financial contribution that a project operator must make after the transfer of responsibility to the competent authority. This means that the operators may remain liable for *all* the costs that occur after the transfer. As was pointed out in Chapter 6 by a number of industry respondents, when asked about the uncertainties related to the extent and scope of the financial security provisions, this then means that project developers and operators cannot accurately quantify their risk exposure, which in turn leads to a slower development of the projects themselves.

In reference to the uncertainty and risks of CO_2 storage, as Phillips (2014) pointed out in an interview, "…it is very difficult to prove that [CO_2] won't leak. [He thinks that] there is an issue around how you handle that uncertainty."[287] Furthermore, evidence presented in Chapter 6 also points to the distinction between quantifying and detecting CO_2 leakage. As far as it relates to the latter, there was a general consensus that current technologies are sufficient for detection and monitoring of the CO_2 underground to a 'reasonable degree of certainty'. In relation to the former, however, the biggest uncertainty remains the ability to effectively quantify any fugitive emissions from the storage reservoirs. This will be particular important in regulatory terms under the EU ETS Directive, which applies in the case that any leakage results in emissions or release to the atmosphere, or the water column. In addition, when it is

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[285] Zheng (2012).

[286] Bolscher et al. (2014). p.7. Available at: http://www.ccs-directive-evaluation.eu/assets/Uploads/CCS-Directive-evaluation-Interim-report.pdf.

[287] Phillips, I. Interviewed by: Maver, M. (January 31, 2014).

difficult to determine which monitoring techniques are most suitable for quantifying CO_2 leakage, and little data exists about the uncertainty in the quantification of these techniques, it only complicates things further.

As evidenced from Chapters 4 and 5, which have analysed the legal and regulatory frameworks for CCS in the EU and the UK respectively, there are no provisions that would explicitly state what level, in numeric terms, of uncertainty and risk is legally acceptable. As mentioned, the CCS Directive does address the behaviour of the CO_2 plume in its provisions, but does not touch on the quantification activities, which in a case of a leakage event take place under the Monitoring and Reporting Guidelines (MRGs). Even the MRGs, however, do not specify any detection limits. While the CCS Directive does not address uncertainties in the monitoring program or any detection limits, the EU Commission did issue a Decision in June 2010[288] on monitoring and reporting for CCS, in which it notes, for example, that "the amount of emissions leaked from the storage complex shall be quantified for each of the leakage events with a maximum overall uncertainty over the reporting period of ± 7,5 %. In case the overall uncertainty of the applied quantification approach exceeds ± 7,5 %, an adjustment shall be applied, as follows:

$$CO_{2,\,Reported}\,[tCO_2] = CO_{2,\,Quantified}\,[tCO_2] \times (1 + (Uncertainty_{System}\,[\%]/100) - 0{,}075)$$

Essentially, what the above equation implies is that CO_2 storage project operators should be as accurate in their accounting and reporting of the estimates of the escaped CO_2. However, given the current availability of monitoring technologies, accounting for the total amount of escaped CO_2 from a storage complex, which in some cases could be kilometres wide, is to date still extremely difficult. As was sounded by a good majority of the interviewees in this research, monitoring is still extremely expensive and some monitoring technologies currently being developed are not practical to implement just yet.

Although, Wartmann et al. (2009) ask an interesting question, whether there is even a need to consider any detection limits[289] in the first place. They believe that any

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[288] EU, 2010. Commission Decision of 8 June 2010 amending Decision 2007/589/EC as regards the inclusion of Monitoring and Reporting Guidelines for greenhouse gas emissions from capture, transport and geological storage of carbon dioxide. Available at: http://eur-lex.europa.eu/legal-content/EN/TXT/HTML/?uri=CELEX:32010D0345&from=EN

[289] Detection limits could be defined in a number of ways, such as by: the fraction of a background CO_2 flux, as the percentage of the CO_2 that will be injected into the storage reservoir, a specified amount of

seepage that is too small to be detected can by definition not be quantified and thus included in any emission accounting (p. 4464). In other words, any seepage that is too small to be detected could be disregarded, provided that a good monitoring program is in place and the rigorous site selection was done. A bigger question for them, in respect to emissions accounting is the accuracy in the estimates that can be detected. In relation to CO_2 storage operations, under the MRGs, accuracy requirements can pose a much greater challenge, given the limited experience with monitoring of seepage from CO_2 storage reservoir, and in light of the existence of uncertainties, especially in the case of saline aquifers.

The principal difficulty, in seepage estimates, thus remains the magnitude of uncertainty still present. As such, many of the interviewees, as well as the literature to an extent, argue for the imperative to continue with the scientific research and development of appropriate monitoring approaches, especially for estimating seepage from reservoirs. This will lead to a better understanding of the uncertainties, increase the knowledge, and serve as the ‘antidote to the fear’, as Ralph Waldo Emerson would say.

One general consensus that also seems to appear both in the literature review (see Chapter 3), and in the interviews with industry respondents and other stakeholders from the academia (see Chapter 6), is that uncertainty, and residual level of risk, will always be there, given that it is extremely difficult, if not impossible, to prove a negative – i.e. no leakage. At the same time, there seems to be near unanimous agreement that it will in the end come down to whether it is shown to the satisfaction of the relevant competent authorities, that the best currently available technologies have been used, precautions taken, and that appropriate procedures were followed.

The findings from Chapters 4 and 5, confirmed by responses from the interviewees in Chapter 6, thus indicate that when it comes to managing the uncertainties and risks related to underground storage of CO_2, the driving vehicle remains the so-called governance network, with the legal and regulatory frameworks being the main supportive tools.

CO_2 emissions per year, a prescribed CO_2 flux, etc. Wartmann et al. (2009) suggests that each approach has its own merits and drawbacks in terms of simplicity or type of storage project (p. 4463).

7.2.2 Precaution: mediating between technological development and governance

One of the underlying themes of this research has been the nature of the task at hand – safely storing CO_2 underground despite the existence of uncertainties and inherent environmental risks. While the need for the deployment of CCS as a climate change mitigation tool, has to date widely been acknowledged, various observers would still debate as to how the associated risks can best be managed. As such, another underlying theme of this thesis has been this gap between the ability to effectively manage the environmental risks, and at the same time not restrict the technological innovation necessary for CCS. As chapters 3,4 and 5 have shown, the use of 'precaution' sits in the middle of seeking to mediate between the two – the management of risk/governance and technological development.

7.2.2.1 Precautionary principle and governance

Precautionary Principle

In explaining the European approach to CCS development, management of environmental risks and technology development, is seen best through the use of the precautionary principle. In brief, the precautionary principle is in essence a kind of guide for policy makers, which stipulates that in condition of uncertainty, decision-makers should act so as to prevent potentially serious or irreversible environmental harm. In other words, according to this principle, uncertainty cannot be an excuse for regulatory inaction.

The precautionary principle, as Chapter 4 has examined, has to date been firmly embedded in many of the EU's treaties and reflected in many of the laws and CCS-related policies, such as waste management or integrated pollution prevention and control, for example. The rationale behind applying the precautionary principle in the EU is essentially, first and foremost, as a risk assessment tool. In other words, the principle in a way compels the policy and decision-makers to collect, gather and analyse data and evidence, and potential risks on that evidence. In particular when it comes to new areas and technologies such as CCS.

Whereas opponents of CCS for example, would use the principle to argue for inaction and non-deployment of this technology, in light of the uncertainties and risks involved, its proponents on the other hand, use it as a form or kind of reassurance tool. In other words, the latter would argue that precisely because of the application of this principle in that caution is being taken, observers should be reassured that appropriate safeguards are in place to ensure the safety of the technology.

Based on the critical realist ontological perspective adopted in this research, a major limitation of the precautionary principle is also in the notion that a definitive conclusion about the nature of risk is possible. Rather, risk is seen 'as if' real, meaning the concept of risk is essentially often about perception, and to some extent socially constructed. In other words, any scientific assessment is not going to be entirely neutral/objective, and could thus result into inconsistent policies and regulations, and as a result into their inconsistent application. This inconsistency in application then in turn can lead to companies feeling a sense of unpredictability or uncertainty, which can lead to further slowing down of progress, in terms of technological development and deployment. So, when asked about their perception of the current legal and regulatory framework, a number of interviewees pointed out that there are still limits when it comes to the application of the precautionary principle. This belief was evident in the context and content of the monitoring and verification requirements, which often costs a lot of time and money, potentially slowing down progress.

Essentially, the application of the precautionary principle entails a risk assessment and management framework in which the scientific uncertainties associated with long-term storage and possible negative impacts are addressed. In other words, the precautionary principle is the characteristic and guiding element of the legal and regulatory frameworks, and for the overall governance of CO_2 storage.

Governance

As mentioned in Chapter 2 on theory and methodology, the concept of governance means different things to different people, and has in the literature become a notoriously slippery term. Governance, in this study, is thought of as the systematic interaction between numerous stakeholders, including the private and public sector, citizens, NGOs, etc. In addition, governance represents the incorporation of various norms and principles that are used to guide a polity (i.e. the EU) in a particular direction. As Chapter 3 has demonstrated, as far as it relates to the governance of CCS in the EU, a key element has been the institutionalization of the precautionary principle, and the inclusion of multiple stakeholders in the policy-making process.

In case of the latter, the term ‘governance network’ emphasizes and focuses on the recurring or institutionalized formal and informal resource exchanges between governmental and non-governmental actors (Davies, 2011: 3). In other words, the nature of the so-called governance network is mainly about information gathering and resource exchange. As was discussed in Chapter 4 as well, the EU institutions themselves are relatively resource poor, in that even though they possess their own in-house experts in an area, outside expertise from various stakeholders, including the industry and research institutions, for example, are often sought and are seen as crucial.

As described in Chapter 2, on the theoretical framework of the thesis (section 2.2), looking at the act of governing has become the matter for both public and private actors, neither of which, as Damgaard (2005) points out, have the capacity to address the public policy problems alone, but rather “find themselves participating in governing schemes characterized by resource dependencies” (p. 2). As such, governance, as mentioned, becomes in large part about *information gathering*. However, the nature of governance is then also about gathering support, in particular from those who will be most implicated by the technology. This includes the industry, or project developers, as well as the general public. The latter, however, is for the most part formally excluded from the policy-making process.

As mentioned, in Chapters 4 and 5, where the legal and regulatory frameworks for CCS in the EU and the UK were examined, respectively, there are no explicit provisions that would require include the general public in CCS project development and deployment. The public’s voice/view is mostly represented in the policy and decision-making process by various environmental NGOs, such as Bellona, Green Alliance, E3G, and Greenpeace, to name a few. Even though, technically, project developers are not required to consult the general public on matters relating to their projects, apart from mandatory consultations during the environmental impact assessment (EIA) process, most project developers will have some extent of public engagement in place. This has been the case primarily in light of the cancelation of a number of projects in Europe, with the key example being the project in Barendrecht, Netherlands.

7.2.3 Regulation: a mediating tool between technological development and governance

In light of what was discussed in Chapter 3 and mentioned in Section 7.1 of this chapter above, the main uncertainties and challenges continue to lie in the storage component of the CCS chain. Given the existence of these uncertainties, and the identification of a growing range of unknowns (i.e. tracking CO_2 underground), and the unknown-unknowns, which cannot be eliminated, permanent risk management is required. Essentially, this is the goal and objective of the legal and regulatory frameworks for CCS. In Europe, as focused on in Chapter 4, this is mainly the 2009 EU CCS Directive, whereas in the UK, risk management is embedded in the legal framework which came in anticipation of the CCS Directive (i.e. Energy Act 2008), and a number of Regulations which came as a result of its transposition into national law.

Apart from providing a comprehensive overview of the governance of CCS in Europe, and in the UK as a case example, given the set out central research question, the central aim of this study was an analysis of how, and to what extent, regulations help mediate between CCS technology development and the management of CO_2 storage risks, in the presence of scientific uncertainty. As the section above explains, and the research argues, the application of the precautionary principle essentially serves as the building block of this bridge between technology development and governance, or management of risks related to CO_2 storage.

Managing the risk of leakage

Both the CCS Directive, and CCS Regulations in the UK take as their primary objective to regulate a safe and environmentally sound geologic storage of the captured CO_2. These legal and regulatory frameworks are based on the notion of minimizing the risks and verifying storage, as well as the remediation of potential damages that may occur.[290] In other words, the CCS Directive and UK regulations on CCS represent a risk management framework, set to ensure that this technology would be deployed in an environmentally safe way. As mentioned, the primary

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[290] The CCS Directive sets out substantial requirements and criteria for site selection and characterization, and for obtaining exploration and storage permits (i.e. procedure, conditions, content, requirements for review, changes and withdrawal). In addition it also includes provisions on and discusses obligations for CO_2 stream acceptance criteria, reporting and inspections, financial security and financial mechanisms, third party access, and trans boundary cooperation.

objective of this research was to assess whether these frameworks mediate between the management of the risks of CO_2 storage, and the deployment of the CCS technology.

In the review of the scientific literature, it was shown that when it comes to geologic storage of CO_2, one of the main risks, and concerns is related to the leakage of the CO_2 from a storage reservoir. As mentioned above, the theoretical understanding of 'risk' in this study is one of critical realism, meaning that while potential for CO_2 leakage is there, the level of risk, and its acceptability will often vary between stakeholders. Moreover, there is no agreement as to what leakage rates are likely from any given reservoir. Various studies have come to estimate these to range from 0.01% to 1% per annum[291]. Most authors agree, however, that leakage is likely to occur, and that the rate of that leakage is heavily dependent on many factors, in particular on the surrounding geology or the vicinity of other exploration wells.

Well integrity is another issue that increases the risk of CO_2 leakage. However, as Hepple and Benson (2004) conclude in their study on the implication of surface seepage on the effectiveness of geologic storage of CO_2, even if small amounts of the CO_2 do escape form a reservoir back to the atmosphere, this does not preclude the process and technology from being an effective climate change mitigation strategy. Both the scientific and legal communities, for the most part acknowledge that the risk of leakage is there, and will vary between storage sites.

In order to prevent, or better said, manage the risk of leakage, and thereby to human health and the environment, the CCS Directive, and subsequent regulations in the UK lay down extensive requirements for the entire life cycle of a storage site – from exploration, selection and permitting, operation, closure and post-closure. This research has shown that the central features of both the CCS Directive as well as the regulations in the UK, as well as the governance framework as a whole, are the permitting regime and monitoring and verification, which in essence also characterize the management of risks related to CO_2 storage.

Permitting and monitoring

Injection of CO_2 is essentially only allowed to occur in carefully assessed and characterized storage sites[292], and is preconditioned on the project operator obtaining

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[291] See for example Chow et al. (2003), IPCC (2005), Tao et al., (2010), White et al., (2003), Trabucchi et al., (2012).

[292] Article 4 of CCS Directive.

both an exploration permit[293] and a storage permit.[294] [295] Once issued, the storage permit also needs to be submitted to the European Commission for review. This is done so as to increase the transparency of the process, thereby aiming to enhance the public confidence in the process and a particular project.

However, the current legal and regulatory regimes in the EU and the UK set a number of requirements and criteria (i.e. on reporting and inspection – Art. 14 and 15 in CCS Directive) that have to be met by the permit holder. Failure to do so, or in case of failure to communicate any matters of concern related to the operation and integrity of a storage site, can result in the competent authority (CA) or the European Commission to either change, update or withdraw a storage permit (Art. 11 in CCS Directive). In a case when a permit is revoked, the CA is responsible for closing the storage site, as well as for remediation. All associated costs, however, are to be born by the previous operator.

The main purpose of the CCS permitting regime is, as mentioned, to provide environmentally safe geological storage of CO_2. A key part of the permitting regime, and a pre-condition for approval of the permit, is the monitoring plan (Art. 13(2) in CCS Directive), which has to be submitted for approval together with an application for a storage permit.[296] A number of interviewees, as shown in Chapter 6, also pointed out that it will come down to project operators' conformity with the monitoring plan, that will serve as the basis for CA's decision on whether requirements for the transfer of responsibility have been met.[297]

As this thesis has demonstrated in Chapters 3,4 and 5, as well as confirmed in Chapter 6, where interpreted results of the interviews conducted are presented, monitoring and verification is *the* essential component in assessing whether the CO_2 is behaving as expected, and if any identified leakage or irregularities are damaging to the environment or human health. In this process, a number of different monitoring

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[293] Article 5 of CCS Directive.

[294] Chapter 3 (Articles 6 through 11) of CCS Directive.

[295] The storage permit is intended to be the core instrument in ensuring that the requirements of the CCS Directive, and subsequent MS(UK) regulations are met, as well as that the geological CO_2 storage is done in an environmentally safe way.

[296] The main purpose of the monitoring plan is essentially to monitor for any irregularities, migration of the CO_2, leakage or significant adverse effects for the surrounding environment (Art. 13(1) in CCS Directive).

[297] Unless a storage permit is explicitly withdrawn, the operator remains responsible, until transfer of responsibility occurs (Art. 18) for any monitoring, reporting and corrective measures, based on the post-closure plan, which also has to be submitted in the original permit application (Art. 17(2-3)),

technologies are available, for example, to help define vertical and lateral migration of injected CO_2, and help to reassure that the injected CO_2 remains underground.

As several studies[298] have also pointed out, there is no ‘cookie cutter approach’ to the selection of monitoring technologies, as every site will be different based on its geology and/or capacity. The legal and regulatory frameworks take account of that fact, and are not prescriptive in terms of the types of monitoring technologies that are to be used. The CCS Directive, as well as the UK Regulations, when it comes to the type of monitoring technologies to be used to meet the requirements of establishing and updating the monitoring plan, only state that the choice of monitoring technology shall be based on the *best practice available*, at the time of the design.

Essentially, this research has thus far demonstrated that, when it comes to the management of environmental risks of CO_2 storage, what is written in the current legal and regulatory frameworks for CCS in the EU, and in the UK given that it was taken as a case study country, in theory at least, serves to provide a sufficient level of risk management. It would not be true to make claims as to their effectiveness, given that no commercial-scale projects exist. However, as results from Chapter 6 have shown, it is the belief of those involved with the development of current CCS/CO_2 storage projects, as well as other stakeholders, that for the most part, ‘everything is there – it just needs to be road-tested’.

Facilitating or slowing down technological development?

One of the goals of this research, as mentioned above, was to examine the impact of the CCS legal and regulatory frameworks acting as constraints or drivers for the development and deployment of the CCS technology.[299] In other words, the research has attempted to clarify whether the current frameworks in place today, at the EU level, and in the UK, has led to an improved environment in which innovation and CCS technology development can take place, or whether as a result of these regulations, they are being suppressed.

However, as has already been noted in this study, both via references from the literature and with responses from the interviews with various stakeholders, one of the primary reasons for the slow development of CCS technology in the EU, has for the

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[298] See Wells et al. (2006), Mathieson et al. (2010), Leuning et al. (2008).

[299] By ‘CCS technology’, I refer to the CCS process as a whole, including capture, transport and storage component. The term is used for simplification purposes, and does not refer to any technological component in particular. These are specifically mentioned when intended to do so.

most part been the lack of sufficient policy incentives for the project developers. This refers to both short- and long-term perceptions that the investments into CCS projects will eventually pay off. Policy (un) certainty has been identified as the key barrier for CCS at this moment in time in 2015.

Nevertheless, in the UK, the recent Electricity Market Reform (EMR)[300], under which long-term contracts in the form of feed-in-tariffs with contracts for difference (FiT CfD), the introduction of a carbon price floor, and an emissions performance standard, was for the most part welcomed by majority of the stakeholders as the first market based incentive mechanism that would support investment in not only CCS, but in other low-carbon power generation technologies as well. While the EMR is said to increase the degree of certainty for CCS, given that commercial-scale projects are needed as soon as possible, uncertainty still exists about the timing for the implementation of this framework remains, the application of the FiT CfD to emissions-heavy industries and power generation projects currently not in the CCS Competition.

In any case, analysis in chapters 4 and 5 has also shown that there are still a number of other potentially contentious issues that could prevent the investment in, and development of CCS projects. These relate particularly to the issues of transfer of responsibility, and lack of clarity on the financial security and financial mechanism provisions. Nevertheless, as interviewee responses, presented in Chapter 6, have shown, on a general level, there is a wide consensus among the stakeholders, in including the CCS industry, that as it stands, the legal and regulatory frameworks do not present any major barriers to the development of CCS. The lack of clarity on certain provisions, and any uncertainties, are expected to be ironed out between the project developers and the competent authorities, before the final investment decisions (FIDs) are made.

A good example of such cooperation and negotiation, between the project developer, the competent authority, and the European Commission, is seen in the case of the ROAD project in the Netherlands[301]. One of the key outstanding issues in this

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[300] The EMR, and its mechanisms, hope to create a stronger market structure to aid the development of CCS, and other low-carbon technologies, with the aim of increasing energy security and other climate change goals.

[301] The ROAD project is being developed in a joint venture by E.ON and GDF Suez, and is funded through the EU's EEPR funding scheme, the Dutch government, and the Global CCS Institute. Whereas GDF Suez E&P Nederland B.V. is the intended partner for the CO_2 transport, TAQA Energy

project appeared during the permitting stage. The developers believed that the required level of detail in the monitoring and corrective measure plans, as required by the CCS Directive to be submitted at the time of the permit application, was too great. A suggested solution by TAQA Energy B.V., the ROAD project's storage permit holder and storage operator, was to lower the level of details in all the plans in the application, but update these plans prior to injection. They argued that the plans in the permit application provided sufficient information and the level of detail to prove that the CO_2 can safely be stored, thereby complying with the CCS Directive requirements.[302] In the end, the competent authorities, as well as the European Commission, were satisfied with the level of detail and the characterization and assessment of the storage site and complex, confirming the suitability of the chosen storage location, thereby granting the storage permit.[303]

These examples go to show how project developers have interpreted outstanding legal and regulatory issues and were then able to reach an agreeable solution with the competent authorities.[304] It also supports the view of this research, that for mediation between managing the environmental risks and development and deployment of CCS technology to be most effective, the regulators must work closely with storage site operators. As such, governance networks are as important, if not more so, than the regulations themselves.

7.3 Concluding remarks

7.3.1 Implications and originality

This research has set out to uncover and provide a more in-depth look into both the process and the nature of governance and regulation of CCS, in particular for CO_2 storage, in Europe, while taking the United Kingdom as a case study example. Pursuant to the main research question, the main objective was to determine whether the legal and regulatory frameworks effectively mediate between the management of

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B.V. is the partner for CO_2 injection and permanent storage. The latter is also the storage permit holder and storage operator.

[302] Operational parameters, the choice of specific monitoring instruments for example, were said that they could be elaborated upon in the final plans, which were to be submitted to the competent authority and the EC one year before the injection of the CO_2 would start.

[303] Case study of the ROAD storage permit. *A report by the ROAD project - part of the European CCS Demonstration Project Network.* Available at: http://decarboni.se/sites/default/files/publications/111356/case-study-road-storage-permit.pdf.

[304] Nevertheless, the project was put on hold due to the lack of funding, and is currently (November, 2014) waiting for final investment decision (FID) to be adopted.

environmental risks associated with CO_2 storage, and the development and deployment of CCS technology.

As discussed in Chapter 3, and mentioned at the beginning of this chapter, the literature on CCS, let alone on the governance of the technology, is still relatively new. Thus, one of the contributions of this research is on the general level, in that it adds to the growing literature on both the governance, as well as regulation of CCS, and the storage part of the chain in particular. More specifically, it provides an updated picture of the current regulatory situation, in 2015, which could be a useful reference for a number of stakeholders, in particular in light of the upcoming review of the EU CCS Directive in 2015. Claims to originality are also based in that the study of governance, or the management of risk as this thesis understands the concept, is approached from a critical realist perspective, which sits between the still prevalent positivist and interpretive approaches.[305]

Apart from solely environmental or technical challenges still at hand (i.e. in managing risks and development/deployment of CCS), given the existence of various other economic, political, legal and/or social challenges, the literature on governance and CCS should continue to increasingly focus on best-practice and what can be learned from different levels of governance (i.e. national, state and local). At the same time, gathering as much information as possible from other polities that share some of these challenges would also be beneficial. As such, further and comparative research on governance between different jurisdictions such as the EU and the US for example can be useful for the academic, policy, industry and other stakeholders.

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[305] As mentioned, this thesis views the reality as neither entirely objective nor subjective, and argues that the management of risks and deployment of CCS technology resists either a positivist or interpretive approach, making a critical style most appropriate. Within this style, human behaviour is argued to come from the standpoint of meanings and intentions, assuming that people as well as organizations and institutions have various norms and strategies which dictate their behaviour and performance. An epistemological view is then that knowledge comes as a result of past attempts at dealing with similar problematic issues and situations, and is therefore gained by acting on the beliefs and experiences/principles adopted in the past.

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Appendices

APPENDIX A: (Changes) in the EU voting procedures

Prior to the signing of the SEA, the European environmental policy, as mentioned, had fairly little legal basis. Legislations related to environmental matters could only be passed if they were directly relevant to the completion of the internal market, and even then must have passed by on the basis of unanimity in the Council of Ministers.

The SEA, on the other hand, in hopes of making the decision-making in the EU more efficient and thus expedite the single market integration, increased the participative role of the European Parliament (EP) in the decision-making process[306]. It also expanded the areas covered by the quality majority voting (QMV) procedure. Nevertheless, legal acts, which pursued environmental protection as an independent objective, were still based on unanimous vote in the Council of Ministers, and the role of the EP remained merely consultative (Bähr, 2010).

The TEU in 1993 then considerably extended the areas where QMV applies, albeit with certain exceptions[307]. This, in conjunction with the co-operation procedure, made it regarded as the norm and the standard legislative procedure for environmental matters (Wilkinson, 2002). Nevertheless, even though the TEU established a more efficient decision-making procedure for environmental policy, some of its arrangements were still seen as complex with certain procedures existing side by side, and there being a potential for conflict between environmental measures and the approximation of laws in connection with the internal market (Europa, 2013).

The Treaty of Amsterdam, which entered into force in 1999, then further addressed the decision-making procedures. Its most significant contribution came in the form of a procedural change with the extension of the co-decision procedure[308], originally introduced by the TEU in 1993, on most environmental protection issues[309].The co-

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[306] The EP's role was increased by giving it the power of second reading of legislative proposals, via the co-operation procedure. For example, if the EP would disagree with a position of the Council, following its second reading, the Council could either adopt the EP's decision via QMV, or reject it by unanimity only.

[307] Ex-Art. 95 TEC, now Art. 114 TFEU. Exceptions to QMV include things like environmental taxes, town and country planning and land use.

[308] This was achieved by amending ex-Art. 130 into Art. 175 TEC (now Art. 192 TFEU).

[309] Exceptions to the co-decision procedure in environmental policy, in which the EP receives only a consultative role and thereby also no veto power, and the Council has to decide unanimously, refer to policy outputs which relate to: i) fiscal provisions; ii) town and country planning; iii) quantitative management and availability of water resources; iv) land use not including waste management; or v)

decision procedure is essentially the legislative process central to the EU's decision-making system, and has become widely used for decisions in environmental matters[310] (Krämer, 2006). With the passing of the Lisbon Treaty in 2009, this procedure became known as the ordinary legislative procedure, and has essentially the norm for most policy and legislative measures in the EU (environmental) governance system[311].

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choice of energy sources and the general structure of energy supply in the Member States (Art. 175(2) of the TEC).

[310] It starts with a legislative proposal from the Commission, which submits it to the EP and the Council. At this point the Council may then amend the proposal only by unanimity, and following the reading and opinion from the EP, may adopt it by QMV, if it approves the EP's amendments contained in its opinion, or if the EP does not suggest any amendments. Otherwise, the Council establishes a common position, which if approved by the EP, or if it opts out of the second reading, the legal act is adopted. A legislative proposal is deemed to have failed if an absolute majority in the EP rejects the common position. An amendment to the Councils common position may also be proposed by an absolute majority in the EP, which upon acceptance by the Commission, the Council may adopt the act by QMV. However, if the Commissions makes further amendments, the Council has to vote unanimously in order to pass the proposal. If the Council does not agree with all amendments, a Conciliation Committee is established, which if it does not reach a compromise, deems the legislative proposal as rejected. However, if the Committee reaches an agreement on a joint text, this text then requires the approval of an absolute majority in the EP and a qualified majority in the Council for it to be adopted as a legal act (Bähr, 2010: 92-93; Krämer, 2006: 71-72).

[311] Ex.Art 251 TEC, now Art. 294 TFEU.

Glossary of Terms

Concept	Definition
Bounded rationality	The ide that when individuals and/or businesses make decisions, their rationality is limited by a variety of factors such as their cognitive limitation, availability of information, and the availability of time.
Carbon capture and storage	The process whereby the CO_2 is the process, whereby up to 95% of the CO_2 emissions produced from large stationary emission sources in electricity generation and industrial processes is captured and thereby prevented from entering the atmosphere. The CO_2 is first captured, then under extreme pressure put into a liquid-like state, transported to a pre-selected storage site, and stored up to 3km below the surface. Storage can occur either on- or off-shore.
Carbon dioxide	A colorless, odorless, and the primary greenhouse gas emitted through human activities such as fossil fuel burning. Burining of carbon-based fuels has lead to its increased concentration in the atmosphere, leading to climate change, such as global warming and ocean acidification.
Carbon Sequestration Leadership Forum	An international initiative, consisting of 23 member countries and the European Commission, to advance carbon capture and storage (CCS) technology.
CCS Industry	A concept used to describe the private sector companies that are involved in the development of carbon capture and storage projects.

Climate change	A concept which refers to the changes in the Earth's climate over time. Although climate change is caused by many factors such as biotic processes, variations in solar radiation received by Earth, plate tectonics and volcanic eruptions, among others, the largest contributor to the changing climate - global warming - over the past 150 years has been found to be anthropogenic (human).
CO2 storage	Part of the CCS chain, where the CO_2 is injected deep (up to 3km) below the surface for permanent storage. It can occur either on- or off-shore, in saline aquifers or depleted oil and gas reservoirs.
Competent authority	The primary government authority in each EU Member State, which is delegated the lead authority, capacity and responsibility to issue, review and terminate CO_2 storage and exploration permits. Once injection ceases, and a certain period elapses, the competent authority will also accept the responsibility for all legal obligations from a storage site operator.
Critical realism	A philosophical approach, originally developed by Roy Bhaskar, which combines the philosophies of science and social science in order to describe the interface between the natural and social worlds. This research adopts a critical realist perspective in that it views risks of CO_2 storage 'as if' real - given the uncertainties and different meanings to different stakeholders.
Department of Energy and Climate Change	A UK government department created in 2008 to deal with climate change issues. Majority of the department's budget is on managing UK's historic nuclear sites. It is also entrusted to develop strategy and policies on energy and the environment. It is headed by the Secretary of State (for Energy and Climate Change), who is also the Competent Authority for CCS in the UK.

Energy security	The availability of natural resources required to meet energy consumption demands. Uneven distribution of energy supplies (i.e. coal, natural gas) has led to vulnerabilities for a number of countries, who are highly dependent on natural resources from other countries (i.e. Russia).
Enhanced oil recovery	A process whereby the remainder of crude oil can be extracted from an oil field. It is also referred to as improved or tertiary recovery of oil, as the process is done after primary and secondary extraction. The captured CO_2 can be used for this purpose; in the US it is also the primary driver for the development of CCS technology.
Environmental Impact Assessment	A formal process which is used to predict environmental impacts/consequences, both positive and negative, of a proposed plan, policy or program prior to the decision to move forward. For CO_2 storage projects, an EIA must be made during the scoping/characterisation phase - before any injection occurs. No EIA is required for experimental CO_2 storage projects in Europe.
Fracking	A process of extracting natural gas/shale gas. The gas is located in tightly compressed shale rocks deep below the surface. The drilling is done thousands of meters below the surface, normally at depths of 1500m to 5000m. In contrast to conventional gas extraction techniques, however, the drilling is done horizontally, so as to maximize its economic feasibility. Once the boreholes are lined with steel and concrete casing, a mixture of water, chemicals and sand is injected at very high pressure in order to fracture the shale, after which the shale gas flows back to the surface where it is captured.

Global Carbon Capture and Storage Institute	An international institute, established in 2009, whose mission is to accelerate the development, demonstration and deployment of CCS. Its members consist of governments, corporations and smaller companies, as well as research bodies and NGOs. Every year it produces a comprehensive report (Global Status of CCS) which provides an overview of global and regional developments in CCS and what is required to promote the development and deployment of the technology.
Governance	A process of governing, which encompasses efforts undertaken by a government, the private and public sector institutions, including NGOs. In this research, governance is understood as the management of risks related to CO_2 storage.
Governance network	A relatively stable horizontal articulation of interdependent yet autonomous actors, whose interactions occur through negotiations within a regulative, cognitive and imaginary framework. This framework contributes to the production of a public purpose; in this research the development of CCS technology and management of associated risks, in particular in relation to CO_2 storage.
Governance Network Theory	A general theory which focuses on the manner in which environmental risks are dealt with and managed through joint action and interaction.
Greenhouse gases	A gas in the atmosphere which absorbs and emits radiation; a fundamental cause of the greenhouse effect. Primary greenhouse gases include water vapor, methane, ozone, and carbon dioxide (CO_2). It is estimated that up to 40% of the increase in atmospheric CO_2 concentrations since the industrial revolution in 1750 has occurred as a result of human activities - combustion of carbon-based fuels (i.e. coal, oil, natural gas).

Overburden	A top layer of rock, soil and ecosystem which lies above a coal seam. In respect to CO_2 storage, it should provide a seal so that the CO_2 injected into the ground does not escape to the surface.
Oxy-fuel combustion CO_2 capture	A process of capturing the CO_2. The fuel (i.e. coal, biomass) is burned in pure oxygen, as opposed to air, such as in other two capture methods. Once Nitrogen (N) is removed from the air, by an air separation unit, the remaining pure oxygen is combined with the fossil fuel in a boiler, where combustion takes place. This generates steam, which is used to power the turbines and generate electricity, while the flue gas consisting of CO_2 and water vapour is recirculated to control the boiler temperature and to be cooled. The CO_2 is then dehydrated, compressed and made ready for transportation and storage.
Parts per million	A commonly used measure to refer to the concentration of CO_2 in the atmosphere. It refers to the number of molecules of CO_2 divided by the number of all other molecules in the air. As of 2015, the average global CO_2 concentration level is 400ppm; highest ever.
Plume	Dispersing volume of CO_2-rich phase contained in a formation, such as an oil and gas reservoir or saline aquifers.
Post-combustion CO_2 capture	A process of capturing the CO_2. In this method, combustion of fossil fuels is done in a traditional manner (i.e. using a boiler or a combined cycle gas turbine), followed by a separation of the CO_2 from the flue gas, most often by a chemical sorbent such as amines or ammonia. For majority of the already existing power plants, this will be the main option for capturing CO_2, given the space requirements of other two options to construct new equipment, which in many cases the existing power plants might not have.

Pre-combustion CO_2 capture	A process of capturing the CO_2. In this method, carbon is removed from the fossil fuel prior to combustion in a gas turbine. Coal is combined with oxygen to create a gas (‘syngas’), made up of Hydrogen (H) and carbon monoxide (CO). Water (H_2O) is then added to the ‘syngas’, through a water gas shift reaction, whereby CO is converted to CO_2, which is then removed from the fuel by a separation process. Hydrogen is then burned in a combined cycle gas turbine to generate electricity; process referred to as Integrated Gasification Combined Cycle (IGCC).
Risk society	A term used to refer to a modern society, and the manner in which the society organises itself in response to risk. This society is considered to be preoccupied with the future and safety, which in turns generates further notions of risk. In other words, modernisation has brought with it risks, and in dealing with these risks, other risks are generated. i.e. as a response to climate change, CCS, and CO_2 storage in particular creates other risks such as water contamination, earthquakes, etc.
Saline aquifer	An underground rock formation where saline water occupies the small spaces between the grains of rock.
Single European Act	The 1986 Act was a first major revision of the 1957 Treaty of Rome, which aimed to remove some of the barriers to economic integration, increase harmonization and competitiveness among the Member States, and to streamline the decision-making within the EU. Amongst other commitments, the SEA is significant in that for the first time the EU also became committed to include environmental protection in all of its sectorial policies.

The Carbon Capture and Storage Association	A leading CCS industry lobby, based in London, UK. Its members consist of companies in manufacturing and processing, power generation, engineering, oil and gas, as well as other stakeholders including from the energy, legal, banking, consultancy and project management sector. Its goal is to promote the business side of CCS and ensure commercial-scale CCS deployment. It also works together with the UK Government and the EU Commission on policy and regulatory developments.
The European Commission	The executive body of the European Union. It is responsible for proposing policy and legislation, including the 2009 CCS Directive, which established the legal framework for the environmentally safe geological storage of CO_2. Although competent authorities in each Member States are responsible to implement the Directive within their respective frameworks, the European Commission retains the authority to issue opinions and review CO_2 storage permits.
Uncertainty	Although the term is subtly used differently depending on the discipline, it generally refers to the state of being uncertain about a particular outcome. In this case, although there is strong evidence that permanent CO_2 storage is safe, there is still uncertainty about the precise movement of the CO_2 once it is injected underground, and the extent of this movement, and potential leakage to the surface, over extended periods of time.

United Nations International Panel on Climate Change (IPCC)	A scientific intergovernmental panel, under the United Nations, which is set up to assess the scientific information relevant to human-induced climate change, its impacts and options for adaptation and mitigation. Established in 1988, it consists of thousands of scientists and other experts, which contribute to the writing and reviewing of the reports, and in essence is also considered to be the highest accepted authority on climate change.