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Reawakening A Paralysed CCS Agenda in Europe

A Study of Industry Stakeholders' Positions
on Carbon Capture and Storage Technologies

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Globalization
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Problem description -

The study's purpose is born out of the need for urgent climate action. In spite of the European Union having in place the most stringent climate policies globally, measures combatting climate change are yet not effective enough. Although global CO_2 emissions might have almost stalled in 2014, the stock of carbon that has been emitted to the atmosphere since the industrial revolution will continue heating up the planet. In light of the Paris Agreement (2015) and the EU Energy Roadmap 2050 (2011), these continuing trends require urgent climate action in all sectors. Carbon Capture and Storage (CCS) technologies have been recognised as one out of a portfolio of necessary solutions to solve the climate puzzle (IPCC 5^{th} Assessment Report, 2014). CCS refers to the technological solution to capture CO_2 emissions emitted by large power and industrial plants, followed by transporting and storing the CO_2 in suitable geological formations. The technology has the potential to prevent 90 percent of the CO_2 from being emitted. Its deployment has, however, proven very slow. Little movement in the CCS community has been observed in recent years due to a complexity collection of challenges such as lack of funding, excessive liability implications, public concern related to the risk of CO_2 leakage and the involvement of many stakeholders in CCS projects. The combination of these has resulted in a near paralysis of the CCS agenda. Energy intensive industries, which today account to about 30 percent of the EU's total emissions, have few or no alternatives for deep decarbonisation except with CCS. This suggests that there is a need to revive the CCS debate and foster its deployment in Europe. To enable more suitable policy making for CCS, understanding energy intensive industries' positions on CCS is essential. The purpose of this study is therefore to understand what role the CCS positions of two prominent energy intensive industries, the cement and steel industries, play in CCS deployment. Furthermore, these industries' extended societal responsibility in sustainable development is discussed from a stakeholder integration and corporate responsibility perspective. As there is limited time for implementing effective climate mitigation measures, adequate policy development is crucial. Therefore, this study envisions contributing to support energy intensive industries' efforts on CCS deployment in order to reawaken a paralysed CCS agenda in the European Union.

Hence, the study:

1. outlines the context of urgent climate action and the need for CCS installation in energy intensive industries;
2. reviews the state of the art research on corporate responsibility and stakeholder integration in sustainable development;
3. assesses, investigates and develops understanding of energy intensive industries' positions on CCS deployment and their role in the transition towards a low-carbon economy;
4. develops recommendations to support and facilitate industry CCS deployment.

Preface

I hand in this study as the master thesis of the MSc Globalisation, Politics and Culture taught at the Norwegian University for Science and Technology in Trondheim. The study has been conducted in cooperation with the environmental NGO Bellona Europa based in Brussels. The necessity for urgent climate action and my inspiration by the work of Bellona Europa gave birth to the study. The research was developed and conducted in an environment where Carbon Capture and Storage technologies are well-regarded as part of the solution to solve the climate puzzle and that the technologies offer a large potential to decarbonise both the power and the industry sector. Bellona Europa has more than a decade of experience with advocacy work supporting CCS deployment in Europe. From the beginning onwards, and throughout this research process, I have taken a favourable position towards CCS as a climate technology. The opportunity to conduct the thesis in this setting gave me invaluable insights in the complexities associated with CCS deployment and their challenges – without this knowledge; I would not have been equipped to see the study through. I therefore hand in the thesis with deep gratitude to all the wonderfully inspiring colleagues at Bellona Europa; for welcoming me so warmly and supporting me through the whole process. I have appreciated all the feedback I have been given, as well as all the useful discussions on industry CCS.

Further, I thank my supervisor, John Eilif Hermansen at the Department of Industrial Economics and Technology Management at the Norwegian University of Science and Technology, for patiently responding to all my questions and guiding me over a long distance; for his genuine interest in the research topic and brining my slightly bombastic advocacy language into a less conclusive academic format. I wholeheartedly thank Mathilde and Ivonne for actually bothering to thoroughly read, comment and discuss my thesis, and finally I highly appreciate Teodora and Hugo for taking the time to proofread the work.

Nothing alone can singlehandedly save the planet. Nevertheless, the idea that my research could to the slightest extent contribute to combatting climate change, has been an endless source of motivation throughout these last months.

Rannveig van Iterson, Brussels, June 2016

Abstract

On the backdrop of the urgent need to combat climate change and in light of the Paris Agreement, Carbon Capture and Storage (CCS) technologies are a recognised part of the solution solving the climate puzzle. Institutions such as the Intergovernmental Panel on Climate Change, the European Union and the International Energy Agency all define CCS as a necessary climate technology to fully enable the transition towards a sustainable low-carbon society by 2050. The steel and cement industry are heavy CO_2 emitters in the European Union. A large share of these CO_2 emissions are unavoidable process emissions that are not associated with fuel combustion. This demands urgent action on CO_2 emission abatement in industry. At the moment CCS installation has become a recognised technological solution for decarbonisation of energy intensive industries. Due to unfavourable framework conditions an almost paralysation of movement in CCS deployment is observed in the European Union.

This study investigates the relationship between industry stakeholders' positions on CCS and their transition towards a sustainable low-carbon economy. It addresses a research gap by assessing the cement and steel industries' positions on CCS and their identification of inadequate framework conditions currently challenging industry CCS. Furthermore the study discusses industries' extended societal corporate responsibilities in a low-carbon economy in light of sustainable development. The main results indicate that industries' positions on their responsibilities in a low-carbon economy are used to justify their non-engagement in large scale CCS. Industries solely recognise capturing CO_2 emissions as their societal responsibility and should thus not be expected to engage in full chain CCS projects. As the needed CCS infrastructure is currently not available and unfavourable framework conditions are prevailing, the cement and steel industries associate CCS installation with unaffordable large risks. The study therefore recommends that, contrary to the 'polluter pays' principle, public authorities should enable industries to make the necessary investments into capturing CO_2. Further, public authorities should take on the task to develop the stable and predictable framework required, and initiate the construction of CO_2 transport and storage capacity.

Contents

List of acronyms

CCS	Carbon Capture and Storage
CEF	Connecting Europe Facility
CO_2	Carbon dioxide
CT	Climate technologies
EC	European Commission
EFTA	European Free Trade Association
ETS	Emissions Trading System
EU	European Union
EUA	Emissions Unit Allowance
ICCS	Industry Carbon Capture and Storage
IEA	International Energy Agency
IPCC	Intergovernmental Panel on Climate Change
Mt	Million tonne
MEP	Member of European Parliament
NER	New Entrants Reserve
NGO	Non-Governmental Organisation
NORDICCS	The Nordic CCS Competence Centre
RES	Renewable Energy Resources
TFEU	Treaty on the Functioning of the European Union
UN	United Nations
UNFCCC	United Nations Framework Convention on Climate Change
ZEP	The European Technology Platform for Zero Emission Fossil Fuel Power Plants

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1 INTRODUCTION

Energy intensive industries such as steel and cement cause significant quantities of carbon dioxide (CO_2) emissions to the atmosphere both through fuel combustion and the production processes itself. The large carbon problem is not related to fuel combustion, the so-called process emissions, are inevitable through current production processes. In 2015, the cement clinker industry in the EU emitted 113 776 million tonne (Mt) CO_2 equivalents, and the steel industry caused 106 388 Mt CO_2 equivalents in the same year (European Environment Agency, 2016). Respectively, they constitute about 6.3[1] percent and 5.9 percent of the total emissions in the EU not including emissions from the aviation sector. In comparison, energy intensive industries all together constitute almost 32[2] percent of the CO_2 emissions in the European Union, excluding aviation emissions, emphasising the urgent need and the large potential to cut emissions in energy intensive industries.

However, despite the urgent need to combat climate change and in light of the Paris Agreement, efforts to abate anthropogenic impacts have been worryingly low in the energy intensive industries, disregarding cement and steel industries' energy efficiency efforts implemented the last two decades. To fully decarbonise these industries, it is at present recognised that Carbon Capture and Storage (CCS) technologies offer the sole means to decarbonise these processes. The UN's Intergovernmental Panel on Climate Change strongly communicated the acute need to deploy CCS technologies if we are to make the transition to a low-carbon society by 2050 (IPCC, 2014). This message is accompanied by the technology roadmaps for decarbonisation published by the International Energy Agency and the EU Energy Roadmap for 2050. Simply put, capturing and storing carbon dioxide as a climate technology, "prevents large amounts of carbon dioxide (CO_2) from being released into the atmosphere (Global CCS Institute, 2015). Despite the consensus on the necessity of CCS application, both in the power and industry sector, an almost paralysation in CCS efforts are observed. The energy intensive industries have to a certain extent engaged in CCS projects in their production plants, but merely on research level. Therefore, this study sheds light on the European energy intensive industries, steel and cement, and their positions on CCS technologies. It seeks to understand the reasons behind the slow efforts for deep

[1] These numbers are calculated based on the total emissions from all installations under the EU Emission Trading System (ETS) amounting to 1800 373 Mt CO_2 equivalents in 2015 (European Environmental Agency, 2016).

[2] This number is calculated based on that all energy intensive industries under the ETS emitted together 574 965 Mt CO_2 equivalents in 2015 (ibid.).

decarbonisation of their production processes and industrial CCS installation, despite these industries facing increasing political and societal expectation to do so.

The following introductory chapter outlines the assumptions the study is grounded on; it firstly examines the context of inevitable climate change taking place and the Paris Agreement; then the chapter provides an overview of the climate ambitions set by the European Union (EU) as the study is limited to understanding steel and cement industries' located within the EU. Furthermore, it highlights the current developments on a slow moving CCS agenda in the EU and the key deployment challenges encountered by industry stakeholders so far; it considers the relevance of the EU's strategy for re-industrialisation of key industries such as steel and cement and lastly the chapter identifies the research gap and the academic relevance and contribution of the study; as well as defines the research issue followed by the scope and structure of the study.

1.1 Background of study

> Climate change is one of the main environmental problems, perhaps all the more worrying because it is impossible to predict exactly how it's going to develop and what the consequences will be. Its causes, however, are known. Climate change stems mostly from the greenhouse effect – meaning the excessive retention of solar energy in the atmosphere due to an accumulation of certain gases, particularly CO_2. [...] The main sources of CO_2 emissions are industrial production, transportation and, more indirectly, deforestation (Huwart, 2013, p. 112).

It is indisputable that immense global economic growth has been dependent on industrialisation. These same industrial activities are those causing alarming atmospheric carbon dioxide concentrations. To that regard, further sustainable economic globalisation and growth, fair for all, cannot rely on fossil fuel consumption and industrial activity as we know it today. The transition to a green low-carbon economy is dependent on decoupling economic growth from greenhouse gas emissions. The global economy grew by three percent in 2014 (PBL Netherlands Environmental Assessment Agency, 2015, p. 4). Nevertheless, the question on how to create an economy where CO_2 emissions are not a natural consequence of economic growth, and simultaneously ensuring that cutting emissions do not hamper industrial competitiveness, is one of the major challenges the EU economy currently faces. In a European industrial setting, these concerns are one of the most relevant for key energy intensive industries. It is clear that to be able to comply with the climate commitments, all sectors have to carry their fair share. Due to the steel and cement industries' accounts for large

shares of CO_2 emissions in the EU, the potential and need to cut emissions in these industries is therefore significant.

Since the first United Nations Conference on the Human Environment in the beginning of the 1970s, the necessity of restructuring the global economy into a sustainable society has become generally accepted (UNEP, 2012b, p. 5). Climate science observes that the CO_2 concentration in 2014 was at 397 ppm, which is about 40 percent higher than in the middle of the 19th century "with an average growth of 2 ppm/year in the last ten years" (International Energy Agency, 2015, p. 7). Furthermore, 2015 came to be the first year where the CO_2 concentration in the atmosphere hit 400 CO_2 parts per million. The Intergovernmental Panel on Climate Change (IPCC) has estimated that to be able to stay inside the two degree limit the weight of CO_2 in the atmosphere must be less than 800 Giga tonne CO_2 – in comparison, since the industrial revolution human-kind had emitted 531 Giga tonne CO_2 by 2011 (IPCC, 2013). In the last decade global emissions increased by an average of four percent annually, however, the global emissions rose by merely half a percent in 2014 (PBL Netherlands Environmental Assessment Agency, 2015, p. 4). The outcome of the Paris Agreement, restating to limit global warming to well below two degrees, and ultimately taking those measures needed to limit global warming to 1.5℃ above pre-industrial times, commits a global community to take real measures. However, the Agreement leaves open the possibility for the parties to continue emitting emissions, therefore, it will require even higher percentage emission reductions annually after the peak of 450 ppm CO_2 concentration.

EU environmental policy and climate action is recognised as one of the most stringent frameworks globally. In 2011, the EU launched its Energy Roadmap 2050, committing the EU to reduce "greenhouse gas emissions to 80-95% below 1990 levels by 2050" (European Commission, 2011, p. 2). The roadmap identifies several decarbonisation strategies for the European economy; all scenarios rely on renewables, energy efficiency and significant deployment of CCS, both in the industry and power sector (European Commission, 2011, p. 8). The European Commission's message for the need for CCS in the 2050 perspective recognises that due to the unavoidable process emissions of some industries, there is a need for industrial CCS application almost without conditions:

> "On one hand there is absolutely recognition of the need for CCS demonstration to deployment because there is this acknowledgement that we will need it for both the power and the industry sector. But of course there is this nuance that for the power sector we need CCS to meet the targets cost-efficiently, at least for some member states. For the industry sector it is recognised and stated that we need CCS to reach the climate targets, without any conditions basically" (European Commission, 2016a).

Nonetheless, the Paris Agreement questions whether the EU's climate efforts are stringent enough to limit global warming. The EU's Climate and Energy Framework 2020-2030 serves as the common framework for energy policy and climate action until 2030 and sets common climate targets. The objective of the targets is to "continue to drive progress towards a low-carbon economy which ensures competitive and affordable energy for all consumers, create[s] new opportunities for growth and jobs and provide[s] greater security of energy supplies and reduced import dependence for the Union as a whole" (European Commission, 2014, p. 3). The 2030 targets include the 2020 climate targets and strengthen them for the decade after 2020. The framework commits the EU to reduce its greenhouse gas emissions by 40 percent by 2030 compared to 1990 levels. Furthermore, energy efficiency and the share of renewable energy sources shall make up 27 percent each respectably (European Commission, 2014). To that end, a revised EU Emissions Trading System (ETS) shall serve as the main mechanism for emission reductions in the industry and power sectors (European Commission, 2014). The ETS is both a market tool gradually ensuring emission reduction in the power and industry sectors and a tool to raise funds to support the uptake of low-carbon technologies. The ETS is based on the principle of setting a price on per emitted tonne of carbon dioxide and trade those emissions allowances among industry and power installations. The intention is to deliver greenhouse gas emission reductions within the industry and power sectors in the EU in the most cost-effective way. The total amount of allowances for trading, 'the cap,' is reduced annually by a certain percentage, ensuring emission reductions. The ETS system is at present the largest carbon market system globally and currently legally binds 45 percent of the EU's emissions from 11.000 power and industry installations and aviation within the 28 EU member states and the three European Free Trade Association states (European Commission, 2015).

The ETS has, since its establishment in 2005, failed to provide the incentives needed for low-carbon investments. In particular, limited effect on increased deployment of CCS technologies has been observed as the low price of the emission allowances which have not provided the needed financial value for the industry and power sector to take active measures to reduce their emissions. Because of the low price on the CO_2 allowances, fiscal revenues earmarked for the New Entrants Reserve (NER 300) were severely reduced. The fund was earmarked for low-carbon innovation in both renewables and CCS. At the time when the NER 300 program was negotiated, the price of the allowances was estimated to 30 Euros, however, at its lowest, the price has amounted to merely two to three Euros, reducing available funding for low-carbon technologies drastically. The fundamental problem with the ETS is that private

investors have not had a reason to believe in the policy commitment of significantly reducing emissions. The price of allowances effectively blocked a possible change in the private sector's energy consumption pattern (Wolff & Zachmann, 2015, p. 10). Consequently the ETS, which binds the EU industry and power sector to gradually decarbonise, has not provided the needed incentives to do so.

1.1.1 The potential for CCS technologies in industry

The necessity to enable CCS in industry does not relate to them being energy intensive, but that large shares of their emissions are caused by the production process itself, so-called process emissions. Therefore, "[e]ven if the entire planet manages to switch to renewables and nuclear energy overnight, we would still be emitting CO_2 through industrial processes" (Finkel & Smith, 2016). In cement production about 60 percent of the CO_2 emissions are "generated by carbonate oxidation in the cement clinker production process, the main constituent of cement and the largest of non-combustion sources of CO_2" (PBL Netherlands Environmental Assessment Agency, 2015, p. 38). The same applies for steel production; emissions are related to the process itself. Non-combustion CO_2 emissions from "blast furnaces used to produce pig iron and from conversion losses in coke manufacturing" cause about 70 to 80 percent of the emissions originating from the iron making, are related to the steel making process (PBL Netherlands Environmental Assessment Agency, 2015, p. 40). These process emissions cannot be abated by energy efficiency measures or alternative fuels. To that end, they constitute a large carbon problem in the European steel and cement industries.

Nonetheless, Carbon Capture and Storage (CCS) technologies offer the potential to fully decarbonise these industries. CCS as a climate technology is contested in many settings as various concerns are perceived associated with its deployment. The technology is, however, generally well-regarded by intergovernmental institutions such as the IPCC, the EU and the IEA as they recognise that CCS will have to play an essential role in the transition to a low-carbon economy. The IPCC affirms that "[m]any models cannot reach about 450 ppm CO2eq concentration by 2100 in the absence of CCS" (IPCC 5AR, 2014). CCS technologies enable the possibility to capture and store carbon dioxide with the purpose of avoiding large amounts of CO_2 emissions from being released into the atmosphere. CCS has a significant decarbonising potential as it prevents CO_2 emissions by approximately 90 percent from being

emitted to the atmosphere (Global CCS Institute, 2015). The technology involves "capturing CO_2 produced by large industrial and power plants, scrubbing it to remove all impurities, compressing it for transportation and then injecting it deep into a rock formation at a carefully selected and safe site, where it is permanently stored" (ibid.). CCS technologies hence refer to three separate and very different technological processes respectively referred to as 1) capture of CO_2, 2) transport of CO_2 and 3) storage of CO_2. The capture process refers to an engineering activity of the "separation of CO_2 from other gases produced at large industrial process facilities such as coal and natural gas power plants, steel mills and cement plants," (ibid). The CO_2 capture from industrial point sources such as steel and cement production is referred to as *industry CCS* as opposed to capturing CO_2 emitted by power plants. This study solely investigates the positions industry stakeholders have on CCS – consequently, when referring to CCS in this study, the deployment of industry CCS is discussed. Moreover, the transport process is currently expected to initially take place through ship transport and later when larger volumes of CO_2 are transported through pipelines. The CO_2 storage process is a geological process that allows for permanent storage of CO_2 in geological formations either offshore or onshore and thus prevents it from being emitted to the atmosphere. Storage of CO_2 and the construction of storage capacity is currently associated with the largest technological challenges. There is need for further research and knowledge building on CO_2 storage and CO_2 injection into reservoirs (Røkke, 2016). However, there is an academic consensus that the risk of CO_2 leakage from storage reservoirs is so minimal that storage can be trusted (Røkke, 2016). Europe has a large potential for storage capacity development, as it is estimated that 300 billion tonnes of CO_2 could possibly be stored across the continent (Røkke, 2016), making the debate of CCS deployment in Europe possible.

– The technological readiness of CCS in industry

This study does not question the technological side of CCS deployment, however a certain overview of the readiness of CCS should be provided. The current status of CCS is that it is technologically feasible, that there are some uncertainties about risks, but these are deemed as manageable (Anderson et al., 2009). Carbon capture is already done in the steel and cement industries, however merely on research level. Capture technologies are, for example, tested for the cement industry at the Norcem plant in Norway, and in the steel industry the HIsarna process is tested as a capture technology. On a global scale, more than two decades of experience in full scale CCS installation has been gathered; however, large scale realisation in

industry CCS in the EU has not yet emerged. In the research community there is a general consensus that the technologies are available and can be deployed; however, there is room for further improvement in cost reductions, optimizing the technologies and economics of scale (Røkke, 2016). When looking at the cement and steel industries specifically, post-combustion technologies in cement and steel industries are estimated to be mature enough to deploy. The International Energy Agency (IEA) and the United Nations Industrial Development Organization's (UNIDO) technology road map for CCS application indicates that for capturing high purity CO_2 sources such as ammonia, ethanol and natural gas processing, are at the moment technologically mature enough to commercialise. For separating and capturing CO_2 from flue gas from cement and steel production, the technologies are expected to mature within the next five to fifteen years depending on the type of technology (IEA & UNIDO, 2011, p. 9).

Moreover, as CCS is related to significant investments, cost reductions are essential to push for its deployment (European Commission, 2016a). As the technology only has been commercialised in one place, in the Boundary Dam Project in Canada, actual deployment of the technology would enable large cost reduction in CCS installation. At Boundary Dam it is estimated that the second plant could be constructed with 30 percent less costs (Global CCS Institute, 2015b). Furthermore, there is a need to focus more on researching the energy penalty associated with CCS installation and how to reduce it. The energy penalty is the increased energy consumption an industrial plant experiences when running the capture unit installed at the plant. It amounts to "roughly 10–40% more energy than a plant of equivalent output without CCS, of which most is for capture and compression" (IPCC, 2005). Naturally, there is a large potential for both cost and energy consumption reduction in CCS, which certainly would ease the deployment of CCS.

– A paralysed CCS agenda in the EU

Contrary to CCS being deemed technologically mature enough for commercialisation, it seems that "CCS is not going anywhere" (European Commission, 2016a). There are multiple explanations for the slow movement on the CCS agenda in the last decade. Up until 2009 great enthusiasm for CCS to be the next break-through technology was observed (European Commission, 2016a). At the time, almost exclusively only power sector CCS was on the agenda – industry CCS was not considered to the same extent. Financing mechanisms such as

the EU Emission Trading System setting aside 300 million allowances into the NER 300 fund earmarked for low-carbon innovations in both CCS and renewable energy sources, constituted the one-sided approach to CCS deployment as the NER 300 funding was not made eligible for industry CCS projects. At the time the fund was large enough to support demonstration of CCS, however, when the economic crisis hit and the price of CO_2 allowances dropped, the funding was dramatically reduced. This has partly explained why no CCS project, neither in power nor industry CCS, has been realised with support from the NER 300 program.

Additional explanations for the slow movement in CCS can be traced back to lacking targets for CCS on an EU level. In contrast, the EU has set a target for the share of renewable energy for both 2020 and 2030 (European Commission, 2014). This forces member states to take concrete measures on how to meet the renewable targets; and, according to the interim reports, member states are generally keeping up (European Commission, 2015b). In comparison, in non-EU member state Norway, the government set a target for having one full-scale CCS project up and running within 2020. The target has forced the authorities to take concrete actions. Currently three test projects have the potential to become the flagship project of the Norwegian government which will either Yara in Porsgrunn, Norcem in Brevik or Klemetsrud in Olso. Despite the fact that actions have been taken very slowly by, the fact that a set target exists in Norway has pushed things forward. The non-existence of similar targets at EU level can partly explain the slow movement on a European level (European Commission, 2016a). A decade ago it would possibly have been politically feasible to set such targets (European Commission, 2016a). However, as the ETS has come in place, it is likely not politically possible to agree on such a target in the current political climate. This is compatible with the European Commission's stance on technological neutrality meaning it does not prescribe the type of technologies that should be utilised, as long as they lead to CO_2 emission reductions.

Further, da Silva (2015) recognises several other barriers to CCS deployment additional to the low CO_2 price and missing targets, namely public acceptance challanges, lack of financial incentives, lack of political support, lack of cooperation among actors, uncertain liability of CO_2 storage and technological uncertainties (da Silva, 2015). All these challenges constitute a complex picture explaining the almost non-existent movement on the CCS agenda in the EU today. CCS is associated with large initial investment costs as well as high operational costs, and therefore there is a double risk with CCS installation that investors have not been willing to take (European Commission, 2016b). Additionally, a significant barrier to CCS deployment has been public acceptance challenges. To varying degrees, depending on

geographical location and which stakeholders you ask, the geological storage of carbon dioxide is not perceived as a safe and secure climate mitigating technology by the general public (da Silva, 2015). In spite of the recognised need for CCS technology, public acceptance of CCS faces varying degrees of reluctance and often outright opposition. Associated concerns are the possibility that it might divert attention away from renewables and that CCS is very costly. Further public confidence challenges originate often from the perceived risk of leakage of geologically storing CO_2 and uncertainty about associated risks. Nonetheless, CCS promoters see CCS risk management in the following way:

> "Overall, in looking at the risks of CCS, one has to consider the risks of both implementing it and of not implementing it: the precautionary principle applies as much to employing CCS to avoid global warming as it does to avoiding leakage from CCS.
>
> The basic conclusion is that because the risk from climate change due to fossil fuel emissions is larger and far more difficult to manage than the risk from CCS, the risk of leakage from storage should not impede CCS development overall" (Anderson et al., 2009, p. 4650).

The consequence of negative perceptions or misconception of the risks associated with CCS is non-deployment. As industries have few alternatives for decarbonisation, increasing the understanding of the pressing need for CCS as a mitigation tool is key. All means to combat climate change will be needed to address climate change, as there is "little evidence that renewable energy will be able to carry the job alone" (Anderson et al., 2009).

Overall, these factors have halted CCS deployment to a near paralysis of the CCS agenda and a certain disillusion among CCS supporters can be felt. As a consequence, a move away from power sector CCS and an emerging interest for industry CCS is observed. The power sector seems currently not to be moving forward on CCS anymore – which is a discouraging sign when keeping in mind that it is expected that fossil fuels will continue to constitute a part of the energy mix until at least 2050 (Meer, 2016). The initial focus on power sector CCS seemed logical at the time, as it has a much larger carbon footprint than the industry sector (Sheffield University, 2016). Even though the industry sector does not emit as much as the power sector, it is often more cost effective to pursue industry CCS. This is due to the purer CO_2 streams associated with industrial activities which in turn often render the capture cost of CO_2 per tonne less expensive than capturing from power plants (Sheffield University, 2016). Power CCS can be seen as an alternative to other, more sustainable, energy sources such as renewables, justifying the argument that CCS would prolong the use of fossil fuels. In other words, this diverts attention away from investing in renewables such as wind

and solar power. On the other hand, energy intensive industries cause large CO_2 emissions by the production process itself, regardless of the type of energy source that is used for the heating process. Therefore, industries such as cement and steel have few alternatives to reduce emissions other than with CCS. Consequently, the conditions for the two technologies are very different. There is, therefore, a more general recognition of the need for *industry CCS* and that the CCS agenda should be pushed forward through industrial CCS application. This need is echoed by the European Commission's main advisory platform on CCS technologies, the European Technology Platform for Zero Emission Fossil Fuel Power Plants (ZEP). The platform never truly managed to integrate industry stakeholders in the CCS work ZEP was conducting; however, in the course of power CCS not moving forward, ZEP is currently taking steps to integrate industry stakeholders to initiate a push for industry CCS (Sweeney, 2016).

This movement is acknowledged by the European Commission (2016a), as one can lately "see that there is a change of direction from power to industry CCS, now we try to put forward the need to invest in CCS because of industry" (European Commission, 2016a). As long as there are no realistic alternative materials for cement and steel, CCS has been demonstrated to be the sole solution to decarbonise industrial processes. Globally we depend on energy intensive products (Røkke, 2016), and "[i]f the EU wants to take its 2050 targets seriously, then industry CCS must be taken into use. The other low-carbon technologies depend on the price, but industry CCS one needs to do it unconditionally" (European Commission, 2016b). As the EU Energy Roadmap 2050 spells out:

> "CCS is also an important option for decarbonisation of several heavy industries and combined with biomass could deliver "carbon negative" values. The future of CCS crucially depends on public acceptance and adequate carbon prices; it needs to be sufficiently demonstrated on a large scale and investment in the technology ensured in this decade, and then deployed from 2020, in order to be feasible for widespread use by 2030" (European Commission , 2011, p. 12).

1.1.2 Reindustrialising European cement and steel industry

In the transition towards decarbonised European energy intensive industries, any comprehensive strategy for decarbonisation at European level seems not to exist. However, on the backdrop of a steadily declining European industry, and especially in light of the financial crisis, the European industries have shown "difficulty in renewal and adaptation to the new global environment and therefore trouble in maintaining a strong industrial base and a

competitive position at the international level" (Dhéret et al, 2004, p. v). The industrial sector suffered heavily in the economic crisis starting in 2008, and the steel and cement industries are still struggling to get out of the economic downturn facing international competition (Røkke, 2016). Thus, as a prolongation of the "smart, sustainable and inclusive growth," the so-called Europe 2020 targets, (European Commission, 2010) the European Commission launched a strategy for reindustrialising Europe (European Commission, 2014b). The EU's climate and energy policy is based on the principle of resource efficiency. The objective of the principle is to "decouple [our] economic growth from resource and energy use, reduce CO_2 emissions, enhance competitiveness and promote greater energy security" (European Commission, 2010, p. 15). The strategy was launched to counter the negative growth that the Union experienced during the financial crisis. The EU's climate and energy policy is based on further growth to be realised in an ecological and climate friendly manner; it is fundamental to be able to simultaneously reduce greenhouse gas emissions, as well as increasing economic output. The lack of a comprehensive strategy for decarbonising the European industries is, however, not compatible with the Paris Agreement, possibly jeopardising any full decarbonising target. In spite of the EU currently being on the path to manage its target of 20 percent reduction of CO_2 emissions within 2020, this is largely explained by the downturn in industrial activity as a consequence of the economic crisis. Furthermore, CCS for industry can enable the reconciliation of the EU's climate change mitigation and re-industrialisation objectives by preserving jobs in the European industries and simultaneously meeting climate targets (Sheffield University, 2016). CCS deployment in the EU is suggested to be able to create and secure jobs in fuel supply, CCS equipment manufacture, plant operation and CO_2 storage facility operation (ZEP, 2013, p. 8). This illustrates the potential CCS had for a competitive decarbonised industry in the EU.

1.1.3 Relevance and contribution

As outlined, CCS in industry can play a major role in decarbonising the European energy intensive industries and simultaneously ensure that these industries are not relocating outside the EU. Despite these beneficial factors of CCS, large scale deployment of CCS has not taken place in Europe. Up until this point, energy intensive industries' positons on CCS and why they have not engaged in large scale CCS has not been extensively researched. In this vacuum the study is positioned to provide insights on the attitudes industry stakeholders have towards CCS and generates understanding of the main barriers and benefits industry perceives being

associated with CCS deployment. Much of current research concludes that most industry stakeholders view the affordability of CCS as the main concern, however the nature of the concerns vary across groups. Industry stakeholders' main attitudes towards CCS have seen it as an important technology, but have not been willing to take the risk of investing in it (Ashworth, 2015, p. 450). Consequently, studying industry stakeholder's positions on CCS is of high societal and academic relevance. In turn these insights could be of benefit to ensure that industry CCS projects are realised in Europe.

1.2 Research question & objectives

The research problem of this study is grounded in the need for urgent climate action and drastic mitigation of CO_2 emissions. Energy intensive industries are large emitters of CO_2 and thus have to carry a heavy load in abating those emissions. Climate technologies such as CCS have been recognised to play a focal role in solving the climate puzzle; nonetheless, several challenging factors have proven to stand in the way for effective CCS deployment. As such, the purpose of the study is to develop better understanding of the energy intensive industries steel and cement's positions on CCS. The research question is, therefore, what role do industry stakeholder's attitudes towards CCS deployment play in the transition towards a low-carbon economy? For effective policy development, understanding the industry's positions and related framework conditions is essential to equip decision-makers to pursue more suitable policies facilitating deployment of CCS in industry installations. The purpose is therefore to facilitate the development of suitable policies supporting key industries to ensure their competitiveness and simultaneously commit to climate targets. To answer the research question, the following three research objectives are defined. The study:

(1) Assesses energy intensive industries' positions on and perception of CCS;
(2) Investigates industries' extended responsibilities in a low-carbon economy;
(3) Develops policy recommendations to facilitate industry CCS deployment.

1.3 Structure and scope of study

The scope of this study is limited to industry's positions on CCS. Even though CCS is estimated to be of essential importance for decarbonisation of both the fossil fuel sector and the energy intensive industries, this study is limited to understanding industry stakeholder's perceptions of CCS and how the industry itself perceive the main barriers for deployment.

Even though there is a large group of stakeholders involved in industry CCS, it is essentially the industry itself that has to implement CCS, thus their concerns have to be taken into consideration if they are required to cut emissions by 80 to 95 percent CO_2 emission within 2050. Therefore, in spite of NGO's traditionally having been encountered as important stakeholders in CCS deployment, their view points are not considered in the research. Based on earlier research on NGO attitudes (Anderson & Chivari, 2009), these stakeholders have not been considered as relevant in CCS deployment. NGO's have proven to be both in favour and against CCS projects. Nonetheless, the "stake" that NGO's have in CCS is their advocacy in favour of the public interests. Both those opposing and promoting CCS argue to speak in the favour of the public and future generations. As the research question is posed, and as NGO's and the public are not those that eventually will engage in CCS projects, NGO's positions on CCS have been disregarded from this study. Furthermore, this study recognises that there are large potentials for CO_2 reductions on the consumption side of products, however as CCS applies to production processes, this research focuses on how industries can reduce emissions on the production side. This study does, therefore, not discuss emission reduction from a life cycle perceptive of products.

Subsequently, this study is structured as follows: after the introduction of the context of the study in Chapter One the methodological framework applied is outlined in Chapter Two; then Chapter Three examines the theoretical framework discussing stakeholder theory and the extended responsibility of corporations in sustainable development. Chapter Four follows with the analysis of the empirical data collected, and subsequently Chapter Five is dedicated to discussing the data in light of the theoretical concepts, provides for policy recommendations drawn on the earlier chapters and proposes recommendations for needed changes to push industry CCS forward. Finally, Chapter Six sums up the main findings of the study as well as suggesting further possible research issues.

2 METHODOLOGICAL FRAMEWORK

To provide answers to the research objectives, the following chapter outlines and discusses the research model and the data collection and analysis methods applied. The study is based on a qualitative methodological approach, the study utilises a modified version of Davis's (1996) research model for decision-making in business as it provides a flexible and structured framework for researching complex social phenomena. Further, the main methods applied are in-depths interviews and literature search. Additionally, the chapter discusses relevant issues of reliability and validity.

2.1 Qualitative research methods

Researching social phenomena such as positions on CCS as a climate technology make qualitative research methods very convenient, as qualitative methods are designed to acquire a deeper understanding of complex social phenomenon (Thagaard, 2003, p. 11). Qualitative methods provide thorough data on narrow subjects, and therefore interpretation of the data plays a large role in the research. The most widely used data collection method is in-depth interviews providing for comprehensive insights into individual informants' viewpoints. To that regard, qualitative research methods fit excellently to understand industry stakeholders' positions on CCS. Qualitative methods require a systemised approach to handle the large quantity of collected data (Thagaard, 2003, p. 14), and thus Thagaard (2003) underlines the importance of alternating between reflecting on the research process and being open and flexible and taking systematic methodological decisions. The following chapter justifies and reflects on the methodological choices taken during this research process.

2.1.1 Research model

The study applies Davis' research model for systems thinking and decision making in business which equips the researcher to easily recognise and differentiate the various research concepts that constitute the complete study. It is considered that the application of the model structures and strengthens the research at hand. The pieces in the model are observation, context, concepts, constructs and final conclusions as illustrated in Figure 1. The figure illustrates the research pieces that constitute this study. Starting from left to right, Davis (1996) defines *observations* as the context and facts collected in order to ground the research

into reality (p. 26). The need to combat climate change and the observation of energy intensive industries emitting large amounts of CO_2 that cannot be abated except with CCS, constitute the context of the study. Further, *concepts* are the building blocks that originate from scientific research (ibid), meaning they are constructed and generalised ideas that originate from facts; because when there are no developed research concepts, constructing theory is not possible. Research concepts differentiate from facts and observations in the sense that they are abstract and only exist because researchers have agreed on their existence. The concepts in this study are corporate responsibility and stakeholder integration to ensure sustainable development. *Research problems* are therefore the arising questions about the relationship between one or more concepts that are to be answered. In this study this associated relationship questions the relation between industry stakeholders' positions on CCS and their influence in the transition towards a low-carbon economy. Deriving from the research question, hypothesises arise. *Hypotheses* "are conjectural statements of the relationship between two or more variables that carry clear implications of testing the stated relations" (Davis, 1996, p. 29). They are therefore "tentative statements" considered to be plausible given the available information. Based on previous research, it is plausible to assume that certain attitudes towards CCS slow down its deployment. *The hypothesised relationship in this study is the assumption that the energy intensive industries' positions on CCS application affect industries transition towards a low-carbon economy; assuming that if these are better understood, could facilitate the development of policies fit for industry CCS to kick off the CCS agenda again.* Furthermore, Davis argues that when a hypothesis has been verified extensively, the relationship between the concepts can be considered *law*, however in most business research, relationships are usually only verified to a certain extent, making them only 'weak laws.' This undoubtedly applies to all social sciences, due to the assumed social complexity making it nearly impossible to account for all possible variables. Only after extensive research, associated relationships can be given a lawlike status (p. 30). A theory can then be defined "as an interrelated set of statements of relationships whose purpose is to explain and predict" (p. 30), as scientific theories are grounded in empirical facts. As the researcher cannot take all possible variables into account, a research model is a simplified version of a phenomenon. Conclusions are thus derived based on a simplified version of a phenomena and a set of weak laws and empirical generalisations (p. 32). As verification of associated relationships requires extensive resources and time, only limited testing of the relationship between industry positions on CCS and their impact on industries transition to a low-carbon economy is possible. This study therefore delivers a contribution to further theory

development, however cannot fully verify the associated relationship. The study therefore provides general conclusions and develops recommendations to enable better policy development to kick off industry CCS deployment. Figure 1 illustrates the various research pieces that constitute and structure the study.

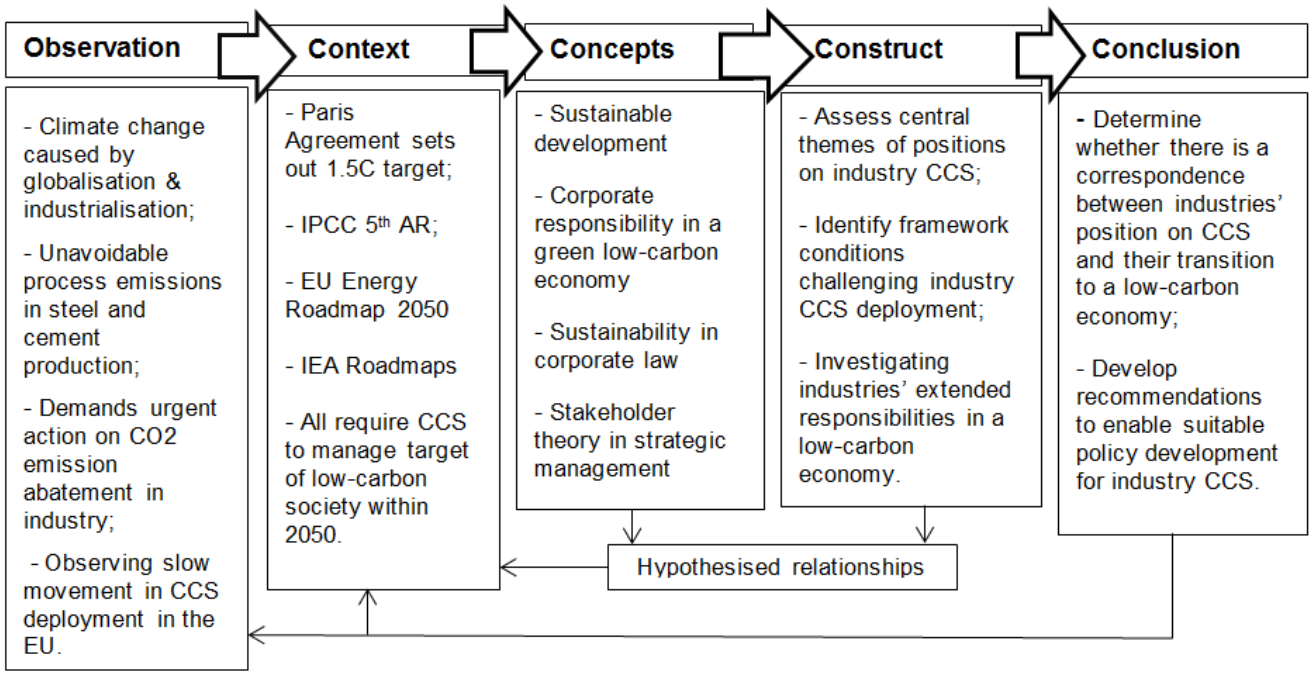

Figure 1: *Modified version of Davis' (1996) research model for decision making in business*

2.1.2 Data collection methods

The qualitative data collection methods applied in this thesis are use of secondary literature and in-depth semi-structured interviews with relevant stakeholders.

– Secondary literature

The study relies to a large extent on secondary literature and journal articles for structuring the theoretical framework and literature building up under the empirical data collected. It has been considered as beneficial to combine several sources of data to verify collected data from the interviews. Some of the positions of industry stakeholders are public positions which are easily accessible. Nevertheless, the data collected through the interviews provide for a much broader and nuanced picture of these attitudes. Especially the reports and publications of the

associations for the European steel and cement industries have been valuable strengthening the quality of the analysis.

Further secondary literature invaluable to the study is the extensive research that has been conducted on the concepts of sustainable development, corporate responsibility in a green low-carbon economy, sustainability in corporate law and stakeholder theory in strategic management. The theoretical literature collected for this study originates mainly from literature lists from previous courses conducted, supplemented with further perspectives on recommendation by the academic supervision of this study. The work done by Griggs et al. (2013) and Rockström et al. (2009) on defining sustainable development and planetary boundaries are considered very relevant. Further work that deserves to be highlighted is Porter and Kramer's (2006) and Sjåfjell et al. (2015)'s contribution on corporate responsibility in sustainable development. Additional literature on CCS and stakeholder perceptions has been searched for through the search engines Scopus and Google Scholar with search words such as *CCS, industry, perceptions, public acceptance, stakeholder* and *framework conditions* were searched for in different combinations. Out of these searches the work on social barriers to CCS done by Ashworth et al. (2015) has contributed to a large extent to the analysis. Further literature has been collected though recommendations of articles, reports and other literature from colleagues and interview informants. From this method Henriksen and Ombudstvedt's (2014) work emerged and have proven very useful. Additionally, a large extent of the relevant literature was found in reference lists of other articles and together this constitutes a comprehensive base to combine the existing knowledge on CCS as a climate technology and corporations' social responsibility in regards to sustainable development.

Furthermore, a large set documents, reports and technology roadmaps published by the European Commission, International Energy Agency, the United Nations and the Intergovernmental Panel on Climate Change are used to articulate the context of the study. These are all well recognised institutions and the use of their literature is considered as thrust worthy sources of information. Furthermore, the IPCC Special Report on Carbon Dioxide Capture and Storage (2005) and the Global CCS Institute provide among others essential understanding of the technological context of CCS.

– Semi-structured interviews

Complimenting literature search, in-depth semi-structured interviews have been conducted. Qualitative interviews bring the researcher very close to the informants and thus the understanding of the data (Thagaard, 2003, p. 18). The loose character of semi-structured interviews has provided for a flexible and informative manner to conduct the interviews, giving room for the interviewee to speak freely and for the researcher to ask spontaneous and interesting questions that rose whilst conducting the interview. The interview guide was developed in an inductive manner, as the questions asked were developed based on experiences made in earlier work in the CCS field and previous research on the matter. Therefore the questions were to a lesser extent derived from theoretical concepts. This has turned the research into applied science with a large empirical data set. The questions focused on eight central themes as these where recognised as the main challenges and positions relevant for the study; perceptions of CCS, perceptions of industry CCS, challenges of CCS deployment, CCS in the 2050 perspective, alternatives to CCS, CCS as a competitive advantage, CCS deployment facilitation by authorities and CCS communication. The informants where questioned on their positions on the benefits and challenges on the particular topic. The complete interview guide can be found in the Appendix.

In all, ten interviews were selected and conducted based on their expertise and relevant stakeholder position regarding CCS. For the sake of the research, a spectre of interests is represented in the study to better understand the complexity of the framework conditions that relate to CCS deployment. Hence, not solely representatives from the energy intensive industries steel cement have been interviewed. The dataset contains seven interviews with representatives from the energy intensive industries cement and steel in Europe; two informants are officials from the European Commission and one informant well-known in the CCS research community. The industry informants representing the European associations for steel and cement are both representing an interest lobby and their answers are considered from this perspective in the analysis. It has therefore been important to keep in mind why stakeholders are representing certain opinions and what their reasoning for their position is. Furthermore, both industries are represented in the data set through informants employed in the industries themselves – nevertheless in the department's responsible dealing with sustainability and climate change challenges. The interviews conducted with the officials from the European Commission and the research community have provided for invaluable input on the political context and insights in the technological readiness of CCS. Over all, in

spite of the research focusing on industry stakeholder's positions on CCS, the professional opinions by decision-makers in policy development and the research community, are considered invaluable contributions to the study.

The selected interviewees have been sampled based on the method of what Thagaard (2003) refers to as convenience sampling or 'non-probability' sampling (p. 54). This entails contacting possible informants purposefully and based on their position in a certain organisation or institution, as well as those that have been convenient to contact for the author. The selection process of the informants has been based a quota sampling method (Thagaard, 2003, p. 55) where the informants have been determined based on their affiliation and competence in the field. As CCS deployment is highly complex, involves many stakeholders, and is not a reality yet, it is of utmost importance to base research on informants that have a thorough understanding beforehand. Until CCS projects are real and tangible, it is not directly relevant to ask the general public of their opinions. Bellona Europa's network and recommendations of colleagues have provided the researcher with a comprehensive sample of informants from the CCS community in Europe. It was consciously chosen to contact informants via the email account and signature of Bellona Europa. This was considered to provide a higher response rate, as it was expected that informants to larger extent would be willing to spend time on being interviewed. By using the Bellona signature, the author could rely on the NGOs trusted name and reputation, saving the research for valuable time. Most likely this gave the researcher access to informants that possibly would not have responded just as willingly. Whether the informants thence provided a modified version of their answers to the author, well knowing of the researcher's favourable position towards CCS, might well be the case. Nevertheless, as considered above, the informants are experts; therefore, the researcher's position on the subject should not have influenced their answers.

Furthermore, all except one of the interviews were recorded and large parts of the interviews were transcribed. About half of them were conducted in person and half either via phone call or Skype call. As the research questioned the interviewees' professional perceptions of CCS, and not their personal attitudes, it was not regarded as a limitation to conduct interviews via phone or Skype. As all the interviews were expert interviews, the informants were estimated to be comfortable to speak on the topic and hence on the phone as well. The interviews lasted between half an hour and an hour – which has provided for a large dataset. Some of the informants have wished to stay anonymous in the study whilst others have expressed their consent to be referred to by name. Therefore some are referred to only by

institution or the organisation affiliated with, others by full name. See complete list of conducted interviews in the reference list.

2.1.3 Method of analysis

To make sense of and structure the primary data collected during the interviews, *thematic analysis* has been considered to be the most useful for these purposes. This section discusses the method applied to code, structure and recognise patterns of themes across the data. Thematic analysis has become a common method in qualitative social science research (Braun and Clarke, 2013) as the method is suitable to answer most research questions. It builds on the method of analysing themes that are recognised within the collected data. In the process of understanding the character of the industries' positions on CCS, it is very useful to be able to categorise and group repeating elements into themes. This study takes an inductive approach to the research, as the interview guide was developed inductively and the theoretical perspectives were applied after the data was collected. The analysis therefore does not exclusively consider themes recognised in the data, however these are analysed in light of theoretical perspectives of stakeholder integration in strategic management and corporate responsibility in a sustainable low-carbon economy. As the method focuses on recognising themes across data, a limitation of the method can to a certain extent be seen when researching contradictions and differences between variables. To ensure that differences in the data are still considered, these are highlighted specifically in the analysis chapter.

The analysis is loosely structured around the eight themes that where discussed during the interviews. The transcription of the interviews was followed by familiarisation of the data through reading and rereading of the material as recommended by Braun and Clarke (2013). The arising themes constituting the final analysis are restructured and adapted categories from the interview guide. During the research process the focus was slightly modified and themes have been relabelled according to interesting aspects recognised in the analysis of the data. Those informants affiliated with the industry sector have weighed most into the analysis, nevertheless, the data retrieved from the research community and policy developers have provided invaluable information to understand the context of the research and provide for input for the recommendations developed in the study.

2.2 Research ethics

The ethics considered in the study are mainly those related to informed consent. This research principle refers to that those taking part in the study are fully aware of their participation and have the opportunity to withdraw from the study at any point of the research (Thagaard, 2003, p. 23). Furthermore, the interviewees have the right to get an overview of the research, agree to whether they are recorded, and agree to how they are referred to in the study. In all the interviews, the author discussed before the interview was conducted whether the informant agreed to be recorded and how the informant wished to be referred to in the study. This is essential as research participants have the right that that their data is treated in confidentiality (p. 24). This refers to the right to be treated anonymously and that information displayed cannot somehow damage the privacy of the respondent. As discussed above, some of the participants were comfortable with disclosing their full name, others only the institution or organisation they are affiliated with. This is respected in the research. No other sensitive issues were considered to be relevant of the study.

2.3 Reliability and validity

To strengthen the quality of the study and its conclusions, the reliability and the validity of the research should be considered. Bryman (2008) suggests that the *reliability* of a study is when it constitutes a possibility to replicate the results, when the same methods are applied. However, to ensure the reliability of qualitative studies is a very challenging exercise, as data derived through qualitative methods are almost impossible to replicate. In qualitative studies it is therefore of higher importance to ensure internal reliability referring to whether the research methods applied are consistent with the research question and the results derived. As such, conducting in-depth interviews with industry stakeholders to research their positions on CCS installation is regarded as a highly suitable method to answer the research question. The researcher had at the point of interview guide development, already acquired a well-developed understanding of challenges concerning CCS deployment. This ensured that the questions that were included in the interview guide in turn were directly targeted at positions and perceptions of CCS already recognised. This is considered to strengthen the reliability of the study. To avoid that the interview guide was too coloured by pre-developed perceptions of CCS, before the finalising of the guide the questions were discussed with the academic supervisor of this study.

The *validity* of the research refers to integrity of how the findings have been derived, how credible the conclusions are, how the analysis has been conducted and how the researcher has chosen to interpret the data. It is therefore essential to reflect upon once own position in the research and take into consideration once own position in the research (Kitchin & Tate, 2013, p. 6). This study was conducted at an environmental NGO's offices. Being part of a working environment at the Bellona Europa office, has undoubtedly coloured the analysis by the views and perspectives of the organisation. Nonetheless, assessing industry stakeholders' positions on CCS through the eyes of an environmental NGO has ensured the climate perspective focus in the study. In spite of CCS being a contested technology among NGO's, the overall goal for the environmental movement is to reduce emissions and thus combat climate change. Industries' interests are not always aligned with those in favour of reducing emissions. The main purpose of the study is to shed light on decarbonising possibilities for energy intensive industries, hence conducting the research from a NGO perspective is strengthening the validity of the research.

Nevertheless, research biases can possibly arise unconsciously when the researcher works in an institution over longer time. As the author carried out the research in a civil society setting supportive of CCS deployment, the analysis is inspired by being conducted in a surrounding where CCS is well-regarded. Presumably, institutionalised biases have arisen, as the study's outcome might have been influenced by the norms and values there as the researcher "becom[es] a part of the phenomenon" (Laurier, 2010, p. 118). This has undoubtedly coloured the study, not even talking of the birth of the research issue itself. However, in qualitative research the researcher itself is the instrument, attaining objectivity is impossible. As such, it is of great importance to elaborate on researches positions and biases to understand how the findings are interpreted. In spite of the analysis being conducted through the analytical eyes of an environmental NGO, it is considered to provide the analysis and the discussion chapters with an external perspective that ensures the validity of the final conclusions drawn.

Moreover, to strengthen the validity of the analysis and conclusions derived, the various informants are referred to directly in the analysis in accordance to the format they wished to be referenced. To demarcate clearly between the informants' statements and the interpretation and the analysis of the researcher, is essential to increase the credibility and thus the quality of the research. Finally, those informants that requested to review the final version of the analysis, were given the opportunity to do so. Overall, issues concerning reliability and validity have been carefully considered throughout the research process.

Finally, the question on whether there is a possibility to generalise from the final results in this study must be seen in that qualitative research is associated with few study cases, therefore, it is not commonly described as generalizable. However, that does not imply that qualitative research cannot be of valuable beyond its context. The value of transferability of the results of this study grounds in the holistic approach of the study and therefore it is suggested that the results can be of value to understand positons on CCS in other energy intensive industries as well.

3 THEORETICAL FRAMEWORK

The following chapter discusses the theoretical framework and concepts the study applies to analysing energy intensive industries position on CCS technologies. Extensive research has been conducted on stakeholder views on CCS, especially the social dimension of what the public and civil society perceive of CCS. However, the underlying flaw of all research on positions on CCS is the fact that the subject towards the perceptions are asked for, is not yet real. It all boils down to asking relevant stakeholders on their possible concerns or perceived benefits of a very intangible concept as CCS. It is more comparable with questioning stakeholders on what they think about flying carpets, and asking about what they consider to be the benefits and what would be their potential concerns on the topic of flying carpets. In the current literature stakeholder approaches have been applied to understand various interests that are associated with CCS deployment. As stakeholder integration in strategic management is encountered as one of the most essential elements in facilitating the transition towards a sustainable society (Elkington, 1998), the following chapter firstly discusses the concept of sustainable development; then, in order to understand the positions of industry stakeholders towards CCS, a stakeholder approach to strategic management is examined, followed by a discussion on corporate responsibility in a sustainable economy.

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3.1 Sustainable development

The sustainable development agenda and environmental concerns about the planet have fortunately enjoyed increasing importance since the 1970s. Elkington (1998) pioneered the concept of the 'triple bottom line' for businesses, developing the argument that business cannot only serve the claims beneficial for its profits, however business must serve its benefit for and be equally concerned with the planet and people, hence the triple bottom line. He criticises the current form capitalism is structured in, and develops therefore an argument that if the global society is not to deplete its recourses, business must change its behaviour dramatically. Further development cannot rely purely on economic growth for the sake of the planet running out of resources – hence the global community is dependent on further sustainable development. Griggs et al. (2013) have therefore developed the definition of sustainable development one step further. Current capitalistic structures cannot weigh social, planetary and economic concerns equally. They argue that we are dependent on "development that meets the needs of the present while safeguarding Earth's life-support system, on which

the welfare of current and future generations depends" (Griggs et al., 2013, p. 306). Consequently, this definition does not equally weigh economic, planetary and social considerations, but emphasises safeguarding of the Earth's life support. They put forward the argument that economic growth and societal welfare both depend on the state of the Earth system, hence environmental protection should be the most urgent concern to act on of the three pillars making up sustainable development. Therefore, the big CO_2 emitters, the cement and steel industries, could most effectively contribute to sustainable development by abating their emissions.

3.2 Stakeholder theory in strategic management

In a world where the realisation that climate change is becoming urgent and where external stakeholders such as governments, civil society organisations and the media are increasingly seeking to hold companies accountable for their environmental and social impacts, changing expectations of business behaviour is increasing (Porter & Kramer, 2006). Increasingly consumer demands are changing to favour businesses that manage to incorporate aspects of corporate sustainability into their supply chains. In the last decades the notion of that managers not only bear responsibility towards shareholders has gained foothold broadly. Strategic management has traditionally focused on granting rights and privileges towards shareholders, however the definition of who has a share or a 'stake' in the corporation has been widening. Freeman (2001) proposed the concept of stakeholder theory for the modern firm through launching the stakeholder enabling principle. The essence of the principle is that corporations shall be managed in the interests of its stakeholders, defined as employees, financiers, customers, suppliers and local communities (Freeman, 2001, p. 47). Derived from this principle, a stakeholder in a corporation are those "groups and individuals who benefit from or are harmed by, and whose rights are violated or respected by, corporate actions" (Freeman., 2001, p. 41). Stakeholder theory analyses the role and interests that involved actors play in the project or policy matter at hand. Freeman (2001) pioneered stakeholder theory in strategic management of the firm. The method rose as a response to a need for managers to be responsive to external environmental and unexpected changes (Baumgartner & Ebner, 2010, p. 77). Baumgartner and Ebner (2010) emphasise that in the current reality, corporations have to adapt to external factors, and not solely internal matters. It has become a necessity for corporations to have to react to the trends that are emerging on the sustainable

development agenda – and still manage to stay competitive in rapidly changing markets. Stakeholder integration implied for corporate managers a notion to include a broader group into their corporate planning than merely the stockholders or owners of the organisation – hence the shift away from the earlier primacy of the shareholder. For managers this came to be an approach that requires large efforts of communication and interaction with a much larger stakeholder group. Freeman stresses that corporations must therefore not only abide by the law and regulations, however, make efforts to meet the claims by all stakeholders equally (Freeman, 2001). Freeman acknowledges that some stakeholder's interests are conflicting with each other, leaving it to managers to balance these claims and interests as best as they can. The basic principle of taking a stakeholder approach to strategic management is that all stakeholders are equal. Freeman highlights that firms have to consider the "claims of customers, suppliers, local communities, and employers […] though in general they are subordinated to the claims of the stockholders" (Freeman, 2001, p. 39-40), meaning that in practice some stakeholder's interests are considered more important than others. Integrating all stakeholders' interests in the corporation's activities became often seen as a constraint on the core business of the organisation, namely, to maximise shareholder's profits. As Freeman underlines, organisational management should maximize stakeholder profits as a whole, hence bringing the stakeholders to the centre of an organisations business. This is in contrast to engaging in external opinion management of stakeholders. The notion that firms shall meet the claims of all stakeholders, has triggered increased level of regulatory frameworks to grant these rights and privileges – hence not only the expectation of meeting these claims constrains firms, however legislation is increasingly in place to ensure that those rights are granted (Freeman, 2001, p, 40).

For the purpose of the analysis in this study, it is relevant to make a distinction between what is a stakeholder and an actor. As Freeman outlines, he suggest that the stakeholders are those directly influences by the firms activates – the narrow definition of a stakeholder. However an actor is in social science, as Barker (2011) emphasises; an agent or agency is the capacity to act and decide on their own choices independently. Therefore an agent or actor can both be an individual, a corporation or an organisation that has decision-making capacity. Agents or actors tend to work on someone's behalf and not in its own interests (Barker, 2011). In the context of CCS projects, civil society organisations could be defined as actors, but not stakeholders. They are not directly affected and do not have a 'stake' in the CCS project, however their advocacy work either in favour or against the project, has proven to have a direct effect on project outcome. Civil society advocates do

however argue that they represent the interests of the pubic and future generations. From that perspective civil society organisations' claims on industries' decisions to change their behaviour, has been and is to play a role in future CCS deployment in industry.

In line with Freeman's definition of a stakeholder, local communities are seen as a stakeholder. For CCS projects, the most relevant stakeholders are the claims of the local communities, as up until now these have had major influence stopping projects from moving forward. The challenge of CCS communication is to ensure that it is communicated in the interest of the public, which is in opposition to the traditional communication on possible CO_2 leaking from storage that worries the public and local communities. Considering that the public trust is higher in civil societies statements on CCS, compared to the industry itself, communicating that CCS is in the publics' and the environments interest, is of high importance. Porter and Kramer (2006) stress that a firm cannot fully rely on stakeholder integration as they themselves are the best positioned to evaluate what is considerations are needed to be taken for ensuring the companies a favourable market position in the future.

Nevertheless, some stakeholders are not encountered for in Freeman's definition of stakeholder theory, as he only takes account of stakeholders that represent a human interest in the natural resources. Elkington (1998) acknowledges the importance of stakeholder integration into corporate decision making to facilitate the transition to a sustainable society. He broadens the stakeholder definition by adding additional stakeholder groups to the analysis that cannot claim their rights by voicing their opinion. Such stakeholders are the concerns of future generations' interests in corporate behaviour. Elkington defines these stakeholders as quasi stakeholders. As they are to be affected by decisions made in business today, they are legitimate stakeholders to take into account in business activities. Deriving from this string of thought, in spite of establishing that civil society is not a stakeholder in CCS projects, such organisations could be seen as the representation of those future generations that cannot voice their own concerns and claims in business decisions today.

If NGOs act as quasi stakeholders voicing the interests of the general public and future generations, Terwel et al. (2011) add an interesting perspective on trust-based public acceptance on stakeholder motives. They argue that attitudes towards CCS are defined according to the perceived trust in the stakeholders (p. 182). They find that people tend to trust environmental NGO's more than industrial stakeholders, and not based on their competence in the field. The discrepancy in trust is explained by the integrity of the organisations. This was explained as "environmental organizations were thought to be involved in CCS due to 'public serving' motives such as concern for the natural environment

and future generations" (p. 185). Industrial stakeholders, on the other hand, "were anticipated to be involved in CCS primarily out of "organization-serving" motives such as profit maximization or image building" (ibid.). Such findings suggest that industrial stakeholders wishing to utilise CCS to abate their CO_2 emissions face an even higher public acceptance barrier if they were to implement CCS.

Further Ashworth et al. (2015) recognise that a significant amount of research has been based on interviewing stakeholders and their take on CCS. This has allowed for more in-depth understanding of their views on CCS. Anderson and colleagues found in a large Europe wide survey in 2009 that in general European stakeholders are at least are moderately supportive of CCS and that they believe that CCS can play a role in the national emission mitigation plan. The survey disclosed that environmental NGO's and parliamentarians are more reserved towards the risks that are connected to CCS (p. 4651). Naturally, how CCS is communicated and who communicates about it, will be essential to ensure public confidence and political support of CCS.

3.3 Corporate responsibility and corporate law

So what responsibilities does the modern cooperation have? Traditionally the main objective of corporations is to "maximize profits and shareholder values" (Dicken, 2011, p. 222). To ensure the best position for an organization – hence maximise its competitive advantage, it must predict its external environment and continuously internally adapt to this external circumstances; followed by adjusting accordingly to continue its beneficial position in the market. Organisations are recognised not to be independent islands, however open systems that are interconnected with a much larger network. To understand these interconnections and the interdependence between them is a large part of the stakeholder mapping and comprehending what interests the various stakeholders have in the company. Furthermore, "a globalized world has led to increased expectations of businesses responsibilities and a changing paradigm of what is perceived to encounter corporate responsibility" (Scherer and Palazzo, 2011). Increasingly environmental targets have been defined by governments, the EU and the global community through the UN climate negotiations, however, a comprehensive strategy on how to meet these targets is not defined and facilitated yet. In European Union law Article 11 in the Treaty of the Functioning of the European Union (TFEU) enshrines sustainable development to be mainstreamed into all EU legislation:

"Environmental protection requirements must be integrated into the definition and implementation of the Union's policies and activities, in particular with a view to promoting sustainable development." Wiesbrock and Sjåfjell (2015) emphasise the importance of the Article as it incorporates the definition of sustainable development of Griggs et al. stressing that all welfare is dependent on the state of the planetary health. Through the article ensuring that environmental concerns are taken in all policy development, demonstrates how the principle of sustainable development has evolved into becoming the overall legal principle in EU law (p. 2). Despite Article 11 being a legally binding rule, its implementation and enforcement has been and is to a certain extent totally ignored in other EU legislative policy development. Nevertheless, within the EU, increased expectation of the industry taking the necessary steps to make the deep CO_2 emission cuts that are needed, have been rising. For example Article 191 (2) of the TFEU enshrines the polluter pays principle as the base for EU environmental policy. It states "that environmental damage should as a priority be rectified at source and that the polluter should pay," and thus holds those emitting pollutants responsible for paying for abating those emissions. In spite of the legal principles and rules being in place, real commitments to decarbonise the energy intensive industries vary to a large extent.

This can to a certain degree be explained by the voluntariness of taking environmental concerns on board into business activities. The concept of Corporate Social Responsibility (CSR) is defined by the European Commission as "a concept whereby companies integrate social and environmental concerns in their business operations and in their interaction with their stakeholder on a voluntary basis" (European Commission, 2011, p. 3). The European Commission emphasises that CSR efforts are actions beyond companies' legal obligations towards the environment and society. In strategic management corporate social responsibility is often referred to voluntary activities that an organisation can engage in. There are large developments in the field of climate policies on the corporate level, however not the stringent measures that are needed. This can be exemplified with the CSR EU Directive on non-financial reporting. The intentions of the directive are by all means in the right direction, however it only states that firms *should* report on their non-financial and it applies only to large companies with more than 500 employees. The directive urges firms to report on "environmental matters, social and employee aspects, respect for human rights, anticorruption and bribery issues, and diversity in their board of directors" (European Commission, 2016). Regardless of the non-binding aspect of the directive, the fact that a directive has been established, creates a leaving point for starting to define a more formal and structured approach towards CSR activities.

A challenging aspect of CSR is and has been a missing common understanding of the concept. In Dahlsrud's (2008) examination of CSR definitions he clearly observed the lacking of a unified definition of CSR. Due to the soft law character of CSR a unified definition is challenging to find. CSR is very much based on voluntary activities that corporations engage by their own choice, resulting in every firm creating their own understanding of what CSR entails. Dahlsrud found five dimensions in the concept of what the extended corporate responsibility notion entails in current literature. The five dimensions of CSR dimensions are definitions that entail elements of the environment, social, economic, stakeholder and an aspect of voluntariness (p. 4). All the dimensions are interlinked as increased stakeholder integration enforces both social and environmental claims to cooperation's beyond the shareholders financial claims. In the necessary transition towards a green and low-carbon economy the voluntary dimension of CSR creates a challenge. One can definitely observe an increased expectation of the industry sector taking the needed actions, however, the general observation is that industries cannot merely be excepted to abate their environmental impacts, they need to be *required* to. The voluntary aspect constitutes a large part of the CSR concept. Porter and Kramer (2006) highlight that a focal part for companies to engage in CSR activates is the importance of moral obligations of the company's duty to be a good citizen and to "do the right thing" and pursue ethical business strategies. Therefore those companies that do implement environmental polices into their strategies do so out of business interest as they expect that a concerned consumer is willing to pay for a sustainably produced product – or based on an honest understanding of the pressing need to implement stringent emission mitigating measures to halt global warming. This implies that there is a market for sustainably sourced and produced products. The question whether there is a market for low-carbon steel and cement is therefore very relevant to pose.

However, there is a trend that corporate responsibility is moving from being voluntary activities corporations engage in, to becoming more similar to corporate law that firms are required to comply with. Sjåfjell and colleagues (2015) recognise that the still prevailing norm of shareholder's primacy is the main challenge blocking companies from developing into more suitable companies. They add that it explains why voluntary efforts by companies such as CSR activities cannot be sufficient in order to transition towards a sustainable society. The short termism in shareholders' thinking does not foster sustainable company development. Sjåfjell et al. have dissected the legal base for shareholders primacy – and not found a legal base for its continuation, thence in corporate law, the primacy of sustainable development should be enshrined into corporate law – hence ensuring that sustainable

development is a principle corporations *have to* comply with. In order to make the transition towards a sustainable society, a reform in corporate law is required, fully integrating environmental concerns into the core of the regulatory frameworks business needs to comply with (Sjåfjell & Richardson, 2015).

Moreover, Porter and Kramer (2006) argue that a company's extended responsibility, its CSR activities, lays in the intersection between its business activities and its social and environmental impacts, defined as strategic CSR. They argue that if CSR is applied correctly in the sense that it is mainstreamed with the rest of the corporation's activities, then these would provide the firm with a favourable position in the market, and simultaneously create value for society. Porter and Kramer (2006) point out that that for too long CSR is seen in opposition to the core activities of business – as if social and environmental concerns are on the cost of profit serving activities. Therefore they stress the importance of business creating *shared value* for both the firm and society. In the case of energy intensive industries, their core activity is to produce and sell products that emit large quantities of CO_2, hence to minimise their emissions would be the largest value for society as a whole. Their largest responsibility is thus to minimise their external environmental impact would be cutting their emissions to such large extents that it matches their fair share to commit to the two degree global warming limit. By no means does that imply that the European steel and cement industries are entitled to meet the claims of its suppliers, employees and other relevant stakeholder, as well as comply with the relevant legislative framework. However, the largest external impact these industries have on the environment is the emitting of the pollutants. In line with Porter and Kramer's argument, business should mainstream their largest environmental impacts into their core business to ensure competitive advantage.

Nonetheless, Million (2015) suggests that strategic CSR, as Porter and Kramer define it, builds on cost-benefit analysis, hence companies, where shareholders' primacy is still prevailing, are mostly likely to only invest in environmental sustainability if it benefits the company financially. Therefore, the chances that business managers invest enough in sustainability to satisfy the required needs are small. Therefore, only in the case if there is a market for low-carbon steel and cement, this would prove Porter and Kramer right that streamlining CSR into core business, creates competitive advantage. If that market does not exist, political tools to create such markets could be attained through green public procurement, and hence enforce environmental concerns to be taken in all public tendering.

4 ANALYSIS

The following chapter analyses the data collected during the interviews. Firstly the steel and cement industries positons on CCS are identified, and what they see as their societal role in a the transition towards a sustainable low-carbon economy; secondly the industries' take on CCS in a 2050 perspective is analysed; third, from the industries' perspective the current main challenges of industrial CCS deployment are identified; forth, alternative decarbonising measures to CCS in steel and cement are presented; fifth, the potential of CCS installation as competitive advantage for industries is examined; finally, industries' engagement in CCS communication is analysed. The empirical data is discussed in light of the theoretical framework and concepts in Chapter Five.

4.1 Identifying steel and cement industries' positions on CCS

According to Ashworth et al. (2015) industry stakeholders' main attitude towards CCS has been seeing it as an important technology for decarbonisation, but have not been willing to take the risk in investing in it. The informants in this study have provided however a more nuanced picture. Both the steel and cement industry indicate their responsibility for large amounts of CO_2 emissions and subsequently the obligation to take the necessary steps to abate them (Meer, 2016). Overall, the industry representatives are very much aware that they have a carbon problem caused by industrial processes, emitting CO_2 that cannot be abated by switching to renewable energy sources. The informants tended to agree that there is a need for large scale CCS deployment by 2050 and that they as industry are willing to move on CCS. The European Cement Association's (CEMBUREAU) position representing the European cement producers inform that if 80 percent CO_2 reduction in the cement production is to be achieved, breakthrough technologies must be commercialised (CEMBUREAU, 2016). This message is echoed by the European Steel Association (EUROFER) by stating that within the steel industry, it is assumed that CCS can play a role in mitigating CO_2 in the future and in order to cut emissions by more than 50 percent within 2050, CCS must be applied (EUROFER, 2016). Furthermore, they recognise the need of decarbonising of the industrial processes as society is dependent in the products of cement and concrete (CEMBUREAU, 2016) and steel (EUROFER, 2016). In spite of the common recognition of the need to abate emissions, there is not a clear consensus on how these processes shall transition into low-carbon industries:

> "When you look at the facts from the industry perspective, power industry, energy intensive industry we are clearly convinced that 95% or 80 % CO_2 reduction will not be achievable without a solution of Carbon Capture plus something. What that something should be is open for discussion. When we are looking at solutions for our sector, then there is no way out of carbon capture in the future […]. We are convinced internally in the company that if we are going to achieve 95% reduction in the cement production, then CCS to a certain volume must come in place. How much we don't know" (Meer, 2016).

This underlines the industries' understanding that the production of near zero CO_2 steel and cement is dependent on the industries' CCS installation. Furthermore, both cement and steel industry representatives indicate that the extended societal responsibility they as industry carry is solely limited to capture the CO_2 they emit. All industry stakeholders have echoed the same message about CCS; industry can only be held responsible for the capture part of the CCS chain (Meer, 2016; Bjerge, 2016; CEMBUREAU, 2016; EUROFER, 2016). The business of "the steel industry is producing steel, this is our business" and therefore the steel industry has a reluctant relationship with engaging in transport and storage of CO_2 (EUROFER, 2016). This has proven to be one of the barriers of CCS deployment. Further deployment challenges are discussed later in this chapter.

As all low-carbon roadmaps require significant CO_2 reductions, industry has become dependent on developing CCS. The steel industry has been engaged with CCS since the last decade through the European Ultra Low Carbon dioxide Steel Making program. In the early 2000s the industry realised its major CO_2 issue, hence they invested in research on CCS technologies. The funding was matched by the European funding mechanisms 70 million euros. Through the program a vast diversity of technologies for significant reduction in CO_2 emissions where researched that would equal more than 50% reduction. These where at narrowed down to four major technology developments for the industry, where three of them depended on CCS to make the 50% reduction. These developments where intensely discussed in the industry and seriously considered, but due to various challenges never seen demonstrated in large scale (EUROFER, 2016).

Similar developments have been seen in the cement industry. Until today all CCS projects in cement are self-financed with some public funding support. Through the current project developments, industry show they at least intend to take part in the transition to a low-carbon and a sustainable society and see the necessity to take part in the technology developments that are taking place (Meer, 2016). Whether it is a sign of genuine future commitment to CO_2 reductions, cannot be inferred before actual large scale CCS projects are

commercialised. Nevertheless, as stated by one cement industry representative: "If governments want CCS then we will follow, it is very simple" (Meer, 2016).

4.2 CCS application in the 2050 perspective

Deriving from the informants, both the steel and cement industry seem to be convinced that CCS will play a role in order to achieve the 2050 decarbonistion target of 80-95 percent CO_2 emission reduction. However, "[w]hen you want to achieve 95% reduction or even more, you have to have an economic environment where you can do it, and I don't see that happening at the moment and in the near future" (Meer, 2016). The steel industry supports CCS and believes it can play a role in the 2050 perspective, but it sees challenges connected to its deployment (EUROFER, 2016). In light of the Paris Agreement, cement industry representatives stated that the "Agreement has made an impression on the cement industry realising that also we have to contribute to ensure the compliance of the Agreement. We need CO_2 capture to manage this and thus the cement industry must do something. We cannot sit on and wait for others to move" (Bjerge, 2016). Bjerge underlines that the climate agreement has made an impact and that people in the industry to a larger extent are referring to the vision of zero emissions by 2050.

On the other hand more pessimistic attitudes are observed in the steel industry. A steel representative stated that the industry seems to have decided to wait and to see what happens towards the outcome of the Paris Agreement. Some discussions on transition arrangements that need to come in place have been seen, however, most likely globally it is expected that there will be a decade where the global community is feeling its way forward during the implementation of the Agreement. Until there is a form of global consistency in the regulatory framework for industry, there will be hesitancy in making real investments in CCS (Sheffield University, 2016). Furthermore, industry informants stated that in 2050, they expect CCS to be an integrated part of our everyday lives and that it will be an essential industry with a significant amount of employment and competence is located (Stuen, 2016).

4.3 Current challenges of industrial CCS deployment

The current challenges identified with industrial application of CCS have according to the informants tended to circle around several, but very similar challenges and barriers resulting in a complex interdependent picture. An element that applies to all challenges is that none of

these barriers are technical. The same consensus seems to be found within the industry; technological concerns tend not to be the issue – these are engineers that are experienced with large engineering projects. The few technological issues that do still need to be solved are best solved by actually deploying the technologies (Røkke, 2016; Sweeney, 2016). Nevertheless, seven main challenging non-technical barriers are recognised in the data, hence the following section contains a compressed analysis of the most significant perceived deployment challenges.

4.3.1 The lack of legislative predictability

Inferring from the informants, both the European steel and the cement industry witness that the EU's Emission Trading System is not delivering what it was expected to deliver. The main challenge with the ETS is the lacking of legislative predictability and hence not incentivising private investments in climate mitigating efforts. As the system has undergone several regulatory rethinking's since it saw daylight in 2005, industry considers there to be a lack of even a minimum of legislative stability that is necessary to be able to reach a final investment decision in CCS projects. Industry does not foresee this regulatory stability established through the current ETS reform in the EU for the next decade either, creating few of the needed investment incentives (Meer, 2016; Røkke, 2016). At the moment all CO_2 emissions cuts delivered in the two sectors cannot be traced back to the ETS mechanism as the system has not provided for a sustainable project for carbon reduction in industry in the EU yet (Meer, 2016). The current CO_2 reduction projects developed in the cement and steel industry have been mostly self-financed with some support from other public support mechanisms (EUROFER, 2016; CEMBUREAU, 2016). The industry understands therefore that "whilst governments are asking us to [cut emissions], we feel that governments are not giving us the instruments to embrace it, such as the needed legislation" (Meer, 2016). The low confidence in the ETS reform creating the legislative predictability needed to drive low-carbon investments, does not create incentives for investment. At present installing CCS is seen as an additional cost punishing industry within the EU (Meer, 2016; EUROFER, 2016). With lacking adequate legislation, the steel and industry expressed concerns to have to relocate outside the EU, if not a favourable framework is set in place (ibid.). With the current low CO_2 price, there are few economic incentives to do the needed investments, and as such, the ETS contributes little to mitigate CO_2 emissions. Legal questions of who owns the possible CO_2 reductions made through CCS projects, results in undefined uncertainty of

responsibility of the CO_2 reduction and hence the value of the ETS price (Meer, 2016). As the price is very low, it is not a directly relevant issue at present, however, if the ETS price would have been significant, questions of who gets the value of reduced emissions, would create economic incentives, thus it is clear that these legislative questions must be clarified (Meer, 2016). These concerns are understood by the European Commission as it sees that with ETS not delivering, there is no real push for industry to cut their emissions;

> "[CCS] indeed requires more work, as mostly CCS requires very big investments. They are really huge projects, not only that, but especially for industry it is very difficult. [Industries] understand the need [to cut emissions], it is not that they don't. We have been talking to associations like cement producers. They understand the need. They do their research, but at the moment they don't really need to incorporate CCS to meet their targets, so they don't do much" (European Commission, 2016a).

Further lacking legislative stability is recognised by industry respondents regarding the directive on the geological storage of CO_2, the so-called CCS directive (2009/31/EC). The purpose of the CCS directive is to regulate CCS if it was deployed in EU member states, and ensuring that the associated risks of long-term storage are born (Ashworth, 2015, p. 456). The problem with the implementation of the directive has proven to be the large disparity on how the directive has been interpreted. The implementation of the directive has varied according to what perceptions there is of CCS among the public in the specific member state (European Commission, 2016a). An example is Germany's choice to implement it as a compromise where onshore storage is not allowed, however offshore storage is made possible up to a volume of 600 000 tonne CO_2 annually. In other member states, such as Belgium, onshore storage has been allowed. For industry the flexibility on how to implement the directive has created legislative uncertainty, in spite of the opposite intentions of the directive. Further, uncertainties related to the CCS directive stated by the informants where questions of who is responsible for CO_2 that is captured in an industry plant and injected into storage. Questions concerning which actors are liable for the stored CO_2 are not clarified through the CCS directive. The directive for instance requires 20 years of liability of CO_2 storage by the operator. This has been considered to be a too long duration to require from operators (Ashworth et al., 2015). When industry believes it is solely responsible for capturing CO_2, legal questions about which actors are responsible for what naturally arise. Further informants raised concerns about who is to take responsibility for possible risks of the CCS installation on the rest of production at the production site (Bjerge, 2016). The current framework for CCS is characterised by high levels of unresolved issues associated with counter-party

dependence. In essence, both the steel and cement industry informants call upon the need for clarifying legal hurdles and strengthening the regulatory framework that is associated with large scale CCS deployment. There is a clear need to establish a "flexible, but yet predictable framework" (Henriksen & Ombudstvedt, 2014, p, 6732) to reduce the current risks.

4.3.2 The lacking business case for CCS

The overarching current barrier informants highlighted is the missing business case for CCS. This challenge is interlinked with several barriers as both a lacking stable legislative framework and lack of adequate funding currently provides no business case for CCS. It is recognised that there is a crucial need of a CCS model that makes economically sense (Røkke, 2016). Informants from both industries express concerns that are connected to financing and affordability when competing in a global market. At the moment industry has no other way to pay for CCS and other mitigating efforts, than passing on the cost to its consumers (Røkke, 2016). Consequently, at the moment CCS installation is solely seen as an additional cost (EUROFER, 2016; CEMBUREAU, 2016). The costs of cement and steel production are estimated to be doubled with CCS (CEMBUREAU, 2016; EUROFER, 2016). Industry sees that at current conditions, commercial CCS will not be realised in Europe before 2030 if not supported extensively by governments and EU institutions. In case of the Norcem cement plant in Norway, they are depending on public funding from the government and will depend on large capital investment from the Norwegian government, if the project is to be commercialised into large scale (Bjerge, 2016). This has raised questions on the need for both upfront capital investment support and operational support to run the capture plant (Bjerge, 2016).

These concerns all amount to that the industry is concerned about being outcompeted by cement and steel producers that do not have to comply with similar stringent decarbonising targets. The message is echoed by the European Cement Association stating that the ETS requires the industry to abate emissions, however at the current price of the allowances it is not viable to abate those emissions. Therefore large investment decisions have been difficult to take especially when company parents are located outside the EU. The European Steel Association (2016) in particular suggests the need for CCS to be turned into a business case by authorities. When here are no commercial grounds for CCS, "the lack of CCS specific frameworks and economic incentives represent serious obstacles for deployment" (Henriksen

& Ombudstvedt, 2014, p. 6736). Therefore, there is a need to establish investment clarity to support these industries (European Commission, 2016b).

4.3.3 The challenge of competing on a global market

Closely linked with the latter barrier is that the European steel and cement industries are not competing on a solely European market. Both steel and cement industry informants argued that when the best performing plants located in Europe are required to invest in CCS, but still in international competition, they are pushed to relocate outside the EU were there are few or no CO_2 reduction requirements. The cement industry affirmed therefore that the consequence of not supporting CCS deployment in the EU could possibly be that their sector would emit more CO_2 emissions on a global scale (Meer, 2016). They argue that if the current developments are continued in Europe, then CCS development will take place in China. CCS technologies are currently developed in Europe, but these are copied in China at a rapid pace (Meer, 2016). Industry in China feel mainly that CCS is an back-up low-carbon option because there is felt to be done too little to reduce the costs of CCS (Ashworth, 2015, p. 455). This has however been changing and the Chinese have included CCS in their decarbonisation agenda, hence there is a change in who is driving the CCS agenda forward in favour of the Chinese. As the EU and the member states at present are doing little to invest in CCS, the technology development could easily take place elsewhere. "If the EU and the European cement industry are not able to start to work on CCS/CCU for cement industry very soon, China will copy these innovative technologies with the big chance that the EU will fund CCS projects in the cement industry in China because the EU doesn't want to fund in Europe for whatever reason" (Meer, 2016) argued the cement industry when underlining the danger of industry moving their production outside the EU. Getting large scale CCS up and running speaks in favour to abate climate change, but losing the lead in CCS technology development is not beneficial for European industries and the EU economy (Meer, 2016). The potential relocation of the steel and cement industries could be very damaging to the EU economy and would result in high levels of jobs lost.

4.3.4 The lack of adequate funding mechanisms

Nearly all informants underlined the need for authorities to make more funding available for the industry. Funding has been available through the ETS, however, as the ETS has failed to deliver its promised carbon price, enough funding has not been available. As CCS requires

both high capital investments and high operational expenditures, current funding mechanisms that only support capital investment are not supporting CCS project adequately. Up until now, the energy intensive industries have financed most of the CCS developments themselves, but the cost of realising large scale CCS application is too large risks to carry for industry (Meer, 2016). Due to different understandings of what responsibility industry has to take, existing public funding mechanisms have been inadequate to facilitate the industry sector. The challenge for industry has been that EU support mechanisms for CCS have relied on full chain CCS projects; therefore, the industry's position on CCS is not reflected in existing funding schemes. The intentions behind the NER300 program were very positive as the program made the needed funding to demonstrate CCS available (EUROFER, 2016). However, the eligibility criteria in order to realise projects under the NER300 program were hard to fulfil and companies had to take on more risk than they were willing. The NER300 was never applicable to industrial CO_2 emissions and it required verified permanently stored CO_2 emissions, to be granted as a successful project, hence the cement industry accounted it to be never realistically relevant funding for their sector (Meer, 2016). The steel industry recognised the eligibility criteria to be unrealistic for industry to fulfil (EUROFER, 2016). Furthermore, other funding mechanisms such as the Horizon 2020 program tended to not be enough funding to be applicable for CCS projects (Meer, 2016).

When the NER300 program was established, general optimism was seen within the CCS community and it was expected that the member states would provide for the rest of the required funding. Member state support has however been unfortunately low. The industry themselves realise as well that when a project is developed, industry must financially contribute to a project themselves in order to ensure full commitment to the project (Meer, 2016).

As the NER300 program has proven to be very inadequate for industry CCS, in the process of rethinking the ETS, the European Commission has proposed an Innovation Fund to replace the NER300 program. The ETS reform does not provide the certainty that the Innovation Fund will provide the necessary conditions for industry CCS either, as the legislative process is not completed yet. The new fund is expected to be extended to apply to low-carbon innovation in industry. However, industry informants recognised that the Innovation Fund that the eligibility criteria must be very flexible in order to be applicable to industry CCS (EUROFER, 2016). Furthermore, informants suggested that in the European context, there should be support mechanisms in place until at least 2030, after that CCS should have its play in the low-carbon society.

In spite of industry asking for funding beyond the ETS funds earmarked for low-carbon innovation, the European Commission believes it has "granted a lot of money for CCS already, but the less success the projects have, the less inclination is there to spend even more money on CCS" (European Commission, 2016b). Nevertheless, the Commission acknowledges that the rules of both the European Energy Recovery Program (EERP) and the NER300 could have been more adequately designed:

> "The EEPR rules are very flexible, very supportive of the projects, which involves the risk of that you in the end have no project, but you have already spent a lot of money. The NER300 rules are more carefully linked to actual CO_2 injection. The benefit for us is that when no money is wasted when no project is being granted. No money is spent needlessly, but on the other hand it puts more pressure on the sector. And simply with the exception of the Netherlands and recently the UK, no other member state put enough money on the table to match commission efforts. And we need to think about, are we wrong or are they wrong?" (European Commission, 2016b).

This underlines the conflict between designing adequate funds and the concern about wasting public funding to unsuccessful projects. Moreover, one of the industry representatives referred to a meeting with the European Commission where it had been stated they would not facilitate CCS in industry for the next three to four years – suggesting little willingness from the EU institutions' side to facilitate and support further CCS development in industry. The institutions are expecting that industry should be able to manage to get a project off the ground based on the current conditions (European Commission, 2016b). In contrast, industries points out that:

> "We see that governments are asking a lot of things from us, but forget a lot in order to ensure the wanted developments. It is not that we don't want to, that is not the point. We as HeidelbergCement want to move on CCS/CCU, etc. We are convinced that we have to move and we are able to move. The point is that it is not possible for the moment being limited by the economic and legislative perspective" (Meer, 2016).

Additionally, steel industry representatives pointed out that the right risk sharing profile between industry, EU and national authorities has not been seen anywhere in European CCS projects. There is no clear regulation of who should take what financial risk (Sheffield University, 2016). The industries therefore call for risk financing as well as projects are not always successful (CEMBUREAU, 2016). Industry is still struggling with the aftermath of the economic crisis and cannot financially afford to fail projects (EUROFER, 2016).

4.3.5 The challenge of public perception

After discussing the economic challenges concerning CCS deployment, most informants tended to highlight the social barrier of CCS where local communities have shown scepticism towards utilisation of CCS. Public acceptance has proven to stop CCS deployment in several projects, such as in the Barendrecht project in the Netherlands. Further, in Germany the public fears what storing CO_2 potentially could do in the long run. Opposition has circled around concerns of storage and possible contamination of drinking water (Reissfelder, 2016). "Storage of CO_2 probably represents that part of the CCS-chain that gives rise to the most complex issues and novel challenges" (Henriksen & Ombudstvet, 2014, p. 6730). Politically it has become suicide in Germany to publically push for CCS, which is a very unfortunate as the potential for CCS in Germany is very high due to their large coal industry. These issues are lessening the political momentum for pushing for CCS as "convincing the politicians to put their weight behind CCS is quite difficult, because the public support is not strong for CCS" (Reissfelder, 2016). Public perception barriers are very much grounded in lack of understanding and low trust of industry and new technologies. However, the industries themselves do not see the technology as a barrier, as they trust the technology and its maturity (Sheffield University, 2016).

Da Silva (2015) acknowledged already in her research that utilisers of CO_2 tend to see the public acceptance barrier as the largest challenge to CCS deployment. One of the representatives from the steel industry confirmed that they see public perception as one of the main barriers of CCS deployment (EURFOFER, 2016) as this hinders development of transport infrastructure and storage capacity across Europe. Public concerns of CO_2 leakage from storage limits subsequently politicians to support development of CO_2 storage capacity (Sheffield University, 2016). Without developing storage capacity – CCS cannot be realised. In the case of the public, it is fairly simple to influence the public against CCS. However, it is very difficult to persuade the public for something (European Commission, 2016a). Therefore, in countries very sceptical to CCS deployment such as Germany and Austria, perception barriers are essential to overcome.

The member states that have showed most interest in doing CCS have been the Netherlands, UK and non-EU country Norway. All of these have enough storage capacity offshore. Most likely, therefore, these countries have tended not to experience large public perception issues concerning potential CO_2 leakage. Nevertheless, Norcem foresees possible public acceptance challenges with their plans for temporary storage capacity at their

production site (Bjerge, 2016). Countries where only onshore storage would be possible, public perception is a real concern that has hindered projects from moving forward. Public perception is much more a challenge for onshore storage. If onshore storage is avoided, then the perception barrier could be avoided (European Commission, 2016b).

4.3.6 The non-existent developments in transport and storage capacity

Most informants argued that the almost non-existent development in transport and storage capacity for CO_2 is blocking deployment (Røkke, 2016). As stated, industries' acknowledge only CO_2 capture as their societal responsibility of the industry; for example, at HeidelbergCement's plant in Brevik in Norway, only capture technologies are tested and the feasibility studies for transport infrastructure and storage capacity is defined as public actors' responsibility and subsequently delegated to adequate public authorities (Bjerge, 2016). The fact that very few member states are truly interested in and committed to deploying CCS, does not accelerate the development of transport and storage capacity. At present possibly only non-EU country Norway and the Netherlands are truly devoted to CCS deployment. Up until November last year the United Kingdom had been committed too, until the UK government's decision to cancel the one billion pounds earmarked to be spent on CCS development, brought the UK's commitment to at least a temporary end. There is thus a conflicting relationship between few countries interested in developing CCS infrastructure and the EU institutions and national governments requiring industry to reduce CO_2 emissions by 95 percent within 2050. Too few countries are really looking in the long term perspective that is needed to trigger CCS projects. CCS development is dependent on cross border infrastructure development, transport pipelines and storage capacity, however transport and storage infrastructure is member state competency, thus most of the infrastructure must be developed at member state level. When few countries are financially committed to developing it, the EU institutions have limited powers change this (European Commission, 2016a). In order to manage to cut emissions by 95 percent, there is no other way out then with CO_2 storage. All the other mitigating efforts will only be a contribution (Meer, 2016), making CCS infrastructure essential.

Ashworth et al. (2015) add the fact that when states are defining their mitigating strategies and including CCS or not, the debate goes beyond the technical and political discussion. The concerns revolve around cost and the high energy penalty that would add to governments concerns that are already troubled by making ends meet. Especially after the

financial crisis in 2008, politicians have to argue their case even more cleverly, if it shall be generally accepted that such large shares of public spending shall be earmarked for investments in CCS (p. 455). Costs have proven to be very damaging for CCS projects. For example, Poland is clearly not moving forward due to the large costs (p. 455), making Poland the large elephant in the room in EU climate action. The consequence of no CCS infrastructure being developed, industry stakeholders do not "see the conditions fulfilled to create in the foreseeable future, the necessary oversupply of transportation and storage capacity. And these conditions are really necessary for [the industry]. If they are not fulfilled, […] we cannot rely on technology that will not happen. What we say is that if this technology was really applied and deployed, we will also use them" (EUROFER, 2016). Therefore, member states lacking interest or ability to financially support CCS, is on a European level very damaging for future large scale CCS deployment.

4.3.7 The challenge of climate scepticism

In spite of all the scientific data proving climate change, concerns about the lacking awareness and interest into really making the needed efforts to combat climate change was observed by some informants:

> "The understanding that we have to remove CO_2, the general understanding of the urgent need to combat climate change is lacking. It is very similar to that environmental organisations are communicating in general; the lacking understanding that the climate issues requires concrete changes in our everyday lives. It is totally lacking. We easily believe simultaneously that somebody else will fix the problem, or technology will, but climate change does affect what we do in our daily lives" (Stuen, 2016).

This underlines the challenge of communicating the urgent need to combat climate change, and hence cut CO_2 emissions (Ashworth et al. 2015, p.456). The UN climate negotiations have not proven (yet) to have born the needed fruits for true action, and the Paris Agreement of December 2015 is still in its infancy. With a very optimistic take on it, the agreement to limit global warming to stay well below two degrees, will provide the targets that are needed for real action and leadership to pave the way forward to a low-carbon society. However, as Stoknes (2015) emphasizes, climate scepticism is however still an everyday challenge. Stoknes' (2015) early work towards a new psychology of climate action reasons that human inaction regarding climate change can be explained by the Climate Paradox. It refers to the paradox that contrary to the fact that the scientific data proving climate change in the last two

decades has been exploding, the level of climate action initiated has been disappointingly low. The doubt of climate change taking place is vanishing with every scientific article produced. Nevertheless, Stoknes' point is that we have enough data to realise that strong climate action efforts are needed, why is humanity not taking the necessary actions to encounter it? He answers his own question that humans are in denial toward climate science, as acting upon this knowledge would require deep and radical changes in our own lifestyles and requires large reshufflings of public budgets. Stoknes reasons that there is a psychological explanation of the Western world's inaction, and argues that there are physiological barriers towards climate action. Unfortunately, the large share of the public or business managers do not feel that pressing need (Stoknes, 2015) hence the mitigating efforts are only seen as an extra cost, and losing the favourable competitive position of the organisation. Therefore the voluntary basis for climate action is far from enough in regards to real efforts that are required. The environmental policies in Europe are one of the most stringent on a global scale. Nevertheless, if climate action is not felt as urgently among business managers, then environmental concerns have to be ensured differently.

4.4 Alternative decarbonising efforts to CCS

Related to the CCS debate, several informants tended to focus on alternatives to CCS, especially alternatives to the storage part of the CCS chain; alternatives that could avoid the identified challenges outlined in the above sections. As industries are feeling the pressure from governments and the EU intuitions to abate their emissions, they are searching for alternative ways to reduce CO_2 emissions. Up until now, both industries in the EU have focused on energy and resource efficiency improvements (Sheffield University, 2016; Meer, 2016). These measures have largely been motivated by economic interests to survive from the economic downturn. Both the steel and cement industries are still suffering and hence both sectors are continuously keeping their eyes open for new business opportunities. It is estimated that there are some further energy efficiency potential in the sectors, about ten percent (Sheffield University, 2016). These efforts have turned the steel and cement industry in the EU into the best performing plants globally, however the industry has realised that if they are to commit to the target of 80 to 95 percent reduction, CO_2 storage is required (Røkke, 2016).

Due to the slow movement in transport and storage development, there is little sense for a cement or steel plant to initiate CO_2 capture at their production site when there is no place to deliver the CO_2 (Røkke, 2016). In the wake of these non-developments, the technologies that enable CO_2 conversion into purchasable products are observed; these developments are those referred to as Carbon Capture and Utilization (CCU). The captured CO_2 can be turned into for example alternative fuels, bioethanol, chemicals, minerals feedstock, methanol, and algae production. CO_2 mineralization and utilization requires increased energy consumption to produce the products, hence the climate effect of CCU is uncertain. The industry representatives argued that their industry encounters CCU as a serious business opportunity for the future, even though it is uncertain how much emissions are reduced. The informants acknowledged the importance of taking part in the technology development that is happening at the moment. Both industries recognise CCU as technology driven and are presently testing CO_2 utilisation technologies in their respective sectors (Meer, 2016; EUROFER, 2016). The industries see a new market for these types of materials as there are actors willing to pay a high price for CO_2. The CCU projects currently researched are however marginal, referring to conversion of merely 10 000 tons of CO_2 (Meer, 2016).

Furthermore, the informants believe that the developments in CCU could bring developments in CCS forward (Meer, 2016). The steel industry in particular looks at CCU as possible synergies between different sectors to enable resources from steel production as resource to produce alternative fuels and feedstocks that can be used in the chemical industry (EUROFER, 2016). CCU cannot be the solution for all sectors, but it can be the solution for one plant – as several technologies might have to be applied in the same industrial plant (Meer, 2016). With transport and storage development lagging behind, some plants cannot rely on the CO_2 transported somewhere else, and hence are dependent on relying on different technologies (Meer, 2016). It was highlighted that especially in remote areas, at significant distance from coastal areas or rivers, no transport system is most likely to come in place in the near future and thence CCU could be an alternative (Meer, 2016). The industries' positon is that there is not one solution for climate mitigation, thus several technologies must be applied. It is estimated that carbon utilisation can only contribute to about ten percent of the CO_2 reductions (Sheffield University, 2016), because there are such large amounts of CO_2 from integrated steel plants and there is not a large enough market for those products that can be produced out of the CO_2 at the moment (Sheffield University, 2016; Meer, 2016). An illustrative example is Yara's plant in Porsgrunn in Norway alone produces enough CO_2 for the whole European beverage and food industry.

From a research perspective, it is argued that CCU as a technology should be conducted, however it can only contribute to mitigating climate change and makes most sense in Enhanced Oil Recovery as the CO_2 is stored permanently (Røkke, 2016). To that regard the Zero Emissions Platform argues that "CCU must include permanent CO_2 storage to qualify as a climate mitigation technology" (ZEP, 2013, p. 3). Nevertheless, if CCU can be an accelerator for CCS, then it could be a very useful contribution (Røkke, 2016). As Ashworth et al. (2015) underline CCU could possibly kick off the CCS agenda to ease the economics of CCS as was done in the Canadian CCS project in Boundary Dam (p. 455).

Industry's enthusiasm for CO_2 utilisation is furthermore grounded in that it avoids all barriers associated with CO_2 storage such as financing, transport and liability and avoids public perception challenges as well as it being a business opportunity (CEMBUREAU, 2016; EUROFER, 2016). Therefore, the story of CCU has proven to be a development that is very easy to communicate: "[CCU] contributes to the circular economy. You make something useful of the CO_2 and put it back into circulation as opposed to storing when you treat it as waste. Meaning CCU is very easy to communicate" (European Commission, 2016a).

The steel industry is calling for funding to support CCU projects, however the European Commission indicates it will not support CCU under the ETS, "because the ETS is about removing emissions. And with CCU you circulate them, and at some point they get back into the air. From a climate perspective CCU make only sense in mineralization, as it is permanently stored in building blocks and materials. These exist, but the volumes are very small. It doesn't make a very big difference. This is our position" (European Commission, 2016a). In summary, CCU is seen as an alternative to CCS, as a certain disillusion with CCS can be observed. The industry representative organisations express an enormous trust in CCU as a climate mitigating technology (EUROFER, 2016; CEMBUREAU, 2016), however their committed interest might be purely based on it being a new business opportunity.

4.5 CCS as competitive advantage

When questioning whether a market for low-carbon steel or cement would exist in the EU, and hence bring a competitive advantage for those plants investing in CCS, an almost consensus was acknowledged , that under current conditions, CCS is only an additional cost to the production. As the same environmental stringent legislation does not apply globally, the additional cost would drive European steel industry out of business (EUROFER, 2016). However, taking a positive perspective, in the upcoming decades the Paris Agreement should

provide a globally consistent framework incentivising CCS investments. Taking a negative perspective, it will still take years before any global consistency in environmental standards, delaying CCS deployment in utterly.

The cement industry highlighted that several times attempts were made offering carbon-neutral cement on the market, however consumers tended not to purchase these products. The consumers of the cement industry are in general not to end consumers, but construction companies which seem not to have the needed interest in consuming carbon-neutral products (Meer, 2016; CEMBUREAU, 2016). The cement industry is moving on carbon capture in order to be technologically ready when CCS becomes a competitive advantage, but at the moment the potential for CCS being of competitive advantage is not seen. The question of whether there is a market for so-called green cement or steel would therefore lead to discussing the potential for Green Public Procurement (GPP). This would be a political decision to push for procurements standards that require use of low-carbon products (Reissfelder, 2016). GPP is really in its infancy and public procurement tends to still be on a cost base. Nevertheless, GPP could be a tool to push for a market for low-carbon cement and steel (Reissfelder, 2016). The cement industry informants argue that only a small group of consumers are willing to pay that extra cost (Meer, 2016). Political consumerism can only work if there is a consumer group that can afford to buy the more expensive product. Thence, if authorities would pay the price difference, green industry could possibly thrive (Reissfelder, 2016). At the moment the cement industry expresses no wish to compete on green cement, as it is assumed the there is no market outside the EU. Moreover, European tendering process tend to be based on price, therefore there are few incentives to compete on green cement in Europe either. Nevertheless, other informants observed that a maturing process was taking place in the cement industry, acknowledging the industry could fully take part in the technological development of CCS and use the front runner advantages in the green cement industry (Bjerge, 2016), assuming there are front runner advantages. In theory competitive advantage could be attained, but at the moment far from realisation. If the CO_2 price would increase, then CCS would become a competitive advantage (Bjerge, 2016). At the moment that does not seem very likely (Sheffield University, 2016).

Furthermore, one steel representative suggested that in the future those sectors and plants that have access to storage capacity relatively easily and at a relatively low price, could have a competitive advantage over those sectors and plants located at a distance from coastal areas (Sheffield University, 2016). A possibility would be that new investments are made in those coastal regions and a restructuring of industry toward coastal areas might take place

(Sheffield University, 2016). Currently, one can observe different positions on CCS depending on where industry plants are located in Europe. Members of the European Steel Association are mostly located away from the North Sea, hence there are few easily accessible storage options offshore. Onshore storage causes large public acceptance hurdles, EUROFER's favorable position on CCU. In the long term, being located close to offshore storage possibilities could thus be of competitive advantage (Sheffield University, 2016).

4.6 CCS communication

There are public perception challenges associated with CCS deployment, therefore CCS communication and how to frame CCS projects to the public is essential for CCS to be successful. Among the informants it came clear that no stakeholder is really fond of CCS; CCS is a lot of effort, it is counterintuitive, it is expensive and even requires significantly more energy consumption. Thence, to communicate such a contested technology has proven to be difficult. Some informants highlighted the need to change the story of how CCS is communicated, and shifting the focus away from power CCS, has become a part in that movement (Sweeney, 2016). Advocates for CCS, namely, the European Technology Platform for Zero Emissions Fossil Fuel Plants (ZEP), recognise that the language used until now has not communicated the benefits of CCS – merely the drawbacks of CCS. Informants seemed to agree that the CCS community has used inadequate language when communicating about CCS and partly therefore the ZEP platform has seen the need to shift away from power sector utilities and hence the collaboration has been extended towards the industry sector (Sweeney, 2016).

In Norway there in general been low skepticism towards CCS as illustrated in the general acceptance of the project in the local community at the Norcem project in Norway (Bjerge, 2016). CCS is mostly perceived as a climate change mitigating measure. In spite of much higher level of insights in perceptions and the large extent of research on the social dimension of CCS, Ashworth notes that the level of overall awareness has changed relatively little. During the last decade, this could be traced back to the fact that no full scale CCS project has been commercialised in Europe, meaning no real public engagement with CCS projects has not been necessary (Ashworth, 2015). This is very much in line with the observation of limited active outreach in the Norcem project before the final investment decision is taken. They have however been very responsive if the public have requested information about the project (Bjerge, 2016). There is a perception that there is no value in

communication actively outward about a project that has not reached final investment decision yet. Furthermore, other industry representatives suggested that they engage in little communication on CCS except when project results are communicated on (Meer, 2016). Outreach tends to take form in more bilateral settings between stakeholders such as the European Commission and the European Parliament.

Furthermore, Ashworth et al.'s (2015) main conclusions is that knowledge and awareness of CCS, both its benefits and risks, are still generally low – this has come clear that the public overall is not comprehending that risks of intangible concepts and few stakeholders know enough about them to estimate the real risk (p. 457). As methods of monitoring and of storage wells have made major technical improvements, one still sees that the risks perceived by the technical personnel, and public, differs to a large extent. Eurobarometer assessed in 2011 people's understanding of the issues related to climate change and their awareness and acceptance of CCS (Eurobarometer, 2011, p. 4). As there has been little significant movement on the CCS agenda these last years, one could expect that the data from 2011 can be still regarded as relevant. In general there is still poor understanding of the technology across Europe and the member states. Possibly, the prevailing misconception of CCS is related to the industries choice not to proactively flag their position on CCS to avoid the public perception barrier. Anderson et al. (2009) therefore question how to communicate risk about a technology that seems to be quite contested, at least outside the research community.

Therefore, communication style and type of outreach must be project specific (Ashworth, 2015, p. 453). This research has resulted in a best practice guide for project developers to use in when communicating about new project developments. Brunsting et al. (2011) emphasise the importance of early public engagement to see the needs and adapt communication methods towards these needs (p. 1651). Hence it is clear that "the better communicators take into account receiver characteristics, most importantly their concerns, needs, and values, the more likely the chance of a well-informed, constructive dialogue" (p. 1661). Most research seem to recognise that to minimize public opposition to CCS projects, the earlier the communication and engagement is initiated, the larger the chance of it being successful (Brunsting et al., 2011). In the program it was shown that "the willingness and the ability to engage stakeholders at their level has proven to be an effective way of addressing concerns, questions, and building public understanding of the CCS process" (Greenberg et al., 2009, p. 4711). Based on the in depth knowledge of the local community, a thorough engagement program was developed. As Anderson et al. (2009) recognise, for CCS projects

to be accepted, constructive engagement is needed, and not mere opinion management (p. 4653).

The public have tended to be critical towards new technologies, especially in Germany and Austria. Cement industries do not wish to proactively communicate on CCS to the local communities, in order to avoid public opposition to the technology (Meer, 2016). It could possibly result in having to close down the production plant. Therefore a conscious strategy has been to limit communication on CCS. Since the industry agrees that they are solely responsible for capturing CO_2, they do not see it as their responsibility to extensively communicate on CO_2 storage projects either.

Furthermore, Terwel's findings on trust based public acceptance on stakeholder motives suggest that industrial stakeholders wishing to utilise CCS to abate their CO_2 emissions, face an even higher public acceptance barrier if they were to implement CCS. The results might be very logical as NGO's in general are perceived to serve the interest of the public and industry tends to act in the benefit of the corporation. NGO's are however not directly involved in CCS deployment, and speak either in favour or against CCS. They will not be involved in the physical engineering of a carbon capture unit on the industrial applications of a cement producer or a power plant. Hence, the "trust" lies in reality in the hands of those engineers building the technology – not in the NGO people advocating for CCS. This would indicate that industry stakeholders are exceptionally vulnerable to public acceptance when implementing CCS. Ironically, or not, the large point sources of CO_2 emissions, and hence those that need to implement CCS, are hampered by a public that does not believe in the good intentions of the industry. It illustrates the power of civil society actors in CCS communication and therefore the cement industries choice to avoid active outreach on CCS, seems under current conditions to be a well-grounded decision.

Such strategies do not speak for ensuring the deep decarbonisation of industrial processes that is necessary for the near future. In order to build the broad acceptance for CCS that is needed, one would assume that under-communication of CCS most likely is not the winning strategy to ensure CCS deployment in the long run. Building trust and relationships are the key factors in developing public acceptance. Therefore, integration of all involved stakeholders in the communication from an early stage on in a project, is needed to ensure that all involved understand the technology and the rationale of applying CCS; which in turn strengthens the possibility of project commercialisation (Stuen, 2016). NGO's representing the quasi-stakeholder of future generations; tend to represent the most reluctant views, as they weigh potential risks more heavily. Very often the argument of that investments in CCS are

diverted away from potential investments in renewable energy are echoed (Ashworth, 2015, p. 452). However, civil society tends to see climate change as a more urgent threat than industry stakeholders – and as NGO's are powerful communicators to the public, it is essential that a broad understanding of CCS as a climate technology is ensured. Henriksen and Ombudstvedt (2014) argue that CCS outreach and communicating the need of CCS to build public confidence, should lay in the hands of public authorities. Keeping in mind that storage of CO_2 triggers most public scepticism, and CCS infrastructure development should be a public responsibility, delegating CCS communication to governmental actors seems logical and necessary.

5 DISCUSSION AND RECOMMENDATIONS

The following chapter is devoted to discussing the research objectives through the empirical data presented in the analysis. The data is discussed in light of the concepts examined in the theoretical framework chapter. Firstly the chapter provides a summary of the analysis (1) to assess energy intensive industry's positions on and perception of CCS. Secondly, the chapter discusses theoretical concepts in light of the analysis (2) to investigate industries' extended responsibilities in a low-carbon economy. Thirdly, the chapter provides recommendations that are derived from the data analysis and discussion (3) to develop policy recommendations to facilitate industry CCS deployment.

5.1 Assessing industry stakeholders' positions on CCS deployment

Deriving from the data analysis, the steel and cement industries in the EU, tend to see the need for researching and investing in CCS. They are aware of the large CO_2 emission footprint they have and acknowledge that CCS is necessary in the transition towards a low-carbon economy in 2050. They fully comprehend that in order to decarbonise their processes, implementation of CCS at their industrial installations is obliged. Therefore, the industries' positon has been to engage with CCS in the form of investing in research and piloting projects; however, the industries do not foresee large scale demonstration and commercialisation to take place within EU under the current conditions. The EU Emissions Trading System does not provide for the economic invectives to install CCS and decarbonise the processes. Unresolved liability issues within the CCS directive are not creating the needed stable and predictable framework industry is dependent on to invest in large scale CCS. Overall, the steel and cement industries express that an adequate legal framework must come in place; major funding sources must be made available and hence a business case for CCS application will have to be realised in order to push CCS in industry forward. At the moment governmental funding is hardly available for industry. Therefore, the industries state that this has resulted in industry having to carry all the risks associated with CCS, such as developing the technologies needed at own cost and with little support to commercialise the technology. Consequently, both the steel and the cement industries articulate concerns about having to relocate outside the EU where there are less stringent legal requirements for CO_2 reduction if

these incentives do not come in place in the foreseeable future. As such, the concerns of the industries draw a complex picture of challenges to be resolved and can be summarised as following:

> "The emissions from industry are more dispersed and smaller, than the power sector. So the total volume of the CO_2 emissions from an industry plant is much smaller than a large power-plant. What happens is that the even for a cement or steel plant it would not make sense to invest in a whole value chain. They can invest in the capture, and that is completely their business. It is kind of easy for them, it is costly of course, but they can work it out. But then the transport, building the transport pipelines, or developing the storage site is completely different business. So they have to enter into agreement with companies doing that, and these companies do not exist basically. To make the storage sites worthwhile you have to collect the CO_2 from several sources, so you would need some sort of clustering and it needs a lot of preparation. Because the exploration of the storage sites takes years to be sure you can store safely there, so there is a lot of investment that must be done in advance without you knowing whether you will be able to store or not. Therefore it is a need for public support for this part, which is really transport and storage, because of all this reasons. There is kind of a market failure. There is an investment that needs to take place, but has to be ready from 2030; however, there is a lot of work prior to 2030 which needs to be done. Planning the infrastructure, exploring the reservoirs, and this is not happening. Or no, it is happening but really at a scale that is not sufficient" (European Commission, 2016a).

The industries' position on CCS is that their societal responsibility is limited to capturing CO_2. Combined with the almost non-existent movement of public authorities developing the needed CO_2 transport infrastructure and storage capacity, are all crucial bottlenecks to overcome. As a reaction opposing the lacking storage development, industries are looking into what business opportunities Carbon Capture and Utilisation can bring. Utilisation of CO_2 could serve as a business opportunity to offset the additional costs CO_2 capture brings. Nevertheless, this raises questions to what extent CCU can contribute to preventing CO2 from being released and whether there is a market for all the materials and products that can be produced with CO_2.

Overall, the barriers towards CCS deployment are not technical, as those familiar with the technology tend to trust it (Sweeny, 2016). The framework conditions in the current political economy in the EU are blocking deployment. Furthermore, there seems to be a general understanding among the informants of the severity of the public perception barriers, though these concerns vary across the EU. In general there is a consensus that effective outreach and engagement efforts combined with ensuring that most CO_2 storage capacity would be developed offshore, public confidence challenges can be overcome. Moreover,

those challenges could be overcome by better communicating the benefits of CCS deployment. CCS is recognised as the technology that in the long run can ensure that the European energy intensive industries are able to remain located in the region, as CCS is currently the technology that can ensure that both jobs are protected within the EU and CO_2 emissions are reduced. If a business case would be created for CCS, then CCS could possibly bring re-industrialisation of the EU and climate target commitments together.

5.2 Investigating industries' extended societal responsibility

Thus, what are industries' responsibilities in the transition towards a sustainable low-carbon economy and what can public authorities and society require of them? Informants made clear they as industry fully comprehend that they are required to at least partly fund CCS projects (Meer, 2016). Nevertheless, is industry in the position to require governmental support to implement carbon capture units at all? Keeping in mind the 'polluter pays' principle, one would think, and possibly argue: "It's their emissions, their responsibility."

From a stakeholder theory perspective and in line with Freeman's argument, industry is responsible to take on board its stakeholders concerns and interests to ensure that the value created is maximized for all affected groups. In the case of the steel and cement industry, claims from stakeholders associated with CCS such as local communities or agents such as NGO's have proven not to favour CCS deployment. Stakeholder integration, involving local communities into business decisions, has blocked CCS projects due to the low public confidence in the technology. As NGO's are important opinion shapers on environmental issues, if the public, hence the local community trusts the NGOs that tend to be more hesitant towards CCS technologies, voice these concerns, public scepticism towards CCS as a technology is not surprising. Nevertheless, as Elkington (1998) argues, close stakeholder integration will be one of the most essential elements in facilitating the transition towards a sustainable society, (Elkington, 1998) hence, requiring the integration of civil societies' views as actors who speak in favour of future generations interests. Considering that the public trust is higher in civil societies statements on CCS, compared to the industry itself, communicating that CCS is in the publics' and the environments interest, is therefore very important. For the industry stakeholder themselves, CCS tends to be a doubling in cost of the product they are producing. Hence, in terms of what interest CCS is serving – it is counterintuitive to believe that CCS is serving the interest of the industry at the moment. The extended responsibilities of the industry are to urgently cut emissions in the industrial sector, but this will require

stakeholder's views and concerns taken into account. A CCS narrative and well planned outreach program to ensure that the benefits of CCS are communicated to the public is expected to ensure CCS' success. NGO's will most likely play an important role here.

Moreover, what can be expected of industries' societal responsibility to comply with the principle of sustainable development? According to the polluter pays principle; as cement and steel industry are polluters, they have to pay the damage for those emissions or preventing them from being emitted to the atmosphere in the first place. Similarly, Porter and Kramer argue that as industries' largest impact on the external environment is emitting CO_2, thus it is their social responsibility is to minimise CO_2 emissions. This would produce the greatest *shared value* for both society and the industry itself. The industries' overall position on what their corporate responsibility in sustainable development is, is therefore to minimise CO_2 emitted to the atmosphere. How this is attained, is in principle irrelevant, however as CCS is currently the available technology that can enable this, energy intensive industries' engagement with CCS can be directly associated with their efforts into the transition to a low-carbon economy.

Industry is increasingly held responsible for the minimising their environmental impact, both by expectations of stakeholders, NGOs, the general public and by legislation, thus, solely focusing on profits is not possible within the EU anymore. As illustrated by the informants' responses, they truly feel the pressure to make the required CO_2 emission cuts. Through the ETS, industry is legally bound to reduce their emissions, however as the ETS is a market tool, industry can chose to either sell their allowances and allocate the value of these to prevent the plant from not emitting those emissions, or pay the allowances and continue to emit the CO_2. As the price of the CO_2 is not at a significant level, it is cheaper for industry to buy the needed allowances to continue emitting CO_2. Therefore, the ETS has become a framework lacking the intended incentives for industry to engage in. The effect of the failing system has resulted in a system which industry on an almost voluntary basis can choose commit too. It is thus not surprising to see that industry until now only have done the mitigating efforts such as energy efficiency and applying alternative fuels that are economically motivated.

Therefore, societal expectations of CO_2 reductions should to be more than just expectations, and have to be turned into legally binding regulations. The European Commission argues that it has created the regulatory framework ensuring that investors know what the rules they have to comply with, as well as the European Commission has financially supported projects through the NER300 program and the European Energy Recovery Program

(European Commission, 2016a). Nonetheless, if industry does not invest, then the policy framework has not been sufficient to incentivise the required investments. A framework must therefore come in place that enforces sustainability principles into industrial processes. As there is such a high degree of uncertainty of whether the future reformed ETS can deliver on its promises, developing additional polices forcing industry to engage in deep decarbonisation, is suggested. To that regard, if there is not a large market for low-carbon cement and steel, the pressing need to legally bind industry to implement the principle of sustainable development becomes even more evident.

Therefore, confirming Baumgartner and Ebner (2010) in the current context, industry has to adapt to external factors and not solely internal matters, hence industry cannot only take the economically motivated measures such as energy and resource efficiency – though these are in a climate perspective positive contributions. The essence for industry is therefore to react to the trends that are emerging on the sustainable development agenda – and still manage to stay competitive in rapidly changing markets. This position does however equally weigh environmental responsibility and competitiveness. A principle of the primacy of sustainable development in business subordinates competitiveness from environmental concerns. Sustainable development, referring to the transition to a low-carbon economy, is dependent on that our natural environment is kept intact and that the global resources are not depleted. Planetary considerations are therefore the most important as these are what our and future generations' welfare is dependent on. According to the principle of sustainable development, industries' responsibility is to subordinate economic concerns in favour of environmental concerns.

Not surprisingly, that tends not to be an acceptable alternative for industry. Concluding from the informants' statements, industry tends to be in favour of CCS if they at least are financially as well off through these policies with CCS as without CCS under the current framework. This indicates that they in principle are requiring some sort of protection from international competition. The informants did not refer to such supporting policies as protectionist, but as environmental standards. This underlines as suggested by Millon (2015), if industry does not see the financial benefits of implementing sustainable production processes, they are not willing to implement them. Therefore, affirming from the data, the steel and cement industries are not willing install CCS and act on their societal responsibilities, if it is damaging for their balance sheet

As gloomy this may sound, in an extended societal responsibility perspective and ensuring the transition towards a sustainable low-carbon economy, we cannot afford to let the

steel and cement industries wait to act until more favourable framework conditions are in place. Political processes are dreadfully slow, meaning that before any adequate legal framework is in place, we have waited too long to implement the needed climate measures, if the global community wishes to take the content of the Paris Agreement seriously. Future research might come up with improved methods for decarbonising the steel and cement industries such as alternative CO_2 free materials, however, as we do not have time to wait for these innovations, it is necessary to take the required steps to ensure industry CCS to move forward as a part of the transition to a green low-carbon economy. It seems that even if the global community realises the need for urgent climate action, the will needed to take those necessary measures have proven to be difficult. The diverse perspectives of what the ultimate solution to meet climate change is, is diverting attention away from ensuring real efforts. Most likely we are dependent to combine all climate mitigating solutions to manage to limit global warming to well below two degrees. Either CCS is getting off the ground, or in a concerted effort we agree that CCS is not the future and we make fully use of other measures. In the way that the CCS supporters are acting now (or not acting) has brought real decarbonisation efforts of the energy intensive industries into a state of paralysation – which brings us nowhere in a climate perspective. The global community is in dire need of dedicated solution oriented efforts which includes civil society to change the perceptions of CCS and persuade and pressure industries and politicians to take the real efforts needed. Currently, both industry and politicians incline to wait for each other to act. In spite of civil society not having a stake in CCS projects, they will play an essential role to reawaken the CCS agenda and enable the final push to get industry CCS of the ground.

One can affirm that due to the cement and steel industries' current reluctance to take the associated risk related to CCS investment, social corporate responsibility activities cannot be voluntary. Political decisions must be taken to enforce the environmental standards that are required for industries to cut the needed 80 to 95 percent CO_2 emissions within 2050. Political tools such as green public procurement should be considered to create a market for low-carbon products and incentivise industries to commit fully to large scale CCS deployment. Overall, decarbonising the energy intensive industries in the EU and simultaneously avoiding the industries relocating elsewhere, requires creating a concerted political effort to bring the needed framework in place where industries are economically as well off when fully decarbonising their processes. Climate change is such an overarching global challenge; we cannot leave it up to industry to act. Whatever decarbonising path is chosen for the energy intensive industries in the EU, some form of state intervention is expected to be required.

5.3 Policy recommendations to facilitate industry CCS

The following section provides recommendations that could facilitate industry CCS deployment. The recommendations are derived from the data analysis and discussion and experiences made throughout the research process. As CCS projects are complex with many stakeholders involved, creating clear responsibilities between the actors is key. The policy recommendations are thus not solely applicable to industry stakeholders, however to other relevant involved stakeholders as well.

– Establish a business case for CCS

Currently, the main barrier to incentivising industrial application of CCS is that under the current uncertain circumstances the steel and cement industries operate under in the EU, they do not recognise a business case for CCS. As these industries compete in an international market, they cannot afford such investments. If industry is to realise large scale CCS, they are in need of adequate funding made available and where the eligibility criteria are fit for purpose. The funding conditions of the proposed Innovation fund should therefore be as flexible and dynamic as possible; however, as there is such low confidence associated to an increasing ETS price, funding mechanisms beyond the ETS system should subsequently come in place. The current barriers ground in counter party risk and co-dependence between a large set of stakeholders and it is therefore essential that a clear division of responsibility must come in place in the EU. Investment clarity must be established to incentivise long term investments in CCS.

– Authorities should take the initial initiative to develop CCS infrastructure

As industries only regard capture of CO_2 as their extended societal responsibility, it is essential to decouple the development of storage capacity and transport infrastructure from capture of CO_2. Development of CO_2 transport infrastructure and storage capacity must therefore be encountered as public authority responsibility. There is therefore a necessity that member states think beyond 2030 and plan that their investments up to 2030 may have an impact on the further decarbonisation pathway. An EU wide vision for where one foresees storage sites can be developed and where CO_2 transport pipelines need to come in places is

therefore a necessity. A possibility would be to develop a Europe wide CO_2 storage atlas, inspired by the one developed for the Nordic countries through the NORDICCS project (NORDICCS, 2015). On a European level there is a need to look for solutions for industry to transport their CO_2 to offshore storage locations as there are too many hurdles connected to onshore storage. Furthermore, there is a need for a vision on member state level of their main point sources and which plants or industrial clusters it would be most suitable to initiate installation of capture units.

– Facilitate industrial clustering

If authorities want to pursue CCS projects, and get the enough value per tonne of CO_2, clustering of both industry and power CCS is the way to achieve the overall best outcome has become a general understanding of how to push CCS forward (Sheffield University, 2016). Currently recognised industrial initiatives that potentially could be developed into clusters realising CCS could be the Ruhr area in Germany, the Antwerp region in Belgium or the Rotterdam harbour area in the Netherlands where alliances of the willing for industrial CCS could be initiated (European Commission, 2016b). It is suggested that this is the best way to develop the needed CCS infrastructure. Nonetheless, to minimise the initial risks, industry CCS should start in smaller projects, even though larger projects would be less costly in the long run. As the current conditions do not incentivise such investments, it is essential to keep the risk as manageable as possible. One of the informants highlighted, you need at least one project up and running, so that politicians can stumble over pipes and touch things (European Commission, 2016b). In this way one has an actual project to show for which could ease the possibility for politicians to lay their political weight behind CCS.

– Policies incentivising CCS

At present, is seems that there is a need for political decision-makers to enforce industry to take the necessary steps. Possible policies to incentivise CCS deployment could be changing building standards to require low-carbon products to be utilised when new buildings are constructed (Sweeny, 2016; Røkke, 2016), which would stepping around the political problem of setting a target on CCS in the EU. Additional incentives could possibly be to push for

making green public procurement regimes in the EU mandatory, and thus enforce the wanted tendencies in industry and accept that a certain cost is connected to ensuring climate friendly materials in public procurement. The policies established should establish mechanisms that make choosing sustainable products the natural choice and enforce this with funding mechanisms and product standards. Industries' request for some sort of protection from international competition could possibly be ensured by implementing border tax adjustments on based on the carbon footprint of products when imported into the EU. These regimes are however contested under the World Trade Organisation (WTO) rules, and thus have to be agreed on in the WTO. Additionally, a common EU tax to pay for CO_2 transport and storage capacity development could be suggested, as CCS infrastructure could be seen as a public good, hence ensuring that all European citizens pay for their CO_2 consumed.

– A new narrative for CCS

If developing storage capacity should be government responsibility, the associated communication to build public confidence and communicate the need for CCS, should also lay in the hands of authorities. CCS communication should therefore be a task of the member states that could develop culturally specific targeted outreach programs. There is a need for effective early outreach to the general public to inform and ensure that the low confidence in industries' intentions does not affect the deployment of CCS. Furthermore, an obvious, but possibly overlooked need is to communicate the large source of CO_2 emissions the cement and steel industry actually are. Most people are not aware of the large carbon problem of energy intensive industries, and if this was more widely known, then possibly a market for low carbon steel and cement could emerge and a more widely recognised understanding of the need for CCS application in industry among the general public. A narrative that could be communicated is that CCS is not in the industries' interests – however, CCS is in the interest of the public as it both could be a solution for keeping jobs in the EU and meeting climate targets simultaneously. CCS installation in industry should be in the interest of the public, the environment, future generations and beneficial for the local economy. There is subsequently a need for a new narrative of CCS accessible for the public to understand the need for industrial CCS and its associated environmental and economic benefits for the local economy. CCS therefore should become an essential part of a comprehensive strategy for decarbonising energy intensive industries in the EU.

5.3 Evaluating the study

By shedding light over a relatively limited academically researched topic, the study contributes to a large extent in mapping energy intensive industries' positons on CCS in the EU. The question on whether it is possible to derive further generalisations based on the results beyond the context of this study, relates to the transferability potential of the results. For a qualitative study, relatively many interviews were conducted among the cement and steel industry stakeholders and the informants expressed to overall very similar positions. As further energy intensive industries in Europe such as refineries, pulp and paper and the chemicals industries suffer from large CO_2 problems as well, and they operate under similar conditions as the European steel and cement industries, it is plausible too assume that similar positions on industrial CCS installation could be found. This study can therefore be of academic value beyond the mere context researched.

As discussed in the methodology, the reliability of the study is considered to be satisfactory as the research methods applied have provided the needed data to comprehensively and thoroughly answer the research question. Nonetheless, the researcher has certainly been coloured by taking a favourable stance on CCS as an essential climate technology that can contribute solving the climate puzzle. On the other hand, the research question would not have been developed without the inspirational NGO setting creating the pre-defined viewpoint on CCS deployment. To that regard, a broader set of informants than solely industry stakeholders were interviewed for the purpose of the study; such as decision-makers in policy development and informants from the CCS research community, have provided deeper understanding of the overall context and framework CCS deployment relates to. Given the extensive insights on a complex topic, sufficiently strengthens the validity and the credibility of the derived results.

6 CONCLUSION

The purpose of the study has been to develop better understanding of the energy intensive industries steel and cement's positions on CCS to understand why CCS installation in industry has seen a very slow uptake in the European steel and cement industries. The study has therefore sought answers to understand what role industry stakeholders' attitudes towards CCS deployment have played hindering the transition towards a low-carbon economy. To shed light on the research question, three research objectives have been examined: (1) assessing energy intensive industries' positions on and perception of CCS; (2) investigating industries' extended responsibilities in a low-carbon economy; and (3) develop policy recommendations to facilitate industry CCS deployment. This chapter summarises the main findings of the study and suggests further research possibilities.

6.1 Findings

The main results of the study indicates that industries' positions on CCS in itself do not block the deployment of CCS, however the cement and steel industries' position on their extended societal responsibilities in a sustainable low-carbon economy are used as arguments against installing CCS. The cement and steel industries indicate that they can merely be held responsible for capturing CO_2 emissions and will therefore not engage in CO_2 transport and storage development. Without the required CO_2 transport infrastructure and storage capacity being in place, industries justify their non-engagement in large scale CO_2 capture deployment by there not being any economic rational to do so.

There is no economic rationale for industry to capture their CO_2 emissions due to the unfavourable framework conditions the steel and cement industries' are currently facing. The efforts made by the European Commission to create a stable and predictable framework for industry to invest in low-carbon technologies, have evidently not been adequate as industries have not done so. This is caused by the varying implementation of the CCS directive and the EU Emissions Trading System not delivering on its promises to incentivise decarbonisation. Despite both industries recognising that CCS technologies must be applied on large parts of their plants in the future, the steel and cement industries express concerns about being required to decarbonise their processes to such extent, they will under current conditions be outcompeted on a global market. Under the given terms, CCS installation in industry is an additional cost and as these industries cannot pass on the cost to its consumers because of the

nature of the products, hence installing large scale CO_2 capture in industry would force theses industries to relocate outside the EU. As a way to step around the lack of CCS infrastructure and the related public acceptance barriers to CO_2 storage, industries are currently investing large efforts in CO_2 utilisation projects, which potentially could create new business opportunities. However, in a decarbonising perspective these technologies are estimated to only amount to a contribution to CO_2 reduction as many uses do not permanently store CO_2, which reduces the abatement potential of CO_2.

The steel and cement industries' reluctance to push for further movement on CCS can be illustrated by their CCS engagement being limited to research projects in CCS. Concluding from the analysis, the industries are expressing a need for a certain level of protectionism from international competition if to implement CCS, in order to be economically as well off when fully decarbonising their processes compared to under current conditions without CCS installation. In conclusion, the industries indicate that they regard the technology as important in the 2050 decarbonising perspective, as well as their interest in deploying the technology if the framework conditions would economically allow it. Thence, presumably, if industries could get their industry protected from international competition through some form of state intervention designed as environmental standards or taxes, they would consider deploying CCS. Nonetheless, in an extended societal responsibility perspective and ensuring the transition towards a sustainable low-carbon economy, we cannot afford to let the steel and cement industries wait to act until more favourable framework conditions are in place. As the cement and steel industry currently are not willing to take the associated risk related to CCS deployment, societal corporate responsibility activities cannot be voluntary. Political decisions must be taken to enforce the environmental standards that are required for industries to cut the needed 80 to 95 percent CO_2 emissions within 2050. Overall, decarbonising the energy intensive industries in the EU, and simultaneously avoiding the industries relocating elsewhere, requires creating a concerted political effort to bring the needed framework in place where industries are economically as well off when fully decarbonising their processes. Climate change is such an overarching global challenge; we cannot leave it up to industries to act. Whatever decarbonising path is chosen for the energy intensive industries in the EU, some form of state intervention is expected to be required.

6.2 Further research

Possible further research issues identified are exploring possible policy regimes that could provide the needed incentives for industry to invest in CCS. Such policies could entail border tax adjustments, such as taxing products based on their carbon footprint, and the possible feasibility of such taxes under the World Trade Organisation rules. Further, contract for difference regimes referring to the difference in the price between green power and brown power, have been suggested to incentivise power sector CCS, and these could be assessed and an equivalent for this in industry could be researched. Additionally, further research issues could entail looking at the feasibility of making financial regimes that support industry CCS in the EU beyond the ETS system. Moreover, exploring how possible policies to incentivise CCS deployment, such as changing building standards to require low-carbon products when new buildings are constructed, could be looked at.

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Appendix

Interview guide

1. Perceptions of CCS
    - What perceptions of CCS have you encountered in your industry/your DG?
    - Which one of them do you consider as relevant for its deployment?
    - In case yes, which once and why?
    - Has/is this considered in policy development?

2. Perceptions of industry CCS
    - In your opinion, do you perceive a different attitude towards industry CCS than power-sector CCS?
    - In case yes, which once? In case yes, what do you believe is the reasoning for this?
    - What is your opinion on industry CCS vs power CCS and why?

3. Challenges of CCS deployment
    - In your opinion, which challenges do you regard as the most relevant once related to CCS deployment? (ex. lack of financing, lacking policy support, etc).
    - In your opinion, do the same apply for both power sector CCS and industry CCS?
    - Which one do you regard as the largest challenge?

4. The 2050 perspective
    - In your opinion, can power sector CCS play a role in the 2050 perspective of a low-carbon society?
    - In case, yes, what potential and why?
    - In your opinion, can industry CCS play a role in the 2050 perspective?
    - In case yes, what role and why?

5. CCS as an alternative
    - How do you regard CCS as a solution compared to RES solutions?
    - Can CCS be an alternative in those situations where RES is not an alternative? Ex. Industry CCS, and why? (ex. Energy intensive industries)
    - Do you see alternative solutions for key industries such as cement, steel, pulp and paper, chemicals and refineries to decarbonize their processes?

6. CCS as an competitive advantage
    - Do you encounter that CCS realistically can be of competitive advantage for the power-sector and industry?
    - Have you and your company considered utilising CCS as a tool for decarbonising your processes? Why/why not?

- In your opinion, do you believe that CCS application can be a source of competitive advantage in a 2050 perspective? Why/ why not?

7. CCS deployment facilitation by authorities
    - What is your opinion on authorities' (EU institutions and national authorities) efforts for facilitating CCS deployment up until today?
    - What has been challenging?
    - What could have been done better?

8. CCS communication
    - In your opinion, how do you perceive current CCS communication? (From the European Commission/ your company)
    - Has your company/industry engaged in CCS communication up until this point? In case yes, what kind out outreach?
    - What limitations have been encountered? Potential improvements?
    - In your opinion, how do you think future CCS communication/outreach can be done better?